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Phenology of *Echinacea angustifolia* and co-flowering plants independent study proposal

A recently published paper found that the flowering plant *Echinacea angustifolia* is pollen limited but not pollinator limited. This means that when viewed on an individual spatial level, plants that were more isolated in prairie remnants and had smaller seed sets received more pollinator visits per plant than those located in higher densities. This leads to the questions of what is causing the reduced seed set if it is not the number of pollinators. There have been some very plausible theories constructed. Such as, the pollen the bees are carrying may not be compatible with *E. angustifolia*, the bees might not be sufficient at carrying and depositing pollen, or the flowering phenology may not be synchronous enough within the populations. A previous experiment looked at the pollen interference theory and found that pollen from some foreign co-flowering plants increased the shriveling rates of the styles of *Echinacea angustifolia*. When the style shrivels it decreased the chances the flower has of receiving compatible pollen and thus a lower seed set of viable achenes would result. This led me to the question of: What are the chances that this foreign pollen will actually be deposited onto the *E. angustifolia* plant? Many factors could contribute such as how the bees carry and deposit pollen, which plants they visit, and the synchronous phenology of the two plants. I have decided to focus on the phenology of *E. angustifolia* and compare it to *Heliopsis helianthoides*, *Coreopsis palmate*, and *Carduus acanthoides* and ask the following question:

What is the phenology of *H. helianthoides*, *Coreopsis palmate*, *Carduus acanthoides* and *E. angustifolia*? Does it vary between different remnants? How synchronous are they? Does it vary depending on the spatial scale it is viewed such as population vs. individual density to the nearest plants.

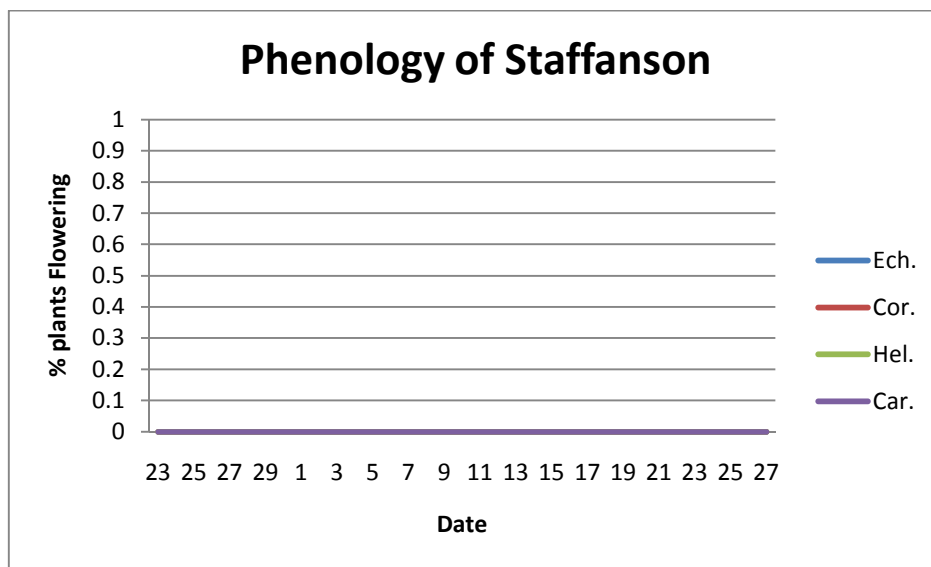
Methods:

To evaluate the phenology of the selected species I have chosen five prairie remnants to study (East Riley, Staffanson, Elk Lake Road, Stevenson's Approach, and Nessman). These remnants vary in size (L,M,S) and degree of disturbance. At each site I will do an entire census of each plant species unless the plants are greater than 30 in which a randomly placed transect of 20 meters will be used and plants will be searched for one meter wide. The sites should be visited every other day. When a plant is first observed to be shedding pollen it will be flagged, mapped, and assigned a number. The flowering start date, flowering finish date, flowering duration, peak flowering intensity/date and flowering will be assessed. Flowering synchrony will be look at in the following comparisons:

1. Individual flowering within species of individual remnants. (in time and space)
 - a. Synchrony of *H. helianthoides* with its self at each remnant.
 - b. Synchrony of *E. Angustifolia* with its self at each remnant.
 - c. Synchrony of *Coreopsis palmate* with its self at each remnant.
 - d. Synchrony of *Carduus acanthoides* with its self at each remnant.

2. Flowering synchrony between species at individual remnants.
 - a. *E. Angustifolia* vs. *H. helianthoides*
 - b. *E. Angustifolia* vs. *Coreopsis palmate*
 - c. *E. Angustifolia* vs. *Carduus acanthoides*
3. Flowering synchrony between species populations of various remnants.
 - a. Synchrony of *H. helianthoides* with its self at all other remnants.
 - b. Synchrony of *E. Angustifolia* with its self at all other remnants.
 - c. Synchrony of *Coreopsis palmate* with its self at all other remnants.
 - d. Synchrony of *Carduus acanthoides* with its self at all other remnants.

The graphs will resemble something like the following:



Materials:

Tags, flags, and tape measures.