The extent of vegetation-driven panel cooling and consequent increase in electricity generation from solar PV sites depend on climate and soil properties

Rebecca Bertel

December 13, 2021

AGU FALL MEETING

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SOLAR ENERGY

Advantages

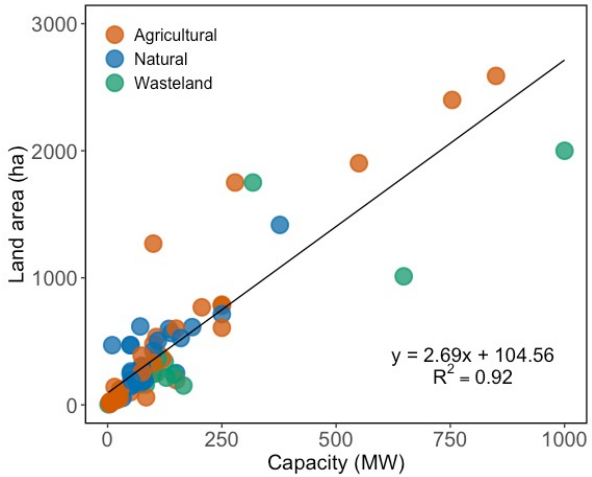
- Lower carbon emissions than fossil fuel generation
- Decreasing cost

Disadvantages

- Larger land footprint
- Long-time commitment

Mitigation

- Integration with other land uses



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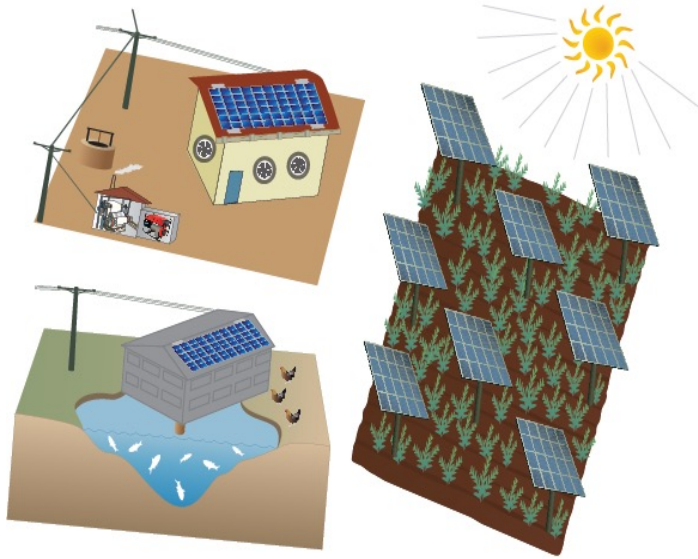

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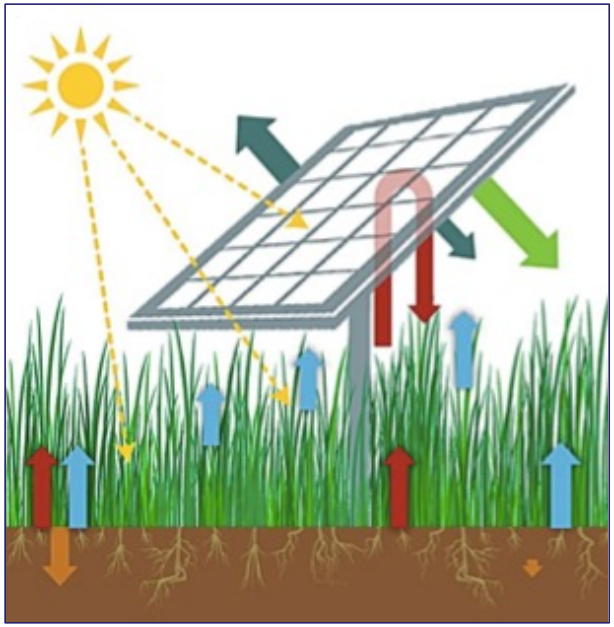
BACKGROUND

- Graham et al., 2021 studied pollinator habitats in dryland agrivoltaic systems
  - Found partial shade was more beneficial than full shade
- Adeh et al, 2019 found solar panel efficiency is a function of microclimate at the PV panel location

Questions

1. What impact does the solar power plant have on the soil properties in the context of vegetation growth?
2. How does dual land use for energy and crop cultivation reduce the land use impact of solar?



