ENR 8780 – Quantitative Methods for Natural Resources, Spring 2020

Instructors:

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Credits: 3 hours

Location: Lecture: 245 Kottman Hall

Schedule: Lectures: Tuesday and Thursday 2:20 – 3:40 PM
Laboratory: TBD (typically Friday morning)

Course Description: Natural Resource and Environmental scientists are often faced with analyzing a diverse array of data from ecological communities, agro-ecosystems, and designed experiments conducted in the laboratory and the field. This includes analyzing how plant and animal communities are organized, and how their distribution is regulated across a variety of scales. Natural Resource and Environmental scientists often use a variety of statistical analyses to examine these relationships, regardless of whether studies are descriptive, mensurative, or experimental. ENR scientists and analysts have a wealth of statistical methods and paradigmatic approaches to make inferences from their data but it is often difficult to determine which method or paradigm will produce the most clear and robust results. This course is designed to help with that.

Course Objectives: The goal of this class is to provide students with an overview of advanced univariate and multivariate analyses employed by Natural Resource and Environmental scientists. Specifically, the objectives of this course are:

- gain working knowledge of advanced univariate and multivariate methods that are used to analyze environment and natural resources data;
- apply advanced statistical analyses to answer research questions that emanate from environmental, natural resources, and related disciplines, or interpret and critique analyses and results of peers;
- learn and practice proper and efficient presentation of statistical analyses in oral and written formats/venues, including theses/dissertations.

Course Format: This class will consist of two lecture periods per week and a laboratory/recitation. Lectures will be led by one of the two instructors and will be divided into three basic categories: 1) basic univariate and multivariate tests; 2) ordination; and 3) classification. Laboratories will generally be open periods where students and instructors can interact analyzing either the students' own environmental data associated with their M.S. or Ph.D. program (if appropriate) or data provided by

the instructor. We be using program R statistical software for all analyses, including homework assignments. Other multivariate analysis software will be available if needed (e.g. PC-ORD, CANOCO).

Course Materials: The following texts will be the primary reference material for the course:

Quinn, G. P., and M. J. Keough. 2002. *Experimental Design and Data Analysis for Biologists*. Cambridge University Press, New York, NY, USA.

McGarigal, K., S. Cushman and S. Stafford. 2000. *Multivariate statistics for wildlife and ecology research*. Springer-Verlag, New York, NY, USA.

McCune, B., and J.B. Grace. 2002. *Analysis of Ecological Communities.* MJM Software Design, Glenedon Beach, OR, USA.

Legendre, P., and L. Legendre. 1998. *Numerical Ecology.* 2nd edition. Elsevier Science B.V., Amsterdam, The Netherlands.

Legendre, P., and L. Legendre. 2012. *Numerical Ecology.* 3rd edition. Elsevier Science B.V., Amsterdam, The Netherlands.

The following texts will be used as reference material for specific software applications to complete homework assignments and the class term project. These will be generally available as e-books, posted on Carmen, or can be lent from the instructors.

Crawley, M. J. 2007. *The R book*. John Wiley and Sons, Ltd., West Sussex England. 942.

Everitt, B.S. 2007. An R and S-Plus companion to multivariate analysis. Springer, Verlag, London. 221 pp.

Leps, J., and P. Smilauer. 2003. *Multivariate analysis of ecological data using CANOCO*. Cambridge University Press, New York. 282 pp.

Zuur, A. .F., E. N. Ieno, N. J. Walker, A. A. Savielev, and G. M. Smith. 2009. *Mixed effects models and extensions in ecology with R*. Springer LLC, New York. 574 pp.

Borchard, D., F. Gillet, P. Legendre. 2011. *Numerical Ecology with R*. Springer LLC, New York, NY, USA. 306 pp.

Other more topically specific reference readings will be utilized and made available to the class on the Carmen/Canvas course website

Assignments: **Grades:** Grading will be based on class participation, homework assignments, presentations, and a research paper.

Data: At the beginning of the semester, each student will identify a specific ecological dataset they will analyze throughout the semester. These data can be

part of the student's MS or PhD research, or if not available or appropriate, a dataset can be provided by their graduate advisors or the course instructors. These data will be used for homework assignments and will be the focus of the research paper. Other data sets will be provided if needed to better suit the various methods as we encounter them.

Homework: Three homework assignments will be submitted and are due on the dates listed in the course schedule. The homework assignments will involve analyzing real data sets using methods demonstrated in the lectures and labs that preceded the due date for each assignment. Data analyses are to be conducted with Program R, unless exceptions are approved by the instructors. The assignment reports will include a concise written summary of results supported with output that is exported or copied from Program R.

