

Name _____ Class _____

Background: α -, β -, and γ -diversity

Overview

In this lab you will sample the species diversity of herbaceous plant between two different plant communities. The term alpha diversity (α -diversity) was introduced by R. H. Whittaker together with the terms beta diversity (β -diversity) and gamma diversity (γ -diversity). Whittaker's idea was that the total species diversity in a landscape (γ -diversity) is determined by two different things, the mean species diversity in sites or habitats at a more local scale (α -diversity) and the differentiation among those habitats (β -diversity).

α -diversity

α -diversity is simply a measure of the number of species (*species richness*) in a specific plot. In this manner, α -diversity can be thought of as plot-level diversity.

γ -diversity

γ -diversity is simply the total number of species recorded in a census of a specific community. γ -diversity can also be thought of as the *species pool*.

β -diversity

β -diversity was defined by Whittaker (1972) as "the extent of species replacement or biotic change along environmental gradients." β -diversity measures the turnover of species between two sites in terms of gain or loss of species. Here γ -diversity is the total species diversity of a landscape, and α -diversity is the mean species diversity per habitat. β -diversity quantifies how many subunits there would be if the total species diversity of the dataset and the mean species diversity per subunit remained the same, but the subunits shared no species.

In the strictest sense β -diversity is measured as:

$$\beta = \frac{\alpha}{\gamma}$$

In other words, β -diversity measures the differentiation in species among plots within a single community. If the mean β -diversity in a community is low (near 0), there is high *turnover* of species from one plot to another. While if mean β -diversity in a community is high (near 1), many of the plots measured share the same species.

Lab 1: Plant Community Sampling

In this lab you will sample the species diversity of herbaceous plant between two different plant communities. Before you begin, determine which two different plant communities you will measure. Examples include: 1) under the canopies of trees vs. in the open, 2) under shrubs vs. under trees, 3) the slope of a stream bank vs. the top of the stream bank, 4) under two different types trees (i.e. oak vs. pine), 5) adjacent to a sidewalk vs. not adjacent to a sidewalk, or 6) mowed vs. not mowed. Many other possibilities exist. Feel free to use your imagination to come up with two different environments to sample.

Which two plant communities will your lab group examine?

Lab 1: Plant Community Sampling

Materials

- Quadrat (1m²) – you can make this by making a string square with each side measuring 1 meter with pencils for corners.
- 2 Clipboards
- Tape

Protocol

Quadrat Sampling

Herbaceous plant communities are very commonly assessed with a quadrat sampling protocol. In this lab, you will use 1 m² square quadrats to estimate the *species diversity*, or number of species, per quadrat. Once you arrive at your plant community:

Plant Community 1

1. *Determine the species diversity of your first plant sample*
 - a) Randomly place your transect in your first plant community.
 - b) Determine the number of unique plant species within your quadrat. This is known as alpha species diversity (α -diversity). Record this in Table 1 under α -diversity.
 - c) Collect examples of all unique species. Tape them to a piece of paper and number them.
2. *Determine the species diversity of your second plant sample*
 - d) Randomly place your transect in another spot in your first plant community.
 - e) Determine the number of unique species (α -diversity) in the second quadrat.
 - f) Identify any species present in the second sample, not found in the first sample. Collect them, tape them to the piece of paper and number them. In Table 1, cumulative diversity. For example, if you found four species in transect 1 and three species in transect 2 (but two of the species in transect 2 were different than transect 1, the cumulative diversity for sample 2 would be $4 + 2 = 6$.
3. *Repeat this procedure a total of 15 times*
4. *Calculate gamma diversity (γ -diversity).*
 - g) γ -diversity is the total number of species present in a plant community. So it will be your final cumulative diversity. Record your result in Table 1
5. *Calculate beta diversity (β -diversity) for each transect*
 - h)
$$\beta = \frac{\alpha}{\gamma}$$

Plant Community 2

This procedure is exactly the same as Plant Community 1. Throw away the paper with the plants taped to them and repeat Steps 1-5 of the Protocol for Plant Community 1 for your second plant community.

