Investigating Determinants of Richness in Ephemeral and Permanent Wetlands Using Linear Models in Shiny[a]

Class Activity

In this activity you will explore a set of data from 57 wetlands: 33 ephemeral ponds and 24 permanent wetlands. You will create and compare linear models of species richness between:

- Ephemeral and permanent wetlands
- Plant species and aquatic macroinvertebrate taxa

in order to determine (a) what factors correlate with species richness in wetlands and (b) whether the strength of the relationship depends on the wetland's hydrologic stability (i.e. whether it is permanent or ephemeral). You and your partner will be given a table that describes the different variables collected in these wetlands.

Part 1: Hypothesis Generation

1. Check out the study area. Go to Google Maps and type in "Chippewa Moraine State Recreation Area". Switch to satellite view and zoom out. What do you notice about the topography and distribution of wetland areas?

2. What types of environmental stresses or disturbances would you expect to be present in each of these wetland types? What types or amounts of competition between taxa would you anticipate (e.g., large competition for light).

Ephemeral ponds:

Permanent wetlands:

3. Speculate as to how plant and aquatic macroinvertebrate richness might differ between ephemeral and permanent wetlands. For each, state this speculation as a hypothesis which provides your rationale or reasoning.

Plants: Macroinvertebrates:

4. Choose an environmental variable that you think most strongly impacts the species richness of plants and aquatic macroinvertebrates? Why do you think this variable has a strong effect?

[a]Adapted from Little, A.M. (2018). Environment-richness relationships in ephemeral and permanent wetlands: Guided inquiry with graph interpretation. *Teaching Issues and Experiments in Ecology, 13,* online at http://tiee.esa.org/vol/v13/issues/data_sets/little/abstract.html

5. Speculate how this environmental variable differs between ephemeral and permanent wetlands by doing some internet research, then state this speculation as a hypothesis which provides your rationale or reasoning.

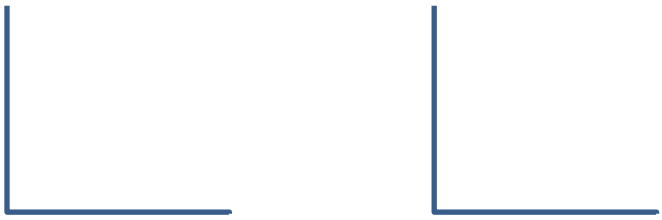
6. Now you will be comparing the relationship between this variable (i.e. the one you chose in Q4) and species/taxa richness in both ephemeral and permanent wetlands. Do you think that the relationship between this variable and richness will be the same or different in these two types of wetlands and why? That is, do you expect an **interaction** between hydrologic stability and the environmental variable you chose, and do you think this interaction is positive or negative? Clearly explain your reasoning.

7. Visualize it! Draw your hypothesis and label the graphs below with:

- Axes
- Lines showing whether species richness increases or decreases with your abiotic variable. Pay particular attention to the slope and intercept.

Plant species richness

Ephemeral Ponds: Permanent Wetlands: Explanation:



Aquatic macroinvertebrate taxa richness

Ephemeral Ponds: Permanent Wetlands: Explanation:

Which variable is your explanatory (aka predictor or independent) variable?

Which variables are your response (aka dependent) variables?

Part II: Create graphs to determine how the data compares to your hypotheses.

Visualize the relationship between plant species richness and your explanatory variable for the ephemeral wetlands by making a graph using the Shiny App at https://kristoforvoss.shinyapps.io/dig_practice/. Your instructor will discuss how to (a) use the app, and (b) how to interpret the model results shown on the model summary tab. Make sure you understand how to interpret the R output before proceeding. Use year 2013!

8. Describe your findings by filling out the following table.

Relationship: Plant Species Richness vs _____

<table>
<tr><th>Ephemeral wetlands</th><th>Permanent wetlands</th><th></th></tr>
<tr><td>Rough drawing of graph:</td><td>Rough drawing of graph:</td><td></td></tr>
<tr><td>Slope Estimate:

Circle one: (nearly flat, positive, negative)</td><td>Slope Estimate:

Circle one: (nearly flat, positive, negative)</td><td rowspan="2">Do slopes differ statistically and how do you know?</td></tr>
<tr><td>Interpretation of slope:</td><td>Interpretation of slope:</td></tr>
<tr><td>Intercept Estimate:</td><td>Intercept Estimate:</td><td rowspan="2">Do intercepts differ statistically and how do you know?</td></tr>
<tr><td colspan="2">R^2 value and interpretation:</td></tr>
<tr><td colspan="3">Overall interpretation of graph:</td></tr>
</table>

9. Inspect your graphs again. Do any graphs have data points that appear to be "outliers" (distant from other observations) or "influential" (i.e. affecting the regression slope)? Explain. *(Note: There are formal statistical tests to determine whether points are outliers and can be discarded. They should not be discarded without thorough consideration.)*

10. Given outliers, R^2 values, appropriate p-values, and the slope of your lines, are there strong relationships between plant species richness and the environmental variable that you chose? Why or why not?

11. Does the environmental variable you chose interact with wetland hydrologic stability as it relates to plant richness? Explain.

Now repeat these same steps for macroinvertebrate richness.

12. Relationship: Macroinvertebrate Species Richness vs_____

Ephemeral wetlands	**Permanent wetlands**	
Rough drawing of graph:	Rough drawing of graph:	
Slope Estimate: Circle one: (nearly flat, positive, negative)	Slope Estimate: Circle one: (nearly flat, positive, negative)	*Do slopes differ statistically and how do you know?*
Interpretation of slope:	Interpretation of slope:	

Intercept Estimate:	Intercept Estimate:	*Do intercepts differ statistically and how do you know?*
R^2 value and interpretation:		
Overall interpretation of graph:		

13. Inspect your graphs again. Do any graphs have data points that appear to be "outliers" (distant from other observations) or "influential" (i.e. affecting the regression slope)? Explain. *(Note: There are formal statistical tests to determine whether points are outliers and can be discarded. They should not be discarded without thorough consideration.)*

14. Given outliers, R^2 values, p-values, and the slope of your lines, are there strong relationships between macroinvertebrate species richness and the environmental variable that you chose? Why or why not?

15. Does the environmental variable you chose interact with wetland hydrologic stability as they relate to macroinvertebrate richness? Explain.

16. Do the results you found in 2013 seem to hold in 2014? Explain. What important variable might change from year to year that would likely influence the strength of the relationships you observed?

Part III: Explaining Results

17. What ecological processes might be responsible for the relationships that you found between **plant** species richness and your environmental variable in ephemeral and permanent wetlands?

18. What ecological processes might be responsible for the relationships that you found between **macroinvertebrate** taxa richness and your environmental variable in ephemeral and permanent wetlands?

19. Ephemerality and permanency both bring different habitat challenges for organisms. How might the specific challenges of the ephemeral habitats have affected your results?

20. Think about the differences in basic survival and reproduction requirements between macroinvertebrates and plants. How do you think these requirements may have affected any differences in your findings between the two groups?

21. Species/taxa richness was notably higher in one of the wetland types than the other. Using the methods of this activity, can you differentiate the effects of ephemerality versus that of wetland size alone? Why or why not?

22. Can you conclude anything about causation from your findings? What other environmental variables could correlate with the one you chose and possibly be affecting species richness?