Near-term Ecological Forecasting Initiative **Summer Course**

Boston University
Kilachand Center
610 Commonwealth Avenue
Boston, MA 02215

July 28 - Aug 2, 2019

https://ecoforecast.org/nefi2019/

Course Description

Iterative ecological forecasts are continually-updated, actionable predictions, with uncertainties, of the state of ecosystems and their services. The backbone of this course covers topics related to the statistics of model-data fusion and forecasting: Bayesian statistics; machine learning; uncertainty partitioning, propagation, and analysis; fusing multiple data sources; assessing model performance; and a suite of iterative data assimilation techniques. While the goals of some ecological forecasts are simply to advance basic science, many are performed to inform the public, managers, and decision makers. Therefore the course also covers the basics of structured decision making and expert elicitation.

Course Objectives

After taking this course, you should be able to generate a forecast from a simple model that makes use of more than one data stream. You should be able to categorize and estimate the uncertainties in the model, propagate this uncertainty into the forecast, and assess the performance of the model. You should be able to assess and critique forecast data products and scientific publications about ecological forecasts, and understand how such forecasts can be used to inform decision making.

Textbook

Dietze, M. C. (2017). Ecological Forecasting. Princeton, NJ: Princeton University Press.

Course Organizers

Name	Institution	email	cell
Mike Dietze, PI	Boston Univ.	dietze@bu.edu	410-533-5130
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Katie Zarada, TA	Boston Univ	kzarada@bu.edu	

Wednesday Round Table
Discussion of issues that span academia, agencies, and non-traditional research both generally (e.g. career options, publishing, funding, etc) and in the specific context of trying to build a community of practice in ecological forecasting. Where is ecological forecasting going, how do we get it there?

Friday Dinner & Social:
For those sticking around Friday night we'll be doing dinner on West Beach in Beverly Farms (121 West St, Beverly, MA 01915). This is a private beach so alcohol is permitted (and will be provided). We'll be leaving right from campus on Friday so if you want to bring bathing suits, towels, etc grab them earlier in the day. The North Shore is a beautiful area, but the water tends to be chilly, and if there's a breeze it can cool off quickly even in the summer so you might want to bring a long sleeve shirt.

Schedule

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:30	Arrivals	Introductions	Hierarchical Bayes (LJ)	Uncertainty Propagation (LJ & MD)	Ensemble Data Assimilation (MD)	Data Fusion (MD)
9:00						
9:30		why forecast (MD)				
10:00		break				
10:30			hands on	hands on	hands on	hands on
11:00		Lightning talks	Structured Decision Making & Expert Elicitation (MD)			
11:30		Project talks		Project	Project	Project
12:00	Lunch (on your own)	Lunch	Lunch	Lunch	Lunch	Lunch
12:30		Complex data in Bayes (SL & LJ)	State Space (SL)	Analytical Data Assimilation (MD)	Model assessment	
13:00	Bayes Primer					Forecast Infrastructure & Automation (EW)
13:30			hands on	hands on		
14:00		hands on			Project	presentations
14:30						
15:00		break	break	break		
15:30			Project	round table		
16:00						wrap-up
16:30		Machine Learning (EW)				

MD = Mike Dietze, Boston University
SL = Shannon LaDeau, Cary Institute
LJ = Leah Johnson, Virginia Tech
EW = Ethan White, University of Florida

<u>Hands-on Activities</u>

The goal of the course isn't just to expose you to the concepts of ecological forecasting, but to give you hands-on experience in applying the tools used. Therefore most lectures are paired with hands-on activities. Most of these activities are independent (you don't need to complete one to move on to the next) and many are open-ended -- there's more you could play with than we expect you to be able to complete in the allocated time. The instructors will often state what the minimal goal of each activity is. Beyond that, we encourage you to complete what you can, play with the activities, and know that you can come back to the activities that you find most important and interesting at a later date. The instructors and TAs will be around to help you with these activities and we encourage you to ask questions and to work in small groups.

