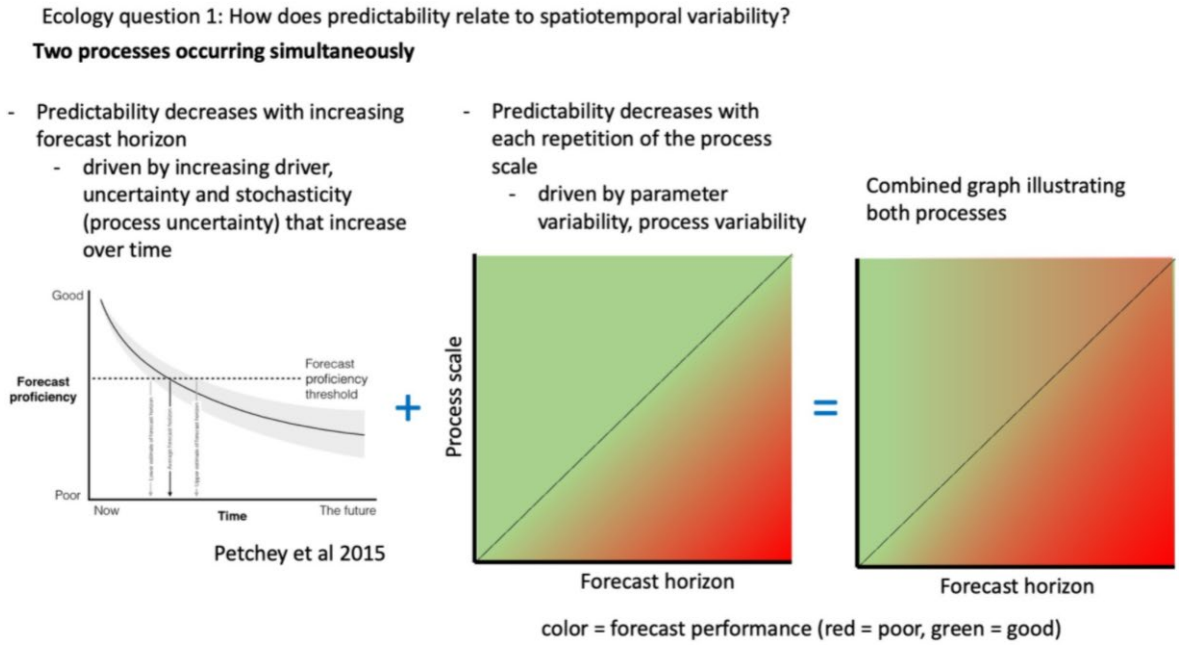
February 22, 2021 Theory Working Group Call

Attendees: Christy Rollinson, Amanda Gallinat, Abby Lewis, Dan McGlinn, Alex Young, Jody Peters
Regrets: Will Pearse, Jaime Ashander, Mike Dietze

Agenda:

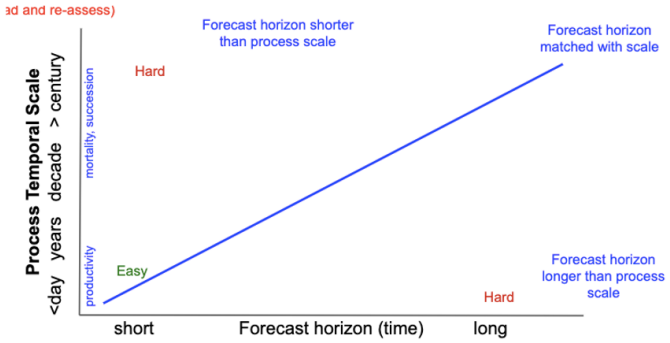
1. Reminder: EFI Steering Committee elections are coming up. Send nominations. To vote, make sure to sign up for membership/renewal
2. Draft Outline of Theory group manuscript
    a. This is based upon previous TG meetings and in particular the Forecasting Hypotheses document
    b. Focus on the definition of predictability and the potential to merge Ecological Questions 1 & 2
        i. Questions:
        ii. 1. How does predictability relate to spatiotemporal variability?
        iii. 2. What factors limit predictability (skill) across scales?
        iv. 3. When does predictability in one context imply transferability to other contexts?

    c. Slack discussion about breaking predictability into a process dependent component and a process-independent component: e.



        i. From Jaime: I really like this decomposition! But curious: do we still think it's "hard" to forecast something over a horizon that is short relative to the

process scale as in the initial figure here?



