The Effects of Snowmelt Timing and Warming on Plant Phenology

LeAnna Warren[1], Laurel Brigham[2]
Front Range Community College[1], University of Colorado[2]

INTRODUCTION

- Phenology, the timing of plant activity, is crucial for maintaining balance in the relationships between organisms and their environment.
- For example, species mismatch in flowering time and pollinator efforts, could threaten plant reproduction (Cleland et.al 2007).
- A warming climate and earlier snowmelt time often cause phenology to advance (Sherwood et al. 2017, Oberbauer et al. 2013, Khorsand Rosa et al. 2015).
- Using an experimental manipulation of both snowpack duration and temperature, we ask how the timing of leaf out, flowering, and senescence of *Geum rossii,* a common alpine species, tracks the environment.
- We predict that both warming and snowmelt may be advancing phenology of *Geum rossii*, and that these factors may be interacting with one another or acting independently.

METHODS

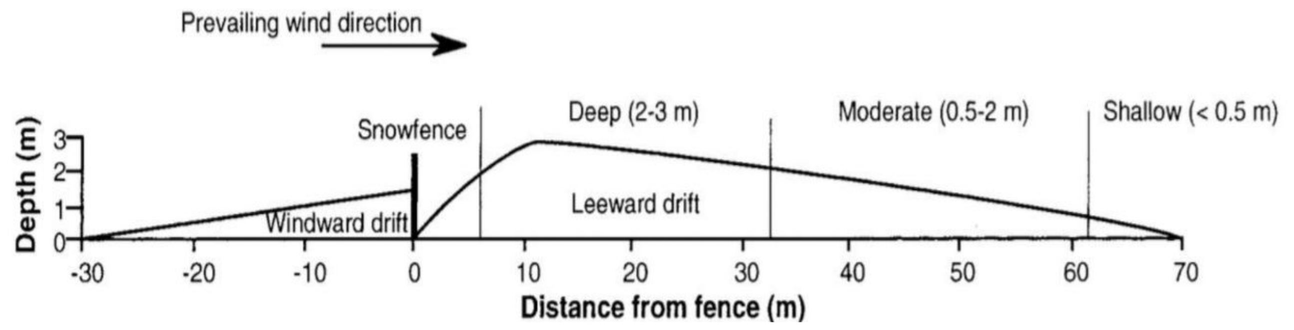

Figure 1. Diagram of Snow fence erected in 1993 (Walker 2019)

- The data for this research was collected at Niwot Ridge in the Front Range of the Rocky Mountains of Colorado, USA (40.05˚N, -105.59 ˚W) (See Fig. 3 below)
- In the summer of 1993, a 60m long by 2.8m high snowfence was erected to create a gradient in snowmelt timing (See Fig.1 above)
- Several International Tundra Experiment (ITEX) chambers were deployed both behind and outside of the snowfence to create warmer conditions. Placed only in the summer months, these chambers increase warming by 2- 5º C (See Fig. 4 below)
- Each warmed plot was paired with a non-warmed plot at late and early gradient points on the leeward side of the snowfence.
- From 1993-1996, three phenological stages of *Gerum rossii* were recorded: leaf out, flowering, and senescence
- While phenology data was collected from 1993-1996, we focus on the final year (1996) after plots had been subjected to 3 years of treatment
- Using the data collected in 1996 we conducted 2-way ANOVAs in R, version 4.0.1 (R Core Team, 2020)
- To meet assumptions of normality, required by parametric statistical testing, we used a Box-Cox transformation on the leaf out data.

