Temporal isolation in the flowering time of fragmented populations of *Echinacea angustifolia*

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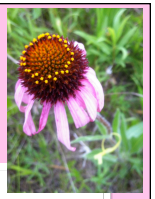

Introduction

In Western Minnesota, large-scale agriculture has encroached upon native prairie, creating isolated remnants. This fragmentation may alter the flowering phenology (timing and duration of flowering) and decrease fitness of prairie flora. Temporal and/or spatial isolation may decrease the pollen flow between remnants, leading to decreased plant fitness. Burning could also alter the flowering phenology and/or synchrony patterns of remnants. All of these conditions may cause plants at different remnants to flower asynchronously, making them less likely to cross-pollinate (Ison, 2010). Synchronously flowering plants would be expected to have higher seed set than those that flower off-peak. This study seeks to discover any differences in flowering phenology between and within remnant prairies and to determine if these differences affect the seed set of flowering heads.

Research Questions

- Is there a difference between the flowering phenology of *E. angustifolia* at different prairie remnants? Furthermore, is there a correlation between the size of a remnant and its flowering phenology?
- Does burning have an effect on the flowering synchrony or seed set of plants within a burned site as well as between burned and unburned sites?

Materials & Methods

- Six prairie remnants of different sizes (located in Douglas County, MN) were chosen during the 2012 growing season and all flowering plants were located. (For the largest remnant, Staffanson Prairie Preserve, a random subset of 40% of all flowering plants was selected)
- Flowering heads were evaluated every two days.
- The first and last day of flowering for each head was recorded.

Study Species: *Echinacea angustifolia*

- Long-lived herbaceous plant
- Native to Western tallgrass prairie
- Self-incompatible

(cannot produce viable seeds using self-pollen)

How do *Echinacea* flower?

- Heads flower in concentric rows starting from the base and proceeding upward.
- Each floret produces a pollen-shedding anther on the first day of flowering and a pollen-collecting style on its second day.
- Styles persist until compatible pollen is received.

First day of flowering - First appearance of pollen-shedding anthers
Last day of flowering - Last day of anther production

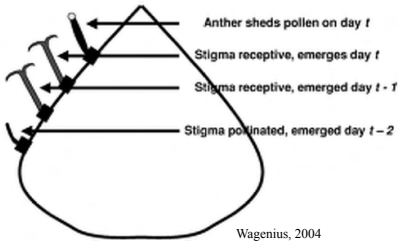

Figure 1. A cross section of flowering *Echinacea*.

Phenology Results

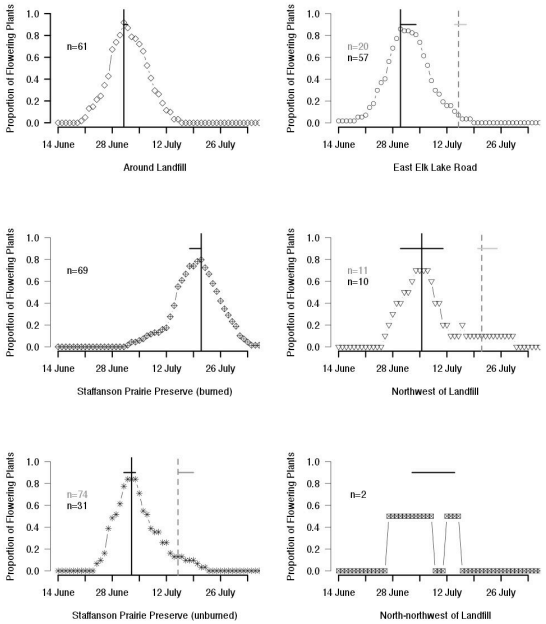

Figure 2. Flowering phenology curves appear normal for all remnants with the exception of North-northwest of Landfill (which contained only two flowering heads). Solid vertical lines mark peak flowering in 2012 based on the greatest proportion of flowering plants. Dashed gray lines represent peak flowering during 2011. Horizontal lines mark the 95% confidence interval based on a bootstrap resampling method with 100,000 repetitions. Each tic mark represents a 7-day span. A total of 230 flowering *E. angustifolia* heads were observed.

Seed Set Analyses

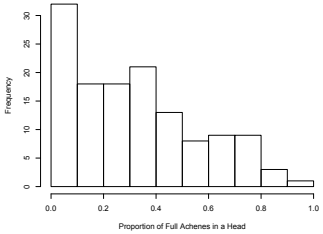

Figure 3. Seed set data is based off of samples of flowering heads from three remnants. A non-random selection of 29 heads from ALF, 31 heads from SPPE, and 69 heads from SPPW were analyzed for seed set. A histogram of seed set, defined as the proportion of full achenes within one flowering *Echinacea* head, illustrates a left skew in the data. Many heads were damaged or defective such that they did not set seed.

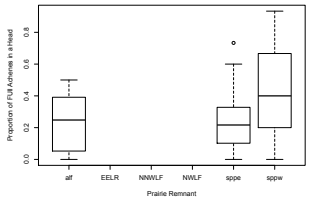

Figure 4. Boxplots of average seed set in remnant prairies. The average proportion of full achenes was 0.238 at ALF, 0.234 at SPPE, and 0.436 at SPPW. Based on an ANOVA test for difference in means, seed set was significantly higher at the burned prairie remnant, SPPW, than the other two remnants ($p < 0.0001$).

Flowering Synchrony Results

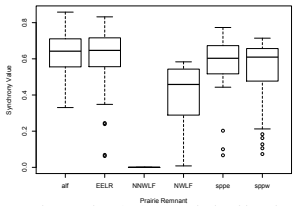

Figure 5. Remnant synchrony values (0-1) were calculated based on an equation that considers the average number of shared flowering days between a focal plant and all other plants in a population (Augspurger 1983). Average synchrony values were SPPE (0.561), SPPW (0.539), ALF (0.636), EELR (0.605), NWLF (0.396), NNWLF (0.000). An ANOVA test for a difference in means (excluding NNWLF due to lack of data) reveals a significant difference in flowering synchrony between remnant populations ($p < 0.0001$)

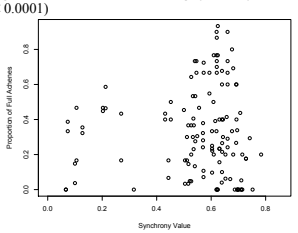

Figure 6. Plants with higher synchrony values also tend to have higher seed set. However, this correlation was not statistically significant ($r^2 = 0.002$, $p = 0.595$).

Conclusions

- Burn treatments can increase seed set in *E. angustifolia* but have no effect on flowering synchrony.
- Smaller remnants experience decreased flowering synchrony.

Further Analysis

- More fine-scale synchrony/seed-set data using data from the beginning and end of flowering for each head.
- Continued research on phenology patterns of small remnants, especially with regard to synchrony.

Literature Cited

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Acknowledgements

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