# Solar Development in Agricultural Wetlands

## Three Years of Study on the Effects of Solar Panels in Agricultural Wet Meadow Type Wetlands

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## Purpose:

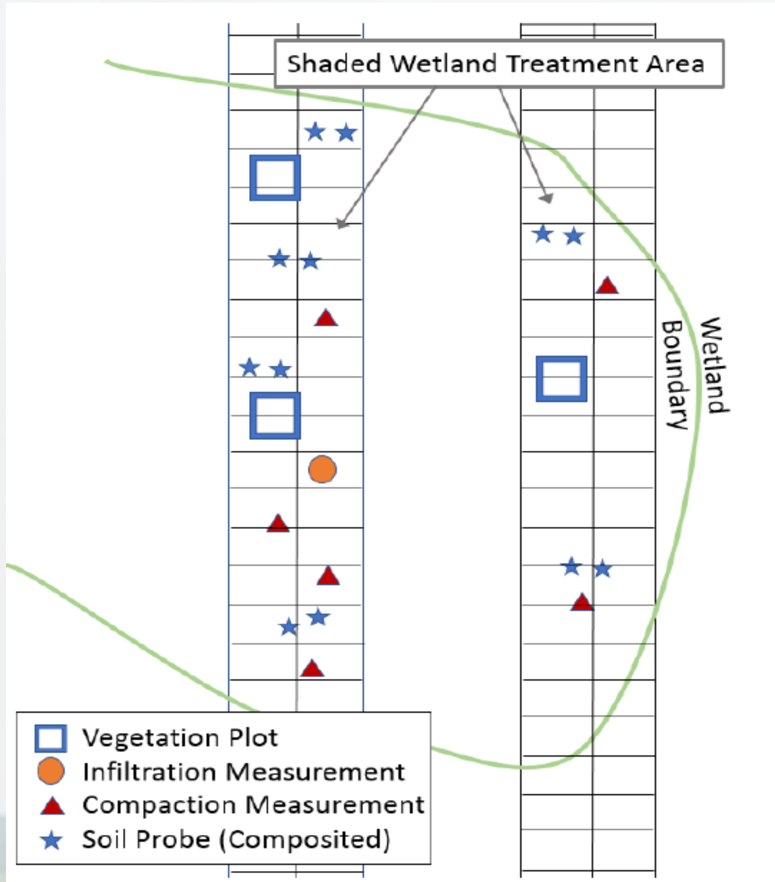
As demand for solar energy increases, so have permit applications to install solar panels in wetlands previously used for agriculture. However, very little is known about the relative physical impacts of solar farms versus agricultural use such as haying. By gathering data on these relative impacts we can inform our policy, best management practices, and permitting requirements.

## Abstract:

Vegetation, soils, hydrology, and other physical data were collected at five sites with solar developments in wet meadow type wetlands. Surveys were conducted in designated sun (between panel rows), shade (under panel), and reference (agricultural wetlands with no panels) areas at each site. Metrics included plant species, vegetation cover, soil compaction, and soil chemistry. Quantitative observations of hydrology and erosion were also conducted. The study began in 2018 and this paper includes data through 2020. At this point in the study, the most relevant data relates to plant species composition and abundance. Mowing regime appears to be the most significant factor affecting wetland condition regardless of the presence of solar panels. However, wetlands with panels tended to score higher in condition, as measured by plant diversity, than hayfields.

# Methodology:

Monitoring included hydrology, vegetation, and soils. Hydrologic monitoring was qualitative, conducted in the spring, and consisted of observations of hydrology and erosion. Vegetation monitoring incorporated three randomly located 1*1 meter plots each in sun treatment, shade treatment, and reference hayfield areas. Species presence and cover, litter cover, and vegetation height were recorded. The Coefficient of Conservatism (CoC), a metric of plant species disturbance tolerance, was used to infer wetland condition. Soil monitoring consisted of six soil compaction measurements and twelve soil samples in each treatment type. The soil samples were tested in a soil lab for several metals and substances. See the QAPP and 2020 final report for more information.





