September 10, 2025 Theory Working Group Call

Attendees: Bilgecan Sen, Abby Lewis, Andrew Allyn, Ruby Krasnow, John Foster, Freya Olsson, Cole Brookson, Jody Peters, Marcus Lapeyrolerie, Hassan Moustahfid
Regrets: Lenny Smith

Agenda:

1. Predictability of Nature synthesis - discuss challenges and opportunities in predictability.
    a. Brainstorm categories for challenges/opportunities/gaps
    b. Consider issues at the community at large level & the small group of researchers level with low hanging fruit and more difficult opportunities
    c. Data interoperability, data “blind spots” - where data is not available, data transferability, methodological challenge/opportunities - can address other challenges, but are hard to implement or are in active development
    d. Data Interoperability - technical challenges of making data streams talk to each other in order to transfer data
        i. Example - forecasting ticks vs dissolved oxygen (time scale, amount of data, measurement uncertainty differences)
        ii. Ties to blind spots - higher resolution data needed for some forecasts
    e. Data Transferability - system level learning about something that is data sparse, using data from other time period or other sites
    f. If a survey saying we are looking for the gaps/challenges for forecasting. Articulate the challenge you have and put it under and umbrella. Do you think people could do that when given description of the categories/umbrellas?
    g. Think interoperability is more of a general issue more than just for data. Whenever we create forecasts - they are comparable and can be used for metanalysis, e.g., NEON Challenge because everything is standardized. The issue is when everyone is doing their own thing and the forecasts cannot be compared - this extends beyond just data.
    h. Want to find patterns of where forecasts are successful and to do that need to be able to compare the forecasts to make them interoperable
    i. Data blind spots think this is equal to missing data. And could be connected to missing data at the appropriate scale. Want to highlight the issue in order to put into grants, this is what is needed so we can make forecasts better
    j. Transferability - is it a challenge on its own that needs to be mentioned? Or can it be included in interoperability?
    k. Methodological challenge/opportunities - building statistical models, teaching statistical models, how to measure model success, computational building
    l. Want to have each challenge motivated by an example - to help people think about what are you trying to do that you can’t currently do
    m. Example AI data fusion - how to bring different types of data together to fuse it and make it accessible to the models. Requires lots of compute power
        i. Think there are solutions, but need coordination

    ii. Goes along with the idea that these things are needed at the community at large level and are high hanging fruit
n. Goal of paper is to provide fodder for grant writing - want to close the gap between challenge and solution as a field
o. What to do with the survey - have 2 perspectives: we have no data and life is hard or we have so much data that it is hard to work with them
    i. Want to link those 2 perspectives and highlight both ends of that spectrum
    ii. Want to get people's actual practical issues. Not things that have been discussed in meeting or learned over their career. But to learn concrete examples - personal stories of challenges
    iii. Categories are to help give some guidance to people we want to get feedback from and then the can modify the categories after getting the examples.
p. Data side - having validation to understand the predictability of model
q. Conceptual side of things - understanding vs prediction. Could use AI model with great prediction skill, but may not understand all the pieces vs a stats model where you know all the pieces, but then don't get good prediction
r. There are different approaches - causal inference vs predictions. Some causal inference may not make predictions. Versus, with species distribution then causal inference have been used to make predictions
    i. Think there are different ways that people are thinking about causal inference and prediction depending on the system
s. Relevant to the point of data volume, collection, FAIR, etc.: https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecs2.70205
t. Continue to push for submitting data to repositories
u. Data fusion project Hassan mentioned during the call: https://www.linkedin.com/feed/update/urn:li:activity:7368058960496500738/
v. EFI Workshop on Cyberinfrastructure: https://ecoforecast.org/community-developed-cyberinfrastructure-workshop/

2. Papers previously discussed/shared during the 2024 calls. Included here for reference
    a. Discussed on 10-7-24 call. Nonlinear population dynamics - https://www.nature.com/articles/s41559-019-1052-6
        i. See notes from the call here
    b. Discussed on 11-4-24 call. Basic principles of temporal dynamics
    c. The intrinsic predictability of ecological time series and its potential to guide forecasting; https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecm.1359
    d. Prediction in ecology: a first-principles framework; https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/eap.1589
    e. Fishing down the food web - https://www.science.org/doi/10.1126/science.279.5352.860
    f. Discussed on 1-14-25 call. Error metrics - the choice of error metrics can influence your overall conclusions. Ideas in this paper could feed into the

synthesis and what metrics to use. Not relevant for forecasting specifically, but useful frameworks https://www.sciencedirect.com/science/article/pii/S0304380023002922?via%3Dihub

g. EDM paper - https://www.pnas.org/doi/pdf/10.1073/pnas.1417063112
h. Pennekamp paper with weighted permutation entropy: https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecm.1359
i. Came up in the 11-4-24 call. Temporal ecology in the Anthropocene https://onlinelibrary.wiley.com/doi/10.1111/ele.12353
j. Came up in the 11-4-24 call. Forecasting phytoplankton blooms https://esajournals.onlinelibrary.wiley.com/doi/10.1002/fee.2376
    i. Here is the Supplemental Table with the specific example: https://esajournals-onlinelibrary-wiley-com.libproxy.rpi.edu/action/downloadSupplement?doi=10.1002%2Ffee.2376&file=fee2376-sup-0003-TableS3.pdf