BIOL 5500: Research Design for Ecologists

I. General Information

Professor: Dr. Kenneth Schoenly
Office: N271
Phone: 667-3949
Office Hrs: MWF 9-10
Email: kschoenly@csustan.edu

Semester: Fall 2013
Credits: Lec/Activity 4
Meeting Times: M, F 3-5:50
Room: N211

II. Course Description

(Catalog Description): A practical, hands-on survey of experimental design and methods, and ecological statistics used by environmental scientists. Emphasis will be placed on published analyses of stressors on ecosystem structure and function. Corequisite: BIOL 5502. Prerequisites: Graduate standing in the Ecology and Sustainability program or consent of instructor. (Lecture, 3 hours; Activity 3 hours) (Fall).

III. Required Readings/Software:

1. Textbooks: *Krebs. 1999. Ecological Methodology, 2nd edition; van Emden. 2008. Statistics for Terrified Biologists*. (Optional text: *L. Mlodinow. 2008. The Drunkard's Walk: How Randomness Rules Our Lives*). Bring both to every class period. Used copies are available through on-line web sites.
2. Software: *Krebs 2009, v 7.2*. (discounted for students). Compatible with new Windows 7 and 8 platforms.
3. CD of papers from the ecological literature and authoritative web sites that offer freeware (free software).
4. Handouts of spreadsheet exercises and accompanying questions to solve as in-class activities or take-home assignments. Most will come from Donovan & Weldon (2002) *Spreadsheet Exercises in Ecology and Evolution* (D&W). These will be sent as attachments in future emails.

IV. Other Available Resources:

Below are some other texts, journals, and authoritative websites on quantitative ecology and related subjects:

Bolker, B.M. 2008. *Ecological Models and Data in R*. Princeton Univ. Press, Princeton, N.J.

Donovan & Welden. 2001. *Spreadsheet Exercises in Conservation Biology and Landscape Ecology*. Sinauer Associates, Inc., Sunderland, MA.

Eberhardt, L. 2000. *A Course in Quantitative Ecology*. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA.

Gotelli & Ellison. 2013. *A Primer of Ecological Statistics, 2nd edition*. Sinauer, Sunderland, MA.

Gotelli & Graves. 1996. *Null Models in Ecology*. Smithsonian Institution Press, Washington, D.C.

Hairston. 1989. *Ecological Experiments: Purpose, Design and Execution*. Cambridge University Press, Cambridge.

Henderson, P.A. 2003. *Practical Methods in Ecology*. Blackwell Publishing.

Ludwig & Reynolds. 1988. *Statistical Ecology*. Wiley-Interscience, New York.

Magurran. 2004. *Measuring Biological Diversity*. Blackwell Publishing, Malden, MA.

Manly. 1991. *Randomization and Monte Carlo Methods in Biology*. Chapman & Hall.

Methods in Ecology and Evolution, a peer-reviewed open-access journal of the British Ecological Society, website: http://www.methodsinecologyandevolution.org/view/0/index.html.

Michener & Brunt. 2000. *Ecological Data: Design, Management and Processing*. Blackwell Science, Edinburgh.

Pielou. 1977. *Mathematical Ecology*. Wiley-Interscience, New York.

Quinn, & Keough. 2002. *Experimental Design and Data Analysis for Biologists*. Cambridge Univ. Press.

Resetarits & Bernardo. 1998. *Experimental Ecology: Issues and Perspectives*. Oxford Univ. Press, Oxford.

Rosner. *Fundamentals of Biostatistics, 7th edition.* Brooks/Cole.

Ruxton & Colegrave. 2003. *Experimental design for the life sciences, 2nd edition.* Oxford Univ. Press.

Scheiner & Gurevitch. 2001. *Design and Analysis of Ecological Experiments, 2nd edition*. Oxford Univ. Press, Oxford.

Southwood & Henderson. 2000. *Ecological Methods*, 3rd ed. Blackwell Science.

