University of Wyoming
Course Syllabus – Spring Semester 2021
Animal Movement and Habitat Selection Modeling
ZOO 5890-04 | 4.0 credit hours | Jan 21 – May 13 | Online

Discussion (on Zoom): Tues 11am-noon,
Lab Prep (on own): Wed 1:00-1:30pm
Lab (on Zoom): Wed 1:30pm-4pm
Optional Lab / Office hours (on Zoom): Thurs 10am-noon

Instructors:	**Jerod Merkle and Justine Becker**
Email:	jmerkle@uwyo.edu, Justine.Atkins@uwyo.edu
Offices:	BS 422 (Jerod), BS 314 (Justine)
Online Office hours	Thurs 10am-noon
In-person office hours:	Email Jerod or Justine to make an appointment
WyoCourses website:	https://uwyo.instructure.com/courses/548225
Course/office hrs Zoom room	https://uwyo.zoom.us/j/94672715781
Slack workspace	https://uwyomovementmodeling.slack.com

Course Goals

This is an intense course for graduate students who are interested in a near complete exposure to, and understanding of, the useful methods available for analyzing animal movement data. Our goal is for students to leave this course with 1) an understanding of the mathematics and statistics behind habitat selection and movement models, and 2) a finished analysis of their own data using quantitative methods in animal movement and habitat selection.

The importance of animal movement

Movement is *the* adaptation that allows organisms to exploit resources that vary spatially and temporally. How, why, and when animals move has many consequences for individuals and populations including fitness (e.g., finding a food source, escaping a predator) and distribution (e.g., home range size, range expansion). Movement can therefore be thought of as the glue that links fine scale behavior at the individual level with population level ecological dynamics. Understanding how and why animals move, along with each movement's consequences, allows for ecological inference that spans animal-habitat relationships, population ecology, animal distribution, and eco-evolutionary processes.

Our assumptions

1. You have a computer with a good microphone and camera, and an excellent internet connection. In most cases, your computer should be able to handle some relatively heavy duty analyses. If you are unsure that your computer can handle zoom and GIS/Statistical analyses simultaneously, you should contact Jerod as soon as possible.
2. You have a chapter in your thesis or dissertation where you must analyze some type of movement data from an animal.
3. You have your own data set of animal movement data.
4. You have previous programming experience in R. All work will be conducted in R, so you must be an intermediate level user of R.
5. You have some statistical knowledge, including generalized linear models.
6. You have some GIS knowledge.
7. You already have some idea of (and have already collected or downloaded) environmental data that you hypothesize to influence your study organisms habitat selection and movement behavior.
8. You are willing to work as a team and help other classmates during class.

Course mechanics

Each week there will be a 1-hour discussion and a 3½ hour lab. Note that you need to be logged into your Uwyo Zoom account prior to joining each class. During class time, you are required to keep your zoom video on. Let Jerod or Justine know if there is some circumstance that precludes you from using your video.

Prior to each discussion, students will be expected to read 1-3 essential papers on the discussion topic AND, for most weeks, watch a mini lecture and/or write a short (1-2 sentences) response to the papers. Note that we will implement active learning techniques during the discussions to facilitate a robust learning environment. Come to class with the expectation and preparation to participate and discuss the topic!

Labs will be based on a lab assignment, where students analyze their own data in accordance with a movement or habitat selection modeling technique. One hour prior to each lab, we will post a video explaining the code for the day's lab. We expect that you will watch this video prior to that start of the lab. We will not provide the code for the day prior to the start of lab, but we encourage you to take notes based on the line numbers in the video or in some cases watch it twice. The entire class can collaborate and help each other out by asking and answering questions on slack (uwyomovementmodeling.slack.com). If you complete all of your work before class time is over, you are expected to spend the rest of class time helping out your fellow classmates.

For each lab assignment, we expect a lab report that includes a short write-up of the analyses conducted, including tables and figures of results (see below for details). Lab reports will be due by submission via WyoCourses on Mondays at 5pm. Grades in the class will be based on the quality and effort put into the lab reports, and to a lesser extent participation within discussions and labs.

