Climate and Flowering:
How does Echinacea respond to varying environmental conditions?

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the echinacea project

CHICAGO
BOTANIC
GARDEN

Background

- Prairies are important, complex ecosystems for many reasons
- Flowering phenology- the timing, duration, and synchrony of flowering- is one important aspect in the study of prairies
  - In alpine systems, increased temperatures and earlier snow melts have been associated with earlier flowering (Innoye et at 2003)

- We use Echinacea as a model species to study the tallgrass prairie
- High variation in the timing, duration, and synchrony over time

What we know about phenology

- Pollinator visitation to Echinacea decreases over season (Ison et al 2018, Ison and Wagenius 2014)
- Herbivory of Echinacea seems to increase later in the season (Ison and Wagenius 2014)
- Effects of climate on phenology in tallgrass prairies is relatively unknown

Do relationships exist between climate predictors and phenological responses of Echinacea?

Methods and Variables

- Long term data set of Echinacea flowering phenology
  - Flowering start and end dates
  - Flowering duration
  - Peak flowering date
  - Flowering synchrony calculated according to the Augspurger method using the "mateable" package in R
- Climate data from PRISM (Oregon State) and the Midwest Regional Climate Center
  - Monthly mean temperatures and precipitation
  - Freezing degree days
 - First occurance of 5 consecutive positive growing degree days (Frank and Holman)
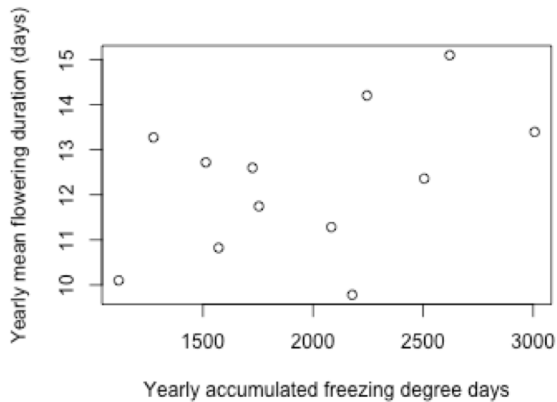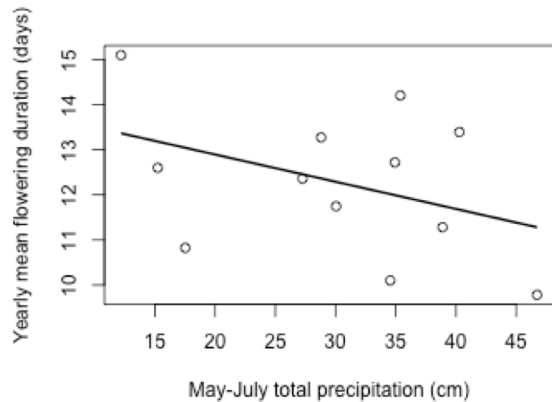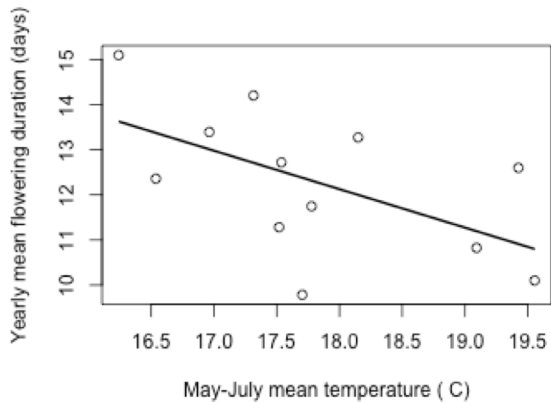
Summary Statistics