Barron-Gafford et al., 2019

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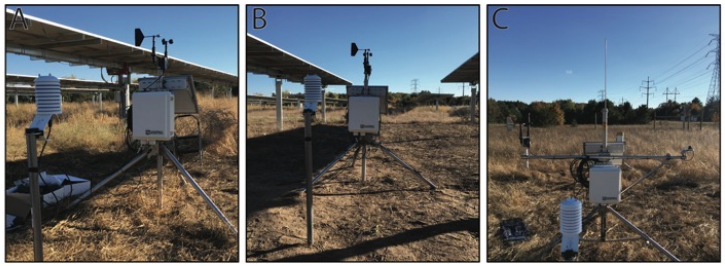
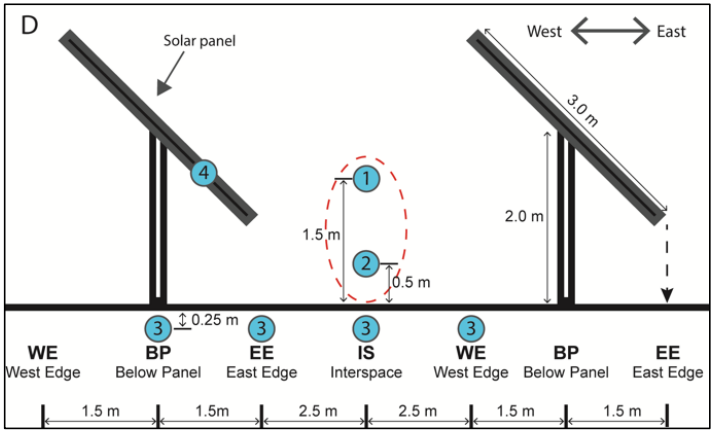
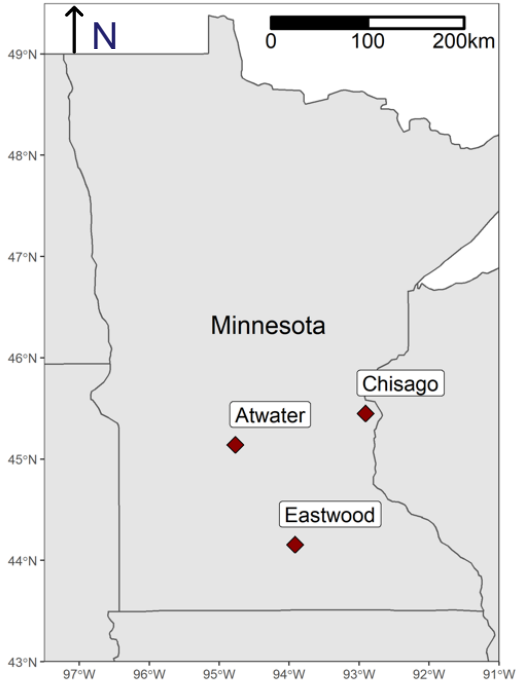
FIELD EXPERIMENT

- Three treatments: **Bare PV, Vegetated PV, and Control** (undisturbed)
- Natural vegetation (seeding)
- Data from May – August 2020 and September 2021





Sensors:
1. Wind Speed and Direction
2. Air Temperature and Relative Humidity
3. Soil Moisture
4. Back of Panel Temperature