Sutherland, W.J. (ed.). 2006. *Ecological Census Techniques*, 2nd edition. Cambridge Univ. Press, Cambridge.

Tangren, J. 2000. A *Field Guide to Experimental Designs*, website: http://www.tfrec.wsu.edu/ANOVA/index.html.

Underwood. 1997. *Experiments in Ecology*. Cambridge Univ. Press, Cambridge.

V. Prerequisites:

Two math courses (undergraduate statistics and calculus) are necessary pre-requisites for this course. Additional quantitative courses that ecologists use as research tools include differential equations, matrix algebra, graph theory, and multivariate statistics, which also expand your "comfort zone" with mathematical concepts. As a graduate student, we expect that you will perform at a higher level, take the initiative on class assignments, have excellent problem-solving skills, become a student member of one or more professional societies (e.g., *Ecological Society of America*, *Society for Conservation Biology*, *International Society of Ecological Economics*), and use ecostatistical methods in your thesis research (just to mention a few). It also affords you the opportunity to take an active role in shaping your future professional growth and for making contributions in your chosen field of study.

To maximize these benefits, both you and the university must make commitments. The university must make available the resources, both intellectual and physical, that are necessary for you to complete coursework, pursue your program of studies, and realize your potential. For your part, you must take advantage of the opportunities the program has to offer by being highly motivated and focused in the first place, and by directing that motivation in a productive manner. If you proceed appropriately, the lectures, homework, exams, presentations, and other course assignments will become exciting challenges and guidelines rather than hurdles and hindrances.

VI. Course Requirements:

This course is a research design and methodology class for the Ecology and Sustainability graduate program. **Ecology is an experimental, observational, mathematical and correlative science.** This course will expose you to many quantitative methods and experimental designs that are used by ecologists to answer environmentally diverse questions. One semester is not enough time to cover all these methods and designs, so **we will explore some of the most common tools and case studies that use them.** Mastering these tools is critical to successful completion of your thesis and to future employment and career building as a professional ecologist.

The course's subject matter will be introduced through formal lectures, assigned journal readings, student presentations, and self-paced lab and field activities that use ecostatistical software and EXCEL spreadsheets. Written exams will require you to know the proper uses, assumptions, limitations, interpretations (but not intimate mathematical steps) of all ecostatistical methods & models used. Successful completion of EXCEL activities will demonstrate mastery of the mechanical (individual calculation) steps leading to correct solutions.

Presentations: You will be required to deliver **two, 30-minute critiques of journal papers** (listed below) and **one spreadsheet/software exercise** featured in the topics list below. I will supply all the papers (with few exceptions) to you as PDF's on the CD that you will receive on the first class day. Each **presentation grade** will be based on your **verbal performance** and a **1-page synthesis** (i.e., study guide for your classmates) that summarizes the paper's questions/hypotheses, methodology, results, and conclusions. Papers will be drawn at random during the 1st few weeks of the semester (i.e., sampling without replacement!); whereas, exercises will be assigned at random 1-2 class periods before their scheduled presentation. It will then be your job to 'marry yourself' to each paper or exercise and hand out your summary page and spreadsheet/software output so you can 'teach' the topic to your classmates and instructor.

Assigned homework will be due at the next class meeting (no exceptions) and handed in (as hard copies); no homework will be excepted as email attachments. **Persons will be called upon at random to present homework and answer questions**. Presentations need to be practiced (several times, if necessary) so they finish under/on time (**no longer than 25/5 min for talk/questions**). Your instructor will evaluate your verbal performance and 1-page syntheses of your papers plus your spreadsheets/other outputs using a standardized grading sheet. **In the event you miss (or are unready to present) your scheduled talk, you will receive an automatic '0' for that assignment. HAVE YOUR PRESENTATIONS/SPREADSHEETS WITH YOU AT THE START OF CLASS (ON COMPUTER, CD OR MEMORY CARD) AND BE READY TO TEACH THE CLASS WHEN YOUR TIME COMES!!**

