Welcome, Fall of 2021 Cohort!

Course Description
In WILD 6500, we examine research design from statistical perspective, showing how data analysis is largely determined by research design and its implementation. Reviews statistical tools for analysis of ecological data in the context of design. Prerequisite: Graduate standing.

Instructor
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Why take WILD 6500?
WILD 6500 takes the task of study design, and uses it to motivate a broad introduction into three aspects of ecological research: statistical methods, computational methods, and communicating data analysis. The course is intended to build basic skills, while at the same time developing broader insights into statistical methodologies.

How to succeed in WILD 6500
- Put in the time. Anticipate investing 2-3 hours on lecture and 1-2 hours on practice problems outside of class per week.
- Rewrite your notes after every lecture. This forces you to interact with the lecture material more slowly, and helps you identify areas where you're uncertain of what's going on.
- Re-do homeworks prior to exams, focusing on problems that you missed the first time through. Re-do problems enough times that you can do them "cold". Identify a set of warm-up problems (the ones you know you struggle with most) to do in the morning before the test.
- Be patient with yourself in R. It is completely normal to struggle with R at the beginning; my goal is to help you get through that struggle as quickly as possible.

Topics
WILD 6500 is intended to provide a broad introduction to the statistical and computational skills you will need as researchers. The course should help you develop proficiency in three broad areas:
- Statistical methodology (both mathematical underpinnings and general concepts)
Statistical Learning Objectives At A Glance

Detailed learning objectives for each section are included further down this document. At the 10,000-foot level, by the end of this course you should be able to:

1. Identify an appropriate probability model for a particular variable of interest
2. Be able to translate a scientific question into a preliminary statistical model
3. Understand how interactions, higher-order terms, and categorical variables enter a linear model
4. Write out a set of covariates in the form of a design matrix, and use that matrix to generate a set of parametric expectations under a particular model
5. Have a basic comprehension of dimensionality in linear models, and describe basic tests for dimensionality
6. Understand and graphically check linear modeling assumptions
7. Understand and explain the role of a null distribution in a statistical test
8. Understand the roles that replication and sampling variation play in statistical inference, and be able to relate that to ecological study design

Computational Learning Objectives At A Glance

By the end of this course, you will be able to:

1. Write code compliant with standard modern style conventions, that includes sufficient annotation
2. Use basic logic (&, |, ifelse, !, etc.) and indexing
3. Write for-loops, ifelse statements, and while statements
4. Design and write functions
5. Be able to test for and correct simple bugs
6. Conduct basic data aggregation and cleaning
7. Design and construct effective data visualizations
8. Conduct all statistical analyses presented in lecture

Course Resources

Course Web Page: https://usu.instructure.com/courses/547318


Software: We will use R throughout the semester for examples, projects, and exams. I also encourage you to start using Markdown or LaTeX for document preparation.

Grading

Grading is based on about 1,000 total points: 250 points each of probability, linear modeling, and experimental design homeworks; and 250 points allocated across a midterm and a final exam.

Exams

Exams are in-class and worked individually. They will be pencil-and-paper, and are intended to assess your knowledge of statistical methodology.

Homeworks

Homework will take on one of two forms:

- Short-answer homeworks (~1/week)
- Research planning reports (4/semester)

I will grade a subset of problems on each homework, and post a complete key outside my office following grading. In order to get full credit on homeworks, you must re-do any problems for which you receive less than full credit (using the key if you want), and submit re-dos to me within one week. If you submit complete revisions, you will earn full credit for the assignment.

Detailed Learning Objectives By Unit

These are subject to refinement, but this is approximately what I expect you should get out of each unit.

UNIT 1: SETS AND COUNTING

Conceptual
UNIT 1: UNDERSTANDING SAMPLE SPACE, EVENTS, AND TRIALS

1. Understand sample space, events, and trials
2. Be able to articulate your particular intended study/dataset in terms of sample space, events, and trials
3. Be able to map out sample space, events, and trials more generally for a broad suite of ecological and biological problems

UNIT 2: PROBABILITY

1. Use the multiplication principle to calculate the total number of possible outcomes could arise for an experiment of a given size
2. Use permutation rules to calculate the number of different orderings in which a set of identifiable events could occur
3. Use combination rules to calculate the number of ways particular set of trials could produce an aggregate outcome of a given size

UNIT 3: LIKELIHOODS

1. Be able to appropriately plug parameters and focal (i.e., "little x") values of random variables into probability models.
2. Be able to explain conceptually what all the terms in the Binomial probability density function "do".

