ECOLOGICAL MODELING AND FORECASTING
SPRING 2021, FREC 4984/5984

Welcome! I am excited to be your Ecological Modeling and Forecasting instructor and to work with you this spring. Before jumping into logistics, I think that it is really important to note that this semester will be different from your (or my) past academic experience. I have carefully crafted plans for this spring semester to ensure that you receive an exemplary education in ecological modeling and forecasting that meets COVID safety requirements. However, it is likely that these plans may have to shift in response to changing policies and guidance from the university as the semester progresses. Any changes to this syllabus will be communicated clearly in class periods and via Canvas.

Given that we are in a global pandemic, it is critical that we take care of ourselves and each other amidst these uncertain times. We are all struggling to adapt to rapidly changing circumstances. As part of this class community, I ask that you extend to your classmates and instructors grace and understanding, as I will for you.

The overarching goal of the course is to teach concepts and skills in ecological modeling and forecasting and contribute forecasts to an international forecasting challenge run by the Ecological Forecasting Initiative. The forecasting challenge is similar to a data science competition where teams or individuals submit predictions of new data that are evaluated using a common metric. The NEON (National Ecological Observatory Network) Ecological Forecasting Challenge asks teams to submit forecasts of NEON data before it is collected as a test of our capacity to predict ecological processes in the future. The Challenge has submission themes that span ecological processes and scale and students in the course will be able to contribute forecasts to any of the challenge areas that interest them. The themes include terrestrial ecosystem carbon and water fluxes, freshwater temperature and oxygen, plant spring phenology, beetle community abundance and richness, and tick population dynamics. More information about the NEON Ecological Forecasting Challenge can be found here: https://ecoforecast.org/efi-rcn-forecast-challenges/. Other universities will be submitting forecasts in similar courses taught in the spring semester, including Boston University and University of California-Berkeley.

TIME AND PLACE:

The course is synchronous via Zoom at 11:00 am – 12:15 pm on Tuesdays and Thursdays

The recurring Zoom link to join lecture is here:
https://virginiatech.zoom.us/meeting/register/tZItfu-gqD8tH9ezULtNcH_XnnWJSMGHyNfz
Lecture is run with expectation of interactive participation via Zoom platform and other software tools, however, if you are unable to join during this time, you will be expected to notify your instructor prior to lecture and watch the recorded Zoom lectures that will be posted on Canvas after lecture.

INSTRUCTOR:

Dr. R. Quinn Thomas
rqthomas@vt.edu

TEXTS:

Dietze, M.C. Ecological Forecasting. Princeton University Press
Available as an e-book through the VT library:
https://ebookcentral.proquest.com/lib/vt/detail.action?docID=4866481

Hobbs, N.T. and M.B Hooten. Bayesian Models: A Statistical Primer for Ecologists. Princeton University Press.
Available as an e-book through the VT library:
https://princeton-universitypressscholarship-com.ezproxy.lib.vt.edu/view/10.23943/princeton/9780691159287.001.0001/upso-9780691159287

COMPUTATIONAL REQUIREMENTS

You need a computer with R and Rstudio installed.

PREREQUISITES

FREC 4984
FREC 3004: Environmental Information or equivalent
STAT 3615 or equivalent

FREC 5984
Graduate Standing

Assumed prior knowledge
- Basic data analysis in R
- Basics of statistics (regression)

LEARNING OBJECTIVES

Having completed the course a student will be able to:

1) Formulate and numerically solve equations that mathematically represent an ecological system as a dynamic model
2) Calculate the likelihood of a data given a model formulation
3) Apply a Bayesian approach to estimate parameters and uncertainty sources for a dynamic ecological model using time-series data
4) Apply data assimilation to a dynamic ecological model
5) Generate, visualize, and evaluate and an ecological forecast

ASSESSMENT

4984 Level
Hands on assignments: 70%
Final *group* forecasting project: 30%

5984 Level
Hands on assignments: 70%
Final *independent* forecasting project: 30%

Assignments:

- Assignment 1: Introduction to Ecological Forecasting via Macrosystems EDDIE
- Assignment 2: From models to forecasts via logistic population growth
- Assignment 3: Probability and Likelihood
- Assignment 4: Bayesian Analysis from scratch
- Assignment 5: Bayesian Analysis in NIMBLE
- Assignment 6: State-space and Hierarchical models in NIMBLE
- Assignment 7: Forecasting uncertainty propagation
- Assignment 8: Sequential data assimilation: Particle Filter.
- Assignment 9: Decision support and visualization
- Final project: Forecast submission to the NEON Ecological Forecasting Challenge

ATTENDENCE

Throughout the semester, please be courteous to all of your fellow students and to me so we can create a positive learning environment. Your attendance is expected at the synrcohous modules (see above) and the exams, and I expect you to be on Zoom on time. Participating lab is an important part of contributing to the class community and critical for understanding the course material.

I will not take attendance but your attendance to class is necessary for you to complete the assignments. Your assignments are required to be turned in on time unless you have an excused reason for a late submission. An excused absence will NOT harm your grades. However, *unexcused* late submission will decrease your participation for the assignment (see Course Policies). Excused absences (per the Dean of Students website, dos.vt.edu/our_services.html) include: illness of student, illness or death of family member/friend, court subpoenas, military orders, etc. This list is not exclusive, so we encourage you to reach out to your instructors if you have any questions. Given that we are in the middle of a global pandemic and many of us are balancing challenging circumstances, we will work with students on a case-by-case basis if unique personal situations arise.

