ENVS 6450 Multivariate Environmental Data Analysis

General Information

Course Description: This course will examine the application of statistical techniques to analyzing multivariate environmental data. Methods will include Ordination (e.g., Principal Components Analysis, NDMS), Multivariate Regression (e.g., Partial Least Squares Regression), and Structural Equation Modelling. Emphasis will be placed on peer and collaborative learning through discussion, and comparative application of analyses to multivariate environmental data in a written scientific report.

Credit Weight: 0.5   **Academic Department (or campus): Environmental Sciences**
Campus: Guelph   **Semester Offering: WinterClass Schedule and Location: Meet 1/week during a 3 hour time slot; Mondays 10:30 a.m.-1:30 p.m. E.C. Bovey 2102**

Instructor Information

Instructor Name: Madhur Anand
Instructor Email: manand@uoguelph.ca
Office location and office hours: EVB 2241, by appointment

Course Content

Specific Learning Outcomes:

1. You will be able to perform multivariate analyses on environmental data using computer software
2. You will understand and be able to communicate the pros and cons of using different multivariate techniques
3. You will be able to complete an independent project in which you analyze data using more than one multivariate analysis and write the results up in scientific format
4. You will be able to create alternate multivariate causal models for environmental data
5. You will enhance your ability to work and discuss in groups and collaboratively

Schedule

Class 1 (January 8): <u>Introduction to Multivariate Environmental Data</u>. Overview of techniques to be covered in the course. Setting up R-Studio and relevant packages on laptop computers. Introduction to data exploration.

Please read Chapter 5 from Zuur et al. 2007 for Class 2.

Class 2 (January 15): <u>Multivariate Regression.</u> We will discuss Chapter 5 from Zuur et al. 2007. We will do some group-work in class. We will work through an example of bivariate, multiple, and partial linear regression in R.

Please read Chapters 12 (PCA and RDA) from Zuur et al. 2007 for Class 3.

Class 3 (January 22): <u>Ordination:</u> Principal Component Analysis (PCA) and Redundancy Analysis (RDA). We will discuss Chapter 12 from Zuur et al. 2007. We will do some group-work in class. We will work through examples of PCA and RDA in R.

Please read Chapters 13 (CCA) from Zuur et al. 2007 for Class 4.

Class 4 (January 29): <u>Ordination:</u> Canonical Correspondence Analysis (CCA). We will discuss Chapter 13 from Zuur et al. 2007. We will do some group-work in class. We will work through examples of CCAs in R.

Please read Grace et al. 2010 On the specification of structural equation models for ecological systems. Ecological Monographs, 80(1): 67–87 for Class 5.

 Class 5 (February 5): <u>Structural Equation Modelling, Part One (Basic)</u>. Discussion of Grace et al. 2010. We will do some group-work in class. We will work through an example of an SEM using lavaan in class.

Class 6 (February 12): <u>Structural Equation Modelling, Part Two (Latent Variable).</u> Deadline to choose an article from the literature (not covered in class) for presentation (Assignment 1) to class (send a copy to Dr. Anand). **In class Quiz** (1 hour).

February 19- Reading Week

Class 7 (February 26): **Assignment 1 due** (presentation of papers chosen from the list below illustrating these techniques in class; ~20 minutes/presenter), plus time for questions/discussions.

Class 8 (March 5): Consultation on Draft Papers. Students will have found a dataset to work on independent project aimed at demonstrating their ability to apply more than 1 multivariate technique and compare and contrast their findings between them. Project will be written-up in the style of a scientific article.

Class 9 (March 12): Draft paper due.

Class 10-11 (March 19, 26): In person one-one meetings to discuss and work on final papers.

Class 12 (April 2): Final paper due at 12:30 p.m. In class-meeting.

Course Assignments and Tests:

Assignment or Test	Due Date	Contribution to Final Mark (%)	Learning Outcomes Assessed
Discussion/class participation		10	See above
Assignment 1	Class 7	15	
Quiz	Class 6	15	
Draft Paper	Class 9	20	
Final Paper	Class 12	40	

<u>Course Resources (all available online through the University Library)</u>

Readings assigned from:

- Borcard, D., Gillet, F., & Legendre, P. (2011). Numerical ecology with R. Springer Science & Business Media.
- Grace, J. B., Anderson, T. M., Olff, H., & Scheiner, S. M. (2010). On the specification of structural equation models for ecological systems. Ecological Monographs, 80(1), 67-87.
- Zuur, A., Ieno, E. N., & Smith, G. M. (2007). Analyzing ecological data. Springer Science & Business Media.

