Synchrony of flowering phenology within clusters depends on the spatial scale at which clusters are defined

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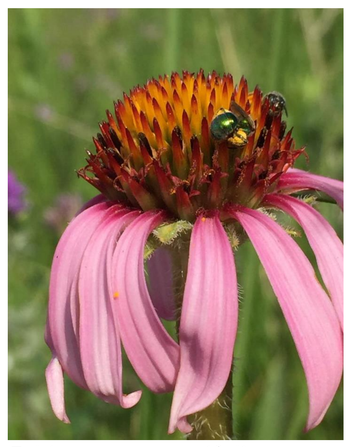
BACKGROUND

- The extent of fragmentation experienced by an individual depends on an individual's perception of scale
- Ecologists need a way to quantify that difference in perception in order to understand how organisms experience fragmented habitat, spatially and temporally
- *Echinacea angustifolia* (a long-lived, self-incompatible perennial) in tallgrass prairie remnants is an ideal study system for testing how perception of scale influences population-level measurements such as flowering synchrony
- A specific perception of scale, in this case spatial connection distance, or *d*, can be used to define clusters of Echinacea and the resulting population-level measurements within clusters



Echinacea angustifolia

QUESTION

How does population-level mating synchrony within clusters vary with *d*?

METHODS

PREDICTOR
We define *Echinacea* clusters using a connection distance, *d*. If an individual has neighbors within *d*, they are in the cluster, and neighbors of those plants that are within *d* are also included.

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RESPONSE
We calculated population-level synchrony, an index including the sum of individual synchronies within a cluster, using Augspurger's (1983) method and R package mateable.

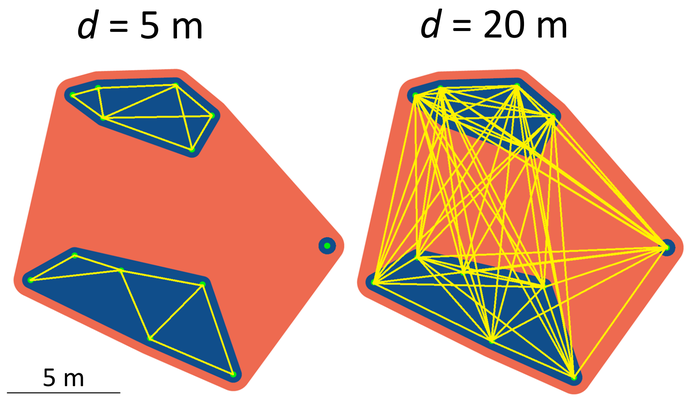

Figure 1. Clusters shaded in blue were defined based on a smaller *d* (left panel). The larger cluster, shaded in orange, was defined by a larger *d* (right panel).

- Select minimally adequate model by using backwards elimination from a linear model
- Determine clusters using R 3.4.3 and R packages sp and rgdal
- 3-year dataset includes precise spatial coordinates and first and last day of flowering for 2,836 flowering *Echinacea* individuals
- 6400 ha study site in western Minnesota

