

# Prediction of Phenological Events Using Historical Data

J. Scott Adams, William D. Pearse, Amanda S. Gallinat Utah State University Department of Biology

## Introduction

Phenology is the study of the timing of seasonal events in organisms. This includes leaf-out, blossoming, fruit ripening, and leaf senescence in plants. Plant species differ in their phenological timing and sensitivity to temperature, and differences among species can lead to changes in competition, growing season length, and interactions with pollinators and seed dispersers (Cleland 2007, Heberling 2019). However, the sensitivities for many species are still unknown. Spring events are known to be responsive to temperature, but less is known about autumn events and how they are related to spring events (Gallinat 2015).

### We asked two main questions about plant phenology:

- 1) How do different plant species vary in their sensitivity to spring and autumn temperatures?
- 2) Does the average timing of spring events predict the average timing of autumn events across species?

## Methods

I digitized and analyzed historical phenology data for 158 species collected in Wauseon, Ohio, from 1883 to 1912 (Smith 1915). I scanned the data using an Optical Character Reader (OCR) and sorted observations using a Python program I wrote.

Question 1: To estimate the sensitivity of species' blossoming, leaf-out, and senescence to temperature, I used linear regressions with seasonal average temperature as the explanatory variable and annual event date as the response variable.

Question 2: To test if spring events predict autumn events, I averaged the dates of each event for each species across all years. Then I ran one linear regression with average blossoming date as the explanatory variable and average fruit ripening date as response variable. I ran another linear regression with average leaf-out date as the explanatory variable and average senescence date as the response variable.

## Results

- 1) With warmer seasons, spring events tended to happen earlier and autumn events tended to happen later.

**Blossoming:** 55/158 species had a significant relationship with temperature. They ranged from  $-6.1$  days/ $^{\circ}$ F (*Portulaca oleracea*) to  $-0.9$  days/ $^{\circ}$ F (*Phlox divaricata*).

**Leaf-out:** 28/158 species had a significant relationship with temperature. They ranged from  $-3.2$  days/ $^{\circ}$ F (*Bignonia radicans*) to  $-0.9$  days/ $^{\circ}$ F (*Acer saccharum*).

**Senescence:** 5/158 species had a significant relationship with temperature. They ranged from  $+7.2$  days/ $^{\circ}$ F (*Lonicera japonica*) to  $+3.7$  days/ $^{\circ}$ F (*Populus deltoides*).



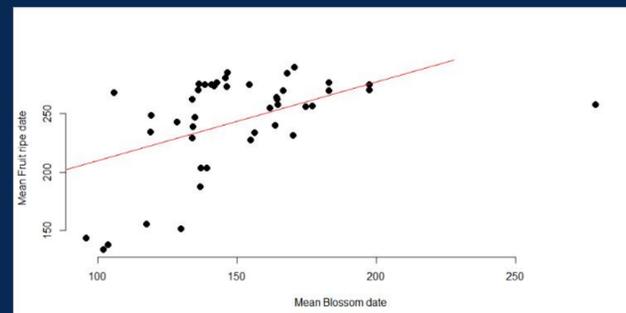
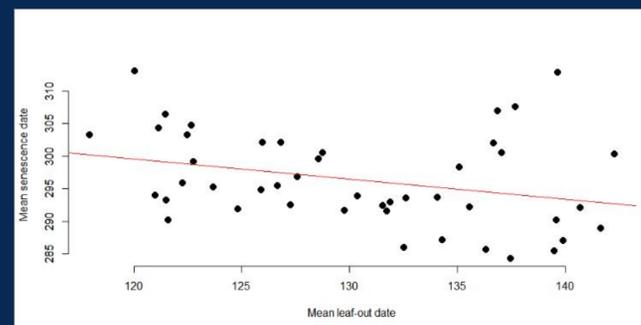
Japanese Honeysuckle (*Lonicera japonica*) has senescence that is sensitive to temperature. Photo by J.F. Gaffard Jeffdelonge



Wild Blue Phlox (*Phlox divaricata*) has blossoming that is not heavily affected by temperature. Photo by Fritzflohrrreynolds

- 2) Spring events have some ability to predict related autumn events. The direction and strength of the relationship differed between vegetative and reproductive systems.

**Species that leafed-out earlier tended to senesce later ( $R^2=0.09$ ,  $p<0.05$ ).**



**Species that bloomed earlier tended to have their fruit ripen earlier ( $R^2=0.24$ ,  $p<0.05$ ).**



## Discussion

- We saw that spring events happened earlier in warmer years. This is similar to what other studies have found (Cleland 2007).
- We found that plants senesce later in warmer autumns, but only 5 species had a significant relationship with temperature. This indicates that, as in other studies, temperature is a less important factor when looking at senescence (Gallinat 2015).
- Species that leafed-out earlier senesced later and vice-versa. Leafing out earlier and senescing later gives the plant more time to photosynthesize but they also have a greater risk of frost damage. Research has shown that some invasive species use riskier strategies to gain a niche in an ecosystem (Wolkovich & Cleland 2011). An example of this in this data is the species Japanese honeysuckle, a hardy species native to east Asia with early leaf-out and late senescence.
- There was an even stronger relationship between blossoming and fruit ripening. In this case, the species that blossomed earlier fruited earlier and vice-versa. This suggests that flowering and fruiting are physiologically linked rather than maximizing a window of time as was seen with leafing.

## References

- Cleland, et al. 2007. *Trends in Ecology and Evolution* 22:7, p. 357-365
- Gallinat, et al. 2015. *Trends in Ecology and Evolution* 30:3, p. 169-176
- Heberling, et al. 2019. *Ecology Letters* 22. p. 616-623
- Smith. 1915. *Monthly Weather Review Supplement* 2, p. 21-93
- Wolkovich & Cleland. 2011. *Front Ecol Environ* 9:5, p. 287-294

### Acknowledgments

Thank you to Dr. Vince Tepedino for making the historical data available to me, and Josh Barney for coding support.