ii. maybe some examples of how this decomposition into “repetitions of the process scale” and absolute time horizon works out in practice would help. How does this play out in forecasting a day ahead for a process that varies over the day, for one that varies over a month? What about a month ahead for both of these. How does this change with the 'grain' of our forecast (i.e., hourly average vs daily average)?

d. Homework: Think of one theoretical ecology question that forecasting is well-positioned to answer that's *not about predictability.* We have batted around the question of whether the current draft is too predictability-focused for a while now, and I think it would be helpful to really address that before continuing in the direction we currently have outlined.
   i. From Jaime: Environmental sensitivity of vital rates, and effects of environmental noise and directional change on population dynamics in general. A nice example of this from the fisheries context is: Britten et al 2017 “Extended fisheries timeline in a changing environment” https://www.nature.com/articles/ncomms15325
      1. This somewhat related to a point Christy made in a comment on the manuscript outline: how data assimilation can be tied to plasticity and variability

e. Does our discussion about the Tick Example and the Phenology Example on the last call influence any of the ideas or hypotheses in the manuscript outline?
f. 100 Fundamental Ecological Questions paper by Sutherland et al. 2012 - useful inspiration.
   i. From Glenda: This would be my pick for a theoretical question that forecasting is well-positioned to address.
      1. POPULATIONS. #21. What are the magnitudes and durations of carry-over effects of previous environmental experiences on an individual's subsequent life history and consequent population dynamics?

3. Notes from call:
   a. Should we treat communities as individualistic (Gleasonian)? Looking into paleo there are no analog communities. Probably shouldn’t expect shifting of species

together. But developing models for every species is unwise/untenable. Is there a middle ground? Does it change with scale?

b. Major challenge in forecasting. We are dealing with multiple competing processes or processes occurring at the same time. E.g. shifts in phenology, but if assuming species composition won't change, then are limited by how far forward we can make the forecasts.
c. Autoregressive models (new to Alex) - the autocorrelation structures/lags seem like they could be relevant to forecasting and species shifts.
d. Ecology of forecasts - spatial and temporal scale and the level of biological organization (single species, community forecasts), life history traits, or time lags (if something has a known time lag in the even, does that give us some broad info about the sources of uncertainty that could be similar to forecasts for another system that also has a time lag).
e. Are there ecological patterns/characteristics of systems that predict the dominant sources of uncertainty?
    i. E.g., Uncertainty = Measurement error, random stochastic
    ii. Communities that are more diverse could be more stochastic (selection for convergence in the niche, or could be with the environment is homogenous in tropical systems that are really divers)
    iii. Environmental texture hypothesis - Mike Palmer wrote in in a Scaling Book (Dan to send the article around). Idea is cool, but relatively untested
        1. Over fine spatial scales encountering bottom of hill to top of hill (smooth gradient)
        2. Intermediate scale - there are many hills so lots of environmental variation (rough gradient)
        3. Large scale - climate overwhelms the response variable (back to a smooth gradient)
    iv. If we know something about the texture or what variable are important - autoregressive patchiness through time, does that improve our forecast through time?
    v. Flip side of uncertainty - covariance - knowing something about one state will let you know something about other states. Use the covariance to understand species coexistence by understanding how species/behaviors exist on the landscape. Tree example. If I know there is a red oak over here, I can be pretty sure that there won't be a pinion pine over here. If I know that red oak is happy here, can I know how well the white oak is doing?
    vi. Clements vs Gleason - species covariance matrix is everyone one independent and need a model for each species, or do the species covary. Then do these pattern be a response to abiotic or biotic factors
    vii. Covariance matrix could be a number of things (e.g., Traits, phylogeny, site attributes)
    viii. Fits into previous conversations

1. Transferability - what is the potential to transfer model for one species to another and what factors do you need to know to be able to transfer the model
2. Abby's figure on Slack - over time/space processes change and may relate to the texture idea.
    a. There will be some change. Some increase in stochastic error that you can't account for. Process based error vs stochastic error
3. Potential framing: transferability as hypothesis testing — if the hypothesis about the ecological process or parameters are true, the *"true" the model will transfer

ix. Met forecasting - on a daily scale meteorology is predictable, but on scale of 20 days it is difficult to predict, so the intermediate. Then when you get to season scale it is easier to predict. So this connects to the environmental texture hypothesis.

x. Species diversity, beta diversity - granted this depends on sampling grain - but with a moth trap/pitfall trap example - can take a step and species change, but on the year to year scale, get the same species

xi. Should we think about sessile vs mobile species differently (e.g., trees get environmental cues from local environment vs birds migrating getting environmental cues from many locations; although over time trees do move and birds can be site specific to their returns on migration so there may be some biotic dependencies that may not be as complicated for plants.

