# Effects of phenology on plant community assembly and structure

March 9, 2023

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## 1 Deadlines & info

Google doc link: `https://docs.google.com/document/d/1hSAbi-9lcc7Pek-CGSs_uZRHI6SD3DPK_fiHJ8Rkz7Y/edit?usp=sharing`

Space for a total of 8,500 words and 120 references has been reserved for your review—counts that will produce our desired 25 typeset pages. This word count is meant to include tables and figures. Each moderately sized figure/table is estimated at approximately 300 words; each large one, 600 words.

It should emphasize where research in a given area should go, as well as where it has been, such that it will influence the future course of knowledge.

- 1-2 page outline: 16 March 2022
- DUE: 17 January 2024

## 2 Outline

**Do next!** Figure out the stuff at the bottom of the figures section (what was I doing? Where does it go or is it just a list to keep ...?). Then, go back to google doc and see where left out stuff fits in (start at 'What do we want people to after reading this?').

1. Intro

   Elsa; see 1. in Google docs

2. Quick overview of assembly theory

   Lizzie; see 2. in Google docs

3. Where phenology fits in the environmental filtering part of community assembly (subheader?)

   (a) Species can only pass environmental filter if they can reproduce within length of growing season (PHENOFIT – predicts species range limits); old work on fruit size etc.

   (b) Dynamics of resources across the season may also functionally filter species through their phenology (left side of resource figure)

      i. Simplest model is chemostat: species pass filter if levels of resource are high enough

      ii. Evaporating single pulse resource: species may invade only at certain levels of resource (includes snowpack/soil nutrients etc.)

      iii. Multiple pulses: some species may persist through whole season or use first or second pulse only

4. Before we dive into biotic interactions: constraints on phenology x other traits (subheader?)

   Elsa; see google docs

5. Limiting similarity of phenology (subheader?)

   (a) Do species with similar phenologies actually compete? (Temporal niches etc.)

   (b) Dynamics of resource availability across the season and creates temporal niches (right side of resource figure, see notes on that below in figure section)

6. Priority effects

   (a) All temporal niches may not be created equally however, because of priority effects

   (b) Priority effects and assembly theory – competitive exclusion is not even across the growing season

   (c) Seasonal priority effects *are* phenology. (Fukami, Stuble). Review them.

   (d) Priority effects suggest there should be a drive to be early, which we do see in some data (flowering times etc.)

   (e) But they have costs: herbivory apparency, frost risk etc.

   (f) And, priority effects are not always competitive . . . Phenological facilitation (Lindsay Leverett 2017: Germination phenology determines the propensity . . . and old work from the 1980s that Lizzie cannot remember the name of but Dan B must know and other literature (seedlings die))

      Could we fit applications into this section?

7. Phenological coexistence

   (a) Current landscape of phenological coexistence theory/experiments

i. 'Modern coexistence' – stabilizing/equalizing
ii. Godoy (and others, Blackford etc.) parameterize models to show trade-offs with phenology
iii. Will review which models have been used for parameterization – are they all the same?
iv. And maybe also compare the types of experiments: All focused on annuals in which systems ...
v. Highlight limitations

(b) Future potential for phenological coexistence theory/experiments

i. Exciting time for coexistence theory as new issues arise (Barabas, Song papers)
ii. Phenology could help push theory forward...
iii. Beyond annual plants
iv. Germination leads to other events ... Community assembly is all about germination/growth and assumes species will flower and set seed (but most studies in modern coexistence only measure seed set, so...)
v. Connect here to *Arabidopsis* models (and common garden across Europe) which is about germination, flowering and seed set (spins back up to life history theory) ... do we need a cross-continental phenological coexistence experiment to (highlight limitations and) push field forward?
vi. Maybe also connect to Chuine... Process-based models focuses on costs of being too early (priority effects?) and whether you can grow in time

8. One step ahead, one step behind

(a) Phenology – runs straight at the tension between life history theory and coexistence theory as somehow separate

(b) Maybe something about evolution and community assembly theory here?

(c) What cues drive priority effects (and thus can we predict them)?

(d) Maybe something about annual/perennial divide ... which is also a systems divide: Phenology is so focused on temperate deciduous forests and coexistence theory is drought annual systems

(e) Bet-hedging, it's a bad romance.

# 3 Figures

1. Competition versus phenological overlap – Can we find real data for this?

2. Resource pulses (temporal resource supply) and coexistence models (chemostat to mid-season drought) – Lizzie

(a) Left panel is just Resource x intra-annual time graphs (referenced in filtering section); Right panel is outcome of niches from coexistence theory

(b) Chemostat model – no resource variation so no temporal assembly, just Tilman's $R^*$

(c) Evaporating single pulse resource (includes snowpack/soil nutrients etc.)– competition colonization trade-off (lottery model and eventually storage effect)

(d) Multiple pusles (monsoon systems of Venable; mid-season drought systems) – can we get real data from NEON perhaps?

3. Multi-dimensional trait space ... early and risky versus competitive and late – list traits ... could do along a season or do a multi-panel figure covering classic frameworks and where phenology fits in:

   (a) Growth x defense

   (b) Grime triangle

   (c) Competition x colonization

4. Evidence for trade-offs based on data (competition - colonizer, where colonizer = growth rate trade-off)

5. Maybe ... Bet-hedging and speed of germination trade-off (speed of germination = germination cues) .... How much you germinate and how fast you germinate are related... Or is this just showing early is fast?

What is the current role of coexistence in community assembly theory (a la phenology)?
Advances in other systems that could be applied to plant systems? (Daphnia resting stages; amphibians)
Think about how much we'll get into invasions/applications before applications section. Variance partitioning – how much does a difference
Getting ahead of your competitors (biotic component) of phenology may be less important than getting it right abiotically.
Relative importance of phenology relative to other traits ...
Relative importance of abiotic versus biotic as a section ...
Schmitt – relative importance of different phenophases
Intensity vs. importance of competition debate:
Intensity – amount that competition reduces biomass
Importance – relative role of competition.

# 4 Miscellaneous