

Culled from:
Coexistence and climate change:
The role of temporal-variability in structuring future
communities

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1 Old ideas

1.1 Mortality & phenology

We also discussed mucking with m_i (the partial mortality of species) to play around with shifts in extreme events such as more frost dates following spring warmth. But the above is more well-demonstrated or expected as climate-related issues so we're not going there. (Note from Lizzie in July 2011: I think this topic will be cool someday as it might be a real issue in subalpine communities, but for now it's not for sure. And given the equations we're using, it's not as crisp as the above to get from *environment* $\rightarrow m_i$. Note from Lizzie in October 2013: there is more on this now and it's been demonstrated for multiple communities. I have a literature review of this in the Appendix to my *New Phytologist* Tansley paper if we ever want to look at this. But I continue to think it is still a touch ahead of its time (which, really, just means that everyone is already excited about it and thus working on it without good data, so once I go running after truly just hot topics, this would be the one to do! But, luckily, I am not there yet).)

1.2 Correlated climate change variables

From an old version of the abstract: Specifically we examine how synergistic effects of climate on multiple abiotic variables—for example, earlier precipitation pulses and higher evapotranspiration associated with earlier snowpack melting in the Sierras—alter coexistence compared to single, unlinked variables ... We (might) find out that synergistic effects of multiple shifting abiotic variables reduce coexistence greater than single variables.

This was our big plan in July 2011, notes include:

- We compare the compounding effect of climate change: examining how shifts in single versus multiple environmental variables affect coexistence.
- As of July 2011 I would say that the greatest interest in setting up the paper lied in focusing on single vs. multiple variables, then putting in tracking as subordinate.

Old list of tasks on this I should make sure are thought through:

- Get on top of climate change lit: which variables will shift? Which ones are coupled and how will their coupling shift with climate change (go from uncoupled to coupled, or vice-versa, or just the coupling itself changes)?
- Does evaporative stress increase with climate change (absolute, versus relative, oceans burn off while temperatures increase etc.)?
- When seasons start earlier does evaporative stress increase (I suspect so, but need to pull together refs)?
- Does lower snowpack mean earlier seasons?

1.3 The endless debate about calculating drivers of coexistence, or not

Do drivers of coexistence change with climate change? Schwing! We decided not to work on this (for now) as of October 2013 meeting. But then we did an about face and were all over it by the December 2013 meeting!

Note: Before our topic of interest was pretty damn significant: Do drivers of coexistence change with climate change (*schwing! Sexy!*)? So we should work this up, if not right away then soon after!

We decided on *no analytical solutions* to storage effect versus relative nonlinearity (which are the main coexistence mechanisms), but we could do some of this conceptually post-simulations. We noted in October 2013 that even if we come up with these analytical solutions we'll still need an example, that is we would have to start with a community of n species that coexists via $z\%$ relative non-linearity, $x\%$ storage effect etc. and then we would impose climate change and see how $z\%$ etc. change.

Again in October 2013: We again discussed the urge to partition out relative non-linearity and storage effect and how they will shift with climate change (fluctuation independent mechanisms seem less important here) but again we felt this was tricky and still depends on the simulations we run so we focused on how we will alter the equations to focus on shifts in the storage effect with climate change.

1.4 Old equation for phenological tracking

Old (pre 2012) version of adding phenological tracking to the model:

$$\hat{\tau}_i = \tau_p - (\tau_p - \tau_i)e^{-\alpha}$$

thus, when:

$$\alpha = 0, \hat{\tau}_i = \tau_i$$

$$\alpha = \infty, \hat{\tau}_i = \tau_p$$

1.5 Old notes about trade-offs

From October 2013:

- We have to create some species differences for the storage effect to ‘ameliorate’ (EMW phrasing here, probably not ideal), so how do we want to do that?
 - mean species differences in c_i and storage effect through g_i
 - mean species differences in $g_{max,i}$ and make them totally equivalent within season and temporal storage effect through $\tau_p - \tau_i$

Stuff: We will build in trade-offs (versus running a bunch of random parameter space models where—in order to get stability—we end up with related trade-offs) such that

we're effectively saying 'the world works this way now, we add climate change and see what happens. . . .' We think these trade-offs should be:

- decrease ϕ_i correlated with τ_i close to τ_p
- (for phenological tracking questions) decrease ϕ_i correlated with higher tracking¹

Update as of 13 December 2013: We're off this idea because we are more interested in shifting variables related to R^* if we are adding trade-offs in.

Question: Should we add asymmetry in g_i such that τ_i earlier than τ_p is worse than τ_i later than τ_p ? **Answer: No!**

1.6 How the growing season ends

Worries over growing season continue (from August 2012 notes)! Worries over very short growing seasons (agree to stay with what we have for now, but keep in mind this possible issue and idea of continuous R dripping in (or cyclically) for 'growing season').

The intra-annual model does not have a useful closed solution (I have some Maxima code that shows only the trivial solution gives an equilibrium). This actually makes sense since the model is not a chemostat (a la Tilman R^*), we have a pulse that drains out and is not balanced by inputs.