- Mean start date ranged from June 27th - July 21st
- Mean duration ranged from 9.7 days to 15.1 days
- Mean end date ranged from July 10th - August 3rd
- Mean peak flowering date ranged from July 3rd - July 26th
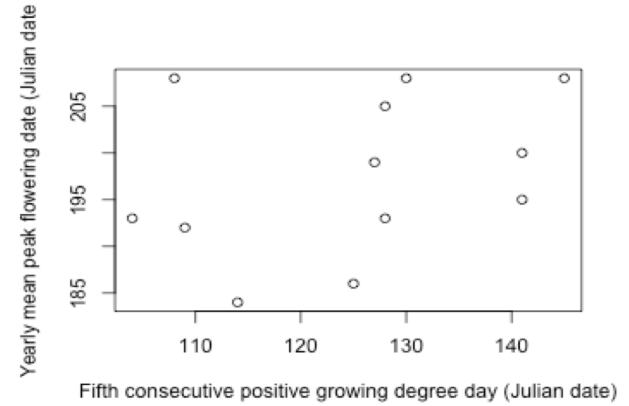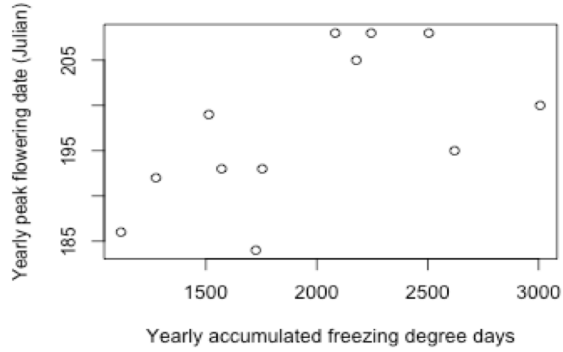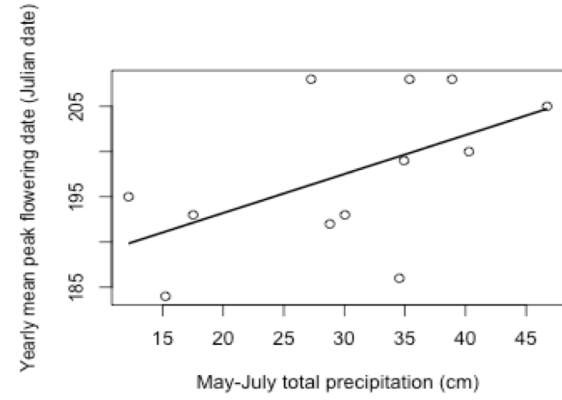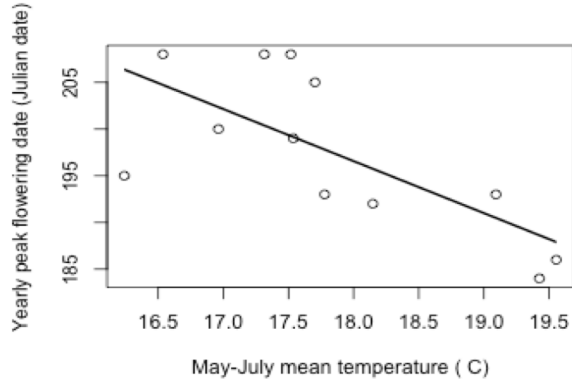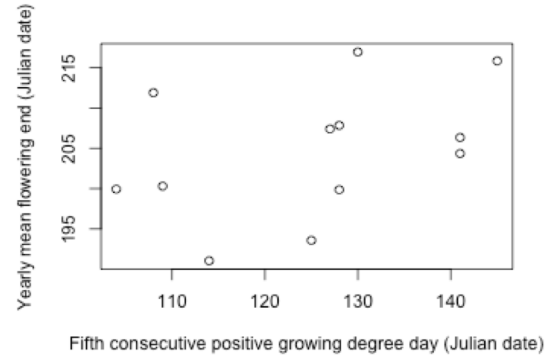- Mean flowering synchrony ranged from .468 - .675