UNIT 4: SAMPLING AND RESAMPLING

1. Understand measures of center and spread
2. Understand sampling variability associated with statistics
3. Understand and be able to articulate the difference between a standard deviation and a standard error

UNIT 5: DESIGN AND POWER

1. Be able to differentiate between scientific hypotheses and predictions for testing
2. Differentiate between scope of inference for an observational study and a designed experiment
3. Know the two questions you should ask when determining scope of inference for a given project
4. Understand how four key factors -- study unit selection, randomization, replication, and local control -- influence study design, know the form of study error each is intended to curtail, and be able to state the problems that can arise when any one of them is overlooked. for designing a robust study

UNIT 6: COMPUTATIONAL

1. Be able to use the agricolae package and the sample function in R to generate study designs.
2. Know the basic ideas behind a statistical power analysis, and have a preliminary concept of how to set one up

UNIT 6: INTRODUCTION TO T-TOOLS

CONCEPTUAL
1. Understand and be able to explain how a z-ratio or t-ratio maps from a raw dataset to a sampling distribution with specified center and spread.
2. Be able to explain how a t-distribution differs from a standard normal distribution. Know the parameters, process, support, and expectation of a t-distribution.
3. Be able to appropriately interpret a frequentist confidence interval, and explain what the confidence level references using a schematic.
4. Know the assumptions of a t-test, and be able to assess those assumptions graphically or logically

MATHMATICAL
1. Be able to write out the t-test likelihood, and connect each element of the likelihood to an assumption of the test
2. Be able to write out a design matrix corresponding to a t-test and couple that design matrix with a vector of parameters to arrive at expected response values for each sampling unit

COMPUTATIONAL
1. Be able conduct one and two-sample t-tests in R by hand and using the t.test function. Be able to interpret output from t.test in the context of real-world scenarios.
2. Be able to simulate "t-test appropriate" data in R
3. Conduct a power analysis of t-test-appropriate data in R

UNIT 7: INTRODUCTION TO ANOVA

CONCEPTUAL
1. Understand why ANOVA is called "Analysis of Variance". Be able to relate this idea to the structure and support of the test statistic
2. Know the ANOVA assumptions
3. Understand the workflow of an ANOVA test (including both the overall F-test and any follow-up tests)
4. Be able to explain multiple testing, and provide at least one strategy for how to accommodate it

MATHMATICAL
1. Write out a design matrix for an ANOVA model

COMPUTATIONAL
1. Be able to conduct and interpret an ANOVA in R
2. Run appropriate ANOVA follow-up tests and interpret their output in R
3. Simulate ANOVA-like data in R
4. Run a basic ANOVA power analysis (this power analysis is somewhat complex, but I want you to have the gist of it)

UNIT 8: SIMPLE LINEAR REGRESSION

CONCEPTUAL
1. Know the linear model assumptions
2. Know the assumed residual distribution of a linear regression model
3. Write out the likelihood of a simple linear regression model
4. Understand the difference between linear and log scaling
5. Be able to interpret R-squared values

MATHMATICAL
1. Write out the likelihood of a simple linear regression model and connect each model assumption to aspects of that likelihood
2. Calculate expected values for each sampling unit given the model fit and design matrix of the linear model
3. Convert linear model results from log to linear scales if the x-variable is log-transformed, the y-variable is log-transformed, or both x and y are log-transformed. Be able to appropriately interpret model results in any of these settings.

COMPUTATIONAL
1. Simulate data under a linear model in R
2. Fit a linear model in R
3. Conduct a power analysis for a simple linear model in R
4. Generate appropriate diagnostic plots and use those plots to assess model assumptions
5. Generate prediction lines and confidence intervals and add those to plots of the raw data
UNIT 9: MULTIPLE REGRESSION

CONCEPTUAL
1. Identify when to include higher order terms (interactions and quadratic terms) in a linear model based on diagnostic plots, and be able to interpret resulting model output
2. Understand the basic principles of model selection
3. Be familiar with two widely-used strategies for model selection: AIC and likelihood ratio tests

MATHEMATICAL
1. Incorporate quadratic and interaction terms into a model's design matrix
2. Generate predictions given coefficient estimates for a model with an interaction or a quadratic term
3. Interpret models with log-transformed predictors or response variables

COMPUTATIONAL
1. Implement AIC-based and likelihood ratio test-based model selection in R
2. Simulate multiple regression data in R
3. Run a power analysis of one model covariate, holding all other covariates constant

UNIT 10: INTRODUCTION TO GENERALIZED LINEAR MODELS

CONCEPTUAL
1. Understand the basic idea behind a link function

MATHEMATICAL
1. Walk through how the log and logit links map from one response space (all positives for the log; bounded 0-1 for the logit) to the whole real line, and explain why this is important.
2. Write out the likelihood for a Poisson regression model and indicate how the likelihood corresponds to model assumptions
3. Write out the likelihood for a logistic regression model and indicate how the likelihood corresponds to model assumptions

COMPUTATIONAL
1. Gain a passing familiarity with the glm() function in R, and be able to use it to fit straightforward Poisson and logistic regression models

Classroom Civility
Utah State University supports the principle of freedom of expression for both faculty and students. The University respects the rights of faculty to teach and students to learn. Maintenance of these rights requires classroom conditions that do not impede the learning process. Disruptive classroom behavior will not be tolerated. An individual engaging in such behavior may be subject to disciplinary action. Read Student Code Article V Section V-3 (https://studentconduct.usu.edu/studentcode/article5) for more information.

