Floral-foliate phenological patterns of deciduous woody plants in an era of global change

Daniel Buonaiuto, PhD Pre-candidate[1,2]; Elizabeth Wolkovich, PhD,1,[2]
[1]Harvard University Department of Organismic and Evolutionary Biology, [2]Arnold Arboretum

Background

In many temperate, deciduous tree species, spring flowering proceeds leaf development (proteranthy), while in others, it is leaf expansion that occurs first (seranthy). It has been suggested that these floral-foliate phenological patterns may, in and of themselves, be essential for the reproductive success of many deciduous taxa (Whitehead 1967, Milleron et al 2012), but the relationships between floral and foliate phenophases are poorly understood (Lechowicz 1995, Wolkovich and Ettinger 2014). A primary step towards understanding the significance of proteranthy (or seranthy) is to evaluate whether theses patterns are incidental, a product of independent timing of flowering and leafing, or determinate, a product of biological constraints between phenophases.

Here, we begin to address this topic by asking the following questions:

- **To what extent do floral and foliate phenophases of an individual species diverge in their response to changing environmental conditions?**
- **How do these divergences effect the floral-foliate sequence?**

Proteranthous *Corylus cornuta*

Seranthous *Prunus pensylvanica*

Divergent responses of floral and foliate phenology

The sensitivity of the phenological response reaction norm to a given environmental cue can different significantly for floral and foliate phenophases, but the divergence of response varies among species, with one species (*I. mucronata*) showering strong coordination between floral and foliate response under different conditions. Additionally, we found that in one species (*C. cornuta*), floral and foliate phenological responses differed in the dominance of one cue (photoperiod or forcing temperature) over the other. These result indicates that independence of floral and foliate phenological responses vary from species to species, which may constrain their ability to reach a phenological optimum as climate changes.

Species	Forcing sensitivity (Flower)	standard error	Forcing sensitivity (Leaf)	standard error	Photo sensitivity (Flower)	standard error	Photo sensitivity (Leaf)	standard error
C. cornuta	-0.6111	0.7409	-3.1638	0.4858	1.5821	0.9408	-3.5052	0.6079
P. pensylvanica	-4.2213	0.7819	-2.7870	0.4721	-2.5676	0.9673	-1.6829	0.5901
I. mucronata	-2.2460	0.3259	-2.8917	0.3678	-1.1901	0.4088	-1.8854	0.4598

Table 1. The sensitivity (Δ eventday/Δ degree C or hour) of floral and leaf phenophases to temperature and photoperiod treatments. Negative values indicate an advance in phenology.

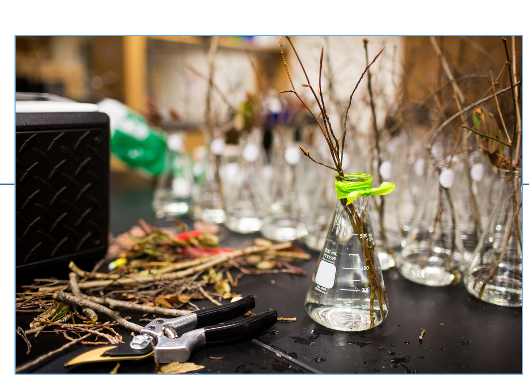
Methods

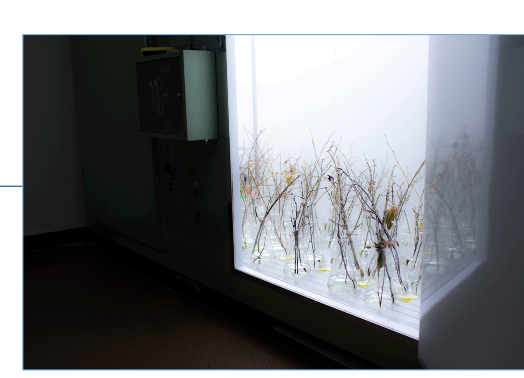
We analyzed existing data from a previous experiment (Wolkovich and Flynn, in press) in which cuttings from woody plant species were grown in growth chambers at the Arnold Arboretum in Boston, MA.

We considered 3 species, pin cherry (*Prunus pensylvanica)*, mountain holly (*Ilex mucronata)*, and beaked hazelnut (*Corylus cornuta)*.

6 replicates of each species were exposed to each of 4 experimental treatments in a fully-factorial design: 2 temperature (20◦C / 10◦C warm vs. 15°C / 5°C cool) x 2 photoperiod (12 vs. 8 h) and monitored at 5-7 day intervals for over 3 months.

Using these data, we compared the sensitivity to treatments (change in phenology event/unit change in cue) of floral and foliate phenophases for each species.





