# Two temporal scales of reproductive synchrony affect the mating opportunity of long-lived perennials

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## Introduction

***Timing matters***

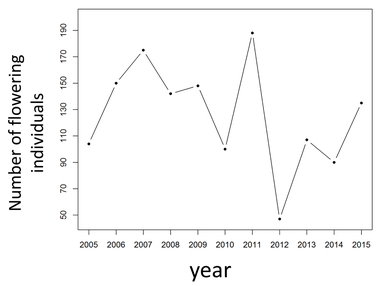
- For perennial plants in temperate climates, timing of flowering may be considered the *day* or *year* that an individual flowers.
- Both scales of timing may affect an individual's reproductive opportunity:
    - Increasing *intra-annual* flowering synchrony improves mating opportunities for individuals flowering near population peak.
    - Increasing *inter-annual* synchrony improves mating opportunities for individuals flowering in high-flowering years.
- Few studies have measured effects of both inter-and intra-annual timing for reproductive fitness.

***Echinacea angustifolia***

- Natural populations of *E. angustifolia* in our study system are isolated and reproduction is mate-limited (Wagenius and Lyon 2010)
- We use the long-lived perennial species, *Echinacea angustifolia* to quantify the consequences of reproductive timing for individual mating opportunity and reproductive fitness.

## Study system

- We monitored phenology and annual reproduction from 2005-2015 in population of *E. angustifolia* (*n* = 232) grown in a common garden experiment
- Variation in flowering phenology causes differences in reproductive success (Ison et al. 2014)
- Individuals' lifetime number of potential mating interactions is correlated with time spent flowering

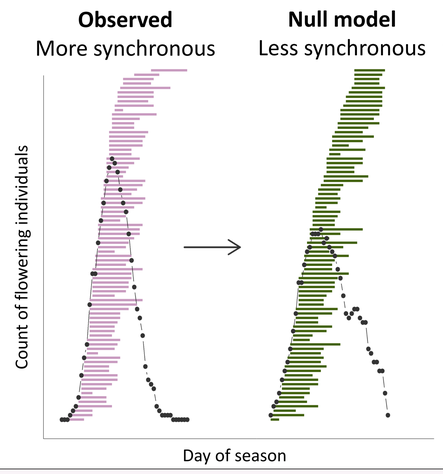



## Methods

1. ***Quantify population reproductive synchrony***

- We estimated the degree of inter- and intra-annual flowering synchrony and compared it to null models

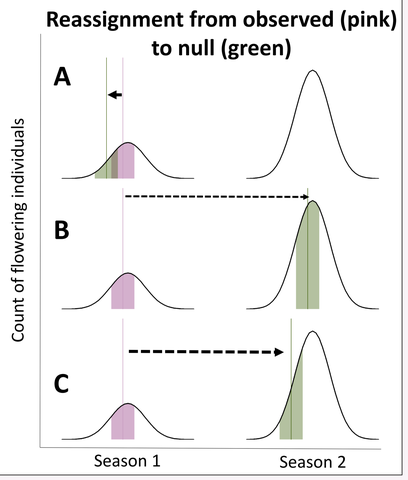
**Synchrony = mean overlap in flowering time of an individual with all other individuals in a population**



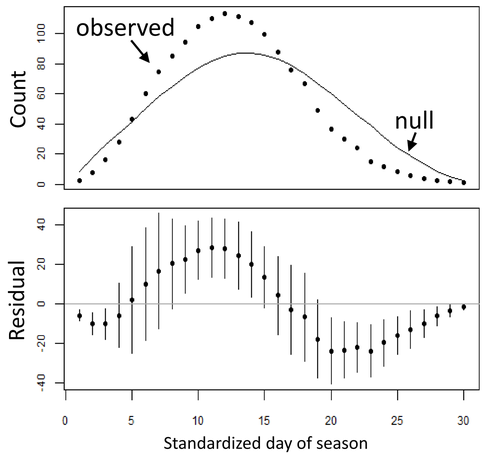

2. ***Determine relative importance of individual inter- and intra-annual timing***

- We quantified individuals' lifetime mating opportunity and compared it to three null models:
  (**A**) intra-annual timing null
  (**B**) inter-annual timing null
  (**C**) both temporal scales null

**Mating opportunity = number of potential mating interactions**

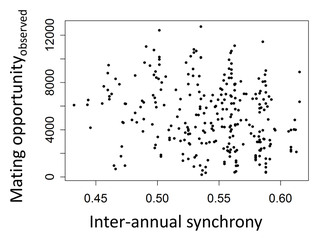



## Results




**The population flowered with a high degree of synchrony both inter- and intra-annually**

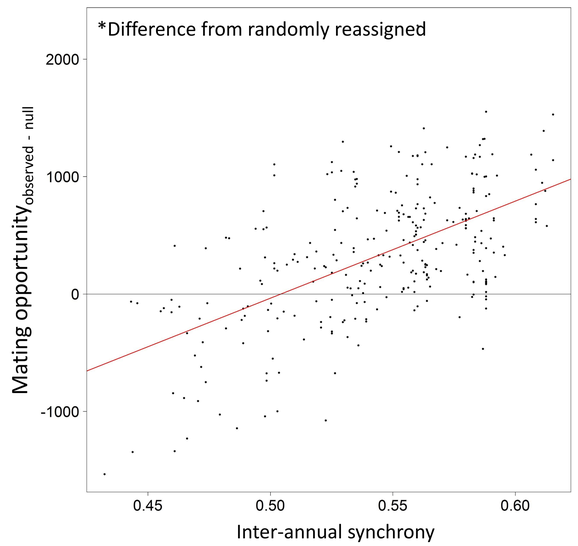
- Observed population flowering synchrony exceeded null models (Figure 3)
- The number of individuals flowering each year fluctuated (CV = 32)




**Individual inter-annual timing strongly predicted mating opportunity**

- $P < .0001$, $R^2 = 0.32$
- Individual intra-annual timing also predicted mating opportunity

**Individual mating opportunity* vs. Inter-annual synchrony**




## Conclusions

- The importance of an individual reproductive timing depends on the degree of **population reproductive synchrony**
- For perennials in temperate environments, **inter-annual timing may increase reproductive opportunity more than intra-annual timing**
- We demonstrated **strong effects of inter-annual synchrony** in an herbaceous species with no distinct population-level reproductive cycling
- **Both temporal scales** of flowering timing influence individual reproductive fitness
- Lifetime **frequency and duration** of reproduction influence an individual's quantity of mating opportunities more than either inter- or intra-annual reproductive timing

## Acknowledgments

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## References

Ison, J.L., and S. Wagenius. 2014. Both flowering time and spatial isolation affect reproduction in *Echinacea angustifolia*. Journal of Ecology 102: 920–929.
Wagenius, S., and S. P. Lyon. 2010. Reproduction of *Echinacea angustifolia* in fragmented prairie is pollen-limited but not pollinator-limited. Ecology 91:733-742.