University Policies & Procedures

COVID-19 Classroom Protocols
In order to continue to provide a high standard of instruction at USU, and to limit the spread of COVID-19 during the pandemic, students are asked to follow certain classroom protocols. These protocols are in place not only for your safety but also the safety of the rest of the campus community. You will be asked to clean your desk area at the start of each class, sit in designated seats, wear face coverings, and follow dismissal instructions. There may be individual medical circumstances that prevent some students from using face coverings. These circumstances will be rare, but if they do exist, we ask that everyone be respectful. It is imperative that we each do our part so that on-campus instruction can continue.

Academic Freedom and Professional Responsibilities
Academic freedom is the right to teach, study, discuss, investigate, discover, create, and publish freely. Academic freedom protects the rights of faculty members in teaching and of students in learning. Freedom in research is fundamental to the advancement of truth. Faculty members are entitled to full freedom in teaching, research, and creative activities, subject to the limitations imposed by professional responsibility. Faculty Code Policy #403 (http://www.usu.edu/hr/files/uploads/Policies/403.pdf) further defines academic freedom and professional responsibilities.

Academic Integrity – "The Honor System"
Each student has the right and duty to pursue his or her academic experience free of dishonesty. To enhance the learning environment at Utah State University and to develop student academic integrity, each student agrees to the following Honor Pledge:
"I pledge, on my honor, to conduct myself with the foremost level of academic integrity."
A student who lives by the Honor Pledge is a student who does more than not cheat, falsify, or plagiarize. A student who lives by the Honor Pledge:

- Espouses academic integrity as an underlying and essential principle of the Utah State University community;
- Understands that each act of academic dishonesty devalues every degree that is awarded by this institution; and
- Is a welcomed and valued member of Utah State University.

### Academic Dishonesty

The instructor of this course will take appropriate actions in response to Academic Dishonesty, as defined the University's Student Code. Acts of academic dishonesty include but are not limited to:

- **Cheating**: using, attempting to use, or providing others with any unauthorized assistance in taking quizzes, tests, examinations, or in any other academic exercise or activity. Unauthorized assistance includes:
  - Working in a group when the instructor has designated that the quiz, test, examination, or any other academic exercise or activity be done "individually;"
  - Depending on the aid of sources beyond those authorized by the instructor in writing papers, preparing reports, solving problems, or carrying out other assignments;
  - Substituting for another student, or permitting another student to substitute for oneself, in taking an examination or preparing academic work;
  - Acquiring tests or other academic material belonging to a faculty member, staff member, or another student without express permission;
  - Continuing to write after time has been called on a quiz, test, examination, or any other academic exercise or activity;
  - Submitting substantially the same work for credit in more than one class, except with prior approval of the instructor; or engaging in any form of research fraud.

- **Falsification**: altering or fabricating any information or citation in an academic exercise or activity.

- **Plagiarism**: representing, by paraphrase or direct quotation, the published or unpublished work of another person as one's own in any academic exercise or activity without full and clear acknowledgment. It also includes using materials prepared by another person or by an agency engaged in the sale of term papers or other academic materials.

For additional information go to: **ARTICLE VI. University Regulations Regarding Academic Integrity** ([link](https://studentconduct.usu.edu/studentcode/article6))

### Sexual Harassment/Title IX

Utah State University is committed to creating and maintaining an environment free from acts of sexual misconduct and discrimination and to fostering respect and dignity for all members of the USU community. Title IX and USU Policy 339 ([link](http://www.usu.edu/policies/339)) address sexual harassment in the workplace and academic setting.

The university responds promptly upon learning of any form of possible discrimination or sexual misconduct. Any individual may contact USU's Office of Equity ([link](https://equity.usu.edu/)) for available options and resources or clarification. The university has established a complaint procedure to handle all types of discrimination complaints, including sexual harassment (USU Policy 305 ([link](http://www.usu.edu/policies/305/)), and has designated the Office of Equity Director/Title IX Coordinator as the official responsible for receiving and investigating complaints of sexual harassment.