Suggested Articles for Assignment 1:

1. Cottenie, K. (2005). Integrating environmental and spatial processes in ecological community dynamics. Ecology letters,8(11), 1175-1182.
2. Graham, M. H. (2003). Confronting multicollinearity in ecological multiple regression. Ecology, 84(11), 2809-2815.
3. Eisenhauer, N., Bowker, M. A., Grace, J. B., & Powell, J. R. (2015). From patterns to causal understanding: structural equation modeling (SEM) in soil ecology. Pedobiologia, 58(2), 65-72.
4. Guisan, A., Weiss, S. B., & Weiss, A. D. (1999). GLM versus CCA spatial modeling of plant species distribution. Plant Ecology, 143(1), 107-122.
5. James, F. C., & McCulloch, C. E. (1990). Multivariate analysis in ecology and systematics: panacea or Pandora's box?.Annual review of Ecology and Systematics, 21(1), 129-166.
6. Ramette, A. (2007). Multivariate analyses in microbial ecology.FEMS microbiology ecology, 62(2), 142-160.
7. Vaughan, I. P., & Ormerod, S. J. (2005). Methodological insights: Increasing the value of principal components analysis for simplifying ecological data: a case study with rivers and river birds. Journal of Applied Ecology, 42(3), 487-497.
8. Wang, I. J., Glor, R. E., & Losos, J. B. (2013). Quantifying the roles of ecology and geography in spatial genetic divergence.Ecology letters, 16(2), 175-182.
9. Pinel-Alloul, B., André, A., Legendre, P., Cardille, J. A., Patalas, K. and Salki, A. (2013), Large-scale geographic patterns of diversity and community structure of pelagic crustacean zooplankton in Canadian lakes. Global Ecology and Biogeography, 22: 784–795.
10. Butterfield, B. J., Betancourt, J. L., Turner, R. M., & Briggs, J. M. (2010). Facilitation drives 65 years of vegetation change in the Sonoran desert. Ecology,91(4), 1132–1139.
11. Legendre, P. (2008). Studying beta diversity: ecological variation partitioning by multiple regression and canonical analysis. Journal of Plant Ecology, 1(1), 3-8.
12. Carrascal, L. M., Galván, I., & Gordo, O. (2009). Partial least squares regression as an alternative to current regression methods used in ecology. Oikos, 118(5), 681-690.
13. Legendre, P., & Gallagher, E. D. (2001). Ecologically meaningful transformations for ordination of species data. Oecologia, 129(2), 271-280.

Course Policies

Grading Policies
All assignments must be submitted both by e-mail and in hard copy by 4:00 p.m. on the deadline date. Late penalty is 10% of grade per day late. Absences only given academic consideration with proper protocols.

Course Policy on Group Work:
Group work may be assigned. In such cases you are expected to work as a team and all members of the team will receive the same grade.

Course Policy regarding use of electronic devices and recording of lectures:

Electronic recording of classes is expressly forbidden without consent of the instructor. When recordings are permitted they are solely for the use of the authorized student and may not be reproduced, or transmitted to others, without the express written consent of the instructor.

University Policies

Academic Consideration

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course instructor in writing, with your name, id#, and e-mail contact. See the academic calendar for information on regulations and procedures for

Academic Consideration:
[Academic Consideration, Appeals and Petitions](#)

Academic Misconduct

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community, faculty, staff, and students to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection. Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor. The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
[Academic Misconduct Policy](#)

Accessibility

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This

relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability or a short-term disability should contact the Centre for Students with Disabilities as soon as possible.

For more information, contact CSD at 519-824-4120 ext. 56208 or email csd@uoguelph.ca or see the website: Student Accessibility Services Website

Course Evaluation Information

Please refer to the **Course and Instructor Evaluation Website**

Drop date

The last date to drop one-semester courses, without academic penalty, is March 11, 2016. For regulations and procedures for Dropping Courses, see the Academic Calendar:
Current Undergraduate Calendar