Chisago, Atwater & Eastwood, MN

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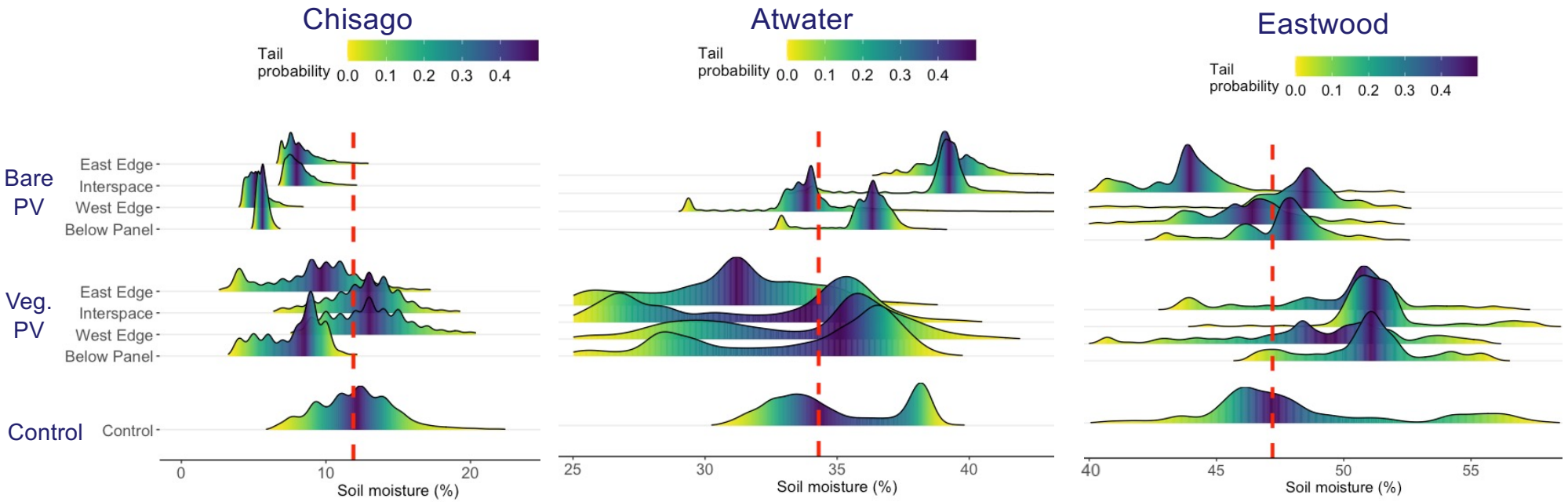

SOIL MOISTURE

- Heterogeneity in soil moisture is created by PV panels
- Higher soil moisture in the Veg. PV than in the Bare PV
- Vegetation homogenizes the soil moisture in the Veg. PV treatment

