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RH: Phenological tracking

Phenological tracking in communities in stationary & non-stationary environments

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Abstract

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Outline

So, there's a pretty basic structure to what we want to walk through:

1. Intro: Understanding how plant communities will respond to climate change requires synthesizing information on both direct effects of climate on species and indirect effects driven by responses to other species' shifts. (Coexistence models based on variable environments allow us to do this, as species respond to shifting resources, which are influenced both by abiotic stressors and the use of the resource by other species.)

2. In *stationary environments* ...

    (a) Describe R* and how species with lower R* always wins (intra-annual dynamics generally) ... need other axis of competition for coexistence

    (b) Moving onto interannual variation: in temporally variable environments species with τ_i closer to averae τ_P should always win

    (c)

    (d) For variation in τ_i to exist, need other axis of coexistence (such as R*)

    (e) But what if τ_i is not a fixed species attribute? Introduce tracking...

    (f) Then speices with higher α should win

    (g) Unless you have another axis of coexistence (such as R* or τ_i)

3. In *nonstationary environments* ... (need some help with phrasing)

    (a) Earlier τ_i is favored more (R* versus τ_i runs: previously these coexisted via a higher R* and less ideal τ_i)

    (b) Tracking is favored more ... or effective τ_i is really favored more (τ_i vs. α runs)

    (c) Tracking is favored more (α versus R*)

4. But this all assumes that nonstationarity happens on only one dimension of the environment; just like species niches, the environment is multidimensional and nonstationarity in it may be multidimensional also.

    (a) Show what happens when R0 get smallers as τ_P gets earlier

5. And, we conclude.

Semi-outline from May 2017

Naive assumption: Trackers will always win; but not always the case in a stationary or non-stationary world.

1. In a stationary world (SW):
    (a) In a stationary world (SW) with no multispecies temporal niche: species with $min(\tau_i - \tau_{P.one.wold})$ wins.
    (b) Simple temporal niche: R^* trades off with τ_i (species with τ_i further from τ_P must have lower R^*.
    (c) Dynamic temporal niche scenario 1: with no difference in R^* among species, then the best tracker (α) often wins, with some nuance about τ_i ... i.e., $\tau_i - \tau_p$ versus $\hat{\tau}_i - \tau_p$ ... something that is weakly tracking may be out-competed by a species with a better mean τ_i. So we need to find cases where tracking does not beat out non-tracker.
    (d) Dynamic temporal niche scenario 2: R^* trades off with α ... and the more complex version where R^* trades off with α and τ_i combo: main point here is that what matter is $\hat{\tau}_i - \tau_P$
2. In a non-stationary world (NSW):
    (a) No multispecies temporal niche (just vary τ_i across species): with you shift from species $min(\tau_i - \tau_{p.old.world})$ to species with $min(\tau_i - \tau_{p.new.world})$ wins.
    (b) With dynamic temporal niche: consider just varying α, then species with $max(\alpha)$ wins.
    (c) What happens to communities that were coexisting via $R * - \alpha$ trade-off?
        i. Perhaps tracking can trump R^* ... Look at: cases where tracker outcompetes species with lower R^* in nonstationary simulations.
        ii. Maybe do runs with stationarity, then non-stationarity: this could tell you things like 'these species will stop coexisting or X% of runs now go extinct or this part of parameter space that was coexisting goes away first' ... we could also do runs with same params started non-stationary period and see if combinations become possible.

Phenology & climate change paper

... below is from (and still in) `VarEnv_notes`
Possible titles: 'Phenological tracking: It's more complicated than you think' (we hope) or 'Phenological tracking: Is it naive?'

