NRM 5302
Theory and Analysis of Animal Movement

Instructor: Justin French
RAS 128
2:00 PM - 3:15 PM, Monday and Wednesday
Email (preferred): justin.french@sulross.edu
Phone: (432) 837-8505
Office Hours: Fridays, 1:00 PM to 4:00 PM, or by appointment.

1 Course Overview

This class is designed as a point of entry to the theory and analysis of animal movements. We begin with the theoretical underpinning of how movements may be scientifically considered, and move to the practical application of that theory. This type of analysis is inherently math-heavy, though it will be explained largely in conceptual terms, rather than pure mathematics. This course assumes students have some statistical training, particularly familiarity with the ideas behind linear models (hopefully generalized linear models).

The course is split essentially into 2 parts. The first half will be interactive, content-heavy lectures to get you introduced to the field. However, learning by doing is more effective than by listening, so the second half is focused on discussing how to interpret other people's models, diagnose the problems with yours, and interpret your own results. Much of the reading will depend on the needs of the class when we get to those issues.

2 Course Philosophy

Animal movements are studied from a variety of standpoints, reflecting the disparate origins of the sub-field. These range from purely theoretical standpoints that attempt to relate the movement of animals to physical equations, to purely empirical approaches that attempt to describe patterns in observed data and inductively consider their consequences. Theoretical approaches tend to over-simplify reality, while purely empirical work tends to wander from sound inference.

I take a theory-informed empiricist approach to analyzing animal movements. I am concerned with solving problems in the real world, which requires empirical evidence from the real world. However, the goal of science is to produce suitable generalizations of reality for wide application. This is where theory shines. Theory can guide empirical work to find better answers, faster. Good empirical work also brings more realism to theory and furthers our general understanding of the world. This is the critical interplay of basic and applied science. You will learn to leverage this interplay to answer real-world questions about the mechanisms driving animal movement, the implications of those mechanisms, and how they may be leveraged to solve management problems.

3 Course Outcomes

By the end of this course you should be able to:

1. Frame movement-focused management problems within a theoretical context.
2. Design a study of animal movement and select appropriate methodologies.
3. Formulate models of movement processes and estimate their parameters.
4. Use these models to make sound inferences and interpret their implications.

4 Required Reading

I will provide a PDF of all required readings. You are expected to have read the paper and be ready to talk about it in the first lecture of their associated week.

5 Assignments

General Assignments

I will assign exercises when appropriate throughout the semester. All work in this class will be done in R, which is a free statistical analysis package (and so much more, as you will see). It is best that you install both R and R Studio, which is a convenient interface. They are available for free download at:

- **R:** `https://cloud.r-project.org/`
- **R Studio:** `https://rstudio.com/products/rstudio/download/`

All assignments integrate written work and statistical results, so we will utilize a typesetting program called LaTeX within R Studio to do all assignments. There are many LaTeX distributions, but TinyTeX is the easiest to get started with and can be installed easily through R Studio: `https://bookdown.org/yihui/rmarkdown-cookbook/install-latex.html`

Exams

Exams will follow the structure and style of Ph.D. preliminary exams. They will consist of a written portion and and oral portion. The writtens will be assigned durring designated exam weeks and tailored to the individual student. Once writtens are completed, the student is responsible for scheduling a time for the oral portion of the exam. I will review the written submission in the interim and the oral questions will be tailored to deficiencies identified in the writtens. Committee members will be invited to participate in the oral portion.

Semester Project

By the end of the semester you will complete a full-blown manuscript featuring an analysis of animal movement. It will be done in R using LaTeXand the BMC journal template, which is used by the journal *Movement Ecology*. I will provide the template via Blackboard.

This assignment will be accomplished in stages. In general, you will follow the following progression:

1. Frame your research question, as well as it's motivations and potential implications
2. Select a framework for answering the question and design the data collection
3. Implement your analysis
4. Interpret results
5. Make inferences and discuss their implications

It is entirely possible for some of you to have a submission-worthy manuscript by the end of the semester, but this is not necessarily required. Because many of you are still collecting data, it may not be possible to produce final results within the semester. However, you will have laid the foundation of the manuscript from top to bottom in a way that only requires adding in new data once it is available and re-interpreting results.

Some of you may not have movement data associated with your projects, but that should not deter you from taking the course. We have a tremendous amount of data on-hand and there are publicly available data sets you can use as well.

6 Grading Policy

Grades are based on occasional assignments, 2 exams, and your semester project. The breakdown is as follows:

- Assignments:.....20%
- Exams:.....30%
- Semester Project....50%

Letter grades follow: $100 > A \geq 90 > B \geq 80 > C \geq 70 > D \geq 60 > F$. There is no curve.

7 Attendance

Showing up is the only way to get the material you need. If you don't come to class, your grade will reflect it with no penalty needed from me. In the event of an excused absence, make arrangements with me to go over material ahead of time.

8 Academic Dishonesty

Academic dishonesty includes copying, sharing, or obtaining information from an unauthorized source, attempting to take credit for the intellectual work of another person, falsifying information, and giving or receiving information about a test, quiz, or assignment to other students. Any student involved in academic dishonesty will receive no credit (0) for work done and/or may be penalized in accordance with published University Rules.

9 Counseling and Accessibility Services

Sul Ross State University is committed to equal access in compliance with the Americans with Disabilities Act of 1973. It is the student's responsibility to initiate a request for accessibility services. Students seeking accessibility services must contact Mary Schwartze, M. Ed., L.P.C., in Counseling and Accessibility Services, Ferguson Hall, Room 112. The mailing address is P.O. Box C-122, Sul Ross State University, Alpine, Texas 79832. Telephone: 432-837-8691. E-mail: mschwartze@sulross.edu.

