Spatial & Landscape Ecology in R (MEES 614)

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Meeting times & location: Monday & Wednesday 11:30am - 12:50pm. Friday 11:00-11:50am. IVN based, originating campus: UMCES - Appalachian Lab.

Textbooks: Required - Spatial Simulation: Exploring Pattern and Process. O'Sullivan & Perry. Wiley-Blackwell (available for free online from UMD library) . Recommended - Landscape Ecology in Theory and Practice - 2nd Edition. Turner & Gardner; Springer-Verlag

Course Description: Nearly all ecological questions originate from the observation that organisms and the ecological processes that influence them vary in space. This course emphasizes broad scale spatial ecological patterns, the processes that generate and maintain them, and the construction of models in R to analyze, simulate, and understand the interplay between pattern, ecological processes, and scale. The objective of the course is to introduce students to ecological theories and concepts relevant to the study of spatial ecological patterns, while providing the R skills necessary to articulate and answer scientific questions by confronting models with data. In addition to programming in R, the course will incorporate tools such as GitHub and R Markdown to teach collaborative research and reproducible science. The course takes a hands-on, student-directed approach to learning and uses lectures, readings, journal discussions, coding assignments, exams, and a capstone project to reinforce concepts.

Prerequisites: Consent of instructor required for registration. General Ecology required. Familiarity with GIS and statistics also desirable. Basic proficiency in R programming highly recommended. The minimum recommended R skill set includes an ability to: (i) read / write datasets, (ii) manipulate common data formats (indexing, subsetting, etc), (iii) produce plots (including customization of symbols, fonts, colors, etc), (iii) use existing libraries and functions to perform analyses, and (iv) independently debug / error-check scripts.

Learning Outcomes: 1. Knowledge :

a. Identify different models and spatial data types and describe their differences.

b. Describe primary theoretical concepts in spatial ecology, emphasizing the interplay

between broad scale (landscape) spatial patterns, ecological processes, and scale. c. Describe how different kinds of models can be used in spatial ecology to analyze

and predict spatial patterns and test hypotheses. 2. Comprehension :

a. Ability to comprehend and evaluate primary literature in spatial and landscape

ecology. b. Ability to explain the relative importance of different biotic and abiotic processes in

generating spatial pattern and how these change across scales. c. Ability to conceptualize spatial analyses required to answer research questions. 3. Application / Analysis :

a. Ability to write R scripts to manipulate, visualize, and analyze spatial data. b. Ability to use file versioning tools (GitHub) and R Markdown to produce

documented, reproducible science. c. Ability to use basic spatial statistics to infer process. d. Ability to use models to analyze and map spatial patterns, such as point patterns,

animal movements, species distributions, and patterns of biodiversity. e. Ability to use and develop dynamic spatial simulation models to test theoretical predictions regarding the interplay between spatial patterns and ecological processes. f. Ability to fit and evaluate spatial models, including accommodating parameter

uncertainty.

Expectations: My goal is to help you meet the learning objectives listed above, but students must be active in this process. Students are expected to (1) attend all class meetings and arrive on time and having completed readings and/or coding assignments; (2) bring with them a functioning laptop with necessary software installed; (3) actively participate by asking questions; and (4) contribute to / lead in-class activities.

Assessment of Learning Outcomes: Performance in each of the learning outcomes will be reinforced and evaluated through a combination of participation in class discussions (10%), quantitative coding exercises (30%), two examinations (30%), and a final project (30%). Performance of the instructor will be assessed through anonymous course evaluations.

Discussions (10%) - Nearly every week we will hold an in class discussion of one or more journal articles. To help kick off the discussion, a student will be selected to briefly summarize the paper(s). In addition, each student will submit one question before class for each assigned journal reading. Students will be evaluated on their preparation, which includes (1) leading discussions, (2) submitting questions, and (3) participation.

Homework (30%) - Concepts learned in the course and proficiency with R programming will be practiced and reinforced through the completion of in-class and take home coding assignments. R Markdown will be used to author homework reports.

Exams (30%) - There will be two exams that will assess understanding of course concepts.

Capstone Project (30%) - We will end the course with presentations of final projects that incorporate the use of spatial analyses and or simulation modeling to explore pattern and process. We will discuss the specifics of the final project a few weeks into the semester.

Grading policy: 25% will be deducted per day from late homework assignments. I do not grant exceptions to this policy, but I drop the lowest homework score from the final grade. Missed exams or late final projects will be excused only in the case of an emergency with supporting documentation.

Syllabus: There will be two weekly 80 minute lecture / discussion periods on Mondays & Wednesdays and one weekly 50 minute R recitation on Fridays. The list of topics and schedule are as follows (subject to revision):

(1) Course Introduction

(a) History of Spatial and Landscape Ecology (b) General Theoretical concepts (2) Overview of Spatial Modeling & Data in R

(a) Types of spatial data (b) Categories of models (c) Three types of spatial simulation models (3) Agents of Spatial Pattern

(a) The abiotic template (b) Biotic Interactions (c) Land Use (d) Disturbance (e) History (f) Biogeography (4) The pattern process paradigm

(a) Foundations of pattern-process (b) What is a pattern (c) What is a process (d) Scale

(i) Components of scale (ii) Detecting changes in process with scale (e) Using spatial models as tools to explore pattern-process linkages (5) Point-pattern Analysis

(a) 1st order structure (b) 2nd order structure (c) Null models (d) Linking process and pattern using point pattern analysis

(6) Modeling and mapping patterns of biodiversity

(a) Species distribution modeling

(i) Background (ii) Niche theory (iii) Fitting SDMs (b) Modeling intraspecific variation

(i) Incorporating climate adaptation (c) Modeling species assemblages (7) Model fitting, maximum likelihood, probability distributions (8) Aggregation & Segregation

(a) Simulating patchy-ness (b) Deterministic vs. stochastic models (c) Bottom up vs. top down controls (d) Landscape Metrics (9) Landscape Connectivity

(a) Habitat fragmentation (b) Corridors (c) Network models (d) Landscape genetics (10) Animal Movement & Dispersal

(a) Fitting spatial models to animal movement data (11) Spatial spread in heterogeneous landscapes

(a) Linking demography and dispersal to predict patterns of spread (12) Applying Spatial Models

(a) Evaluating predictions (b) Assessing parameter uncertainty