Final Project Proposal (Due Wednesday, October 30, 2024)

FW 599: Multivariate Analysis of Ecological Data

**Instructions**

**FW 599: Multivariate Analysis of Ecological Data** is a skills-based course, whereby students will learn to apply various multivariate statistical techniques to complex data sets. In lieu of a final exam, students will be required to submit a final report in the form of a peer-reviewed “journal article.” This project proposal is intended to help guide you in this process. Your proposal will provide the foundation for your final analysis and should demonstrate that you have a clear understanding of the ecological questions driving your work, as well as the potential statistical methods you will use to address them.

Please submit a two-page (single spaced) project proposal in the form of a Word document or Markdown- generated \*.pdf file by Wednesday, October 30th. The proposal should include the following sections:

1. **Background and Justification**: Provide some context for your study system, including details about the ecological setting and key drivers of interest. What hypothesis(es) and/or study questions are you planning to answer using these data? Are there any uncertainties that need to be addressed?
2. **Objectives**: Provide a list of 2 or 3 clear objectives that directly address your project goal(s). These objectives should be ecological NOT methodological. For example, an objective might be to “determine the influence of environmental gradients on species assemblages across sites,” rather than “apply a PCA to species abundance data.”
3. **Methods**: Describe the analytical methods you plan to use to address each of your objectives. I know we haven’t gotten to functional methods like RDA/CCA, PERMANOVA, and classification/regression trees yet, but do your best to anticipate which methods you think will be most appropriate based on your understanding so far.
4. **Expected Outcomes**: Predict what you expect to find from your analysis. Be realistic but thoughtful in considering the results that could emerge based on your knowledge of the system.
5. **Broader Implications**: Discuss the broader impact of your study. How will your findings contribute to the field of ecology, inform conservation practices, or guide management decisions? Think beyond the immediate study and consider how your results may apply to larger ecological or environmental questions.
6. **Literature Cited**: This section is not required and does not count toward the 2-page maximum. Please include full references if you cite any journal articles or reports in your proposal.

Spanning from 2013 to 2019, a Before/After, Control/Impact (BACI) study was conducted by Garcia et. al to assess the role of forest harvest and downed wood on occupancy of Oregon Slender salamanders (Batrachoseps wrightii, BAWR) and Ensatina salamanders (Ensatina eschscholtzii, ENES)1,2. The study quantified occupancy and abundance data for both salamander species, as well as information on downed wood abundance and climatic data in managed timberlands. In September of 2020, the Beachie Creek and Riverside wildfires impacted a subset of these historical survey sites, and we built this project to resurvey the historical study after a severe wildfire event. We surveyed in spring seasons of 2023 and 2024, sampling both historical BACI study locations and new locations, and collected count data for BAWR and ENES as well as a suite of environmental data. Two of my PhD chapters will use this data: the first focusing on occupancy analyses, and the second exploring how the structure and composition of forest floor habitat can impact salamander occupancy in a stand.

This project is focused on two plethodontid species native to the western Oregon Cascade Mountains: the Oregon Slender Salamander and the Ensatina Salamander. The Oregon slender salamander was of particular concern at the inception of the BACI project, classified as G2/G3 species (Imperiled/Vulnerable) and listed as an Oregon Priority Species primarily due to habitat loss and disturbance, though this label was removed in 20213. Still, BAWR is known as a sensitive species with a small home range and approximated dispersal distance of 1.7m. It is one of few species endemic to old-growth forests of the Oregon Cascades, known to be most abundant in older forests with cool, moist environments and large downed wood. In contrast, the Ensatina salamander is widespread throughout the western US, occupy a broad gradient of microhabitats and are considered a generalist species4.

These two species provide an interesting contrast in life histories and potential response to multiple disturbance events, with ENES exhibiting larger dispersal distances, home range sizes, and persisting across broader microhabitat gradients than BAWR, but maintaining a strong association with downed wood and mesic environments owing to their moisture-dependence1,5. Knowledge on the relationship between timber harvest and wildfire is limited in the literature, but evidence suggests that the combination of both disturbances can alter many components of forest floor habitat and microclimate, including carbon storage, ambient temperatures, soil nutrient composition, soil moisture, and within-wood temperatures6. All these things can impact refugia potential for an animal requiring high levels of moisture, stable temperatures, and downed wood refugia, like these terrestrial salamanders.