1. Opening
   (a) Communities shifting due to climate change (species increasing and decreasing)
   (b) Phenology has been implicated in driving this
   (c) The theory goes that as seasons get earlier, earlier species win out over later species (don't get into tracking yet)
   (d) Yet no one to date has ever examined whether this hypothesis is supported through community coexistence theory and models
   (e) So here we provide the first test using a model that explicitly considers how within and between year dynamics can drive coexistence
2. Under this model climate change critically alters the environment in a couple ways
   (a) Climate change...
      i. τ_P gets earlier (i.e., start of season gets earlier)
      ii. $R_0 \downarrow$ (e.g., in systems started by a pulse of water from snowpack)
      iii. $var(R_0) \uparrow$
      iv. $\epsilon \uparrow$ (i.e., it gets hotter and resources like water evaporate quicker)
   (b) Of these, changes in τ_P are aguably the most observed and should be most important to impacts on coexistence via phenology thus we focus on how shifts in τ_P impact coexistence.
   (c) We first examine the role of phenology in a stationary environment ... then to X, Y, Z.
3. Under a stationary environment what trade-off is required with tracking to allow coexistence?
   (a) Two species (i, j) case
      i. Vary τ_P by drawing from a stationary distribution and let R^* and α also vary by being drawn from each of their own (non-joint) distributions, run a bunch of models of 2 species communities and extract co-existing ones.
      ii. Plot $\frac{\alpha_i}{\alpha_j}$ (or, perhaps better: realized proximity to τ_P) by $\frac{R_i^*}{R_j^*}$ for coexisting pairs of species (PhenTrackFig. 1, not currently shown here, see paper notes) – we expect a cloud of space where coexistence is possible.

(b) Multi-species case

   i. (Similar to above) Vary τ_P by drawing from a stationary distribution and let R^* and α also vary by being drawn from each of their own (non-joint) distributions for a $n > 2$ set of species, and pull out coexisting species from each run.

   ii. Plot α (or realized proximity to τ_P) against R^* for each community of coexisting species (PhenTrackFig. 2, not currently shown here, see paper notes), measure the correlation and the noise around it.

   iii. Examine the distribution of correlations (and maybe noise) for all communities (PhenTrackFig. 3, not currently shown here, see paper notes).

4. Under a non-stationary environment of earlier τ_P how: (1) does this trade-off change and (2) do communities change?[1]

   (a) Two species case: take the coexisting 2-species communities from part I and add nonstationarity in τ_P and ...

      i. see how long it takes to lose one species.

      ii. see which ones persist longest and mark on PhenTrackFig. 1 (e.g., re-do PhenTrackFig. 1 with bubble plots or such for how long the two species persist together).

   (b) Multi-species case: take the coexisting multi-species communities from part I and add nonstationarity in τ_P and ...

      i. stop at X timepoint and re-do PhenTrackFig. 2 and 3 to see how they have shiften (e.g., you may lose the middle species — those that are not the best competitors nor the best trackers ...).

      ii. extract timepoints when 10% and/or 50% of species are lost.

      iii. extract when each species is lost in a community and order the species loss of PhenTrackFig. 2.

5. Are there environmental conditions under which tracking won't work as a strategy? (This is the section where we return to R_0 and ϵ, which we just mentioned earlier.

   (a) Thinking about environmental correlations (e.g., spring gets earlier and drier or such), are there some where tracking will not be favored?

   (b) Answer: Yes, probably whenever you shift the environment in another way (in addition to earlier τ_P) that does not impact the competitive dominant but does negatively impact the competitve inferior/tracker (See also Figure 1 below).

   (c) So, for example if τ_P gets earlier *and* R_0 gets smaller then the trackers may decline.

[1] Megan may have better notes on this section

Figures

1. Real-world data showing stat/non-stationarity in environment (ideally τ_P)
2. Real-world data showing tracking (and less tracking)
3. τ_P vs. R* trade-off and histogram of persisting τ_i under stat/nonstat τ_P environment
4. alpha vs.τ_i trade-off and histogram of persisting alpha under stat/nonstat τ_P environment
5. alpha vs. R* trade-off and histogram of persisting alpha under stat/nonstat τ_P environment
6. time-series of one run showing years where τ_i of one species is close to τ_P and other years where τ_i of other species is close to τ_P (and show this shift under nonstat)
7. non-stationarity in $R0$ and τ_P