



Dear Dr. Robins,

Please consider this manuscript "Differences in flower and leaf bud environmental responses drive shifts in spring phenological sequences of temperate woody plants" as a research article in *Journal of Ecology*.

The relative timing of flower and leaf emergence in the spring strongly influences the ecology of many temperate systems, determining growing season length and the timing of critical resources for pollinators and herbivores (Li *et al.*, 2016). For deciduous woody plants, the order and duration of flower-leaf sequences (FLSs) shapes both reproductive fitness and physiological functioning, yet we still do not know how the environment determines FLS variation across species and years. Decades of experimental research has confirmed that both flower and leaf phenology are cued by the same environmental conditions (Körner & Basler, 2010) but shifts in FLSs with climate change suggest that there must be differences in how these phases respond to environmental cues. Identifying these differences is critical for both understanding the basic biology of FLSs and for predicting the magnitude and—ultimately—fitness impacts of FLS shifts with climate change.

Our submission combines new data from a full factorial experiment of the major environmental cues for spring plant phenology—chilling (fall-winter cool temperatures), forcing (warm spring temperatures) and photoperiod—with basic scenarios of future change to predict how FLSs will shift. Our results help explain FLS variation for 10 wild tree and shrub species common to the temperate forests of eastern North America, yielding insights into how FLS dynamics are likely to vary among species and locations over time. Additionally, our work unites decades of research on this topic by showing that two competing hypotheses regarding the drivers of FLS variation can be explained by one mechanism studied under very different research conditions.

We believe this work would be of broad interest to the readers of *Journal of Ecology*, given the relevance of forest trees and shrubs to biodiversity and to ecosystem processes. Our results, of course, have particular relevance to understanding forest plant communities. In particular, we found that the FLSs of wind-pollinated species that flower before their leaves had the strongest response to environmental cues, suggesting they are likely to have the largest FLS shifts with climate change. Given the importance of the time between flowering and leafing for pollen transport in these taxa (Rathcke & Lacey, 1985), our findings suggest that the pollination ecology of wind-pollinated species may be particularly at risk for declines in reproductive performance due to FLS shifts. While much of the research around phenology and pollination in the context of global change has centered around plant-pollinator interactions (Settele *et al.*, 2016), which is of little relevance to abiotically pollinated taxa, our study adds to an emerging body of literature suggesting that the impact of climate change on the reproductive ecology of wind-pollinated taxa must be part of a global change research agenda (Kling & Ackerly, 2020).

The main text of this manuscript is 4,487 words in length and it contains 4 figures. It is co-authored by E.M. Wolkovich and is not under consideration elsewhere. We hope that you will find it suitable for publication in *Journal of Ecology*, and look forward to hearing from you.

Sincerely,

A handwritten signature in black ink, appearing to read "D. Buonaiuto".

Daniel Buonaiuto

References

- Kling, M.M. & Ackerly, D.D. (2020) Global wind patterns and the vulnerability of wind-dispersed species to climate change. *Nature Climate Change* **10**, 868–875.
- Körner, C. & Basler, D. (2010) Phenology under global warming. *Science* **327**, 1461–1462.
- Li, X., Jiang, L., Meng, F., Wang, S., Niu, H., Iler, A.M., Duan, J., Zhang, Z., Luo, C., Cui, S., Zhang, L., Li, Y., Wang, Q., Zhou, Y., Bao, X., Dorji, T., Li, Y., Peñuelas, J., Du, M., Zhao, X., Zhao, L. & Wang, G. (2016) Responses of sequential and hierarchical phenological events to warming and cooling in alpine meadows. *Nature Communications* **7**, 12489.
- Rathcke, B. & Lacey, E.P. (1985) Phenological patterns of terrestrial plants. *Annual Review of Ecology and Systematics* **16**, 179–214.
- Settele, J., Bishop, J. & Potts, S.G. (2016) Climate change impacts on pollination. *Nature Plants* **2**, 16092.