Project Plan

1. Project Title: Identifying factors driving wildflower bloom phenology

a. Group Members:

Alex

BIOL570L Students

2. Topic Background Statement:

Most ecological phenomena have consistent patterns which occur over cyclical or oscillating patterns. The timing and consistency of such cycles are referred to as the phenology of the phenomena. Many ecological patterns can easily be identified to have strong phenologies, such as plankton blooms (Racault et al. 2012), bird migration (Cotton 2003), and plant production (Xiao et al. 2004). Such seasonal cycles of growth, population changes, or activity often rely on environmental cues to initiate such cycles. However, with changes in climate conditions, environmental cues may trigger shifts in phenology differently across different organisms (Badeck et al 2004). This can result in a mismatch between critical functional groups. For example, plants display flowers for pollination (from insects, birds, or other organisms) yet if the timing of flowers shifts, it may cause a mismatch between flowers and pollinator abundance. This can result in impacts to both plant and pollinator populations. To better understand how population might shift in response to changes in climate, it is critical to understand what environmental conditions influence flowering.

However, detecting and researching phenological patterns can be a challenge for researchers. Alpine flowers are by definition in difficult-to-access areas. Furthermore, flowering plants can have very short flowering windows. Thus, detecting flowering requires highly frequent observations and as a result, large amount of labor to observe natural populations. This creates a logistical challenge for researchers. However, by partnering with community-science volunteers, it is possible to increase data collection efforts. In Mount Rainer National Park, scientists have collaborated with recreational hikers to develop an extensive, multi-year dataset observing flowering presence across elevation gradients on Mt. Rainer/Mt. Tahoma (Manzanedo et al. 2022). This dataset facilitates multi-year investigations and already has resulted in publications investigating flowering probability and hiker satisfaction (Ris Lambers et al. 2021).

3. Main Question(s):

How does shifting environmental conditions affect the timing of flowering in alpine wildflowers?

4. Hypothesis(es):

Alpine flowering plants are accustomed to spring blooms, when sunlight is plentiful and there is water from snowmelt, yet the soil is habitable after melting snow. However, the timing of flowering is likely governed by changes in environmental conditions. This study will investigate the major drivers of alpine flower phenology and test several hypotheses: (H1) earlier snowmelts will facilitate earlier blooms as melts may act as a cue for initiating plant growth, starting the cycle earlier; (H2) Because higher elevations typically have harsher conditions, the peak bloom will be delayed at elevation, however, (H3) consistent with climate change theory, higher-elevations will be more sensitive to change resulting in an increased impact of snowmelt changes at altitudes on bloom timing.

5. Proposed Methodology:

a. List of Needed Equipment:

Access to the medowwatch dataset. A computer with R installed.

b. List of Collected Variables:

- Presence of flower (binary)
- Proportion Flowering (continuous)
- Day-of-year of peak-bloom probability (derived from literature, continuous, response)
- Date (date/time)
- Flower species (categorical)
- Plot (categorical)
- Elevation (continuous, predictor variable)
- Snow disappearance Day-of-year (SDD, continuous)

c. Proposed Analysis Method:

The data are collected and maintained by the MeadoWatch program (http://www.meadowatch.org/about.html). With this data, we will investigate how elevation and snow disappearance date influence date of peak flowering probability. The effect of the two environmental variables will be modelled using linear mixed effect models to account for the random variation introduced by species and observation plot. Models will be constructed and evaluated based on AIC-comparison using a forward stepwise model building approach.

6. Group Member Responsibilities:
    a. Analyst: this is an individual project where data will be analyzed independently. There is no need for physical data collection as it relies on published datasets.

7. References:

Cotton PA. 2003. Avian migration phenology and global climate change. *Proc. Nat. Ac. Sci.* 100(21): 12219-12222.

Manzanedo RD. John A. Sethi ML. et al. 2022. MeadoWatch: a long-term community-science database of wildflower phenology in Mount Rainier National Park. *Scientific Data* 9: 151.

Racault M-F. Le Quéré C. Buitenhuis E. et al. 2012. Phytoplankton phenology in the global ocean. *Ecological Indicators* 14(1): 152-163.

Ris Lambers J. Cannistra AF. John A. et al. 2021. Climate change impacts on natural icons: Do phenological shifts threaten the relationship between peak wildflowers and visitor satisfaction? *Climate Change Ecology* 2: 100008.

Xiao X. Hollinger D. Aber J. et al. 2004. Satellite-based modeling of gross primary production in an evergreen needleleaf forest. *Remote Sensing of Environment* 89(4): 519-534.