RESULTS

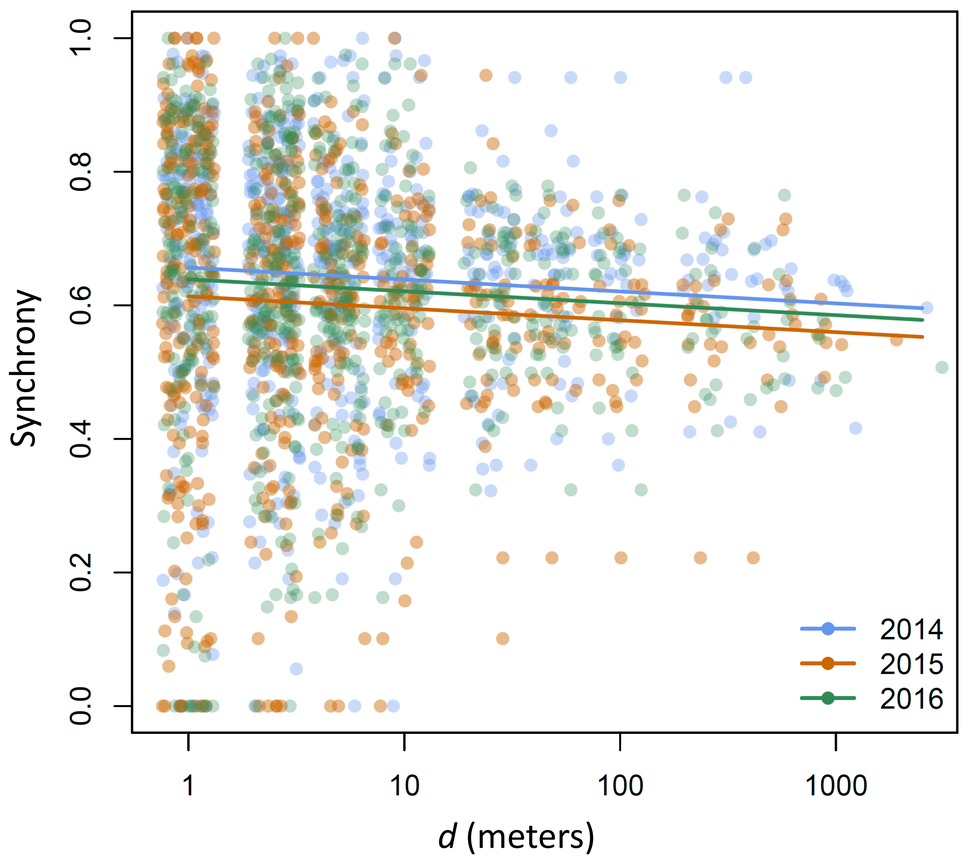

Figure 2. Connection distance (*d*) as a predictor of synchrony, with each data point representing a single cluster at a single *d*. The minimally adequate model is *synchrony ~ log(d) + year*, with parametric bootstrap $p = 0.02$. Points are jittered along the x axis, and colors represent years.

- On average, individual *Echinacea* plants are less phenologically synchronous with their cluster as *d* increases (Figure 2)
- On average, plants in small clusters experience higher synchrony, but much more variation in synchrony than plants in clusters defined by large *d* (Figure 2)
- Bee species, such as generalists that pollinate *Echinacea*, with smaller foraging distances (smaller *d*) experience more synchronously flowering clusters of *Echinacea* and more variation in synchrony than bee species with larger foraging distances (Figure 3)

Clusters defined by three connection distances, *d*

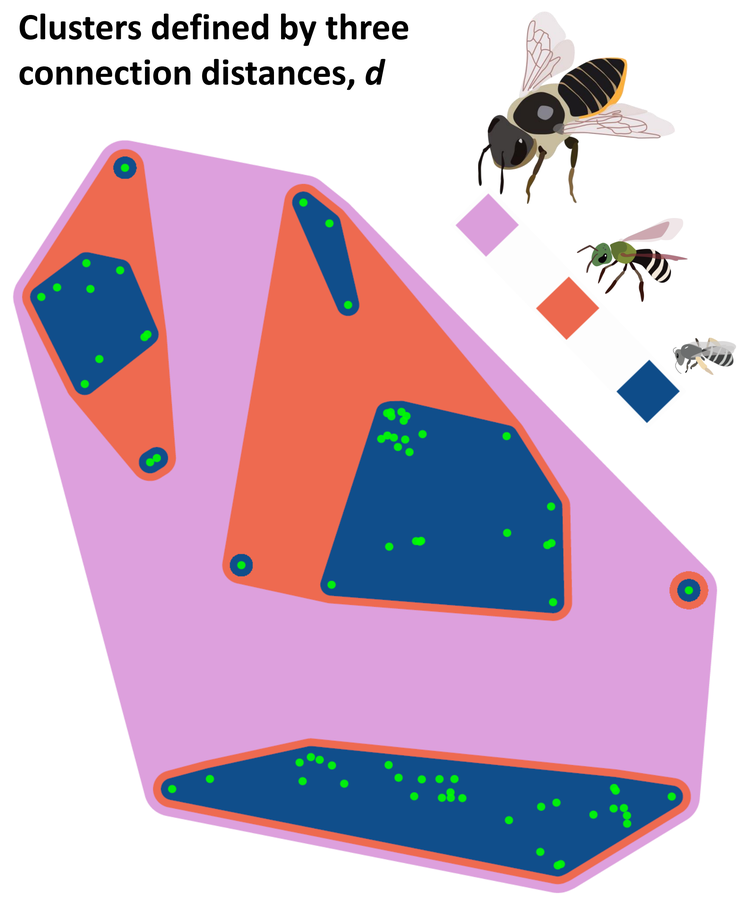

Figure 3. The clusters defined by the largest *d* are pink, second largest orange, and smallest blue. *Echinacea* plants are represented by green dots.

CONCLUSION

Lower phenological synchrony at larger *d* may result from clusters encompassing heterogeneous environments or genetically differentiated patches.

Differences in perception determine interpretation of synchrony, a general phenomenon that affects mating opportunities.

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- Augspurger, Carol K. "Phenology, Flowering Synchrony, and Fruit Set of Six Neotropical Shrubs." *Biotropica* 15, no. 4 (1983): 257-67. doi:10.2307/2387650.