VI. Ecological Software:

We will be using software from commercial and "freeware" sources (see examples below). All of these programs will run on your laptop (PC, Mac, or emulator versions). Commercial software is copyright protected and requires site licenses for individual student use. Unauthorized copying of commercial software is a serious crime, constituting copyright violation. See below for some examples:

EstimateS website: http://viceroy.eeb.uconn.edu/EstimateS (free)
EcoSim website: http://garyentsminger.com/ecosim/index.htm (free)
Exeter website: http://exetersoftware.com/cat/update_ecometh.shtml
Ramas Software website: http://www.ramas.com/indexEnv.htm
Ecological Software Solutions website: http://www.ecostats.com/software/software.htm
Statistical Software for Meta-Analysis: http://www.metawinsoft.com/

Other Helpful Websites (tools) for EXCEL Users:

EXCEL page at mathlab.com: http://www.mathtools.net/Excel/.
PopTools (add-in): http://sunsite.univie.ac.at/Spreadsite/poptools/index.htm.
Alan Barasch's help site: http://xl.barasch.com/.
Mr. EXCEL: http://www.mrexcel.com/.

VII. Student Learning Objectives:

1. The student will become familiar with ecostatistical methods and models used for solving problems and answering questions related to experimental design, sampling, population estimation, life-history theory, community impacts, and other issues.

2. The student will experience how ecological experiments, methods and models can be used to measure and interpret the magnitude of responses of populations, communities and ecosystems to natural and anthropogenic stressors.

3. The student will have enhanced understanding of the peer-reviewed literature in science, its cumulative, self-correcting, and hypothesis-testing features, and be able to present summaries of this literature thereby refining his/her communication and critical thinking skills.

4. The student will be guided in planning their own pilot studies and field experiments and in choosing the appropriate ecostatistical tools and models for analyzing his/her data.

5. This course addresses the University's graduate student learning goals numbered 1, 2, 5, and 7.

VIII. Grading Procedure

As per university regulations, students with excessive absences will be dropped from the class. Two exams (**Fridays: October 11 and December 6**) will be 150 point mixed format. Exams will consist of long and short answer essays, graph/output interpretation, calculations, and ecostatistical questions that will come from the lecture notes, textbook, presentations, software, journal articles, and activities. All requests to take exams at other than scheduled times must be in writing to the instructor **at least 3 lecture days** prior to the scheduled exam date. It is your responsibility to contact me in the event you miss an exam or assignment. If you miss class on a test day, you are required to provide me with relevant written information (e.g., letter from a physician) documenting your absence. The final decision to offer a makeup exam rests with me.

Cheating in any form is inappropriate conduct and will be dealt with swiftly and severely according to Sections 41301 through 41304 of Title 5 of the *California Code of Regulations*" which includes expulsion, suspension or probation.

Grades and Weighting

Lecture Exams (2 @ 150 points each)	300
Journal Presentations (2 @ 150 points each)	300
Spreadsheet/Software Exercise	200
Homework & Miscellaneous	200
Total	1000 points

A = 900-1000, B = 800-899, C-F = 700 or fewer. No +/- grading will be applied to your final grade.