Figure 2. *Geum rossii* Photo credit: Laurel Brigham

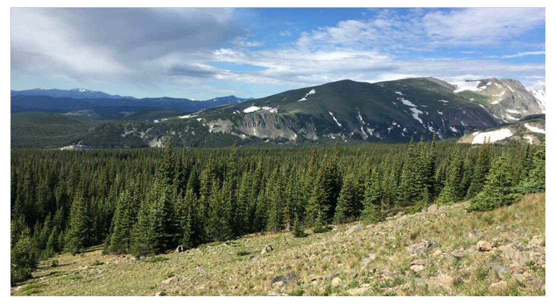

Figure 3. Niwot Ridge area, Photo Credit: Laurel Brigham

Figure 4. ITEX chamber Photo Credit: Niwot Ridge LTER

RESULTS

- Earlier snowmelt advanced leaf out by around 35 days (Fig. 5, $F(1,36) = 230.23$, $P < 0.001$), there was no significant effect of warming.
- Earlier snowmelt advanced flowering by around 28 days (Fig. 6 , $F(1,26) = 331.40$, $P < 0.001$), there was no significant effect of warming.
- Earlier snowmelt advanced senescence by around 11 days (Fig. 7, $F(1,36) = 47.80$, $P < 0.001$) and warming delayed senescence by about 5 days (Fig. 8, $F(1,36) = 8.65$, $P = 0.006$)
- While both earlier snowmelt and warming affected senescence, there was no significant interaction between the two ($F(1,36) = 2.37$, $P = 0.13$)

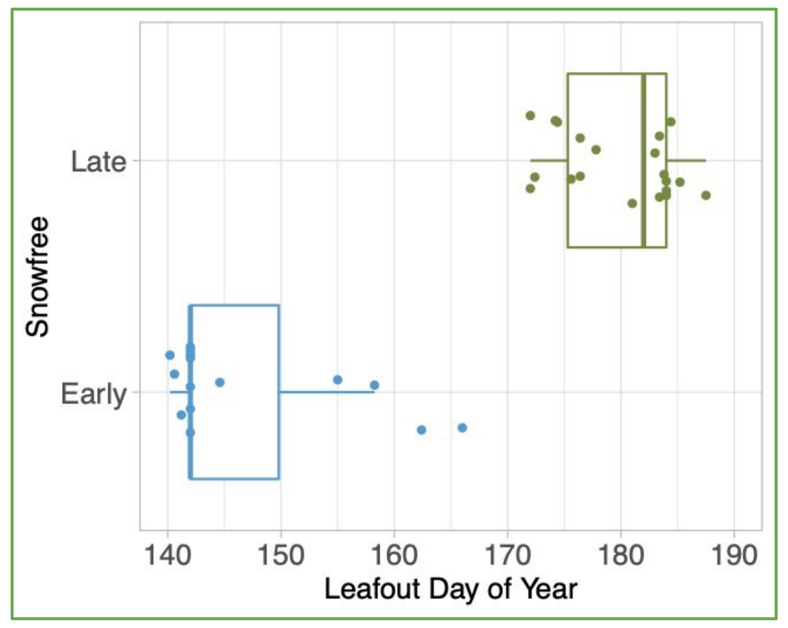

Figure 5. Box plot of leaf out day of year compared with early vs. late snowmelt timing. Earlier snowmelt advanced leafout time of *Geum rossii*. The solid bar within each box represents the median for each data set.