For this project, I want to explore two primary questions:

1. **What site-level environmental conditions characterize different treatment groups? Do certain conditions lead to distinct groupings with higher or lower abundance?**
2. **How do environmental covariates, specifically downed wood metrics, influence salamander occupancy and abundance?**

Question 1

I will use clustering and ordination techniques to try to characterize sites based on environmental variables, working to refine methods used in homework 4 and 5. The most successful clustering analyses have been complete linkage and Ward’s linkage methods using a Euclidean distance matrix on a subset of z-scored environmental data. The ordination analyses that turned out the best for this data were the PCoA and NMDS, but I should be able to get PCA to work as well since my data uses euclidean distance.

So far, I am seeing that the control sites are grouping apart from the rest of the sites, but generally the treatments are not grouping nicely. I think this is partially because I have over 20 environmental variables, some of which measure the same thing in different ways, and that is complicating the analysis. I’ve tried with different subsets of data, but I need to spend more time identifying the variables that are the most important for this analysis. I also have several downed wood metrics which I want to analytically combine into one metric, but I’m struggling with figuring out how. I could calculate the average volume of downed wood, average surface area covered by downed wood, or average number of down logs, all per meter squared. Hopefully refining these will help.

This messy ordination of treatments could also just be due to how messy sites look after these disturbances, and may be hard to group by some of the environmental variables. For example, salvage logged plots often have lots of downed wood because all non-merchantable scraps are left on-site, but this is not always the case because sites may have differed slightly in their composition pre-fire, in fire severity, or in landowner protocol. So some of these sites may score high in downed wood, while on the ground they don’t necessarily look like suitable habitat. Aside from that, this could be a relatively straightforward analysis, once I figure out how to be thoughtful about the environmental variables and make the right analysis decisions.

Question 2

I will try a few different strategies for working with my species data. I plan to try ordination techniques like PCoA with salamander data added to the predictor variable matrix to see how they shake out in relation to site specific groupings. I’ll also try constrained ordination to investigate environmental gradients that may differentiate the two species. I’ll also work with classification and regression trees, which seems like it will be the most successful with my data, to help me parse out important variables that are associated with salamander presence or count.

This investigation will help to understand how habitat features like downed wood are changing under modern disturbance regimes in Oregon, and how those changes are impacting salamander occupancy. Several terrestrial salamander species are considered at-risk, and many have poorly defined distributions and habitat associations, challenging timber producers and resource managers to protect habitats for these species while maintaining timber production and mitigating fire risk. Managing for downed wood in these habitats and understanding their regulatory influence on species of conservation concern will contribute to the holistic conservation of forest ecosystem function in managed landscapes within PNW forests and beyond5,7.

References

1. Garcia, T. S., Johnson, J., Jones, J. & Kroll, A. J. Experimental evidence indicates variable responses to forest disturbance and thermal refugia by two plethodontid salamanders. *For Ecol Manage* **464**, (2020).

2. Kroll, A. J. *et al.* Evaluating multi-level models to test occupancy state responses of plethodontid salamanders. *PLoS One* **10**, (2015).

3. Clayton, D. R. & Olson, D. H. *Conservation Assessment for the Oregon Slender Salamander (Batrachoseps Wrighti)*. (2007).

4. Miller, M. P., Haig, S. M. & Wagner, R. S. Conflicting patterns of genetic structure produced by nuclear and mitochondrial markers in the Oregon slender salamander (Batrachoseps wrighti): Implications for conservation efforts and species management. *Conservation Genetics* **6**, 275–287 (2005).

5. Kluber, M. R., Olson, D. H. & Puettmann, K. J. Downed wood microclimates and their potential impact on plethodontid salamander habitat in the oregon coast range. *Northwest Science* **83**, 25–34 (2009).

6. Kauffman, J. B., Ellsworth, L. M., Bell, D. M., Acker, S. & Kertis, J. Forest structure and biomass reflects the variable effects of fire and land use 15 and 29 years following fire in the western Cascades, Oregon. *For Ecol Manage* **453**, (2019).

7. Betts, M. G. *et al.* Old-growth forests buffer climate-sensitive bird populations from warming. *Divers Distrib* 24 (2018) doi:10.1111/ddi.12688.