Course materials

All necessary course materials, including text excerpts, book chapters, and journal articles will be provided via the course website. There are no required texts that you must buy. All lab work will be conducted in the open source software R.

Course website

WyoCourses will serve as the course website (https://uwyo.instructure.com/courses/548225). We will post any readings, code, and lab assignments there. Go to Movement/habitat sel modeling on your Wyoweb account => Course Tools => Files and you will find everything you need. For time-sensitive announcements and or information, we will email you. We will use your uwyo email address in these cases. If you do not check that email account more than once per day, please figure out how to forward your uwyo email to another account that you check regularly.

Grading

Your grade will come from two things: 1) attendance and participation in discussions and labs (25%), and 2) from our evaluation of the effort put into, and quality of, lab reports (75%). For participation, your grade will come from your attendance, the following rubric, and asking or answering at least 2 questions on slack (uwyomovementmodeling.slack.com). For labs, we will use the top 6 of 8 lab report grades to populate your final grade (detailed information on lab write-ups below). Grades will be based on the following scale: A: 100-90%; B: 89-80; C: 79-70; D: 69-60%; F: <60%.

If you miss class, you will lose your participation points for that day. However, we understand there are sometimes circumstances that result in you missing class. In these cases, please email Jerod and Justine >24 hours before class, if possible, to let us know, and we can discuss possible ways to make up your upcoming absence(s) and class work. If you turn in your homework after the due date/time, we will deduct 10% from that homework's grade. For every 24 hour period after it is late, we will deduct another 10% from that homework's grade, except in extenuating circumstances.

Grading rubric for participation in discussions and labs in-class and outside of class.

	exceeds (A+)	**satisfactory (A)**	**needs work (B/C)**	**unsatisfactory (D/F)**
frequency	actively balances self and peers' participation	actively participates at appropriate times	sometimes participates, sometimes disengaged	seldom participates; generally not engaged
impact on class	expands conversation in novel, mutually productive ways	frequently helps move conversation forward	sometimes advances conversation	comments do not advance or are actively harmful to conversation
listening	holds space so peers are fully included, heard, and engaged	actively and respectfully listens to peers and instructor; does not interrupt	sometimes displays lack of interest/interrupts	projects lack of interest or disrespect for others

preparation	engages with assignments beyond what is assigned	arrives fully prepared with all assignments completed and notes on reading	sometimes arrives unprepared or with superficial preparation	exhibits little evidence of having thought about assigned material
quality	brings in new, relevant material and/or invests in self & peer growth	comments relevant/reflect understanding of assigned texts, previous remarks of peers, and insights about assigned material	comments sometimes irrelevant, betray lack of preparation, or indicate lack of attention to peers' previous remarks	comments reflect little understanding of either the assignment or peers' previous remarks

Lab reports

The goal of the lab report is to encourage you to think about, and interpret, your results using a scientific article format. Reports will consist mainly of a 2-page write-up that includes:

1) Your name, date, and lab report number and title;
2) A brief statement of the objectives of the lab report, the analyses conducted, and the ecological question(s) the analyses will answer (2-4 sentences);
3) A brief outline of the data and methods used (1-2 paragraphs); and
4) Detailed explanation and interpretation of the results.

The 2 pages does not include tables, figures, table and figures legends, or literature cited. Tables and figures should not be embedded in the text but appended after the 2 pages. Text should be 12 point font with 1.15 spacing. Reports must be submitted as a word document or PDF through WyoCourses.