10 ADA Statement

Sul Ross State University is committed to equal access in compliance with the Americans with Disabilities Act of 1973. Students with qualifying disabilities who seek accommodations must initiate a request for a meeting for accessibility services.

Students seeking accessibility services must contact Rebecca Greathouse Wren, M.Ed., LPC-S, Counseling & Accessibility Services, Telephone: 432-837-8203, or E-mail: rebecca.wren@sulross.edu. For more information see: https://www.sulross.edu/page/1384/accessibility-services

11 Course Schedule (Tentative)

- **Week 1 (8/28-9/1):** Concepts of Animal Movement
  - **Reading:** Nathan et al. 2008.
  - Lecture 1: What are we doing, why are we here, how do we measure this stuff?
  - Lecture 2: Statistics, statistics, statistics.
  - Exercise: Peruse the literature.
  - Semester Project: Schedule a time to meet with me about your project.

- **Week 2 (9/4-9/8):** Random walk theory as a basis for understanding movement
  - **Reading:** Karieva and Shigesada 1983.
  - Lecture 1: None, off for Labor Day
  - Lecture 2: The abstraction and why its useful.
  - Exercise: Make up some data.

- **Week 3 (9/11-9/15):** Markov processes and behavior switching
  - **Reading:** Patterson et al. 2009.
  - Lecture 1: Movement as a mixture of random walks.
  - Lecture 2: Conditioning parameters.
  - Exercise: What made the animals switch?

- **Week 4 (9/18-9/22):** Walking in a variable world.
  - **Reading:** Forester et al. 2009
  - Lecture 1: Habitat selection makes walks (partly) non-random.
  - Lecture 2: (integrated) Step-Selection Functions
  - **Second Reading:** Avgar et al. 2016. (Have read by the second lecture)
  - Exercise: How do the rules change (a.k.a. what is stationarity)?
  - Semester Project: Be ready to talk out your research question on Thursday.

- **Week 5 (9/25-9/29):** Space use: an emergent property of movement
  - **Reading:** Van Winkle. 1975.
  - Lecture 1: The Utilization Distribution
  - Lecture 2: Home ranges, The 'problem' of autocorrelation, and other stupid stuff.
  - **Second Reading** Fieberg et al. 2009. (Have read by the second lecture)
  - Exercise: Why do we care about a blob?

- **Week 6 (10/2-10/6):** The *importance* of autocorrelation
  - **Reading:** Boyce et al. 2010.
  - Lecture 1: Autocorrelation **is** information
  - Lecture 2: Quantifying behavior patterns with autocorrelation
  - Exercise: Thinking about stationarity again.

- **Week 7 (10/9-10/13):** Quantifying other emergent aspects
  - **Reading:** Abrahms et al. 2017.
  - Lecture 1: A multitude of metrics
  - Lecture 2: Parsing classes of behavior
  - Exercise: Colinearity (i.e. correlation) is information too.

- **Week 8 (10/16-10/20):** Decisions and an Exam
  - **Reading:** None this week
  - Lecture 1: Discuss your semester projects in light of what you've learned
  - Lecture 2: Exam 1
  - Exercise: None this week

- **Week 9 (10/23-10/27):** Making inferences 1
  - **Reading:** TBD (there will be 2 this week)
  - Lecture 1: Discuss McMillan et al. 2021
  - Lecture 2: Discuss Anadon et al. 2012
  - Exercise: None this week
  - Semester Project: Tell me how your are going to analyze your data

- **Week 10 (10/30-11/3):** Making inferences 2
  - **Reading:** TBD (there will be 2 this week)
  - Lecture 1: Discuss Bar-David et al. 2005.
  - Lecture 2: Discuss Branco et al. 2019.
  - Exercise: None this week
  - Semester Project: Give an update on analysis progress

- **Week 11 (11/6-11/10):** Working out kinks
  - **Reading:** TBD
  - Lecture 1: Model diagnostics and working real-world problems
  - Lecture 2: More model diagnostics and working real-world problems
  - Exercise: None this week
  - Semester Project: Bring your (analysis) issues with you

- **Week 12 (11/13-11/17):** Working out kinks
  - **Reading:** TBD
  - Lecture 1: Yet more model diagnostics and working real-world problems
  - Lecture 2: Even more model diagnostics and working real-world problems (There's a good reason we're spending this much time on this)
  - Exercise: None this week
  - Semester Project: Bring your (analysis) issues with you

- **Week 13 (11/20-11/24):** Current directions in movement ecology
  - **Reading:** You get to pick
  - Lecture 1: Where is the field headed?
  - Lecture 2: Thanksgiving Break
  - Exercise: READ!
  - Semester Project: Finalize and interpret results

- **Week 14 (11/27-12/1):** Time to present your work!
  - **Reading:** None
  - Lecture 1: Present project findings
  - Lecture 2: Present project findings
  - Exercise: None this week
  - Semester project: Get the discussion of implications as far as you can and be ready to discuss with the class

- **Week 15 (12/4-12/8):** Semester projects due, Final Exam
  - **Reading: Smouse et al. 2010**
  - Lecture 1: Discuss your discussion
  - Lecture 2: Final Exam
  - Exercise: None this week
  - Semester Project: Submit your manuscript to me by Friday

- **Week 16 (12/11-12/15):** Finals Week
  - **Reading:** None
  - Set up time for oral exam
  - Exercise: None