Group Projects

The goal of the group project is to take what you've learned in lecture and the hands-on activities and see if you can apply it to a new problem. Students will work in small groups for the final project and make a 10-15 min presentation about what they've accomplished this week on Friday afternoon. The goals of the project are:

- **Calibration**: Fit a simple dynamic model to time-series data, preferably using a Bayesian state-space framework and accounting for the complexities of the data. Make sure to hold out some portion of the available data for validation.
- **Forecast**: Predict or project the dynamics of the system forward from the calibration period into the validation period while accounting for uncertainties. If time permits, partition the forecast uncertainties to determine which dominates.
- **Validation**: Assess model performance against held-out data
- **Analysis:** For the next time point beyond the calibration period, use data assimilation to update the state of the system and re-forecast. If time permits, iteratively assimilate all validation data. How does the uncertainty in your forecast change with lead time and what is the forecast horizon for this system?

The set of projects available to participate in has been pre-selected based on the participation of federal agency personnel as part of the course. The goal is to apply forecasting principles to real-world agency problems, to help agency participants get a jump start on implementing forecasts, and to help establish foster forecasting collaborations between academia and agencies. The set of available projects will be described Monday after lunch. Everyone will be asked to rank their interest in the available projects and then will be assigned to a team by the instructors

R / RStudio

The course activities will be done in R and will be provided as R Markdown (Rmd) documents. Use of RStudio is not required, but activities are prepared assuming you will be working in that IDE.

Git / Github

Course activities and in-house R packages will be distributed via Github, so at a minimum you will be expected to be able to clone / download those repositories (we'll be sending a follow up email in a few weeks with more details on exactly what repositories to install). Bare-bones basics on how to use Github to retrieve course materials is located at the top of our basic R tutorial: https://github.com/EcoForecast/EF_Activities/blob/master/Exercise_01_RPrimer.Rmd

While not required just to download, you'll probably want to create an account at https://github.com/ if you don't have one already.

You are also strongly encouraged to use Github (or equivalent) when collaborating on code for you course projects. We also have a tutorial on using Github for collaborative coding, which is best completed with a partner:
https://github.com/EcoForecast/EF_Activities/blob/master/Exercise_04_PairCoding.Rmd

Code & data management
These are covered in chapters 3 and 4 of the book, which we won't be covering in class.

You may also enjoy:
Wilson, G., Bryan, J., Cranston, K., Kitzes, J., Nederbragt, L., & Teal, T. K. (2016). Good Enough Practices in Scientific Computing. PLoS Computational Biology, 13, 1–20. http://doi.org/10.1371/journal.pcbi.1005510

Bayesian statistics
In addition to basic concepts, we're also going to assume basic familiarity with Bayesian software. Specifically, we will be using JAGS (called through R) for the course tutorials, so you will want to make sure you have install the JAGS software ahead of time (http://mcmc-jags.sourceforge.net/). As a point of reference, we'd like everyone to be able to implement a basic Bayesian linear regression model in JAGS (this is the milestone we aim to reach in the optional Sunday primer).

Software
As mentioned previously we'll be using R / RStudio, JAGS, and Git / Github so you'll want to make sure that those are installed on your laptop and that you bring your laptop to the course (we are not operating in a computer lab).

Furthermore, all the course activities are in the following repository:

https://github.com/EcoForecast/EF_Activities

Which you'll want to 'git clone' (or fork to your local repo) before arriving. A number of activities do rely on additional packages. Most of these are quick & easy, but do make sure you have 'rjags' installed and working.

Readings
From the *Ecological Forecasting* textbook, we're going to assume Ch 3-5 as prior knowledge and will focus the course on Chapters 2, 6, 8, 9, 11, 13, 14, and 17. We're not requiring that folks have read these chapters ahead of time, but if you did want to start diving in ahead of time that's where we're recommend you focus. Any advanced reading you're able to do will make following lecture and doing the activities that much easier.

In addition to the textbook we've provided the following readings:

White EP, GM Yenni, SD Taylor, et al. Developing an automated iterative near-term forecasting system for an ecological study. Methods Ecol Evol. 2019; 10: 332– 344. https://doi.org/10.1111/2041-210X.13104

Ye H, RJ Beamish, SM Glaser, SCH Grant, C-H Hsieh, LJ Richards, JT Schnute, G Sugihara. 2015. Equation-free ecosystem forecasting. Proceedings of the National Academy of Sciences 112 (13) E1569-E1576; DOI: 10.1073/pnas.1417063112

Morgan, M. Granger. 2014. Expert elicitation for decision making. Proceedings of the National Academy of Sciences,111 (20) 7176-7184; DOI: 10.1073/pnas.1319946111

(optional 2nd elicitation paper)
Hagan, A. O. 2019. Expert Knowledge Elicitation : Subjective but Scientific. The American Statistician 73:69–81.