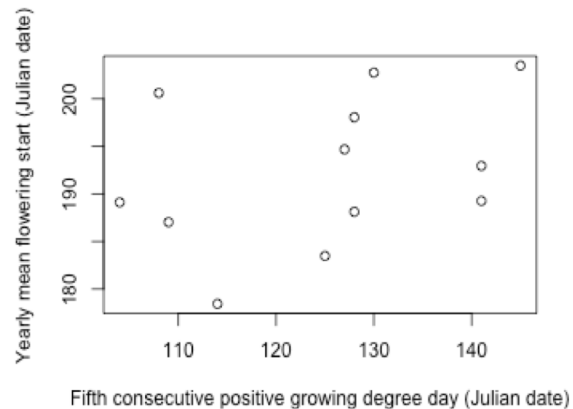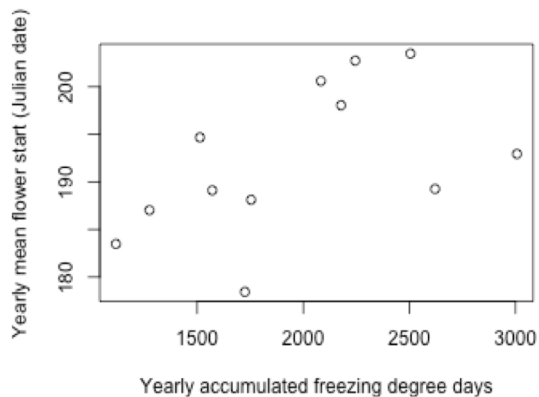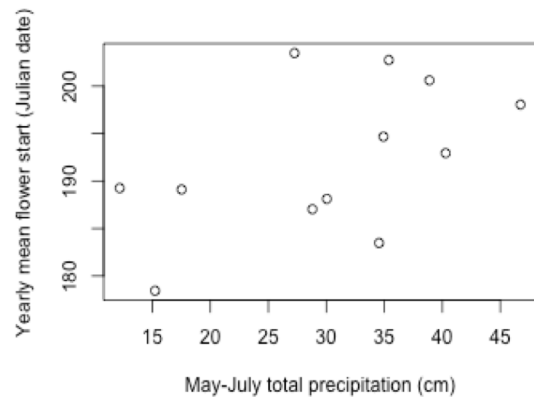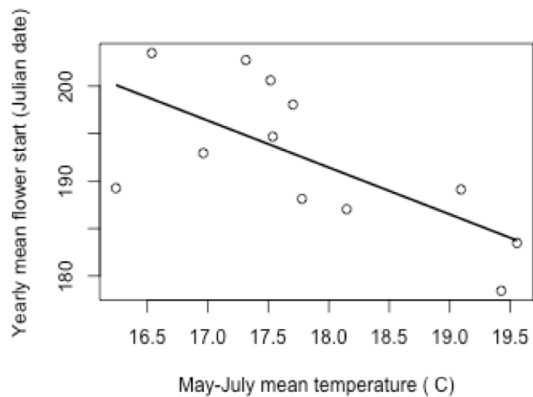
Mean start date= 280 - 4.9(May through July mean temp)
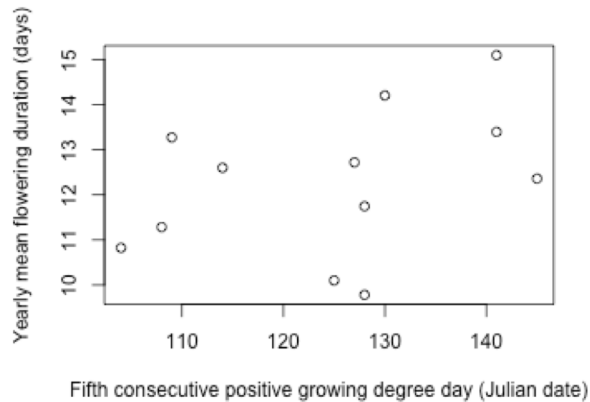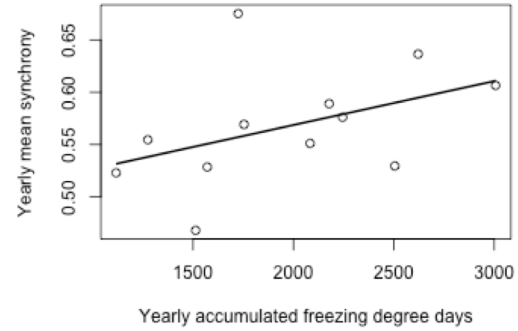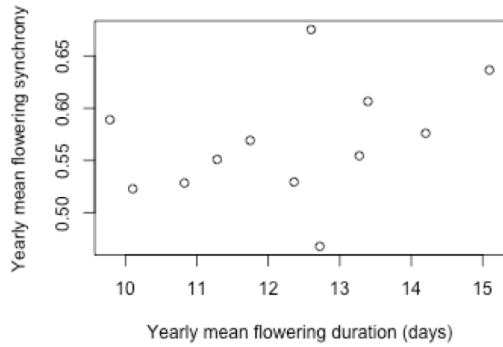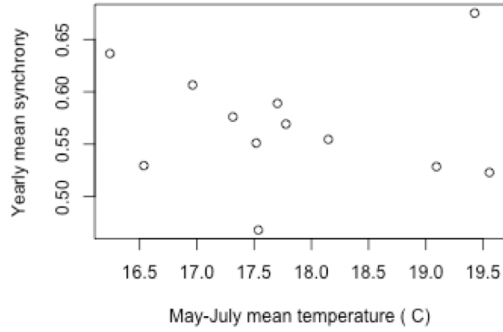
Mean flowering duration $= 31 - .95$(May through July mean temp) $- .07$(May through July precip)