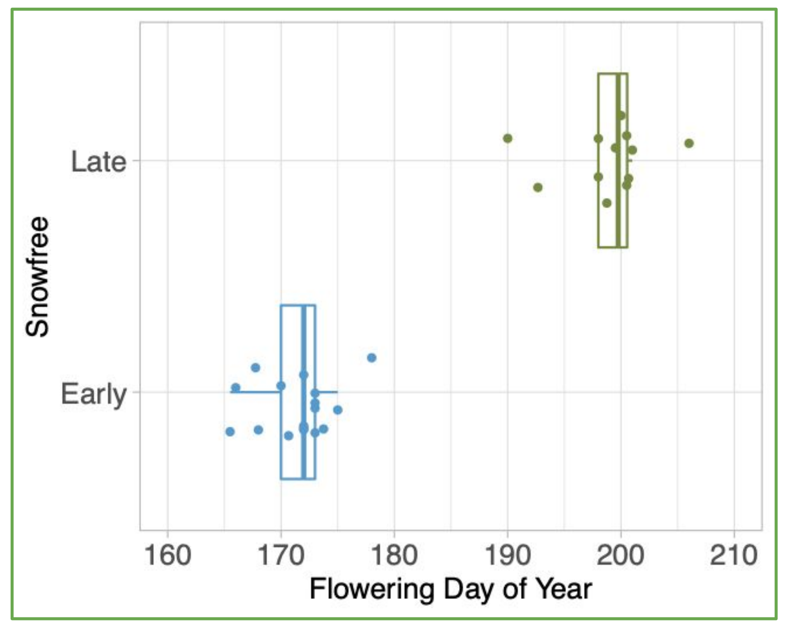

Figure 6. Box plot for flowering day of year compared with early vs. late snowmelt timing. Earlier snowmelt advanced Flowering time of *Geum rossii*. The solid bar within each box represents the median for each data set.

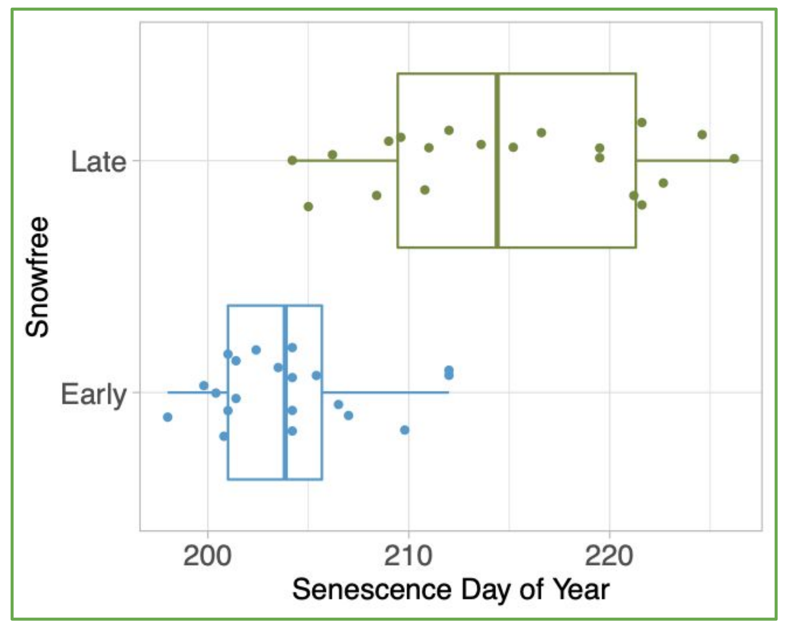

Figure 7. Box plot for senescence day of year compared with early vs. late snowmelt timing. Earlier snowmelt advanced senescence timing of *Geum rossii*. The solid bar within each box represents the median for each data set.

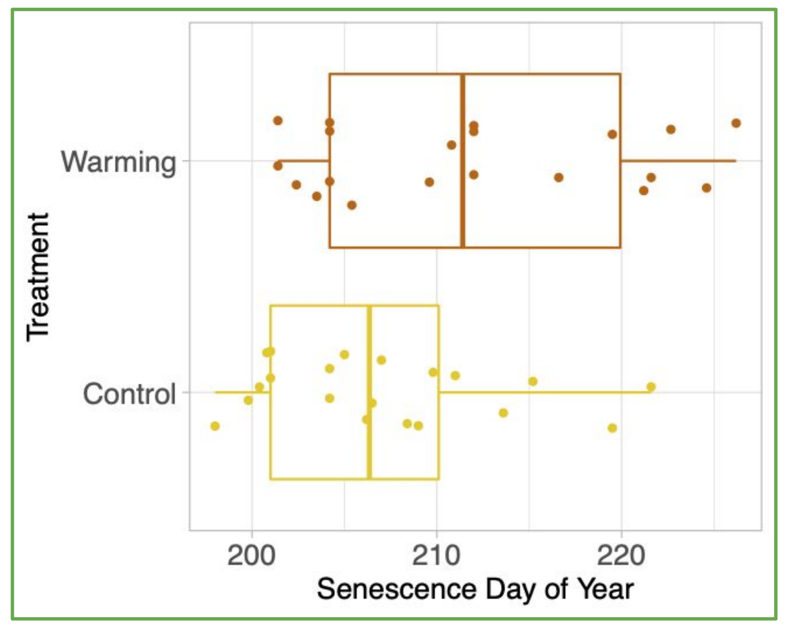

Figure 8. Box plot for senescence day of year compared with control vs. warming for Treatment. Warming delayed senescence timing of *Geum rossii*. The solid bar within each box represents the median for each data set.