### Withdrawal Policy and "I" Grade Policy

Students are required to complete all courses for which they are registered by the end of the semester. In some cases, a student may be unable to complete all of the coursework because of extenuating circumstances, but not due to poor performance or to retain financial aid. The term ‘extenuating’ circumstances includes: (1) incapacitating illness which prevents a student from attending classes for a minimum period of two weeks, (2) a death in the immediate family, (3) financial responsibilities requiring a student to alter a work schedule to secure employment, (4) change in work schedule as required by an employer, or (5) other emergencies deemed appropriate by the instructor.

### Students with Disabilities

USU welcomes students with disabilities. If you have, or suspect you may have, a physical, mental health, or learning disability that may require accommodations in this course, please contact the Disability Resource Center (DRC) ([link](http://www.usu.edu/drc/)) as early in the semester as possible (University Inn # 101, (435) 797-2444, drc@usu.edu (mailto:drc@usu.edu)). All disability related accommodations must be approved by the DRC. Once approved, the DRC will coordinate with faculty to provide accommodations.

Students who are at a higher risk for complications from COVID-19 or who contract COVID-19 may also be eligible for accommodations.

### Diversity Statement

Regardless of intent, careless or ill-informed remarks can be offensive and hurtful to others and detract from the learning climate. If you feel uncomfortable in a classroom due to offensive language or actions by an instructor or student(s) regarding ethnicity, gender, or sexual orientation, contact:

- Division of Student Affairs: [link](https://studentaffairs.usu.edu), (435) 797-1712, studentservices@usu.edu (mailto:studentservices@usu.edu), TSC 220
- Student Legal Services: [link](https://ususa.usu.edu/student-association/student-advocacy/legal-services), (435) 797-2912, TSC 326,

- Division of Student Success: [link](https://studentaffairs.usu.edu), (435) 797-1712, studentservices@usu.edu (mailto:studentservices@usu.edu), TSC 220
- Disability Resource Center (DRC): [link](http://www.usu.edu/drc/), (435) 797-2444, drc@usu.edu (mailto:drc@usu.edu), TSC 101
- Office of Diversity and Equity: [link](https://equity.usu.edu/), (435) 797-1712, studentservices@usu.edu (mailto:studentservices@usu.edu), TSC 220

Please refer to the [Student Conduct Code](https://studentconduct.usu.edu/studentcode) for details on what qualifies as appropriate conduct.
• Access and Diversity: http://accesscenter.usu.edu (http://accesscenter.usu.edu/), (435) 797-1728, access@usu.edu (mailto:access@usu.edu); TSC 315
• Multicultural Programs: http://accesscenter.usu.edu/multiculture (http://accesscenter.usu.edu/multiculture), (435) 797-1728, TSC 315
• LGBTQA Programs: http://accesscenter.usu.edu/lgbtqa (http://accesscenter.usu.edu/lgbtqa/), (435) 797-1728, TSC 3145
• Provost’s Office Diversity Resources: https://www.usu.edu/provost/diversity (https://www.usu.edu/provost/diversity/), (435) 797-8176
You can learn about your student rights by visiting:
The Code of Policies and Procedures for Students at Utah State University: https://studentconduct.usu.edu/studentcode (https://studentconduct.usu.edu/studentcode/)

Grievance Process
Students who feel they have been unfairly treated may file a grievance through the channels and procedures described in the Student Code: Article VII (https://studentconduct.usu.edu/studentcode/article7).

Full details for USU Academic Policies and Procedures can be found at:
• Student Conduct (http://www.usu.edu/studentconduct)
• Student Code (https://studentconduct.usu.edu/studentcode/)
• Academic Integrity (https://studentconduct.usu.edu/studentcode/article6)
• USU Academic Policies and Procedures (http://catalog.usu.edu/content.php?catoid=4&navoid=546)
• Academic Freedom and Professional Responsibility Policy (http://www.usu.edu/hr/files/uploads/Policies/403.pdf)

Emergency Procedures
In the case of a drill or real emergency, classes will be notified to evacuate the building by the sound of the fire/emergency alarm system or by a building representative. In the event of a disaster that may interfere with either notification, evacuate as the situation dictates (i.e., in an earthquake when shaking ceases or immediately when a fire is discovered). Turn off computers and take any personal items with you. Elevators should not be used; instead, use the closest stairs.

Mental Health
Mental health is critically important for the success of USU students. As a student, you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce your ability to participate in daily activities. Utah State University provides free services for students to assist them with addressing these and other concerns. You can learn more about the broad range of confidential mental health services available on campus at Counseling and Psychological Services (CAPS) (https://counseling.usu.edu).

Students are also encouraged to download the “SafeUT App” (https://healthcare.utah.edu/uni/programs/safe-ut-smartphone-app) to their smartphones. The SafeUT application is a 24/7 statewide crisis text and tip service that provides real-time crisis intervention to students through texting and a confidential tip program that can help anyone with emotional crises, bullying, relationship problems, mental health, or suicide related issues.

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