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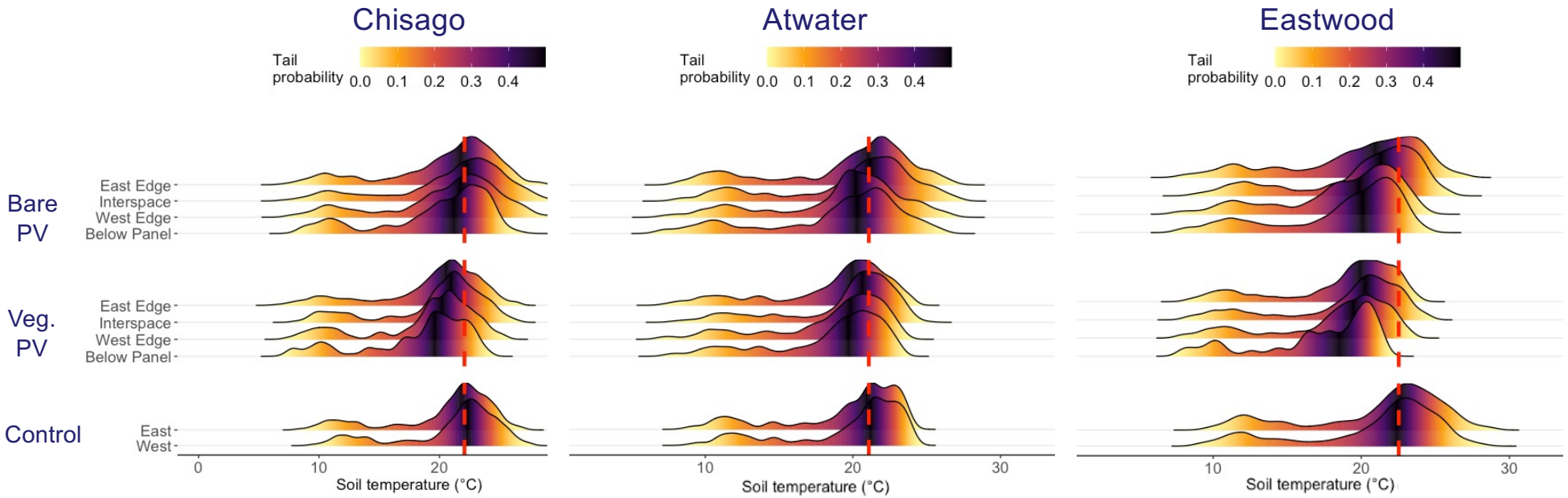

SOIL TEMPERATURE

- Bare and Veg. sites have lower temperatures because of shading
- Bare site has higher temperatures than the Veg. site

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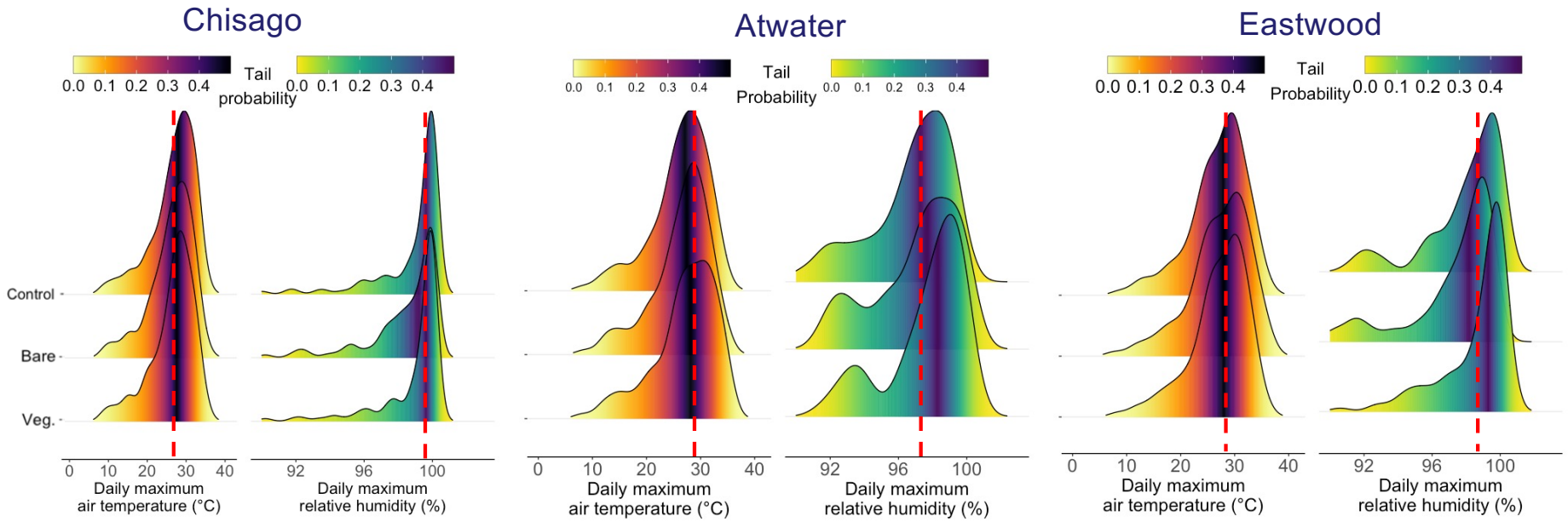