## Methodology: Lessons Learned

Several adjustments to the methodology were made in 2020 to account for emerging issues. Water infiltration was initially measured but the metric was found to be difficult to measure and did not provide consistent or meaningful results. Stem counts in subsets of plots were discontinued because it was impossible to conduct effectively in mowed ecosystems.

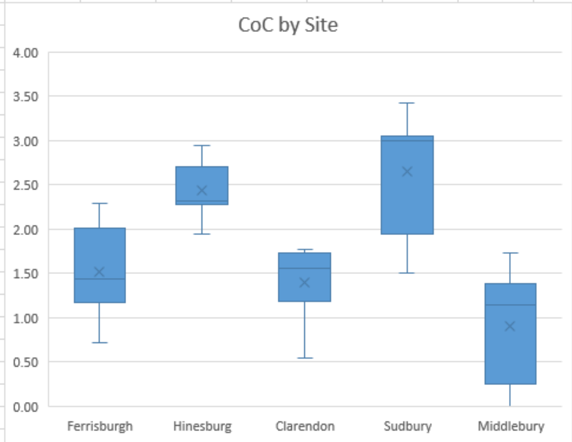
Future studies should also consider issues associated with permanent vegetation plots. Rebar and pins quickly disappeared into the soil due to freeze-thaw and mowing disturbance. Metal detector use is difficult in a solar farm full of metal objects and in areas of dense thatch grass. GPS reliability is low in an area of abundant electrical wires. In some cases metal detector use was not possible. Rebar can present a safety hazard in mowed areas. Larger posts were mowed around altering results.

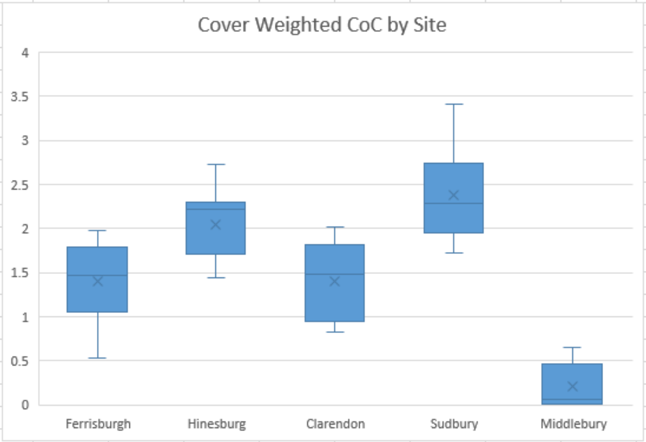
# Results:

Certain metrics reveal potential significant findings but others do not yet show any trends. Soil chemistry results are not showing significant trends between sampling locations. Preliminary soil compaction results seem to indicate that the reference hayfield sites are the most compacted while sunny treatment areas have more compaction than shade treatment areas under the panels. Results below are from 2018-2019.

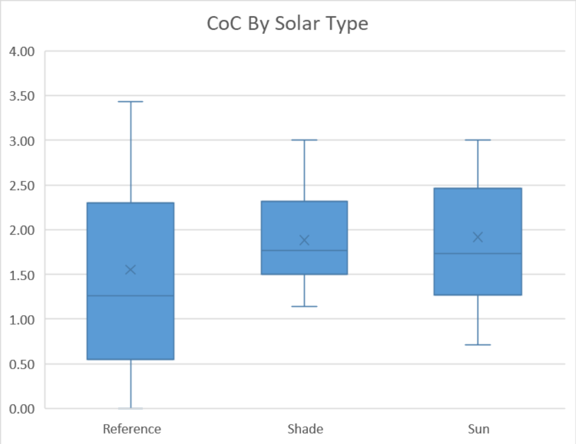
| Type | Count | Average PSI | Variance |
|---|---|---|---|
| Sun | 239 | 84.7 | 2288.4 |
| Shade | 239 | 68.5 | 2761.6 |
| Reference | 237 | 101 | 2553.2 |