IX. Topics, Readings, In-Class/Homework Activities*

TOPIC	READINGS**	JOURNAL ARTICLE(S)
Introduction: ❑ spreadsheet hints/tips ❑ math functions/macros ❑ add-in pack ❑ freeware programs	D&W (Ch 2) V (Ch 1)	Platt 1964 Gleick 1990 Curran-Everett 2008
Properties of Biological Data: ❑ metadata, data archiving & sharing ❑ accuracy, precision, bias ❑ significant figures ❑ taxonomic issues ❑ measurement repeatability ❑ statistical significance & power ❑ geometric, exponential, logistic growth	K (1-10, 554-559, 392) D&W (Ch 5) D&W (Ch 7, 8)	Michener 2006; Cook et al. 2001; Strier et al. 2011 Oliver & Beattie 1996; Wolak et al. 2011; Hayes et al. 1998; Curran-Everett 2010; Thomas & Juanes 1996; Curran-Everett 2009a
Statistical Foundations (review): ❑ three frameworks ❑ standards for statistical inference ❑ parametric vs. non-parametric ❑ random numbers: uniform vs. normal ❑ central limit theorem ❑ central tendency vs. dispersion measures ❑ data transformation ❑ one-tailed vs. two-tailed tests ❑ confidence intervals ❑ sampled randomization tests -- bootstrap (introduction) -- jackknife (introduction)	D&W (Ch 3, 4) V (Ch 2, 3, 6, 9, 10, 19)	Curran-Everett 2008 Ruxton & Neuhauser 2010 Curran-Everett 2009b Curran-Everett 2009c; Meyer et al. 1986
Experimental Designs: ❑ definitions, types ❑ true replication, pseudoreplication ❑ field designs for ANOVA ❑ field designs for environmental impacts ❑ repeated measures ❑ study/visitation effects ❑ meta-analysis	K (340-371) V (Ch 10-11) K (349-362, 567-572)	Hurlbert. 1984 S-O & Murdoch 1986; Heffner et al. 1996 McKone & Lively 1993, Greenwood 1994, Lively & McCone 1994 Underwood 1992; Steinbeck et al. 2005 Gill and Haps 1971 Cahill et al. 2001; Louda et al. 2004 Gurevitch & Hedges 1999; Kotaiho & Tomkins 2002; Curtis & Wang 1998; Vance-Chalcraft 2007

Statistical Distributions & Dispersion Tests: ❑ Poisson ❑ Negative binomial ❑ Goodness of fit tests ❑ Indices of dispersion ❑ Spatial distribution tests	K (114-139, 212-223) D&W (Ch 3)	Myers 1978 Syrjala 1996
Sample Size Issues: ❑ single & two sample tests ❑ sequential sampling ❑ quadrat counts ❑ collectors' curves & stopping rules ❑ quadrat shape & size	K (19-66, 105-154, 304-338) V (App. 1) EstimateS	Marvier 2002 Naranjo & Hutchison 1997 Peterson & Slade 1998. Pringle. 1984.
Mark-Release-Recapture: ❑ Lincoln-Peterson ❑ Schnabel ❑ Bailey's Triple Catch ❑ Jolly-Seber	K (19-69) D&W (Ch 23)	Thorne et al. 1996; Woolhouse & Chandiwana 1990
Species Diversity, Richness, Evenness: ❑ theory & models ❑ alpha, beta & gamma diversity ❑ diversity indices ❑ rarefaction ❑ extrapolation-based richness estimators	K (410-452) D&W (Ch 6) EstimateS	Longino et al. 2002 McCabe and Gotelli 2000 James & Rathbun 1981; Tipper 1979 Colwell and Coddington 1994, Chiarcucci et al. 2003
Null Models and Community Assembly ❑ Approaching statistical models ❑ species co-occurrences ❑ minimum size ratios	EcoSim	Adams 2007; Ribas and Schoereder 2002; Feeley 2003
Analysis of Multivariate Data: ❑ Approaching multivariate data ❑ Binary vs. quantitative measures ❑ Multivariate distance ❑ Ordination ❑ Classification ❑ Multiple regression	K (375-406)	Huhta 1979; Wolda 1981. Kessel & Whittaker 1975; Townsend et al. 1983; Stancampiano & Schnell 2004 Wiens et al. 2001
Review of Student Thesis Projects (Experimental & Statistical Methods)		

* Topic content may be changed due to extenuating circumstances.

**Readings: K = Krebs, V = van Emden, D&W = Donovan & Weldon.

Readings

Platt, J.R. 1964. Strong inference. *Science* 146: 347-353.

Gleick, J. 1990. The census: why we can't count. *NY Times Magazine (July 13):* 22-26.

