ESM 244: Advanced Environmental Data Analysis
Bren School of Environmental Science & Management

**Lectures:** Tuesdays and Thursdays, 2:00pm - 3:15pm, BH 1414
**Labs:** Thursdays, 3:30pm - 4:45pm, BH 1414

**Course forum:** Slack ([sign up here](#))
**Assignments, resources, grading:** GauchoSpace

**Instructor:** Casey O’Hara ([cohara@bren.ucsb.edu](mailto:cohara@bren.ucsb.edu))
**Office Hours:** Tuesdays 3:30pm - 4:30 pm, BH 2001

**Teaching Assistant:** Nathan Grimes
**Office Hours:** Wednesdays 2:00 pm - 4:00 pm, BH 3007

**Overview:** ESM 244 is a survey course in advanced topics in environmental data analysis, including: basics of machine learning, logistic regression, bootstrapping, intro to wrangling and analyzing time series data, spatial data visualization and analysis, principal components analysis, hierarchical cluster analysis, and basic text mining. Focus is on building conceptual understanding and applied skills using real-world environmental datasets. Students will also learn modern methods for publication in data science, including by building a website and Shiny app in R. Throughout, we will reinforce skills for data management and organization, reproducible workflows and collaboration in R, RStudio and GitHub.

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**ESM 244 LEARNING OBJECTIVES:**

- Building on statistics and regression basics from ESM 206, learn advanced methods for analyzing environmental data including logistic regression, time series data, and spatial analysis
- Grow skills for data wrangling, reshaping, and visualization with functional programming in R
- Continue building principles for data organization, conventions and code habits, project management, and reproducible workflows
- Develop skills for communication tools in R (including Shiny and optionally distill, gh-pages)
- Increase confidence and skills for troubleshooting code errors
- Independently find, learn and implement new skills to complete assignments and term projects

**SCHEDULE (TENTATIVE & LIKELY TO CHANGE):**

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture topics</th>
<th>Lab skills</th>
<th>Assignments and Projects</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>ESM 206 review, intro to supervised vs. unsupervised machine learning</td>
<td>Git/GitHub intro and setup with R Studio. Refresh your workflow, wrangling, and ggplot basics, make a map</td>
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<td>2</td>
<td>Model selection, test and training data, cross validation, intro to apps with Shiny</td>
<td>Cross validation to compare competing models Build your first Shiny app</td>
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<td>3</td>
<td>Binary logistic regression</td>
<td>Generalized linear models, binary logistic regression, more Shiny Git branches and pull requests</td>
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<tr>
<td>4</td>
<td>Nonlinear models, bootstrapping</td>
<td>Nonlinear least squares, bootstrapping confidence intervals Shiny continued</td>
<td>Assignment 1 due Shiny app: group and topic</td>
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<td>5</td>
<td>Multivariate data, unsupervised machine learning, principal component analysis (PCA)</td>
<td>Multivariate exploration, PCA, biplots</td>
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<td>6</td>
<td>Partition-based (k-means) and hierarchical cluster analysis</td>
<td>K-means clustering, hierarchical clustering &amp; dendrograms</td>
<td>Assignment 2 due Shiny app: basic structure/theme</td>
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<td>7</td>
<td>Introduction to spatial data (types, projections, CRS, applications)</td>
<td>Working with spatial points, lines and polygons with sf, visualizing spatial data with ggplot and tmap</td>
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<td>8</td>
<td>Spatial data interpolation (kriging) and point pattern analysis (quadrat, nearest neighbor, test for CSR)</td>
<td>Raster example (raster), variograms and kriging in R, spatial point pattern analysis</td>
<td>Assignment 3 due Shiny app: mostly functional</td>
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<td>9</td>
<td>Working with time series data, exploration &amp; decomposition, autocorrelation, forecasting basics &amp; concerns</td>
<td>Wrangling time series with lubridate, feasts, and fable, tsibbles, moving average, and a forecasting example</td>
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<td>10</td>
<td>Introduction to text mining and analysis workflows, sentiment analysis</td>
<td>Working with text data, parsing documents to get tokens, stemming, stop words, and sentiment analysis - text mining and accessing data through APIs</td>
<td>Assignment 4 due (finals week) Present Shiny Apps to class</td>
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LAB REQUIREMENTS:

For in-person labs, you will need to bring your laptop to BH1414 to follow along each week. For remote weeks, follow along with the video on your laptop (if you can have the video on one screen and your code in another, that would be super helpful!).