2 Notes from meeting with various people

2.1 Meeting with Jenn Williams

15 October 2013

There are two big areas in modeling flowering reproduction stuff in plants:

1. When (which year) to reproduce
2. Bet-hedging across years (how much to reproduce)

There is not much (anything of which she is aware) of when within a year to reproduce. She pointed out that this is probably because it's easy to measure how fitness varies year to year but there not very good estimates of how fitness varies with weather a species' phenology is early or late.

¹though we could also alter c_i or u_i , or might work better to adjust a_i so you can make earlier faster growers (or adjust a_i/u_i so when you're faster you're a higher R^*), but we need to check through all this thinking more.

Once she said this I thought 'right!' and this jives with my reading of the literature (especially late 1970s and early 1980s, culminating a little with Ollerton & Lack's TREE paper). But, interestingly, climate change seems to be making this issue of how fitness correlates with phenology a critical topic (and something I realized I sort of work on, ugh). Also, Jeff Diez (new prof at Riverside) is doing some of this with a snowpack study he has started in the Alps (Levine lab).

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Most of the models include multiple decisions. And almost models to date work on death as the cost of reproduction (her and Tom Miller are actually pioneering how to model non-lethal costs such as 'if I reproduce I grow less').

How do models handle competition? They generally include density dependence in the seedling stage. Some sort of DD is necessary for any of the ESS (evolutionary stable strategy) models and everyone just tosses it in at the seedling stage.

Costs vs. trade-offs: costs manifest as trade-offs in many models. She thinks we should totally just toss in a trade-off and go for it. She does this a lot, she is just sure to apply the cost at several different doses (levels) although sometimes she only presents one level.

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She doesn't know the plasticity literature, Pigliucci (looks like he's in UT-Knoxville, I think) does some very general theory and plasticity stuff.

2.2 Meeting with Sally Otto

22 October 2013

Okay, so she didn't really answer my costs versus trade-offs question directly. She just dove in and suggested a new formulation with costs. She felt like a model that incurred mortality when germination occurred before the pulse would be better. You could then treat g_i possibly as a constant or such. I pointed out that g_i often creates $covar(E, C)$ but I think her model may as well, but through the intra-annual part of the equation. I think there are probably other issues with her conceptualization as well (like how we would make tracking happen) but I haven't got there yet.

Let:

D = normal distribution representing time of germination of species i

T = intra-annual time

Then, how about this (with a less funky equation for g_i):

$$N_i(t+1) = s_i(N_i(t)(1 - g_i) + N_i(t)g_i\phi_i \int_{D=\tau_p}^{\infty} norm(\mu_p, \sigma_p)_D [\int_{T=D}^{t+\delta} B_i(T)dT]dD)$$