Curran-Everett, D. 2008. Explorations in statistics: standard deviations and standard errors. *Adv. Physiol. Educ*. 32: 203-208.

Michener, W.K. 2006. Meta-information concepts for ecological data management. *Ecol. Informatics* 1: 3-7.

Cook, R.B. et al. 2001. Best practices for preparing ecological data sets to share and archive. *Bull. Ecol. Soc. Am.* 82: 138-141.

Strier et al. 2011. The Primate Life History Database: a unique shared ecological data resource. *Methods in Ecology and Evolution* 1: 199-211.

*Oliver, I. & A.J. Beattie. 1996. Designing a cost-effective invertebrate survey: a test of methods for rapid assessment of biodiversity. *Ecological Applications* 6: 594-607.

Wolak, M.E. et al. 2011. Guidelines for estimating repeatability. *Methods in Ecology & Evolution* 2. DOI: 10.1111/j.2041-210X.2011.00125.x

*Hayes, J.P. et al. 1998. Repeatability of mammalian physiology: evaporative water loss and oxygen consumption of Dipodomys merriami. *Journal of Mammalogy* 79: 475-485.

Curran-Everett, D. 2010. Explorations in statistics: power. *Adv. Physiol. Educ.* 34: 41-43.

Curran-Everett, D. 2009a. Explorations in statistics: hypothesis tests and P values. *Adv. Physiol. Educ.* 33: 81-86.

*Thomas, L. and F. Juanes. 1996. The importance of statistical power analysis: an example from animal behavior. *Anim. Behav*. 52: 856-859.

Ruxton, G.D. & M. Neuhauser. 2010. When should we use one-tailed hypothesis testing? *Methods Ecol. Evol*. 1: 114-117.

Curran-Everett, D. 2009b. Explorations in statistics: confidence intervals. *Adv. Physiol. Educ.* 33: 87-90.

Curran-Everett, D. 2009c. Explorations in statistics: the bootstrap. *Adv. Physiol. Educ.* 33: 286-291.

*Meyer, J.S. et al. 1986. Estimating uncertainty in population growth rates: jackknife vs. bootstrap techniques. *Ecology* 67: 1156-1166.

Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. *Ecol. Monogr*. 54: 187-211.

Stewart-Oaten, A. and W. W. Murdoch. 1986. Environmental impact assessment: "pseudo-replication" in time. *Ecology* 67: 929-940.

Heffner, R.A. et al. 1996. Pseudoreplication revisited. *Ecology* 77: 2558-2562.

McKone, M.J. and C.M. Lively. 1993. Statistical analysis of experiments conducted at multiple sites. *Oikos* 67: 184-186.

Greenwood, J.J.D. 1994. Statistical analysis of experiments conducted at multiple sites. *Oikos* 69: 334.

Lively, C.M. and M.J. McKone. 1994. Choosing an appropriate ANOVA for experiments conducted at few sites. *Oikos* 69: 335.

Underwood, A.J. 1992. On beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. J. Exp. Mar. Biol. Ecol. 161: 145-178.

*Steinbeck, J.R. et al. 2005. Detecting long-term change in complex communities: a case study from the rocky intertidal zone. Ecol. Appl. 15: 1813-1832.

Gill, J.L. and H.D. Haps. 1971. Analysis of repeated measurements of animals. *J. Anim. Sci.* 33: 331-336.

*Cahill, J.F. et al. 2001. The herbivory uncertainty principle: visiting plants can alter herbivory. *Ecology* 82: 307-312.

*Louda, S.V. et al. 2004. Spatial heterogeneity, not visitation bias, dominates variation in herbivory: reply. *Ecology* 85: 2906-2910

Gurevitch, J. & L.V. Hedges. 1999. Statistical issues in ecological meta-analyses. *Ecology* 80: 1142-1149.

Kotiaho, J.S. and J.L. Tomkins. 2002. Meta-analysis, can it ever fail? *Oikos* 96: 551-553.

