Climate Effects on Plant Range Distributions and Community Structure of Pacific Northwest Prairies

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Pacific Northwest (PNW) prairies are imperiled ecosystems that contain a large number of plant species with high fidelity to this habitat, many of which have northern and/or southern range limits from southwestern Oregon/northern California to Washington. The few remaining high-quality prairies harbor a number of sensitive, rare, and endangered plant species that may be lost with climate change. We are experimentally manipulating temperature and precipitation in three upland prairie sites along a natural climate gradient from southwestern Oregon to central-western Washington to determine (1) how future climate change will affect the range distribution of native plant species, and (2) how viable current restoration practices are under future climate change.

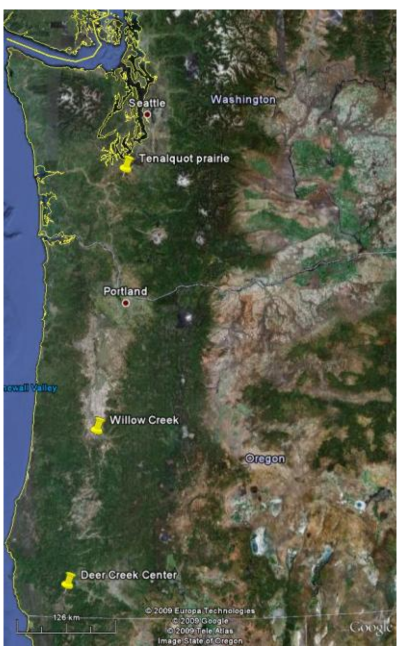

Figure 1. The three sites in this study.

Our specific objectives are to determine:

- the extent to which predicted climate change will affect the distribution, abundance, and fitness of native and exotic grasses and forbs in PNW prairies,
- to what extent and in what ways species' sensitivity to climate change differ as they near the warm and cool ends of their current ranges,
- what life history stages (i.e., germination and establishment, growth to maturity, and reproduction) are most sensitive to climate change in a group of key indicator native species,
- the robustness of current restoration techniques and suites of species to changing climate,
- and if there are key ecosystem feedbacks, e.g., nutrient availability, that determine the viability of the range-limited species and restored communities under changing climate.

We are addressing these objectives by experimentally increasing temperature by 3 ºC with overhead infrared lamps and increasing precipitation by 25% from September through June in a full factorial design at three upland prairie sites along an approximately 600 km gradient of temperature and precipitation (Fig. 1, Table 1). The three sites are in Selma, Oregon at the headwaters of the Illinois River Valley in southwestern Oregon; in Eugene, Oregon at the southern end of the Willamette Valley in central-western Oregon; and in Ranier, Washington in the Puget Trough of central-western Washington. The Selma site is on land owned by the Deer Creek Center, a non-profit environmental education/research facility jointly run by the Siskiyou Field Institute and Southern Oregon University. The other two sites are on the Willow Creek and Tenalquot preserves of The Nature Conservancy in Eugene and Ranier, respectively.

Table 1. Annual temperature and precipitation for each site. Note that the experimental temperature increase of 3°C is similar to the difference in mean monthly temperature among the sites of 2.4 °C. SOR = southern Oregon, COR = central Oregon, CWA = central Washington.

Site	Mean Monthly Temp. (°C)	Max. Monthly Temp. (°C)	Min. Monthly Temp. (°C)	Mean Precipitation (mm)
SOR	12.2	19.9	4.1	1598
COR	11.4	17.3	5.3	1201
CWA	9.8	15.3	4.9	1229

Treatment effects are being examined on 14 native grass and forb species that have their northern and/or southern range limits at, or near, one or more of the sites. The same 14 species have been seeded into each experimental plot in a grid and comprise a group of 'indicator' species of future climatic effects on the abundance and distribution of other native prairie species in the PNW. The range-limited species have been planted in a matrix of 24 native species that are commonly used in the restoration of PNW prairies but that are not necessarily range limited, thus allowing the project to examine climate effects on dominant species and species of particular interest. The same matrix species, or close cogeners if a particular species does not occur locally, have been planted at all sites. All plots have been restored using practices typical of local conservation organizations, including the application of herbicide, mowing, and raking, before any plants were seeded. The restoration treatment reduced but did not eliminate current exotic species in the plots, and we are examining the competitive interactions and succession trajectories of the native and exotic species within each of the treatments. Restoration of the plots began in the summer of 2009, and planting occurred in December 2009.

We are performing an extensive demographic life cycle analysis of the range-limited species, including measurement of treatment effects on establishment, growth, survival, reproduction and phenology. Additionally, we are measuring plant community structure, above- and belowground net primary productivity, seasonal soil nutrient availability, soil organic carbon, continuous soil and air temperature, canopy temperature, and soil moisture in each plot. Other response variables, such as plant physiological responses, will be measured at one or more sites as project resources allow.

Future climate change will almost certainly impact the distributions and abundances of species, with the largest effects on rare species, species with specialized habitats, and species with relatively constrained ranges. Current modeling approaches are inadequate to provide robust predictions of how climate will impact species range distributions and abundances. The combination of a natural climatic gradient, four experimental climate treatments, and planting a common set of species within and beyond their current ranges, will provide a rich dataset to examine the effects of climate change on the distribution and abundance of plants within PNW prairies. This includes an examination of the likelihood of plant species that are near the limits of their current distribution to persist in their current habitats or to expand beyond their current range limits. We are also examining how robust current restoration techniques and plant assemblages are to future climate change. Our results will provide an important case study of how climate change will affect native biodiversity in other grassland ecosystems with high abundances of exotic species.