Results from One Year of Integrated Research: Ecosystem Dynamics in an Agrivoltaic Grazing System

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Motivation

Integrating grazing & solar energy generation has many potential benefits, but important questions remain unanswered:

- Can we **co-optimize** energy generation, livestock grazing, and ecosystem services on the same land?
- How does the **integration** of solar energy generation and livestock grazing alter **ecosystem outcomes** and **carbon cycling**?

Experimental Design & Methods

6-year interdisciplinary study of agrivoltaic grazing systems

Three treatments of ~ **12 hectares** comparing single- vs multi-use land management systems:

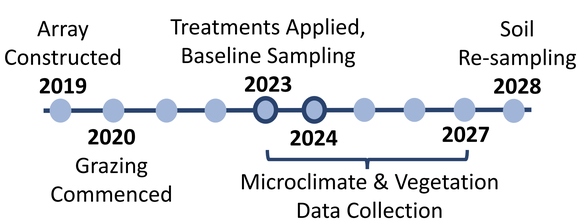
Solar PV
With conventional management (mowing)

Agrivoltaic Grazing
Solar PV integrated with rotational sheep grazing

Grazed Pasture
Open pasture (no PV) managed with grazing

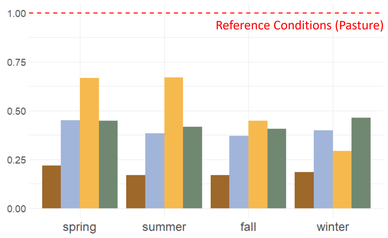
In addition to studying treatment-level differences, our experimental design also focuses on differences across small-scale "eco-zones" within each plot

Collecting microclimate, vegetation, and soil data across 6 years to understand module and treatment effects

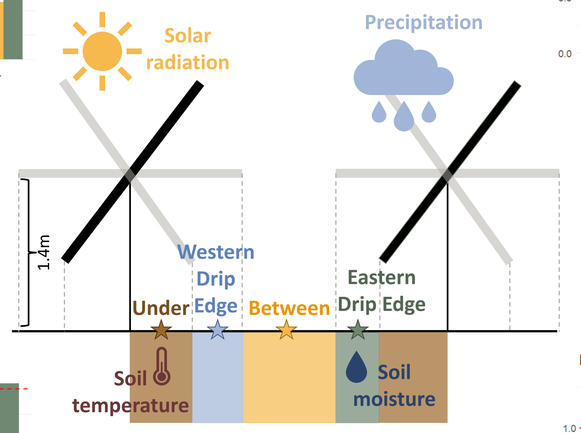


Solar Modules Create a Patterned Microclimate

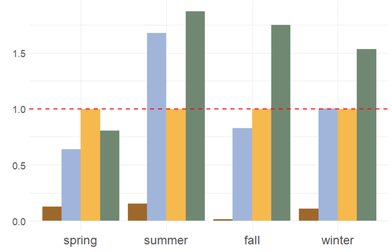
Normalized Ground-Level Solar Radiation by Zone & Season



Solar Radiation
- All zones experience a significant reduction in solar radiation compared to an open pasture.
- Under the panels receives 16-20% of full sun, while the Drip Edges receive 36-45% of full sun.
- Between panels receives the most sun, with 66% of full sun in Spring and Summer.



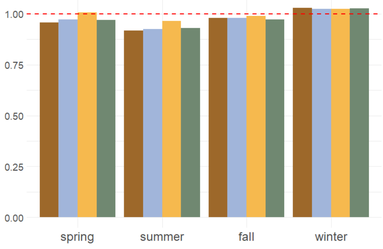
Normalized Effective Precipitation by Zone & Season



Precipitation
- The Eastern and Western Drip Edges receive significantly more effective precipitation than Under and Between.
- Under receives only 1-15% of the precipitation measured in reference conditions.

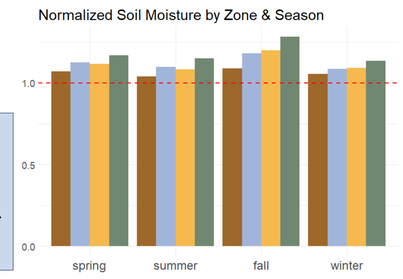
Soil Temperature
- Soil temperature is consistently lower in the array than in the reference in spring, summer, and fall.
- In the winter, soil temperature is higher in the array than in the reference.

Normalized Soil Temperature by Zone & Season



Soil Moisture
- Soil moisture is higher in the array than in the reference across all seasons and zones, with the most significant differences in the fall.
- The Eastern Drip Edge consistently has the highest soil moisture.
- Soil moisture shows more uniformity across zones when compared to the precipitation input patterns.

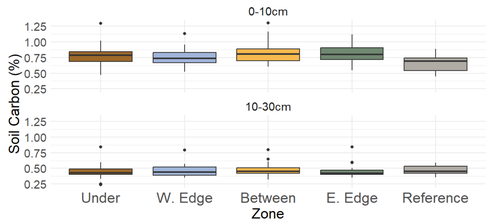
Normalized Soil Moisture by Zone & Season



Ecosystem Dynamics in an Agrivoltaic Grazing System

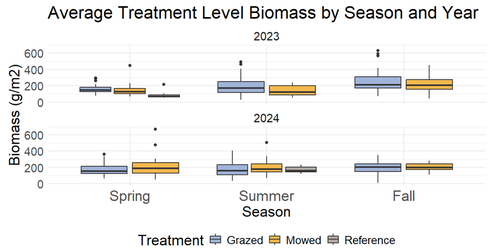
Four years after module installation, soils do not show any differentiation in soil carbon content by eco-zone.

Baseline Soil Carbon

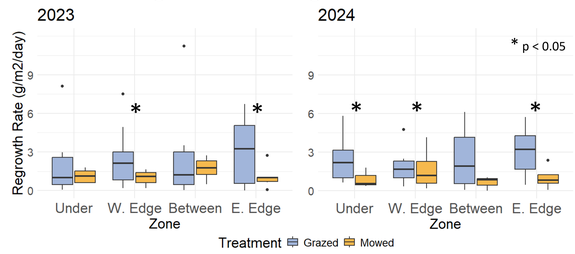


Treatment level biomass (averaged across eco-zones) shows no difference between treatments despite the variability in microclimate.

Average Treatment Level Biomass by Season and Year



Annual Average Biomass Regrowth Rate



- Vegetation samples are collected before & after every vegetation management event.
- Plots are grazed up to five times a year but only mowed twice.
- Regrowth rates are more variable in the grazed treatment.
- In both drip edges, the regrowth rate is higher in the grazed treatment than in the mowed treatment in 2023 and 2024.

Key Takeaways

- Solar radiation, precipitation, soil temperature, and soil moisture vary significantly across zones, creating unique growing conditions.
- Difference between 2023 and 2024 biomass trends emphasize the importance of multi-year studies to capture inter-annual variability.
- Preliminary data highlights need for climate-specific agrivoltaics research.

Next Steps

- Continue collecting microclimate and vegetation data over the coming years to track treatment response and better understand inter-annual variability.
- Resample soils five years after baseline samples were collected to study treatment and eco-zone effects.

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Lab Technicians: Brennan **Cury**, Alex **Schmett**, Nicole **Murray**, Kent **Kleven**

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