3 Figure ideas from 2011

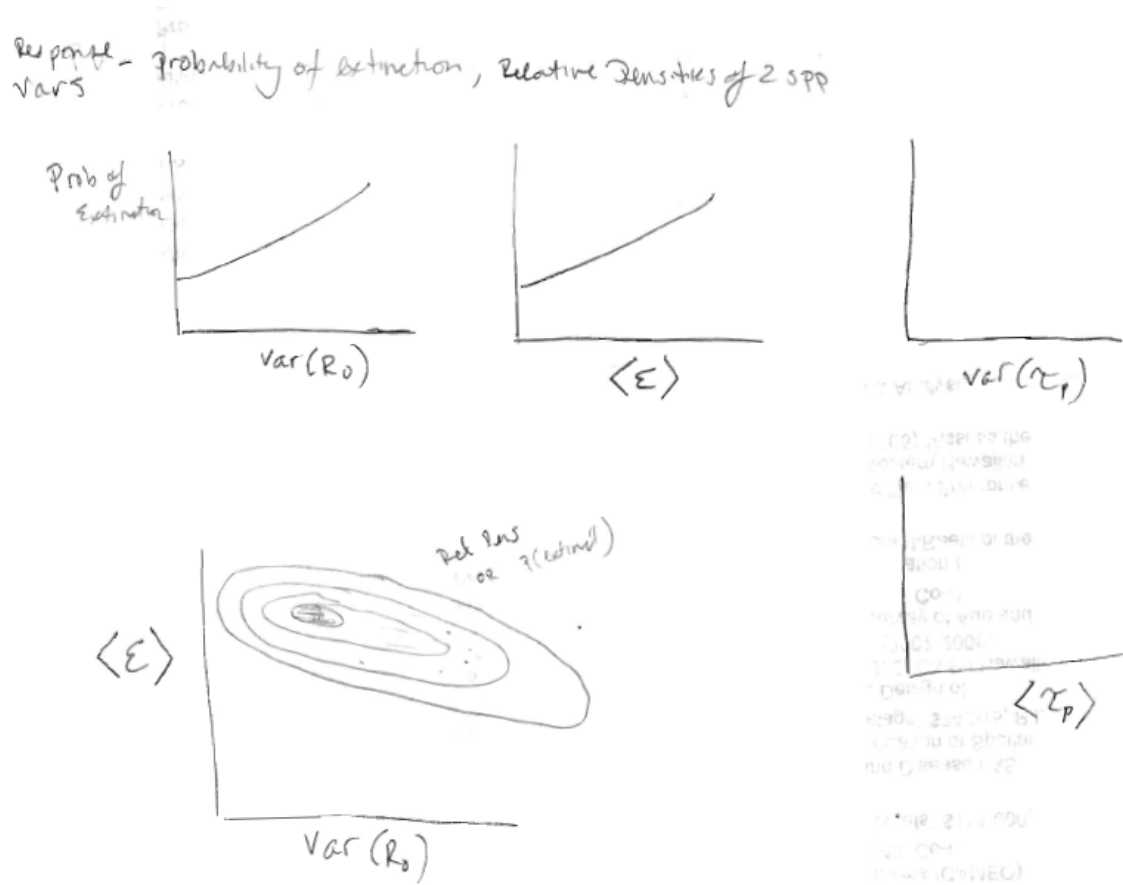


Figure 1: **Synergistic environmental effects (from 2011).** Figure aspirations for part 1 of the paper, which covers how varying environmental variables (τ_p , R_0 , ϵ) alone and in concert (as predicted by climate change) alters coexistence. Single variables will be simple graphs, while contour plots will come in for varying more than one variable together. (There is no phenological tracking by species in this section of the paper.) From July 2011 meeting.

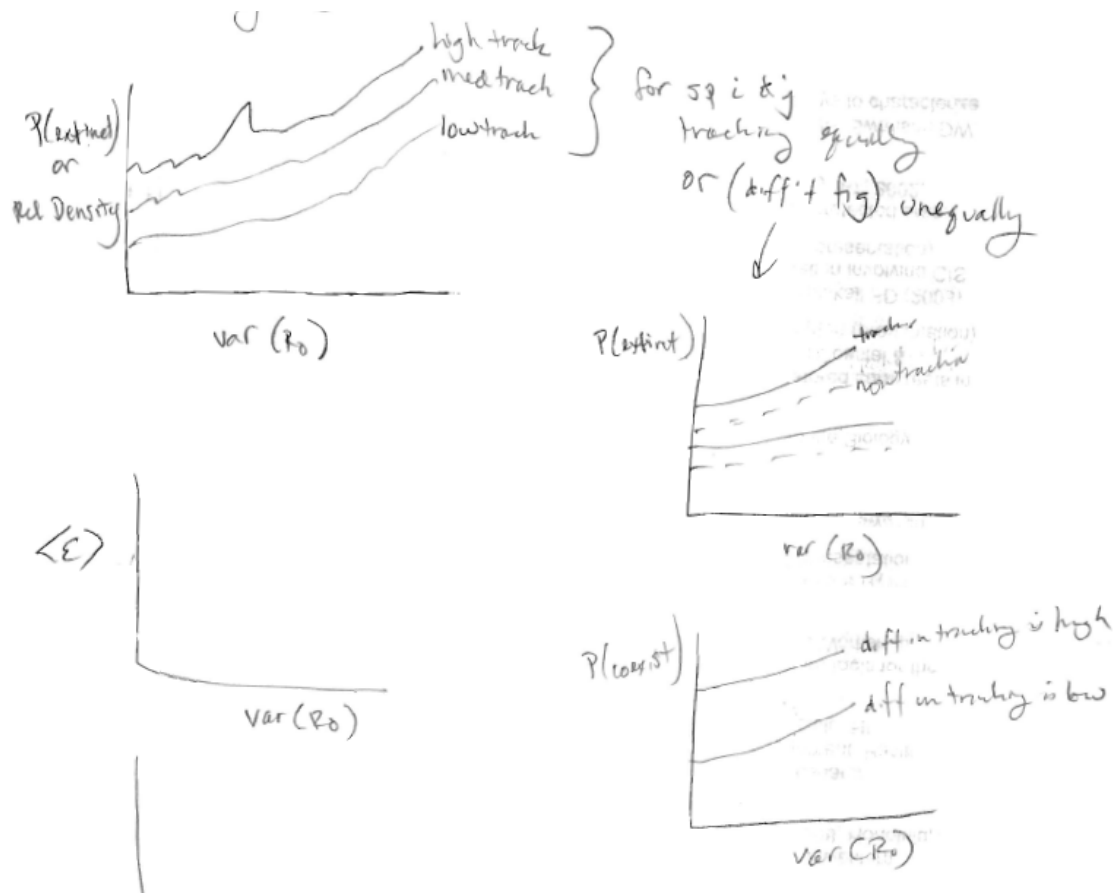


Figure 2: **Phenological tracking and coexistence under climate change (from 2011).** We didn't quite nail these down: do we vary both species so they both track or look at one tracking and one not tracking? Hoping this will become clear as we get the model up and running. From July 2011 meeting.