DISCUSSION

In line with our prediction, we saw earlier leaf out, flowering and senescence of Geum rossii with earlier snowmelt timing.

· In contrast to our predictions, however, temperature did not have a significant effect on leaf out or flowering, though it did delay timing of senescence.

· This suggests that cooling fall temperatures drive Geum rossii senescence, while spring forcing temperatures do not seem to have a strong control on leafout and flowering. Instead, snowmelt timing seems to be a strong driver for the leaf out and flowering time of Geum rossii.

· These findings align with previous studies which saw that earlier snowmelt timing was a stronger driver of phenological shifts than warming for several other alpine and arctic species (Khorsand Rosa et al. 2015 and Sherwood et al. 2017).

· The effects of warming and snowmelt on phenology differ by plant species and the region in which each species is found (Sherwood et al. 2017, Oberbauer et al. 2013, Khorsand, Rosa et al. 2015) This added complexity makes untangling the direct causes of shifting phenology a complicated task.

· Some species with advanced leaf out caused by earlier snowmelt are left susceptible to frost damage by spring frost events and also risk mismatch in timing of pollinator efforts. Both threats would ultimately lower reproductive abilities of a population leading to community shifts in these ecosystems (Sherwood et. al 2017).

· There are also species that are able to adapt to these shifts and could out-compete less plastic species, again leading to a shift in population dynamics (Khorsand, Rosa et. al 2015).

· Future work in phenology research could be focused on accounting for the abundance of plastic species in nature versus the abundance of non-plastic species, and cataloging the responses of each to better inform future conservation efforts.

REFERENCES

Cleland et. al 2007 "Shifting plant phenology in response to global change" https://doi.org/10.1016/j.tree.2007.04.003 (Accessed 2020 06-25)

Khorsand Rosa et. al 2015 "Plant phenological responses to a long-term experimental extension of growing season and soil warming in the tussock tundra of Alaska" https://www.academia.edu/33186329/Plant_phenological_responses_to_a_long-term_experimental_extension_of_growing_season_and_soil_warming_in_the_tussock_tundra_of_Alaska (Accessed 2020 06-25)

Oberbaurer SF et. al 2013 "Phenological response of tundra plants to background climate variation tested using the International Tundra Experiment"https://doi.org/10.1098/rstb.2012.0481 (Accessed 2020 06-25)

Sherwood et. al 2017 "Effects of experimentally reduced snowpack and passive warming on montane meadow plant phenology and floral resources"https://doi.org/10.1002/ecs2.1745 (Accessed 2020 06-25)

Walker, M. (2019). Warming and snow experiment plant phenology data for Saddle snowfence, 1993 - 1996. ver 3. Environmental Data Initiative. https://doi.org/10.6073/pasta/d230ae4b1af1babe9b71f05af7bf4f19 (Accessed 2020-06-10).

ACKNOWLEDGEMENTS

I would like to thank my mentor, Laurel Brigham, for her phenomenal edits, unwavering dedication to my success, and enthusiastic guidance and support in the creation of this poster. I am honored to have had the chance to learn from Laurel during this program. I would also like to thank the RECCS team for this opportunity and for facilitating this program, with a special acknowledgement to Alicia Christensen, Bec Batchelor and Anne Gold for their excellent guidance and support.

The RECCS Program is funded by the National Science Foundation (grant number EAR 1757930). The LTER program is funded by NSF (grant number DEB 1637686).We thank the researchers who collected this data and Niwot Ridge LTER for allowing us to use this data to create a practice presentation. The original research was funded by NSF grants OPP-9400083, OPP-9617643, OPP-9327130, and DEB-9211776.

For more information, contact me: LeAnna.Warren@colostate.edu