Important note regarding attendance in a public health emergency: If for any reason you are feeling sick during the semester and cannot join lecture or lab, please send me an email beforehand, which will automatically provide an excused absence for that day. As any individuals experiencing any symptoms of illness must self-isolate, no verification of sickness from the Schiffert Health Center or the Dean of Students is needed other than the email to me and your TA. If a student becomes seriously ill for an extended period of time or is required to quarantine, the student should contact the Dean of Students, who will provide notification to your instructors and help support you.

TENTATIVE COURSE SCHEDULE

Class	Plan
Tues Jan 19	Introduction
Thur Jan 21	EDDIE 5
Tues Jan 26	EDDIE 5 + relate back to introduction
Thur Jan 28	From Models to Forecasts
Tues Feb 2	From Models to Forecasts
Thurs Feb 4	Dynamic Models + **Intro to NEON Ecological Forecasing Challenge**
Tues Feb 9	Principles of probability + likelihood
Thurs Feb 11	Principles of likelihood
Tues Feb 16	Principles of likelihood
Thurs Feb 18	GitHub
Tues Feb 23	Bayesian Statistics 101
Thurs Feb 25	No class
Tues Mar 2	Numerically solving Bayesian models
Thurs Mar 4	Numerically solving Bayesian models + Priors
Tues Mar 9	NIMBLE
Thurs Mar 11	NIMBLE
Tues Mar 16	Characterizing Uncertainty
Thur Mar 18	State space models in NIMBLE
Tues Mar 23	Hierarchical models
Thurs Mar 25	**NEON Ecological Forecasing Challenge: Historical Time Series Fit**
Tues Mar 30	**NEON Ecological Forecasing Challenge: Historical Time Series Fit**
Thurs Apr 1	From model fitting to forecasting
Tues Apr 6	No class
Thur Apr 8	**NEON Ecological Forecasing Challenge: Initial ensemble forecast**
Tues Apr 13	**NEON Ecological Forecasing Challenge: Initial ensemble forecast**
Thur Apr 15	Sequential data assimilation: Particle Filter
Tues Apr 20	Sequential data assimilation: Particle Filter
Thur Apr 22	EDDIE Module 8: Decision Support
Tues Apr 27	**NEON Ecological Forecasing Challenge: Iterative Forecast**
Thur Apr 29	**NEON Ecological Forecasing Challenge: Iterative Forecast**
Tues May 4	Presentations

ONLINE LEARNING AND ACCESSIBILITY:

If you have a question, please do not hesitate to ask using Zoom chat or unmute your microphone to ask your instructor directly. In fact, other students probably have the same question, and it helps everyone for your instructor to pause and respond.

Please modify your Zoom settings so that your preferred name and pronouns are visible on your Zoom profile. Turning your camera on during Zoom sessions is encouraged but not required, as we are all struggling to maintain sufficient wifi bandwidth! If you have your camera off, please upload a picture to your Zoom profile. See here for instructions on how to modify your preferred name, pronouns, and profile photo: https://support.zoom.us/hc/en-us/articles/201363203-Customizing-your-Profile

We fully recognize that learning via Zoom can be more challenging than in-person instruction. Helpful resources for online learning are available through the university here: advising.vt.edu/academic-success-in-a-virtual-world.html These resources include well-being activities and tips and strategies for virtual learning.

Any student with special needs or circumstances must meet (virtually) with me during the first week of classes. Please send me an email to set up a meeting if you cannot join during the office hour times.

COURSE POLICIES:

- The course uses the R programming language exclusively. R is a common language in data science and ecology. There will be instruction in R throughout the course but this is not a programming course. R is a free language. This allows you to use it in your future career without need to purchase a license.

- **You are expected to bring your laptop computer to each class because you will be using it in most classes. Your laptop must have R and RStudio installed and working.**

- Group vs. individual work: Group vs. individual work: You can get help from your classmates on the assignments. However, you are required to submit your own assignment (no group submissions). The project is group work for the 4984 Students and individual work for the 5984 Students.

- Points will be deducted from late assignments on a sliding scale (10% points deducted per day late).

- The Undergraduate Honor Code pledge that each member of the university community agrees to abide by states:

  "As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do."

  Students enrolled in this course are responsible for abiding by the Honor Code. A student who has doubts about how the Honor Code applies to any assignment is responsible for obtaining specific guidance from the course instructor before submitting the assignment

for evaluation. Ignorance of the rules does not exclude any member of the University community from the requirements and expectations of the Honor Code.

For additional information about the Honor Code, please visit: https://www.honorsystem.vt.edu/

- Your attendance at lecture is expected, and you are expected to be at class on time. Each class may include an in-class activity that requires your attendance to receive credit.

- If you have a question, please do not hesitate to ask. In fact, other students probably have the same question! Come to lecture on time since we will start right away. In particular, the first five minutes of each lecture are quite crucial because they establish the direction for that session. Therefore, if you come in late, certain things may not make sense, and you will miss important announcements. Throughout the semester, please be courteous to all of your fellow students and to me so we can create a positive learning environment.

- All assignments and lecture pdfs will be distributed using Canvas.

- Any student with special needs or circumstances for exams or assignments should make arrangements to meet with the instructor during the first week of classes.

- You are strongly encouraged to complete the Student Perceptions of Teaching (SPOT) questionnaire. Constructive student feedback is important for enhancing the learning experience in this course. Changes to the class and instruction may result from suggestions that are shared with me. Comments about specific aspects of the course or instruction are most helpful. For example, past comments indicated that real-world examples were important for helping students to understand key concepts, and so more of these examples were added to the course materials.