*Curtis, P.S. and X. Wang. 1998. A meta-analysis of elevated CO_2 effects on woody plant mass, form, and physiology. *Oecologia* 113: 299-313.

*Vance-Chalcraft, H.D. 2007. Influence of intraguild predation on prey suppression and prey release: a meta-analysis. Ecology 88: 2689-2696.

Myers, J.H. 1978. Selecting a measure of dispersion. *Environmental Entomology* 7: 619-621.

Syrjala, S.E. 1996. A statistical test for a difference between the spatial distributions of two populations. *Ecology* 77: 75-80.

*Marvier, M. 2002. Improving risk assessment for nontarget safety of transgenic crops. *Ecological Applications* 12: 1119-1124.

Naranjo, S.E. & W.D. Hutchison. 1997. Validation of arthropod sampling plans using a resampling approach: software and analysis. *American Entomologist* (Spring): 48-57.

*Peterson & Slade. 1998. Extrapolating inventory results into biodiversity estimates and the importance of stopping rules. *Diversity and Distributions* 4: 95-105.

*Pringle, J.D. 1984. Efficiency estimates for various quadrat sizes used in benthic sampling. *Canadian Journal of Fisheries and Aquatic Science* 41: 1485-1489.

*Thorne, B.L. et al. 1996. Evaluation of mark-release-recapture methods for estimating forager population size of subterranean termit (Isoptera: Rhinotermitidae) colonies. *Environmental Entomology* 25: 938-951.

*Woolhouse, M.E.J. & S.K. Chandiwana. 1990. Population biology of the freshwater snail *Bulinus globosus* in the Zingabwe highveld. *J. Appl. Ecol.* 27: 41-59.

*Longino, J.T. et al. 2002. The ant fauna of a tropical rain forest: estimating species richness three different ways. *Ecology* 83: 689-702.

*McCabe, D.J. and N.J. Gotelli. 2000. Effects of disturbance frequency, intensity, and area on assemblages of stream macroinvertebrates. *Oecologia* 124: 270-279.

James, F.C. & S. Rathbun. 1981. Rarefaction, relative abundance, and diversity of avian communities. *Auk* 98: 785-800.

Tipper, J.C. 1979. Rarefaction and rarefiction – the use and abuse of a method in paleoecology. *Paleobiology* 5: 423-434.

Colwell, R. and J. A. Coddington. 1994. Estimating terrestrial biodiversity through extrapolation. Philosophical Transactions of the Royal Society of London B 345:101-118.

*Chiarucci, A. et al. 2003. Performance of nonparametric species richness estimators in a high diversity plant community. *Diversity and Distributions* 9: 283-295.

*Adams, D.C. 2007. Organization of *Plethodon* salamander communities: guild-based community assembly. *Ecology* 88: 1292-1299.

*Ribas, C.R. and J.H. Schoereder. 2002. Are all ant mosaics caused by competition? *Oecologia* 131: 606-611.

*Feeley, K. 2003. Analysis of avian communities in Lake Guri, Venezuela, using multiple assembly rule models. *Oecologia* 137: 104-113.

Huhta, V. 1979. Evaluation of different similarity indices as measures of succession in arthropod communities of the forest floor after clear-cutting. *Oecologia* 41: 11-23.

Wolda, H. 1981. Similarity indices, sample size and diversity. *Oecologia* 50: 296-302.

Kessell, S.R. and R.H. Whittaker. 1976. Comparisons of three ordination techniques. *Vegetatio* 32: 21-29.

*Townsend, C.R. et al. 1983. Community structure in some southern English streams: the influence of physicochemical factors. *Freshwater Biology* 13: 521-544.

*Stancampiano, A.J. and G.D. Schnell. 2004. Microhabitat affinities of small mammals in southwestern Oklahoma. *J. Mammal.* 85: 948-958.

*Wiens, J.A. et al. 2001. A canonical correspondence analysis of the effects of the Exxon Valdez oil spill on marine birds. *Ecological Applications* 11: 828-839.

*student presentations