Term project: Starting in the 3rd week (Jan. 21-23) you will be required to prepare a brief **introductory presentation** on your term paper topic (including objectives, questions and/or hypotheses tested, and field/laboratory methods, and description of your data). Using the quantitative methods discussed in this class, students will choose the most appropriate statistical analyses to analyze their data and prepare a **research paper** (prepared in a scientific journal format with publication quality tables and figures) and **final oral presentation** at the end of the semester. We want to also provide an opportunity for feedback and experience reviewing other work, so we've broken the final grade for the research paper into two parts. First, roughly a week or so before you submit your final paper, we intend for each student to exchange their work with another student for peer review. The final research paper will due sometime shortly before finals week.

If you need an accommodation based on the impact of a disability, you should contact us to arrange an appointment as soon as possible. At the appointment we can discuss the course format, anticipate your needs and explore potential accommodations. We rely on the Office for Disability Services for assistance in verifying the need for accommodations and developing accommodation strategies. If you have not previously contacted the Office for Disability Services, we encourage you to do so.

Grading: Letter grades will be assigned for this course. Grading will be based on the following:

Description	% of Grade
Participation	**15%**
Homework (written)	**35%**
Final Research Oral Presentation	**15%**
Final Paper:	**35%**

Grading scale: A (100-93%); A- (92-90%); B+ (89-87%); B (86-83%); B- (82-80%); C+ (79-77%); C (76-73%); C- (72-70%); D+ (69-67%); D (66-60%); E (below 60%).

Topical Outline (tentative):

Week 1: Course Introduction – multivariate data sets, statistical assumptions, getting to know your data. (Jan 7, 9)

Week 2: Statistical Paradigms – estimation methods, alternative approaches. (Jan 14, 16)

Week 3: General Linear Models I – analysis of variance and covariance. (Jan 21, 23)

Week 4: General Linear Models II – multiple regression and diagnostics. (Jan 28, 30)

Week 5: Advanced Regression Techniques I – weighted least squares and mixed models. (Feb 4, 6)

Week 6: Advanced Regression Techniques II – non-linear regression, smoothing and regression splines, quantile regression. (Feb 11, 13)

Week 7: Generalized Linear Models I – maximum likelihood methods, generalized estimating equations, generalized additive models. (Feb 18, 20)

Week 8: Generalized Linear Models II – Gaussian, logistic, and Poisson regression and diagnostics. (Feb 25, 27)

Week 9: Zero-inflated and hurdle models, generalized additive models, multi-model inference. (Mar 3, 5)

Spring Break Week 2: Linear Multivariate Methods I – assumptions and diagnostics, and data requirements (recorded lectures made available. (Mar 10, 12)

Week 10: Linear Multivariate Methods I – ordination with principle components and factor analysis, multivariate ANOVA and discriminant analysis. (Mar 17, 19)

Week 11: Linear Multivariate Methods II – classification with MANOVA and discriminant function analysis. (Mar 24, 26)

Week 12: Linear Multivariate Methods III – ordination with canonical correlation analysis, classification and regression trees, and structural equation modeling. (Mar 31, Apr 2)

Week 13: Species Ordination and Classification I, Community Analysis and Description, Unimodal Indirect Ordination – Diversity and indicator species analysis, cluster analysis, multiple response permutation procedures, correspondence analysis. (Apr 7, 9)

Week 14: Species Ordination and Classification II, Unimodal Indirect Ordination – Canonical correspondence and redundancy analysis, non-metric multidimensional scaling. (Apr 14)

Week 14/15: Student Oral Presentations of Term Projects. (Apr 16, 21, 23)

FINAL EXAM: Term Project Paper

Academic Integrity: The university states that it is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct: **(http://oaa.osu.edu/assets/files/documents/csc_12-31-07.pdf).**

It is our intent to treat each of you as if you are honest. We assume that whatever you say or do is done in good faith. If we suspect that you have breached that trust, our intention is to report any suspected academic misconduct through appropriate channels to the University Committee on Academic Misconduct. The Ohio State University Student Handbook covers the subject should you not understand what academic misconduct is. Of course, we will be happy to discuss the topic with you on a no fault basis if we are consulted before the fact. For additional information, see the Code of Student Conduct at the link listed in the previous paragraph.

Disability Services: Students with disabilities that have been certified by the Office for Disability Services will be appropriately accommodated, and should inform the instructor as soon as possible of their needs. The Office for Disability Services is located in 150 Pomerene Hall, 1760 Neil Avenue; telephone 292-3307, TD 292-0901; http://www.ods.ohio-state.edu/.