Discussion schedule

Wk	Date	Topic	Required readings	Suggested readings
1	1/26	Introduction, syllabus, Why should an animal move? What is habitat, niche?	Hall et al. 1997 (*Wild Soc Bull*)	Hutto 1985 (pp. 455-476 in Habitat selection in birds); Colwell and Rangel 2009 (*PNAS*)
2	2/2	The basics of movement (Random walk)	Nathan et al. 2008 (*PNAS*), Fryxell et al. 2008 (*PNAS*)	Mueller and Fagan 2008 (*Oikos*)
3	2/9	What is a home range, and how is it formed?	Fieberg and Borger 2012 (*J Mamm*)	Kie et al. 2010 (*PROC B*), Borger et al. 2008 (*Ecol Lett*)
4	2/16	Habitat Selection Theory, Ideal Free Distribution	Gaillard et al. 2010 (*Proc B*),	McLoughlin et al. 2010 (*JANE*)

5	2/23	Scale in habitat selection, sampling protocols	Johnson et al. 2006 (*JWM*); Mayor et al. 2009 (*Ecoscience*)	Boyce 2006 (*Divers and Distr*); Northrup et al. 2013 (*Ecol*)
6	3/2	Resource Selection Functions: model selection, and validation	Fieberg and Johnson 2015 (*JWM*), Boyce et al. 2002 (*Ecol Model*)	Hosmer et al. 2013 (chp 4 in Applied Logistic Regression)
7	3/9	Step Selection Functions: sampling availability, conditional logistic regression	Thurfjell et al. 2014 (*Mov Ecol*), Hosmer et al. 2013 (chp 7 in Applied Logistic Regression)	Forester et al. 2009 (*Ecol*), Avgar et al. 2016 (*MEE*)
8	3/16	SSF: temporal autocorrelation, model development and selection	Hosmer et al. 2013 (chp 4 in Applied Logistic Regression), Craiu et al. 2008 (Biometrical J)	Fortin et al. 2005 (*Ecol*)
9	3/23	Model validation, goodness of fit, model performance	Fortin et al. 2009 (*Ecol*); Fieberg et al. 2018 (*Ecography*)	
10	3/30	SPRING BREAK	NO CLASS	
11	4/6	Mixed effects Resource Selection Functions	Gillies et al. 2006 (*JANE*), Muff et al. 2019 (*JANE*)	Craiu et al. 2011 (*J Comp Graph Stats*), Duchesne et al. 2010 (*JANE*)
12	4/13	Correlated and Biased random walks	Bergman et al. 2000 (*Oecologia*), Crone and Shultz 2008 (*Ecol*)	Turchin 1998 (Sections 4.4, 4.4.1, and 4.4.4), Morales et al. 2004 (*Ecol*), Fortin et al. 2005 (*Oecologia*)
13	4/20	State Space / Hidden Markov Models	McClintock 2020 (*Ecol Lett*)	Patterson et al. 2008 (*TREE*)
14	4/27	Continuous time movement models	Hanks et al. 2015 (*Ann Appl Stat*)	Brennan et al. 2018 (*Lands Ecol*)
15	5/4	TBA / Extra week		
16	5/11	FINALS WEEK	NO CLASS	

Lab schedule

Week	Date	Topic	Lab Assignment
1	1/27	Project orientation, get movement data into R, organize GIS data	NA
2	2/3	Intro to movement models: Random walks and behavioral states	1
3	2/10	Home ranges, utilisation distributions, Brownian Bridges	2
4	2/17	Habitat use and Resource Utilization Functions	3
5	2/24	Resource Selection Functions: availability and scale	4

6	3/3	Resource Selection Functions: model development, selection, and validation	4
7	3/10	Step Selection Functions: sampling availability	5
8	3/17	Step Selection Functions: Covariates along, or at endpoints of steps, and values relative to source step	5
9	3/24	Step Selection Functions: temporal autocorrelation, model development, selection, Model validation, goodness of fit, model performance	6
10	3/31	SPRING BREAK / NO CLASS	-
11	4/7	Mixed-effects Step Selection Functions	6
12	4/14	Biased Correlated Random Walks	7
13	4/21	Hidden Markov Models (HMMs) / State Space Models	7
14	4/28	Continuous time Markov chain (CTMC) movement models	8
15	5/5	TBA / Extra week	-
16	5/12	FINALS WEEK / NO CLASS	-

