Site-Specific Variation in Plant Functional Traits Across Microhabitats Under Solar Panels in Coastal Grasslands

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Background

- California aims to achieve 100% clean electricity by 2045.
- Photovoltaic (PV) systems are increasingly installed in sensitive ecosystems like coastal California grasslands.
- Research on utility-scale solar energy has shown delayed blooming time and differences in floral abundance.
- Specific plant traits (e.g., SLA, LDMC, plant height) influence how plants establish near or under solar panels, could potentially favor stress-tolerant or shade-adapted species.
- PV microgrids are smaller integrated systems that can alter local environmental conditions.
- By linking these plant traits to solar microgrid influences, land managers managed for how ecosystems respond and search for sustainable ways to use solar energy.

Figure 1. A microgrid photovoltaic system in a coastal grassland at Lazy J.

Research Questions and Hypothesis

- How do solar panel microhabitats influence plant functional traits such as plant height, SLA, LDMC, and lobedness?
- Which plant functional traits are associated with successful establishment around solar panels?
- Plant functional traits will vary significantly between microhabitats beneath solar panels due to differences in light, moisture, and temperature conditions.

Methodology

- Plant communities were sampled from three grassland sites in Humboldt County, CA: Lazy J Ranch Mobile Park (LZJ), Arcata Airport (ACV), and a grassland in Kneeland (KNE) along an elevation gradient.
- Species composition was collected at each site using six quadrats along three 50-meter transects (n = 18 per microhabitat)
- Traits were assessed in three microhabitats within solar arrays: below the top edge of the panel (T), under the bottom edge (B), and in open areas between rows of panels (F) (Figure 3).
- Dominant species were selected based on their relative abundance in each microhabitat from plant surveys.
- Traits were collected from dominant species: *Agrostis stolonifera*, *Anthoxanthum odoratum*, *Arrhenatherum elatius*, *Avena barbata*, *Danthonia californica*, and others.
- Traits were measured for five individuals per species in each microhabitat (n=5).

Figure 2 & 3. Data collection via transects and quadrats in solar microgrids.

Figure 4. Sampling Design within Solar Panel Microgrids.

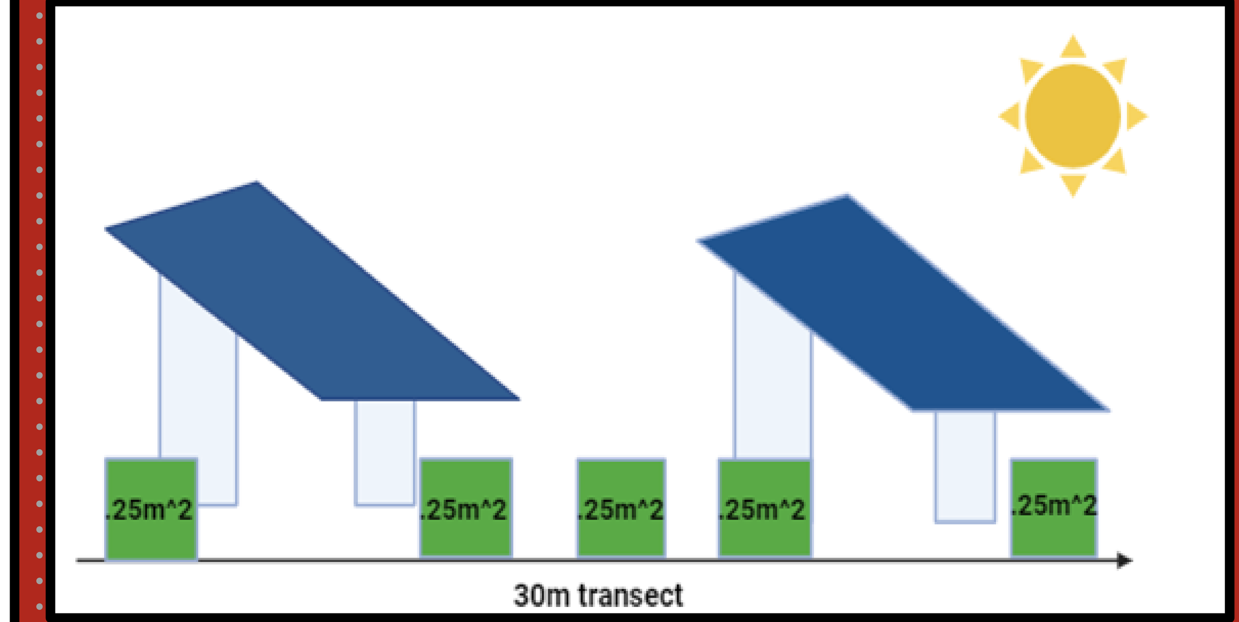
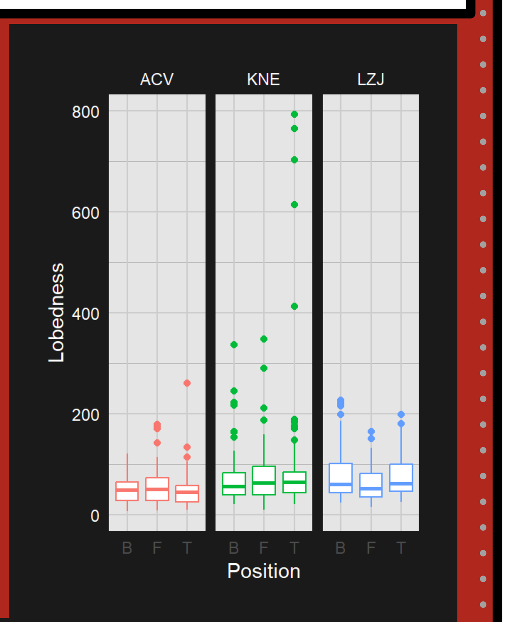


