Yale SCHOOL OF THE ENVIRONMENT

Ucross High Plains Stewardship

FELLOWSHIP BRIEF

Investigating Shrub-Grass Interactions in Big Sagebrush Ecosystems

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The Need.

In temperate drylands, the relative abundance of grasses and shrubs is determined by soil water availability at different depths. The seasonal timing of precipitation interacts with soil texture to control where (depth) and when (season) soil water is available, thereby determining plant community structure. Ecosystems where most precipitation arrives during the warm season and soil water resources are primarily found in shallow soil layers are typically grass-dominated (e.g., the Great Plains), while shrubs become an increasingly important component of the plant community where cool season precipitation contributes to deeper soil water resources (e.g., the Intermountain West). Importantly, many temperate drylands receive a mix of warm and cool season precipitation and thus support a mixture of grasses and shrubs. Although plant-plant interactions (i.e., competition for resources or facultative relationships under harsh conditions) in these communities have the potential to play an important role in determining plant community structure, the nature of shrub-grass interactions under different precipitation regimes remains relatively unexplored.

The Project.

In the western United States, big sagebrush (*Artemisia tridentata* Nutt.) ecosystems span broad gradients of precipitation amount and seasonality across a range of soil textures. These ecosystems are characterized by an overstory of shrubs with an understory of grasses that varies substantially across the West. For example, grasses are a relatively minor component of the plant community in the southern part of the Great Basin, but are codominant with shrubs in central Montana. To investigate the nature of shrub-grass interactions in temperate drylands, we visited relatively undisturbed big sagebrush sites across the West (Fig. 1).

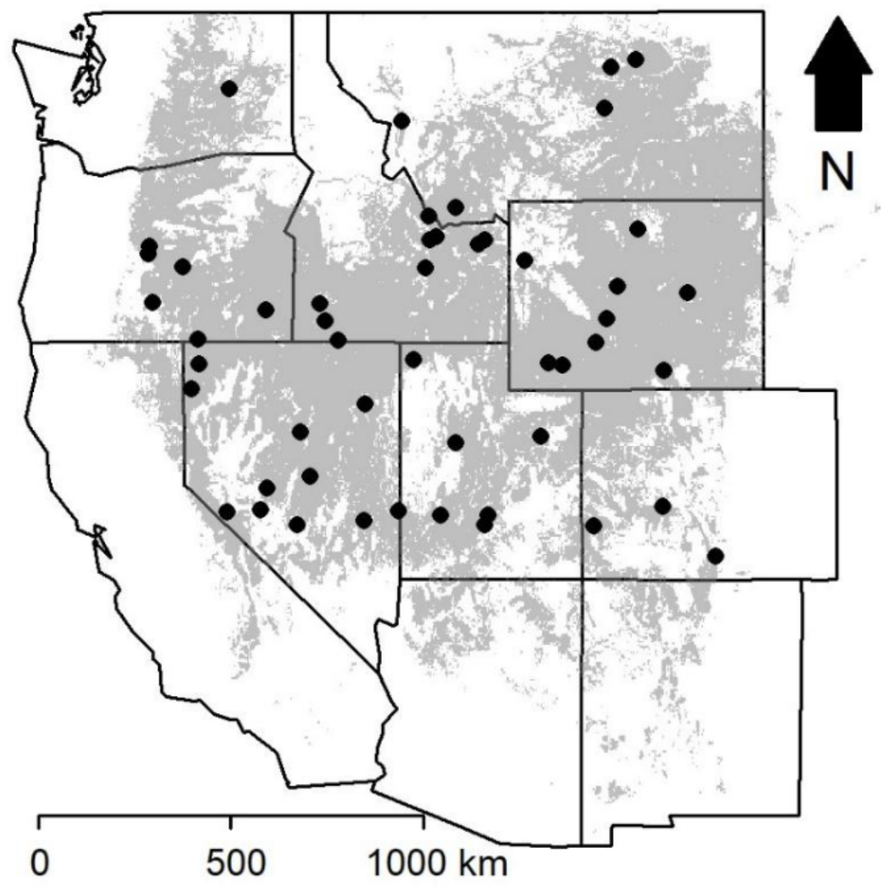

Figure 1: We visited 50 relatively undisturbed sites (black points) across the big sagebrush region (gray area) in the western United States.

At each site, we measured the number and size of perennial grasses and other herbaceous plants under shrub canopies and in open areas between shrubs. We also measured plot-wide shrub canopy cover and collected soil samples that we will use in combination with historical weather data to estimate seasonal soil water availability at different depths using a soil water simulation model.

The Findings.

We measured over 12,000 herbaceous plants growing under and between shrubs across 50 plots. Mean annual precipitation was 154 mm at the driest plot and 690 mm at the wettest plot. Average sagebrush cover across all plots was 24% (range: 9 to 65%) and average perennial grass cover was 20% (range: 0.7 to 59%). We compared average perennial grass cover in canopy and interspace microsites at each site using an interaction index that ranges from -1 (strongly competitive) to +1 (strongly facultative). We found that this index was positively correlated ($r = 0.51$, $p < 0.001$) with the ratio of average winter precipitation to mean annual precipitation (1991-2020), but that it was not significantly correlated with mean annual precipitation ($r = -0.11$, $p = 0.46$). This preliminary result suggests that precipitation seasonality may be more important than total precipitation in determining the outcome of shrub-grass interactions, and we look forward to investigating this effect further using output from a soil water simulation model.

The Impact.

This project investigates how resource partitioning influences coexistence, competition, and plant functional type composition in temperate drylands. Although the results of this research are relevant for temperate shrublands in general, we focus on big sagebrush ecosystems, which are widespread in the West and face multiple interacting threats from invasive species, wildfire, land use change, and climate change. Understanding the underlying relationships between environmental conditions (climate and soils) and plant functional type dominance and interactions will provide insight into how (and where) management goals—such as high-quality wildlife habitat, optimal forage for livestock, or preservation of climate resilient ecosystems—might be achieved under different environmental conditions.

The Student.

Rachel Renne, Western Resource Fellow | Rachel grew up in rural southwest Florida, in the heart of orange and cattle-country. After graduating from New College of Florida in 2008, she began a three-mile-per-hour tour—on foot—of the subtle and dramatic shifts of vegetation across the American landscape, hiking over 11,000 miles on National Scenic (and other) Trails. Rachel completed a Masters of Environmental Science at the Yale School of Forestry and Environmental Studies in 2018 and is now a doctoral student at the Yale School of the Environment. She is interested in combining traditional field data with machine learning to answer fundamental and applied questions about plant community ecology.