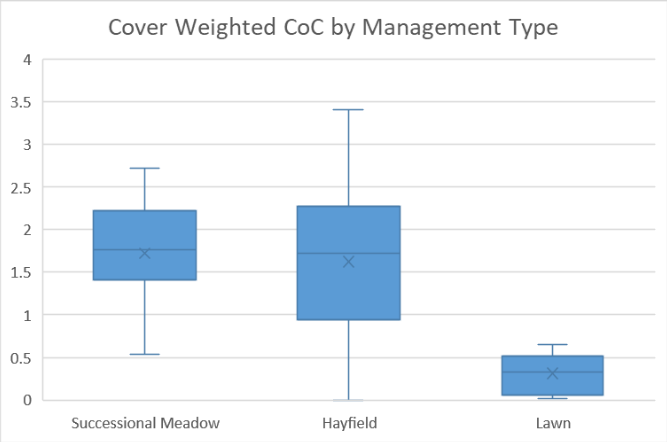
The vegetation data shows total cover being lowest in the shade treatment areas, but these sites had comparable species diversity than other plots and more forbs relative to graminoids. CoC was calculated both as an average number and a number corrected for relative cover of each species. The highest factor for variation was by site with the heavily managed (lawn) Middlebury site scoring lowest.




Other factors with notable variation included the plot type (sun, shade, or reference) and the management regime (lawn, hayfield, or successional meadow that is rarely mowed). Average CoC was better statistically explained by plot type, but the difference was small (reference sites got lower scores potentially indicating worse condition). Cover-weighted CoC was better statistically explained by management type, in particular that the site managed as a lawn received much lower scores.



# Discussion

The initial question asked for this study was whether there are significant alterations resulting from the change in use of agricultural wet [hay]fields to solar development. While results are early and more monitoring is needed, there are some preliminary trends found in the first three years of data collection. So far, the effects to wetlands with (or without) solar panels are most related to the mowing regime of the site. Mowed lawn wetlands are impaired, where a single mowing in late summer or fall (successional meadow) often result in a higher condition than a hayfield. However, if a monoculture of reed canary grass is present (as it was in several successional meadow plots), this usually results in lower wetland quality than a more frequently mowed wetland where reed canary grass is less dense.

The presence of both shade and sun in a solar farm does appear to increase habitat heterogeneity allowing for greater species diversity when observed as a single community. Anecdotally, the areas under the solar panels appear to be adopting a few ecological traits of the understory of forested wetlands, with more forbs and bryophytes present.

Measures to reduce soil compaction during construction or mowing appear to result in better wetland condition. While soil chemistry does not appear to be significantly different between wet hayfields and solar arrays, a conversion from hayfield to a solar farm does result in a cessation of manure spreading or other fertilization which could potentially lead to better water quality in the solar farms. Nutrient inputs were not measured in this study.

The final two years of this study will help determine whether there are specific best management practices (BMPs) which could improve the condition of a wetland under solar panels compared to a hayfield. BMPs could, for example, include the frequency and height of mowing, woody stem and seed plantings, invasive plant management and the use of timber matting during construction.

# Further Study

This study resulted in some preliminary promising findings, but further study would best be adjusted to account for lessons learned here. One of the largest challenges came from the active management of the sites. The ecologist visiting the site did not have control over mowing regime (and in fact altering from the normal mowing regime would alter results), and often also did not have knowledge of when a site would be mowed. Plot condition appeared to take a significant decline after a field was cut, altering results. In recently cut areas graminoid ID was often impossible. Previous species lists from each plot were referenced but this runs the risk of causing bias via missing changes in species composition.

The permanent plots were very difficult to relocate from year to year; posed a potential risk to maintenance crews; led to microplastics litter scattered around the sites; and sometimes were not possible to replicate exactly. Anchoring plots on infrastructure such as panel posts would help mitigate these issues.

A broader study of more sites but with less detailed methodology such as the Vermont Rapid Assessment Method would help increase the sample size to assess general trends. Additional areas for further study include: effects of shade management in adjacent forests, invasive species control, wildlife travel, grassland bird use, and long-term effects.