July 21, 2020 Theory Working Group Call

Attendees: Amanda Gallinat, Jody Peters, Anna Sjodin, Christy Rollinson, Mike Dietze, Kathryn Wheeler, Glenda Wardle, John Foster, Michael Stemkovski, Abby Lewis

Agenda:

1. Peter Adler needs to step down as the Theory Working Group chair. He will continue to provide input and follow discussions, when possible, but does not have the time to join the calls. Does anyone else want to lead/co-lead the group?
    a. Glenda, Christy, Abby, Amanda are all potential options
    b. Jody and Mike to follow up with all 4 about options

2. Update from Anna and Gretchen about their forecasting, prediction, and projection vocab analyses. n=106 respondents to the survey
    a. Figures
    b. Conceptual Diagram
    c. Given the survey data/figures, Anna and Gretchen came up with two ideas for forecast definitions, based on interpretation of the survey data. Anna/Gretchen are happy to have them edited, or a new definition created, by the Theory group.
        i. A forecast is an estimate, and the associated uncertainty of that estimate, about the future state of a system.
        ii. A forecast is an estimate about the state of a system in the future, or in a different space, and the uncertainty associated with that estimate.
    d. What is not considered in these definitions or is there something that didn't come up in the surveys that would be helpful to ecological forecasting.
    e. Novel conditions may be a way to combine forecasting to future time/space. Is "novel conditions" too vague? No analog could be another option. Out of sample prediction.
        i. Out of sample is important, but novel or no analog is not as important. Weather forecasts are typically within the range of what we have seen before. It is still out of sample, but it most likely not be different than what has been seen before.
        ii. How about: prediction out of sample predominantly into the future
        iii. Data on one side of what you are predicting, but not on the other. Prediction has some sort of way to validate it right now instead of waiting. Temporal forecast would need to wait a certain amount of time to validate. Spatial - you would have to go there to validate it anywhere.
        iv. For time - with a hindcast would have data before and after. Whereas in spatial forecasting it is interpolation between two knowns. But this doesn't always happen. Sometimes there is prediction to a new spatial new location.

v. Any out of sample prediction with uncertainty, wouldn't exclude prediction in space. Interpolation is one option. Kriging gives estimated uncertainty at a new location.
vi. Temporal forecasting for weather is not novel. But the underlying assumption is that you have a long time series of data. For space, you may have a different ratio
vii. State-space model - space doesn't have to be geographical, could be temporal. With weather - predicting a new space. Combination of factors. Butterfly flapping wings is a novel condition, but how novel is it if we think about it being n-dimensional.
viii. Channeling Jason - out of sample paleoecological predictions are forecasts. It all happened in the past, but if we haven't seen it yet, it is still a prediction
ix. Babara Han's work - predict what are going to vectors for disease we haven't seen yet.
x. Time series with model for time series - does this count as out of sample predictions since it includes prediction with uncertainty between observations?
    1. Struggled with this for the metadata analysis students are doing.
    2. E.g., If you include anything spatially (points in the circle where you are trying to predict the point in the middle)
    3. More broad way of conceptualizing forecasts
xi. Forecast horizon - a lot of interpolation models don't have the concept of forecast horizon. But could think about this as what the spatial horizon is that you have forecast skill.
xii. Temporal forecasting - it is easy because we know we don't know the future. But for other forecasts, especially for spatial forecasting, we are interacting with the spatial grain. Spatial forecasts overlap with the design of sampling grain. What data you gather constrains the model. There is a model level, a data level, and an out of sample level.
xiii. Something defined as forecast is in the future, but you could study it the same way if you are forecasting something other than temporal forecasts
xiv. Are there tools/methods that others use that can be applied to forecasting and move the ecological forecasting field forward?
    1. In addition to coming up with definitions of what forecasts are, also come up with a clear idea of what forecasts are not.
    2. In ecology see a lot of in-sample model fitting. This does not fit with forecasting
    3. Forecast is interested in making inference based on the state. Modeling is based on making inference based on the state or

parameters. Often predicting a state, but not always. Phenology Design team - is what is predicting a phenological state or a prediction of a data? Prediction of a date would not be a forecast.

a. Predict peak fall color is Oct 14 plus/minus 5 days
b. Predict day at 50% peak color/leaf on. Now predicting timing of the state variable instead of the state variable
c. Difference with phenological forecast - not using state space model, but the state that is updated through time. Updating observed weather, but not the drivers. Using weather state, but predicting the vegetative state.

4. Forecasts usually try to predict state variables, but not exclusively. Could be predicting date or space thresholds and ignoring underlying state variables.

xv. In terms of theory, how to think about forecasting better and do it better. This exercise may not drive this. Could have a method that has nothing to do with forecasting that could drive forecasts forward.
xvi. Stick with what is definitely forecasts and what is definitely not forecasts. Focus on what we know well and put aside the gray areas.
xvii. Survey made it clear that different disciplines didn't agree. We want to be clear for EFI community and for communicating with other groups. Focus on here's the black, here's the white, don't worry about the gray in between.

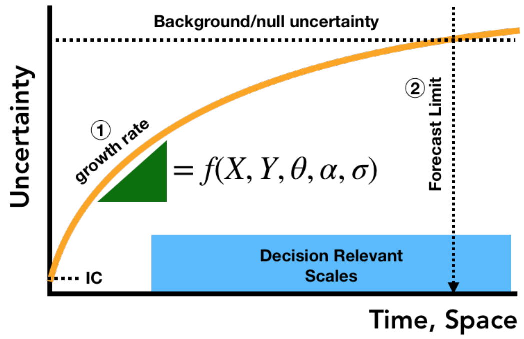
f. If you gave people a histogram and asked them to tell you what it was based on. If you gave people the top words from the histogram: future, predict, model, state, data - how often would forecasts come up? Plug these terms into a web of science search and rank the papers on how often forecasting papers come up. Validate the definition.