Useful Resources and References

- Bolker, B. M. (2008). Ecological models and data in R. Princeton University Press.
- Dale, M. R., & Fortin, M. J. (2014). Spatial analysis: a guide for ecologists. Cambridge University Press.
- Hooten, M. B., Johnson, D. S., McClintock, B. T., & Morales, J. M. (2017). Animal movement: statistical models for telemetry data. CRC Press.
- Hosmer Jr, D. W., Lemeshow, S., & Sturdivant, R. X. (2013). Applied logistic regression (Vol. 398). John Wiley & Sons.
- Joo, Rocio, Matthew E. Boone, Thomas A. Clay, Samantha C. Patrick, Susana Clusella-Trullas, and Mathieu Basille. "Navigating through the R packages for movement." *Journal of Animal Ecology* 89, no. 1 (2020): 248-267.
- Journal of Animal Ecology. (2018). Special Feature (Volume 85) on questions and tools in movement ecology. https://besjournals.onlinelibrary.wiley.com/toc/13652656/2016/85/1
- Manly, B. F. L., McDonald, L., Thomas, D., McDonald, T. L., & Erickson, W. P. (2007). Resource selection by animals: statistical design and analysis for field studies. Springer Science & Business Media.
- Moorcroft, P.R., & Lewis, M.A. (2006). Mechanistic home range analysis. Princeton University Press, New Jersey.
- Morrison, M. L., Marcot, B., & Mannan, W. (2012). Wildlife-habitat relationships: concepts and applications. Island Press.
- Nathan, Ran, Wayne M. Getz, Eloy Revilla, Marcel Holyoak, Ronen Kadmon, David Saltz, and Peter E. Smouse. "A movement ecology paradigm for unifying organismal movement research." Proceedings of the National Academy of Sciences 105, no. 49 (2008): 19052-19059.
- Stephens, D. W., & Krebs, J. R. (1986). Foraging theory. Princeton University Press.
- Stephens, D. W., Brown, J. S., & Ydenberg, R. C. (2007). Foraging: behavior and ecology. University of Chicago Press.

- Turchin, P. (1998). Quantitative analysis of movement: measuring and modeling population redistribution in animals and plants. Sunderland: Sinauer Associates.
- Urbano, F., & Cagnacci, F. (2014). Spatial database for GPS wildlife tracking data: a practical guide to creating a data management system with PostgreSQL/PostGIS and R. Springer Science & Business Media.
- Zuur, A. F., Ieno, E. N., Walker, N. J., Saveliev, A. A., & Smith, G. M. (2009). Mixed effects models and extensions in ecology with R. Springer, New York.

Classroom Climate and Conduct, Classroom Behavior Policy, Classroom Statement on Diversity, Academic Dishonesty Policies, Duty to Report, and Substantive Changes to Syllabus

All these policies can be found here:
https://uwyo.instructure.com/courses/548225/external_tools/86253

Additional COVID-19 Information

Link here: https://uwyo.instructure.com/courses/548225/external_tools/77352

Additional Student Resources

- *DISABILITY SUPPORT SERVICES: udss@uwyo.edu, 766-3073, 128 Knight Hall, www.uwyo.edu/udss*
- *COUNSELING CENTER: uccstaff@uwyo.edu, 766-2187, 766-8989 (After hours), 341 Knight Hall, www.uwyo.edu/ucc*
- *ACADEMIC AFFAIRS: 766-4286, 312 Old Main, www.uwyo.edu/acadaffairs*
- *DEAN OF STUDENTS OFFICE: dos@uwyo.edu, 766-3296, 128 Knight Hall, www.uwyo.edu/dos*
- *UW POLICE DEPARTMENT: uwpd@uwyo.edu, 766-5179, 1426 E Flint St, www.uwyo.edu/uwpd*
- *STUDENT CODE OF CONDUCT WEBSITE: www.uwyo.edu/dos/conduct*