- Recent versions of R (v. 4.2.0 or higher) and RStudio (at least v2022.x, from last year). *If you do not have a laptop that will happily run this software, I encourage you to contact the Bren Compute Team (request@bren.ucsb.edu) to get set up with an RStudio Server account. Click here for instructions on installing R and RStudio.*
- A GitHub account, with Git configured for working between RStudio & GitHub, including a valid Personal Access Token (PAT). **Note:** if you are using a different Git client, that's fine, but we might not be able to help you if you get stuck.
  - [Click here](#) for instructions on setting up Git and GitHub.
  - [Click here](#) for instructions on configuring your Git and setting up a Personal Access Token (PAT). We will walk you through this at the start of the first lab session.

All lab materials (data, keys, links, etc.) will be shared on the course Gauchospace.

COURSE RESOURCES:

There is **no textbook** for ESM 244. The resources we'll use in class are free, open-source books and online tutorials. Several essentials for this class are:

- [R for Data Science](#) by Garrett Grolemund and Hadley Wickham
- [Geocomputation with R](#) by Robin Lovelace
- [Forecasting: principles and practice](#) by Rob Hyndman and George Athanasopoulos
- [Tidy text mining in R](#) by Julia Silge and David Robinson
- [Happy git with R](#) by Jenny Bryan and UBC's stat545 TAs
- [Shiny tutorials](#) from RStudio

GRADING BREAKDOWN:

- Assignments (4): 70%
- Term project 2 (functional Shiny app): 30%

ASSIGNMENTS:

Assignments will be completed in R Markdown, and you will submit the .Rmd and knitted HTML files for grading through Gauchospace. Some assignments may ask you to respond to a reading or resource on the Slack #discussions channel.

TERM PROJECT: See guidelines for term projects [HERE](#)

For your ESM 244 term project, you will design a Shiny app, created in groups of 2 - 3 people, that you'll present to the class during Week 10. Over the course of the quarter, each assignment will have a task related to the term project to help you stay on track.
CODE OF CONDUCT:

All students are expected to read and comply with the UCSB and 206/244 course code of conduct.

From our ESM 206/244 code of conduct: All enrolled students, auditors, and course visitors are expected to comply with the following code of conduct. We expect cooperation from all members to help ensure a safe and welcoming environment for everybody.

We are determined to make our courses welcoming, inclusive and harassment-free for everyone regardless of gender, gender identity and expression, race, age, sexual orientation, disability, physical appearance, body size, or religion (or lack thereof). We do not tolerate harassment of class participants, teaching assistants, or instructors in any form. Derogatory, abusive, demeaning or sexual language and imagery is not appropriate or acceptable.

DISABLED STUDENTS:

Students with disabilities and alternative learning needs are encouraged to work with the Disabled Students Program at UCSB to ensure we can best accommodate you.

COURSE POLICIES:

- Assignments submitted late will only be accepted within one week of the due date, and will be worth 50% of the original score. Homework submitted more than one week after the original due date will not be accepted. We always welcome individual students to reach out to us for extra support and to discuss options as challenges arise.
- Assignments are due at the beginning of lecture on due dates
- Cheating/plagiarism (including in R code) will result in 0 points awarded for the assignment or midterm/quiz/exam and disciplinary action according to UCSB policy. We do expect that you will pull from examples and tutorials by the R community
- If you are worried about your overall grade and/or passing the class, please reach out to us to discuss your concerns