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Common Camas | qʷəɬuʔəl

Camas (*Camassia quamash*), also known as small camas or blue camas, is a perennial forb found in open habitats with seasonally-wet soils that often dry out by spring. In Washington, it ranges from the foothills to mid-elevations on both sides of the Cascades Range.

Throughout the Pacific Northwest, open prairie habitats were maintained by Indigenous communities through the use of fire. However, Euro American colonization brought an end to low-intensity, high-frequency traditional burning practices and a subsequent decline in prairie habit due to tree and shrub encroachment (Hamman et al. 2011). In addition to clearing encroaching vegetation, traditional burning practices also enhanced camas grounds by adding potassium back into the soil (Thoms 1989).

Future changes in climate, including increasing summer temperatures and declines in summer precipitation, could reduce habitat suitability for camas.

We conducted a synthesis of peer-reviewed and gray literature (i.e., reports, previous syntheses, etc.) exploring climate impacts on camas. Below, we describe key findings from these studies and their implications for camas growth and flowering plant density within the geography of the Treaty of Point Elliott.

Effects of Temperature and Precipitation on Camas Productivity and Growth

Very few studies have evaluated the influence of temperature, precipitation or projected future changes in climate on common camas. However, Stucki (2018) evaluated the influence of temperature and precipitation on camas productivity and growth. Key findings include:

- *Precipitation.* Suitable camas habitat is typically inundated for part of the year. Moisture availability influences camas growth, and soil conditions must remain moist through spring for seedlings to survive the initial growth phase following germination (Stucki 2018). If growing conditions are sub-optimal, camas will remain dormant throughout the growing season; dormancy may last for several years (Beckwith 2004). However, if moisture persists long into the summer, camas flowering and seed production may be delayed or reduced, and bulbs may rot in wet conditions (Stucki 2018).

- *Temperature.* While the literature suggests ‘excessively warm’ temperatures may be lethal to common camas, specific temperature thresholds are not reported (Stevens and Darris 2006). Previous research on other temperature geophytes, including *Allium* spp., suggests prolonged warm spring temperatures can advance flowering timing and lead to smaller flowers.

Citizen Science Data Collection & Linear Mixed-Effect Model

Stucki (2018) analyzed long-term monitoring data from citizen science observations (2005-2016) in Weippe Prairie, a seasonal wetland in Idaho dominated by common camas, native graminoids and forbs, black hawthorn trees and introduced grasses. Weippe Prairie was traditionally used by the Nez Perce Tribe for common camas harvest. Camas data was collected collaboratively by the Upper Columbia Basin Network and the Nez Perce National Historic Park (observations were collected for 70 plots, each 0.6 m^2 in size). NOAA’s co-op weather gauge in Pierce, Idaho was then used to access observed temperature and precipitation data for the project site.

A linear mixed-effect model created to evaluate whether climatic variables were correlated with camas density showed that average annual maximum temperature (as it departs from the 30-year mean) is negatively correlated with camas density. Higher maximum average temperatures resulted in declines in camas density and flowering camas density. Additionally, linear mixed-model results demonstrate that flowering camas densities increase with above-average precipitation, and that camas density and flowering plant density decrease with increasing annual average water deficit.

While Sticki (2018) did not model or evaluate the impacts of projected future changes, the results of the linear mixed models can be used to infer the implications of projected changes in annual maximum temperature, annual precipitation and soil moisture. The following projected changes for the Snohomish and Stillaguamish basins are based on projections from the Tribal Climate Tool (Krosby et al. 2018), derived from downscaled MACA projections (Abatzoglou and Brown, 2012):

- **Maximum Temperature (June - August):**
    - By the 2050s (2040-2069) under a high greenhouse gas scenario, the June - August maximum daily temperature is projected to be 76.3 °F, an increase of 7.1 °F from the historical value (1971-2000).

    - By the 2080s (2070-2099) under a high greenhouse gas scenario, the Jun-Aug max daily temperature is projected to be 80.4 °F, an increase of 11.2 °F from the historical value (1971-2000).
    - Results from Sticki (2018) documented an observed decline in camas density and flowering camas density in years with higher maximum average temperatures; this suggests that projected increases in summer maximum daily temperatures may negatively affect flowering density of common camas.

