Do alpine communities experience greater plant-pollinator phenological mismatch than lowland habitats?

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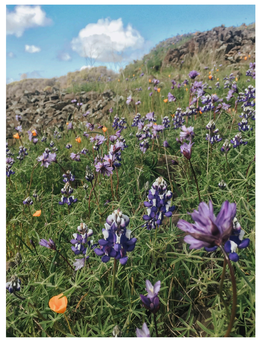
MOTIVATION

- **Phenology** (timing of life history events) is often cued by climate
- Plant and animal **phenology shifts with climate change** (Figures 1 & 2).
- Many important **species interactions** are dependent on phenological alignment (Figure 3).
- Alpine habitats are sensitive to climate change; therefore, **climate-related changes may be more pronounced in alpine communities**.

Alpine habitat and flora at Tahoe National Forest, CA



Lower-elevation habitat and flora at North Table Mountain Ecological Reserve, CA

Alpine habitats *are considered "climate change hotspots" with high biodiversity and species especially* ***sensitive to global climatic warming trends.***

- Intergovernmental Panel on Climate Change, 2014

OBJECTIVE

Assessment of historical trends in plant-pollinator phenological alignment in alpine and lowland habitats using herbarium and museum specimen collection data.

BACKGROUND

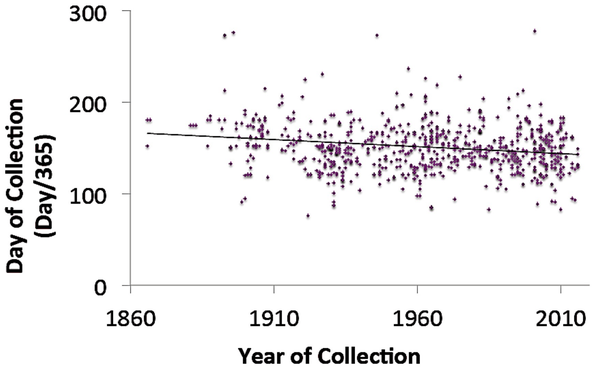


Figure 1. My unpublished data suggest flowering in *Clarkia unguiculata* occurred 24 days earlier in 2016 than in 1866.

Similar trends have been observed in other taxa (Fitter & Fitter 2002, Franks et al. 2007).

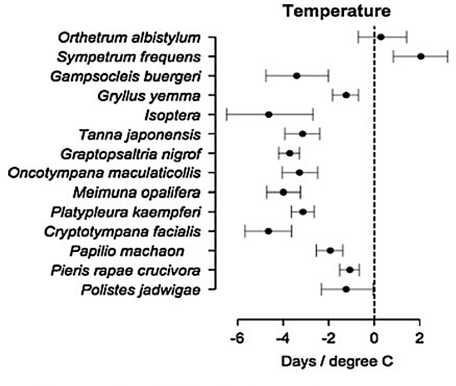


Figure 2. Shifts in insect emergence phenology varies among species in response to temperature

From Ellwood et al. 2012. Similar phenological shifts have also been documented in plants worldwide (Kehrberger and Holzchuh 2019, Theobald et al. 2017, Primack et al. 2004).

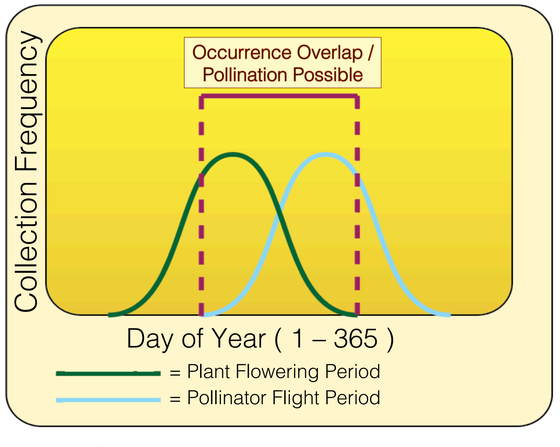


Figure 3. Collection date distributions can indicate flowering and flight periods, providing insight into phenological overlap.

Plant-pollinator phenological asynchrony has been previously identified using historical data (Burkle et al. 2013, Bartomeus et al. 2012).

PROPOSED METHODS

- **Species selection.** Target plants with brief flowering periods, conspicuous flowers, and extensive collection history, and bee species with brief activity periods and extensive collection history.
- **Collection data.** Collection records from online databases (CCOH and entomological databases) sorted by annual collection dates as approximations for flowering and flight periods.
- **Analysis.** Slope of linear regressions between collection date and year will estimate phenological shifts (Fig. 1). Significantly different slopes between plants and pollinators will indicate differential rates of phenological change and potential for phenological mismatch.
- **Alpine-lowland comparisons.** The magnitude of difference in regression slopes between plant and pollinators is expected to be greater in alpine species.
- **Field verification.** Model predictions will be tested by field observation of at least 50% open flowers in plant populations.

REFERENCES

Bartomeus, I., M. G. Park, J. Gibbs, B. N. Danforth, A. N. Lakso, and R. Winfree. 2013. Biodiversity ensures plant–pollinator phenological synchrony against climate change. Ecology Letters 16:1331–1338.

Ellwood, E. R., J. M. Diez, I. Ibáñez, R. B. Primack, H. Kobori, H. Higuchi, and J. A. Silander. 2012. Disentangling the paradox of insect phenology: are temporal trends reflecting the response to warming? Oecologia 168:1161–1171.

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Kehrberger, S., and A. Holzschuh. 2019. Warmer temperatures advance flowering in a spring plant more strongly than emergence of two solitary spring bee species. PLOS ONE 14:e0218824.

Primack, D., C. Imbres, R. B. Primack, A. J. Miller-Rushing, and P. D. Tredici. 2004. Herbarium specimens demonstrate earlier flowering times in response to warming in Boston. American Journal of Botany 91:1260–1264.

Theobald, E. J., Breckheimer, I. and HilleRisLambers, J. (2017), Climate drives phenological reassembly of a mountain wildflower meadow community. Ecology, 98: 2799-2812.

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