AIR TEMPERATURE, RELATIVE HUMIDITY, AND WINDSPEED

- Relative humidity was highest at all Veg. treatments
- Wind speed was slower and multidirectional at Veg.

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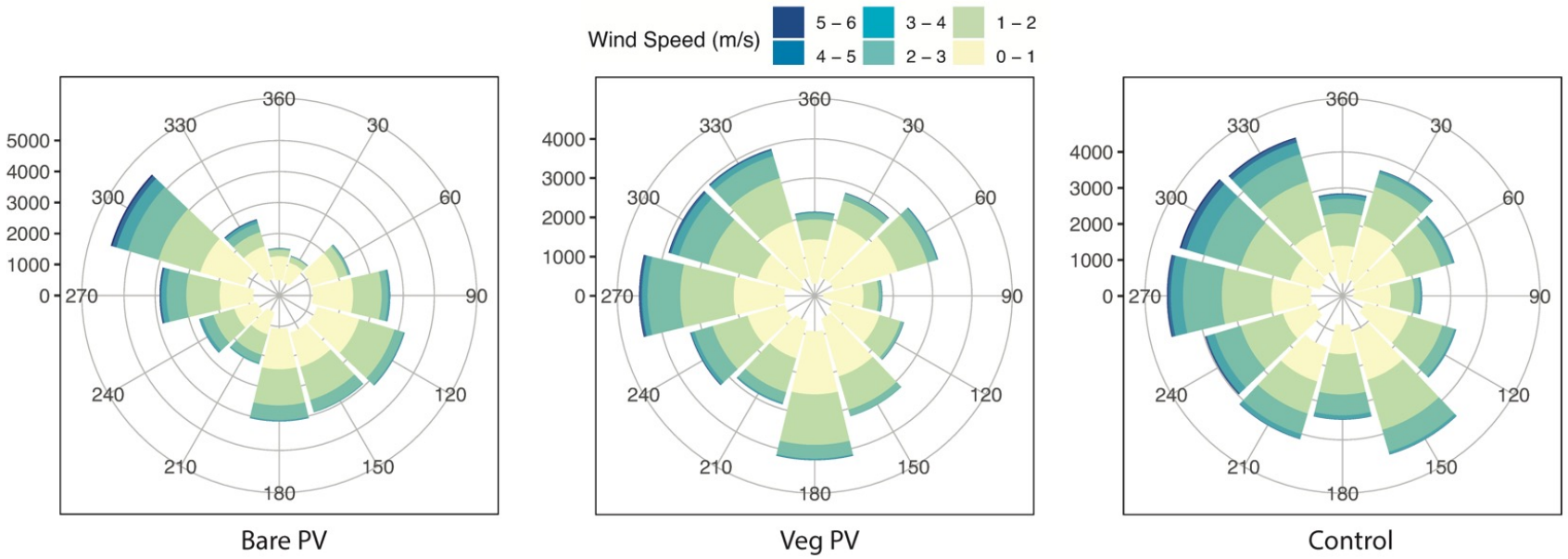

