Capturing phenology from herbarium specimens to understand flowering period in Winecup Clarkia (*Clarkia purpurea* ssp. *quadrivulnera*, Onagraceae)

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Abstract

Herbarium specimens offer a rich data source that until recently has been underutilized in studies of phenology and plant responses to climate change. In this study, we captured phenological data from herbarium specimens of Winecup Clarkia to (1) determine whether this information improves estimates of flowering period based only on specimen collection date and to (2) test whether flowering period has changed over the last century. We captured the number of buds, flowers and fruits on each of 274 specimens from across the taxon's distribution and spanning a 133-year period from 1881 to 2014. The proportions of reproductive structures were used to create a phenological index that was added to regression models to determine whether the index improved model fit. We found that phenological data greatly improved model fit, and year was not a significant addition to the model. This suggests that flowering period has not shifted over the last century. This test case demonstrates the tremendous potential of this approach in understanding the spatial and temporal variation in studies of flowering phenology across the California flora.

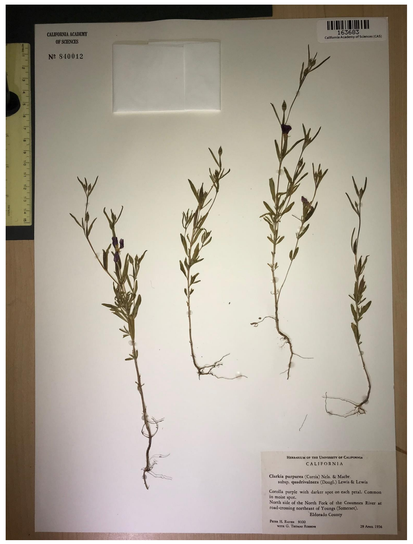
Introduction

Numerous studies have documented climate change. The impact of climate change on various biological systems is not fully understood. Plant phenology has been shown to be responsive to a warming climate, and changes in flowering time have been documented in various studies around the world. In studying the long-term effects on flowering time of plants during a period of rapid climate change, we can obtain a better understanding of further changes we can expect to take place in the future.

Our research questions for this project were:

- Can collection date of specimens improve estimates of flowering period?
- Has flowering period changed over the last century?

Methods



(Image of Clarkia herbarium specimen)

- Imaged specimens were analyzed to identify the number of buds, flowers, and fruits.
- The number of buds, flowers, and fruits were converted to a phenological index.
- The specimens were then georeferenced to find the location of each specimen
- Several regression models were built to determine the relative importance of the phenological index to understanding flowering period

Results

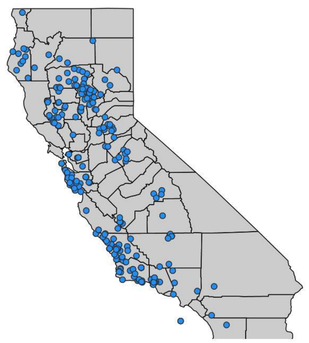


Figure 1. Distribution of Clarkia specimens throughout California

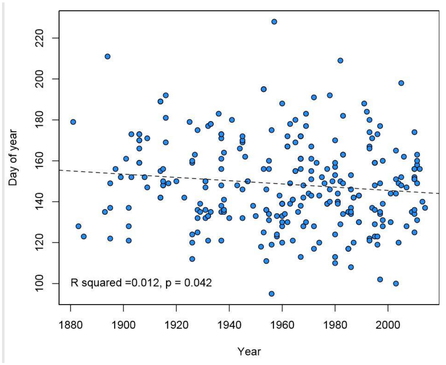


Figure 2. We found no substantial evidence based on this dataset ($R^2 = 0.012$, $p = 0.042$). Phrenologically there has been no change over the late century.

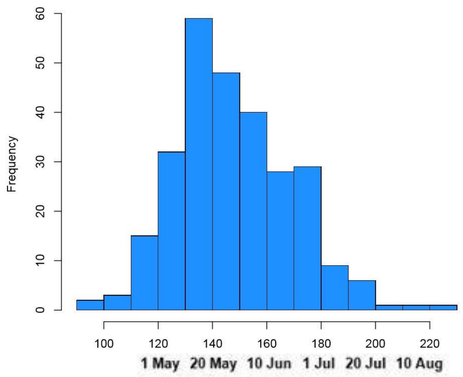


Figure 3. Julian day when specimens were collected. Mean collection date was 130 which corresponds with mid to late May.

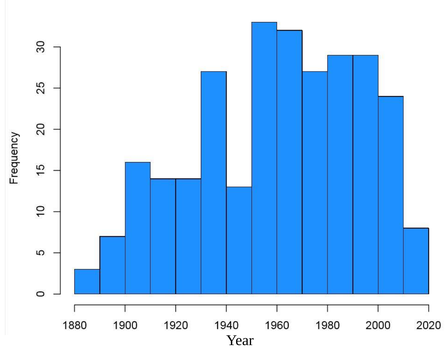


Figure 4. For our dataset we sampled many specimens throughout the 20th century.

Regression Models

	R^2	AIC
Model 1 Day of Year ~ temp + precip	0.18	2400
Model 2 Day of Year ~ temp + precip + PI	0.33	2344
Model 3 Day of Year ~ temp + precip + year	0.18	2401
Model 4 Day of Year ~ temp + precip + year + PI	0.33	2345
Precip only	0.08	2432
Temp only	0.14	2412

Conclusion

The Regression analysis demonstrated the utility of scoring phenological characters in addition to using collection date. In our dataset, collection year was not important, indicating that no significant change has occurred in the last century. Our best-fit model (Model 2) included temperature, precipitation and the phenological index, indicating that all three of these are important to understand flowering time across the species distribution. The potential information we can obtain from these specimens is an important reason why many institutions should continue to maintain herbaria. Raising awareness of these resources is beneficial for many future projects.

Future research

- Comparing two different Clarkia species in the same location to account for a difference in the day-of-year.
- Identifying insect pollinators of the species and note if there is any difference in flowering period and insect activity.

Acknowledgements

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References

Clarkia image Joe Engelbrecht

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