xii. Related to the manuscript: Think about the difference between using forecasting for theory vs using forecasting for prediction. Use for theory - are looking for places where model fails where we reject the null hypothesis

1. Rather than trying to predict a state we are trying to find where the theory doesn't hold.
2. When it fits really well you are still wrong because all the models are wrong, you are just less wrong.
3. Christy's struggle with forecasting and data assimilation is that you are just making the model get the right answer. We want to be right, but what do we learn by being wrong.
4. Petchey 2015 paper on forecast horizons (length of time when you forecast performs no better than baseline) - there is some information contained in yoru forecast until it stops working. But extending that to transferability. Right now thinking about it across time, but could think about it for traits, scale, etc.
5. Uncertainty focus on precision. But don't lose site of the accuracy. Don't just find the time when we are off with precision, but also when we are off with accuracy.

xiii. Dan has recently been looking at maximum entropy models - if you know 2 things, the number of species and the number of individuals and then I can tell you a number of things about the community. The biology is encoded in your two constraints. How to pick constraints around models can shape the answer that comes out. If we only include 1 environmental variable, then won't see the importance, but if we throw in lots of environmental variables then we will see that the environment is really important.

f. Another question: Is diversity declining?
   i. Not sure if it a theoretical question, but a question Dan wants forecasting to help with
   ii. Species range centroid is shifting. There is a northern edge shift, not sure if there is a southern range shift.
   iii. For trees there is a demographic mismatch. See shift in centroid for regeneration, but for things with long generational times, how robust are the match between generational times and adult populations.
      1. Kai Zhu has a paper - leading edge, trailing edge and using FIA data

g. 100 ecological questions
   i. There are a whole category of questions that forecasting can answer which is different on how predictability, transferability changes across scale.
   ii. There are fundamental ecological questions in that 100 questions that are inherently forecasting questions
      1. So this could be good to include in the manuscript
   iii. Are we doing something different from what the paleo people are doing?
      1. Uncertainty - paleo reconstructions haven't done uncertainty like we need it with forecasting. Or the uncertainty is so giant.
      2. Also limited ability to get more data, whereas with the near term forecasting you can say this is our key sources of uncertainty and we can collect data to look into that uncertainty
   iv. Near-term forecasting where we can get. You could save on sampling effort (e.g., soil sampling - because it doesn't change much, but could have high spatial variability). But could use the lag to
   v. We think things are patchy: the environment and species are patchy. Things are clumped. We don't have theories of how they are clumped. What is the patterns of the clumping. Is it different in space and time? With soil example, highlight clumped in space, but smoothly changing/not changing through time.
   vi. If you can identify if there is a lag, then that is the answer. On the variogram, if it flattens out then you have captured the patch. Use this to determine where to get the second sample. This works in time as well.
      1. Sedge example from Dan

h. Another question from the 100 questions

   i. Question #45: What is the relative importance of stochastic vs. deterministic processes in controlling diversity and composition of communities, and how does this vary across ecosystem types?
   ii. Is it stochastic or is it deterministic?
   iii. From tardigrade example, everything everywhere, but the environment selects.
   iv. If there is a mountain range, then organisms can disperse - impediment to propagules and their is an environment
   v. Environmental filtering and dispersal can look similar on its effect on patchiness, but there are probably smarter ways to tease them apart. That is just one response variable.
   vi. Thinking about what factors to your ability or inability to predict your process of interest

4. Next steps for paper and how to move forward
   a. Currently have 2-3 questions about predictability.
   b. Can synthesize another question or 2 that we think ecological forecasting lets us answer
   c. Have paper outline
   d. From Christy's perspective, at some point have to start writing. Need someone to start writing and make executive decisions
   e. Abby put the outline together and is excited and open to leading it and is open to having other contributing
   f. We need to keep in mind that Abby is a student, so want to be cognizant of her schedule
   g. Abby is taking her prelims this semester so won't be able to write much this semester
   h. Could add this as a chapter to
   i. 1 sentence gist of the paper? Near term iterative forecasting is powerful for management, but haven't had the conversation on how it is powerful to address ecological theory.
   j. Prospective piece for Ecology - keep it as a perspective where we do not have all the answer and pointing people to what can be done
   k. Want to keep the paper short and exciting. Not a dense review paper, mechanism of forecasting. Why are forecasts useful to general ecology - address this
   l. Consider a group writing effort. Could cut sections if they do not fit the exciting and brief goal of the paper. Writing by committee. Everyone write a 200 word paragraph on why this so important, what has been done, and what the next steps are
   m. Abby will think more about how to move the paper forward