Illustration of the sampling setup along a 30-meter transect beneath solar panels. Quadrats (0.25 m²) were placed beneath the bottom edge, in the open field, and beneath the top edge of the panels to capture plant trait variation across microhabitats influenced by the solar array.

Results

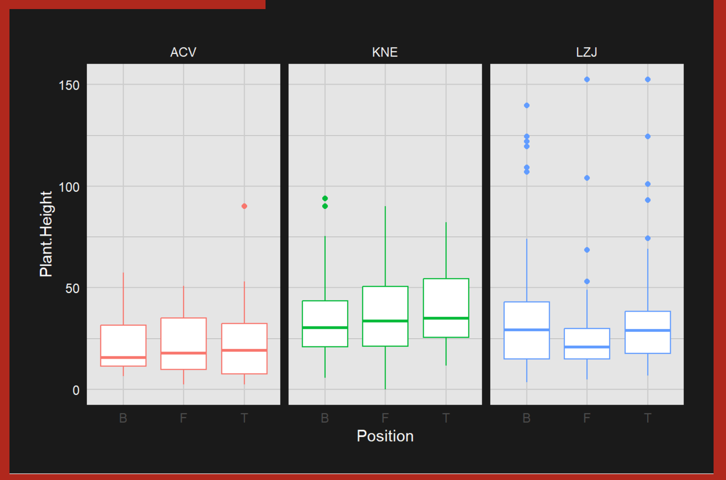
- LDMC (Leaf Dry Matter Content)
  - **Sites** show **significant** differences, with KNE having the highest values, followed by LZJ and ACV. **Positions** did not significantly affect LDMC.
- SLA (Specific Leaf Area)
  - Both **site and position** influence SLA. Top positions have the highest values, followed by the field and bottom. KNE exhibits the highest SLA among sites, with ACV showing the lowest.
- Plant Height
  - Significant differences observed across **sites**, with KNE plants being the tallest, followed by LZJ and ACV. No significant differences by **position**.
- Lobedness
  - **Sites** differ significantly, with KNE having higher lobedness than ACV. No notable differences across **positions**.
- Leaf Area
  - Significant **site** differences, with KNE and LZJ having larger leaf areas compared to ACV. No **positional** effects detected.