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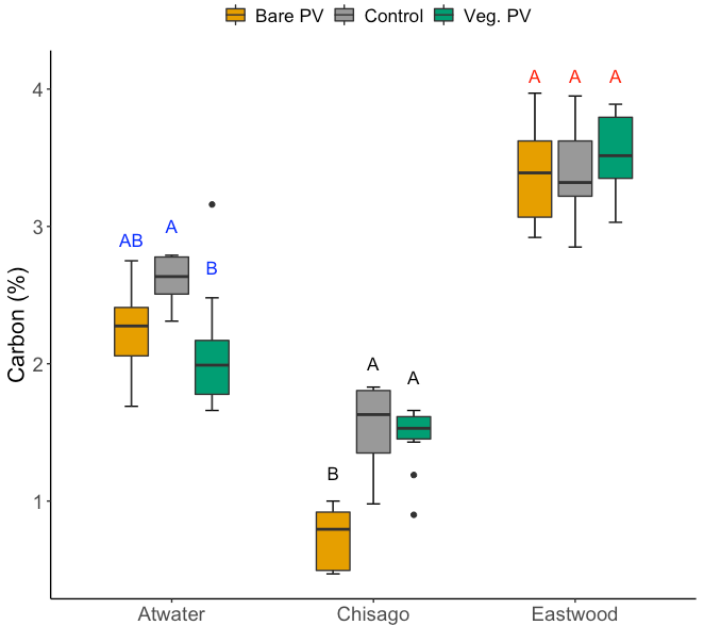

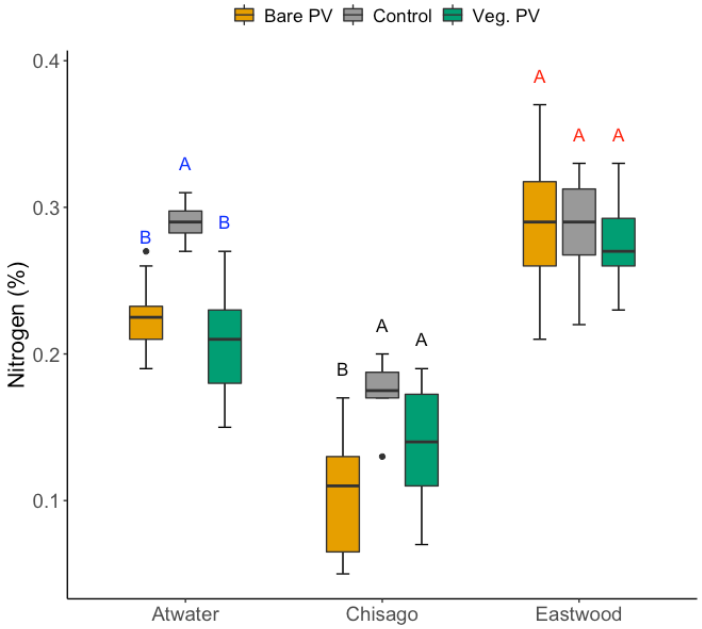

SOIL CARBON AND NITROGEN

- Atwater and Eastwood facilities were waterlogged → may affect nutrient cycling
- Decline in soil nutrients can be mitigated by vegetation
  - Other site conditions must first be considered