3. Continue to discuss Forecasting Vocab Terms
   a. Add definitions/comments to the Vocab Terms Google Doc
   b. Theory group has been discussing for over a year, but we realized we were talking past each other because there was lack of consensus
      i. On the last call, the discussion focused on "Null Models"
      ii. On this call we are picking up on the Vocab list by starting at "Forecast Horizon vs Forecast Extent".
         1. Group thinks that that forecast limit is a better terminology.
         2. Forecast fog
         3. Would be nice if we can work with Anna/Gretchen to get this into the forecast definition manuscript.
      iii. Add a glossary on the EFI webpage for these terms so we are internally consistent

c. Forecast scale - use grain and extent and not use scale because scale is ambiguous? Because they capture different info. Ask specifically for grain or extent.
    i. Forecasts have both resolution and length to them.
    ii. Forecasts are not without explicit considerations for scale
    iii. Resolution instead of grain? Temporal resolution and spatial resolution?
    iv. Add more words. Scale → Time Scale → Grain of Time Scale. Then it will get whittled down with usage
    v. Want to constrain the thinking of new people so more words will be more informative
    vi. Add use cases
d. Next Term: Uncertainty
    i. Do we break it down by the components of uncertainty or define uncertainty itself?
    ii. Point 4a: Probabilistic statement - why not also include the accuracy.
        1. Uncertainty = precision, accuracy = skill
    iii. Point 4d: We learn about uncertainty is related to the way we learn about skill. But uncertainty is the probability distribution that quantifies our state of knowledge or our lack of knowledge of some quantity of interest. Uncertainty is an inherent probability statement. Can have uncertainty about a state, a driver, a parameter
    iv. Distinction between uncertainty and variability and their relationship. They are different, but the distinction is difficult.
        1. Talk about sources of uncertainty
    v. Uncertainty is a combination of error and variability. Have uncertainty about things that are variable. Have uncertainty about things that are stochastic.
        1. Can you perfectly predict the uncertainty about variability?
            a. Yes. You can have a precise estimate of how variable something is.
    vi. Toy model - black or white = 2 states. Variability is low, but uncertain about what state you are in. Vs. you can have all colors of the rainbow, but you can predict what color you will be in.
        1. Variability is low, but uncertainty is high.
    vii. Variability as a component of uncertainty is why it is important to consider scale. At finer scales, you should have less variability. As you scale up you have more variability. But could be reversed. Glenda's checker scale board example. Black and white at a small scale. Gray at high scale.
e. Is scale its own thing? Is it a component of uncertainty? Or is it a bridging concept?
    i. Mike doesn't think it is a component of uncertainty
    ii. Scale and uncertainty are important concepts and we can make predictions how uncertainty changes over scale

        iii. Important questions that have emerged. How do uncertainties scale? Can we understand where the scales of predictability are that are non trivial. Can we understand the patterns? Can we make predictions about what will happen in new systems from forecasts made in other
    f. Next call pick up with Transferability on vocab list

4. Practice forecast comparisons using the RCN NEON Forecasting Challenge Topics
    a. Pick up on this for the next call. Keep it as homework and then discuss as the group.
    b. Pick one Topic for everyone to work on and then discuss as a group. Then move on to the others Topics after that.
        i. **Phenology protocol** has a lot of interest from the group and has been fleshed out the most for the Design team.
    c. We have created Google sheets linked to each of the following forecast topics with questions 3b-3j. Go through the topics you are most familiar with to fill out these questions. For question 3j the format in the Google sheet is slightly different. For each type of uncertainty, enter whether that uncertainty dominates in the first 1/3, middle 1/3, or last 1/3 of the forecast horizon. The common frameworks slides are listed below question 3j for you to reference.
        i. Leaf or mosquito phenology <- We (organizing committee) decided on starting with leaf phenology (specifically forecasting PhenoCam observations) for phase 1
        ii. Carbon and water fluxes (eddy flux) between land and atmosphere
        iii. Aquatic - chlorophyll a. The organizing committee has decided to focus on forecasting water temp and DO
        iv. Ticks - abundance. Timing of the peak or abundance through time as observations come in
        v. Total (Beetle or macroinvert) abundance (all species)
            1. Still being sorted out
    b. For each of the RCN forecasts, what would the units on the x axis be in the following figure?



c. What is the level of organization being forecast (organ/physiology, individual, population, community, ecosystem)?
d. What is the phylogenetic scale of the forecast (if applicable)?
e. What is the trophic scale of the forecast (if applicable)?
f. What would you say is/are the relevant timescale(s) of the process itself?
g. What do you think is the forecast horizon (time till the prediction is doing no better than chance) for this system at the NEON plot/sensor spatial scale?
h. What would you say is the relevant spatial scale of the process itself?
i. How would you describe the spatial scale of the forecast (relative to the process itself)

j. If we divide the time between t=0 and the forecast horizon into 1/3s, what input uncertainty do you think dominates the forecast uncertainty at each point in time?

uncertainty	First 1/3	Middle 1/3	Last 1/3
Initial conditions			
drivers			
parameters			
Random effects			
Process error			