Figure 5. Lobedness across sites and positions



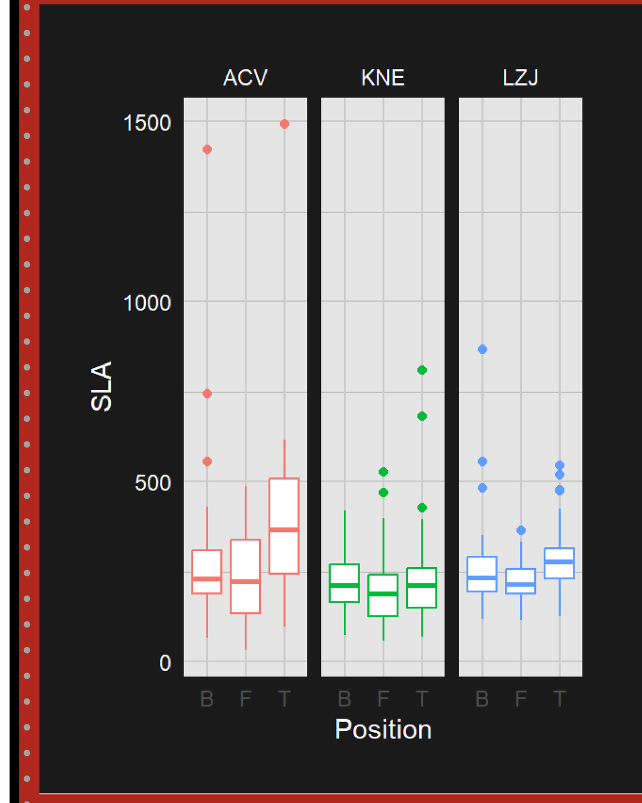
Boxplots show lobedness variation across sites and positions. KNE had higher lobedness, with the greatest variability beneath the top edge (T).

Figure 6. Plant height across sites and positions



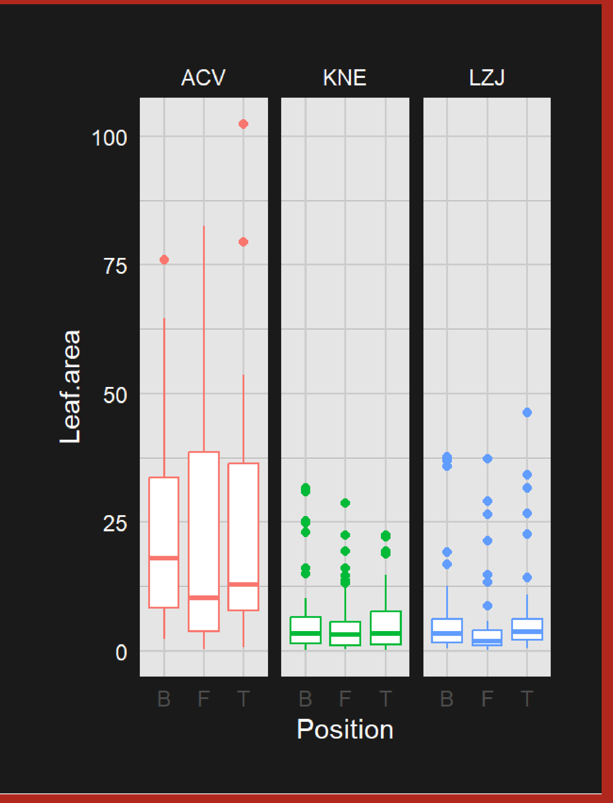
Boxplots display the variation in plant height across three sites (ACV, KNE, LZJ) and three positions within the solar microgrid: beneath the bottom edge (B), in the open field (F), and beneath the top edge (T). ACV exhibits the highest variability, while KNE and LZJ show more consistent plant heights across positions.

Figure 7. Specific Leaf Area (SLA) across sites and positions



Boxplots show SLA variation across three sites (ACV, KNE, LZJ) and positions within the solar microgrid: beneath the bottom edge (B), in the open field (F), and beneath the top edge (T). KNE exhibited the highest SLA, especially at the top edge (T).

Figure 8. Leaf area across sites and positions



Boxplots display leaf area variation across the same sites and positions. ACV had the largest leaf area overall, while KNE and LZJ showed lower and more consistent values across positions.

Literature cited

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Implications

- Solar panels create shaded conditions, which favor species with high SLA, as these plants are better adapted to low-light environments and can efficiently capture limited light.
- Functional traits like SLA and plant height help identify species best suited for growth under panels, supporting targeted restoration and co-use practices.
- Findings can inform designs for native pollinator gardens and managed grazing systems to maximize ecological benefits by selecting proper species that are best suited for these unique microhabitats.
- Site-specific responses highlight the need for tailored management approaches in different grassland systems.

Future steps

- Analyze species composition data to understand plant community differences across microhabitats.
- Study community-weighted traits to assess functional responses to environmental changes.
- Incorporate soil analysis to explore connections between soil properties and plant trait variation.

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