Changes to the floral-foliate phenological sequence

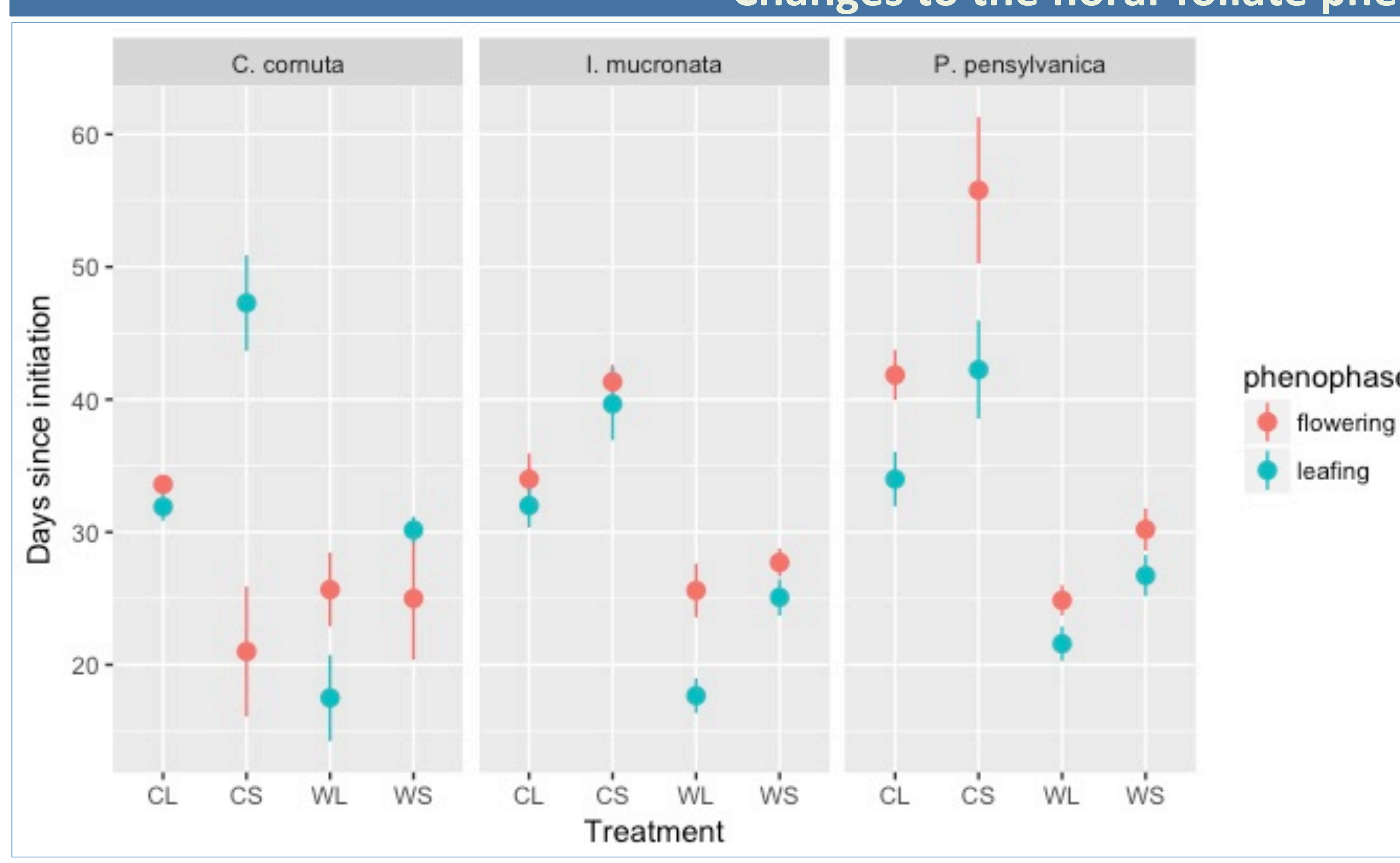


Figure 1. The floral-foliate phenological sequence of 3 deciduous shrubs under 4 temperature and photoperiod treatment combinations, CL (cool/long), CS (cool/short), WL (warm/long), WS (short/long).

In two of the three species (*C. cornuta and P. pensylvanica*), changing environment treatments significantly altered the floral-foliate sequence, increasing or reducing the temporal offset between phenophases, while minimal alterations were observed in *I. mucronata. For C. cornuta*, some treatment combinations even flipped the floral-foliate sequence, indicating that climate change is likely to destabilize floral-foliate patterns in some forest species, while the patterns in other species may be more resilient.

Outlook

These results, which demonstrate a heterogeneity of floral-foliate phenological sequence responses to changing environmental conditions among species, confirm the importance of this line of inquiry for forest community ecology. But there are still many questions regarding the mechanisms and adaptive significance of floral-foliate sequences in deciduous woody plants: To better place these results in the context of a larger forest community, we are replicating this study to include more species and environmental cues. Further, we cannot yet predict how the relative constraint or independence of the floral-foliate sequence may effect the reproductive success of tree species in an era of global change, and future research in this area is needed.

Contact

<Daniel Buonaiuto>
<Harvard University Department of Organismic and Evolutionary Biology>
Email: dbuonaiuto@g.harvard.edu

References

Lechowicz, MJ. 1995. Seasonality of flowering and fruiting in temperate forest trees. Canadian Journal of Botany. 73: 175-182
Milleron, M., Lopez de Heredia, U., Lorenzo,Z., Perea, R., Dounavi ,A., Alonso, J., Gil,L., Nanos, N. 2012. Effect of canopy closure on pollen dispersal in wind-pollinated species (*Fagus syvatica* L,). Plant Ecology. 213: 1715-1728
Whitehead, DR. 1969. Wind Pollination in the Angiosperms: Evolutionary and Environmental Considerations. Evolution. 23:1 28-35
Wolkovich, EM., Ettinger, AK. 2014. Back to the future for plant phenology research. New Phytologist 203: 1021–1023.