- **Annual Precipitation**
    - By the 2050s (2040-2069) under a high greenhouse gas scenario, annual total precipitation is projected to increase by +4% relative to historic conditions (1971-2000).
    - By the 2080s (2070-2099) under a high greenhouse gas scenario, annual total precipitation is projected to increase by +7% relative to historic conditions (1971-2000).
    - Results from Sticki (2018) linear mixed models demonstrated increases in camas densities with above-average precipitation. While projected increases in annual total precipitation could be interpreted to potentially lead to increased camas density, it should be noted that the year-to-year variability is large compared to long term trends. This will result in ongoing fluctuations between wet years and dry years and wet decades and dry decades.

- **Summer Soil Moisture (July - September)**
    - By the 2050s (2040-2069) under a high greenhouse gas scenario, summer soil moisture is projected to decline 15% relative to historic conditions (1971-2000).
    - By the 2080s (2070-2099) under a high greenhouse gas scenario, summer soil moisture is projected to decline 22% relative to historic conditions (1971-2000).
    - Results from Sticki (2018) documented an observed increase in flowering camas density in years with higher minimum soil moisture. This suggests that projected declines in summer soil moisture may negatively affect flowering camas density.

- **Summer Water Deficit (July - September)**
    - Summer water deficit is based on the amount of soil moisture available relative to atmospheric demand for water via evaporation, either from water bodies or vegetation. Projections in Figure 1 show projected declines in summer water deficit across the Puget Sound lowlands for both the 2050s and 2080s.
    - Results from Sticki (2018) document lower established plant density and lower flowering plant density during study years with above average water deficit levels. This suggests that projected increases in summer water deficit may negatively impact camas flowering density.

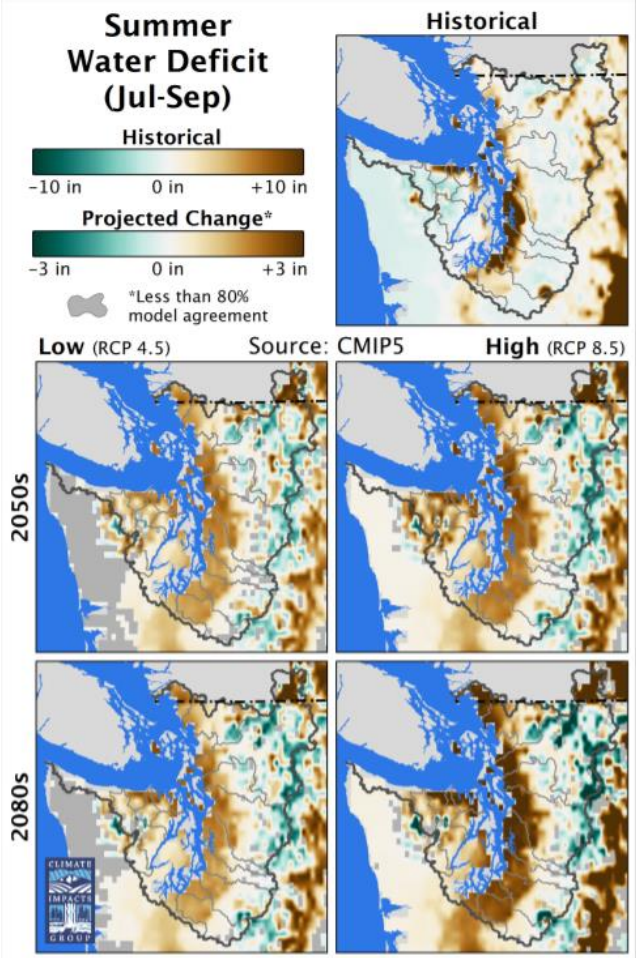

Figure 1. Maps show the historical and projected summer (July-September) water deficit. Maps compare historical conditions (1970-1999) with the projected change for ten global models.Two time periods are considered: the 2050s (2040-2069) and the 2080s (2070-2099), and projections are included for two greenhouse gas scenarios: one low (RCP 4.5) and one high (RCP 8.5). Figure created by Jonathan Picchi-Wilson, Western Washington University, based on the CMIP5 projections used in the IPCC 2013 report. Data source:Mote et al. 2015.