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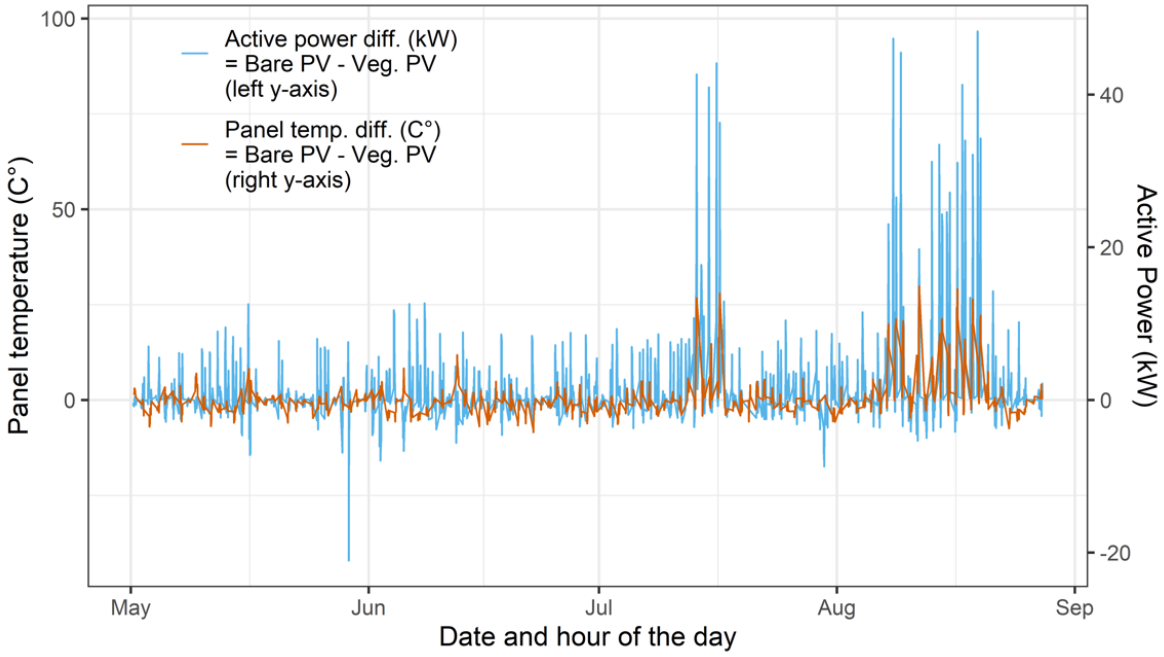

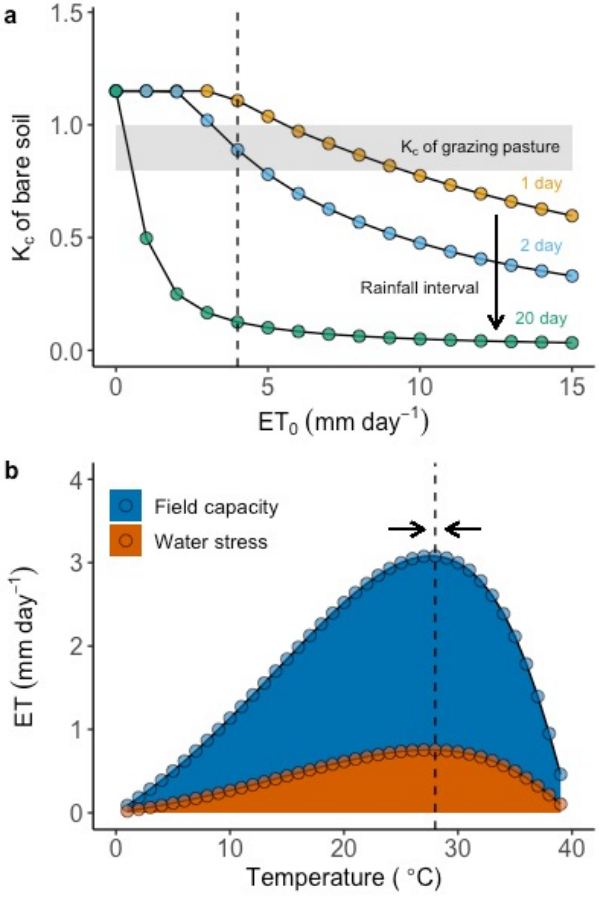

POWER OUTPUT

- Effects of crop cooling on electricity generation are site specific!

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CONCLUSIONS

- Solar panels create microclimates which may be beneficial to organisms of different sizes
  - Soil moisture, soil temperature, wind speed/direction and relative humidity differ
- Vegetation's impact on power production is dependent upon site parameters
  - Climate
- Study is ongoing
  - Sites will continue to be managed
  - Further exploration of the relationship between panels, vegetation, and power production

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THANK YOU

THANK YOU TO DR. RAVI, PAUL CHOI, AND JORDAN MACKNICK

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