Peak flowering date= 334 - 6.8(May through July mean temp) + .36(May through July precip)
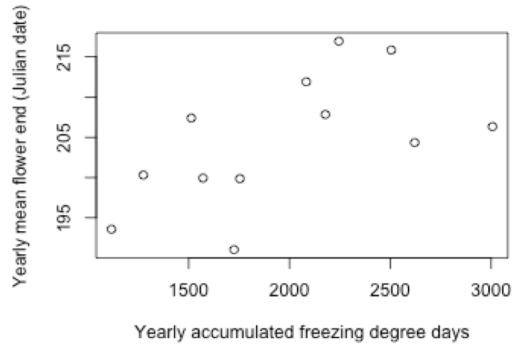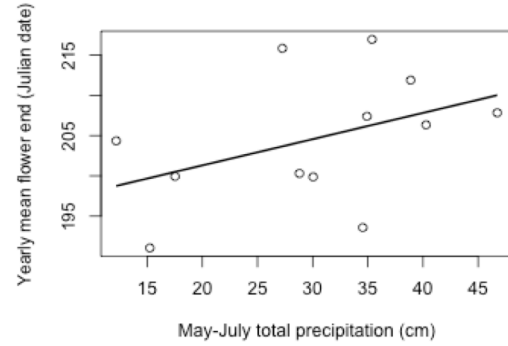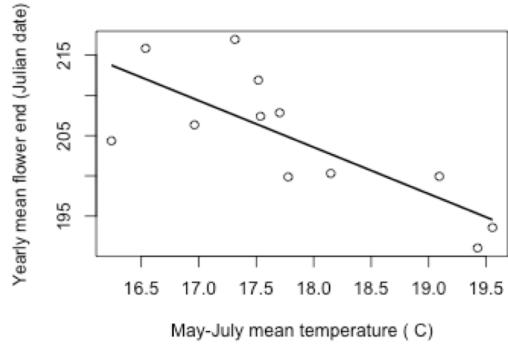
Mean flower end = 294 - 5.4(May through July mean temp) + .25(May through July precip)

Mean synchrony = 1.5 - 5.5e-3(Mean start date) + 8.1e-5(Freezing degree days)

Discussion and Significance

- Per degree warming
  - 5 day earlier start
    - Somewhat in line with previous research (Innouye 2003, Dunne 2012)
  - 1 day shorter duration
    - Maybe not what we would expect
  - Peak is 7 days earlier
  - 5.5 day earlier end
    - Makes sense in light of duration result, but again maybe not what we'd expect
- Precipitation
  - Negative relationship with duration
  - Positive relationship with peak flowering and end date
- GDD and FDD not great predictors in general
  - FDD and synchrony

Discussion cont.

- Generally, May-July temperature and precipitation generally stronger predictors than winter strength
  - Freezing degree days only chosen for synchrony model
  - Probably makes sense for this system
- In general, results show a correlation between earlier flowering and temperature
  - In light of climate change we might expect Echinacea to flower earlier in the season
  - While other factors likely affect phenology, there appear to be real, and in some cases strong, relationships between Echinacea phenology and climate patterns