Climate Change Projections And Potential Impacts On Prairies

Bachelet et al. (2011) provide an overview of climate change projections and potential impacts on Willamette Valley-Puget Trough-Georgia Basin (WPG) prairies and oak savannas. While not explicitly evaluating the potential impacts of climate change on common camas, WPG prairies are characterized by graminoids and forbs -- including common camas.

- **Summer Drought**
  The WPG prairies and oak savannas were established in the early Holocene (11,000 to 7,250 years before present), an era characterized by a warm and dry climate. The WPG prairies and oak savannas were maintained by wildfire and traditional burning practices with high frequency, low-severity fires. These controlled burning practices combined with intermittent soil drought enabled the persistence of these prairies in what would otherwise be forest. As a result, projected increases in summer drought are unlikely to negatively impact prairie communities -- in fact, because reductions in water availability will negatively impact drought-intolerant tree species, this change may ultimately result in prairie expansion.

- **Invasive species**
  Many invasive species found in prairie communities throughout the Pacific Northwest have wide distributions, which suggests they will continue to be successful and compete with native prairie species as the climate changes. However, the drought-tolerance of many prairie species may give them an advantage.

Vegetation Dynamics and Wildfire

Results from the dynamic global vegetation model MC1 (Bechelet et al. 2001) include simulations of vegetation dynamics and wildfire for three GCMs under a high emissions scenario (A2). MC1 simulations do not project a change or shift in grasslands or savannas west of the Cascades. Projected increases in wildfire west of the Cascades, assuming control and suppression, will likely lead to an increase in prairie cover west of the Cascades - however, this was not simulated by the MC1 model before the end of the 21st century.

Synthesis & Key Conclusions

- Projected decline in summer soil moisture and increase in summer temperatures are likely to negatively affect camas.
- Dynamic global vegetation model results do not project a change in grasslands or savannas west of the Cascades, which bodes well for camas. Further, projected increases in wildfire west of the Cascades may lead to an increase in prairie cover west of the Cascades, though perhaps not before end of century.

Opportunities and Considerations for Applying Results

- *Supporting Climate Adaptation:* Results from studies evaluating the effects of temperature and precipitation on camas growth and productivity are useful for understanding, in a general sense, how and where the species may be affected by changing climatic conditions. For example, correlations between climatic metrics and camas productivity and growth suggest camas may be more likely to persist in wetlands with microclimates more resilient to projected changes; management responses could thus include prioritizing protection or restoration of wetlands likely to remain moist through spring, and/or those that are partially shaded and likely to maintain cooler temperatures than unshaded sites. Results also suggest that management actions aimed at maintaining the hydroperiod and water supply for wetlands where camas is found may help support populations under drier future conditions.

- *Identify future research needs*: Limitations of existing models suggest future research is needed to create higher resolution spatial models of projected changes in climatic variables relevant to common camas, or, preferably, climatic niche models or mechanistic models that predict future areas of suitable habitat for camas within the area of interest. Such models would be useful in identifying and prioritizing specific prairies or wetlands for active management, restoration and protection.
- *Integration with local knowledge:* Application of results will be most effective if combined with the local knowledge and expertise of Tribal scientists and knowledge keepers. For example, knowledge of the location of camas populations in prairies or wetlands that may be more resilient to climate change due to cooler, wetter microclimatic conditions could inform actions promoting their protection or restoration.

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Appendix A. Conceptual Model of Climate Impacts on Camas

We created a conceptual model that summarizes the ecological and climatic drivers of camas abundance in western Washington. This model can be used to identify intervention points where management action or traditional practices could help reduce climate risks to camas.

In the model, green arrows indicate a positive correlation between linked drivers or processes (i.e., as variable *x* increases variable *y* increases; orange arrows indicate a negative relationship between variables (i.e., as variable *x* increases, variable *y* decreases); and dashed gray arrows indicate the absence of a directional trend or an area where additional research is needed. Light red boxes are used to highlight human management activities (e.g., forest management or traditional practices) that directly or indirectly influence the abundance of camas in western Washington.

Conceptual Model of Climate Impacts to Camas | qʷəɬuʔəl