Lab 1: Plant Community Sampling

Results

In the field record the alpha diversity (α -diversity) and cumulative diversity for your two plant communities in the table below. Write your plant communities below. Back in the lab, determine gamma (γ) diversity and calculate beta (β) diversity.

Community						
Transect	α	cumulative	β	α	cumulative	β
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
γ -diversity						

Lab 1: Plant Community Sampling

ANALYSIS

In order to summarize data of this nature, we use statistics. A common statistic is mean. However, simply calculating the mean of the two groups doesn't tell us whether or not those two groups are "statistically significantly" different. For that we need a statistical test. For this analysis, we will be using a simple test known as an unpaired *t* test.

Unpaired *t* test

In our case the unpaired *t* test will compare the means of two groups. Our two groups are "community 1" and "community 2." With this test, we will be able to determine whether or not the difference in the means of diversity metrics of your two different plant communities. In other words, we will be able to determine whether or not there is a difference between the α -diversity of the transects of your two different plant communities.

Protocol

Go to: <http://www.graphpad.com/quickcalcs/ttest1.cfm>

1. Under "1. Choose data entry format", select "Enter up to 50 rows."
2. Under "2. Enter data" you will input your data
 - a. First change the label to correspond with the plant communities you sampled (i.e. under tree vs. in open field).
 - b. Input the data from those two columns only.
3. Under "3. Choose a test", select "Unpaired *t* test."
4. Under "4. View the results", click on "Calculate now."

If you have never taken a statistics class before, the results spit out by QuickCalcs (GraphPad Software, 2013) might be a little intimidating. Have no fear! We will just focus on the statistics that will answer our question.

p value

The *p* value allows us to determine whether or not the means of the two samples are "significantly" different. When you take a statistics class, you will learn how this statistic is created. For our purposes, it is sufficient to be able to interpret this statistic without actually knowing how to calculate it.

The *p* value is the probability (ranging from zero to one), that answers whether or not the observed means of two populations (e.g. "under tree" and "open field") are real and not merely a product of chance. In most biological studies, if the *p* value is less than 0.05 we can state that there is, in fact, a "statistical" difference between the two populations. This is somewhat of an artificial cut off, but it is one that is widely accepted in this field of study. Therefore, in our study if you get a *p* value less than 0.05, you can state that there is a "significant" difference between the two plant communities.

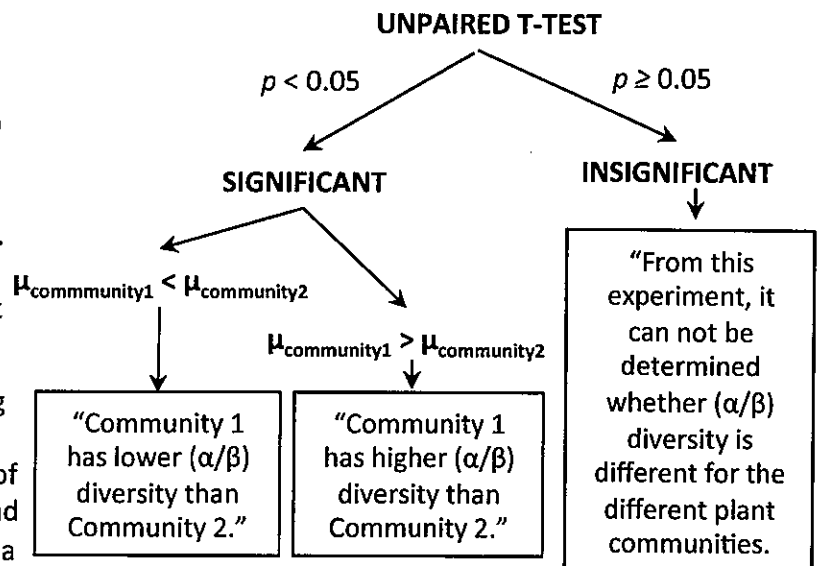


Figure 1. Interpreting the results of the unpaired *t* test.

Lab 1: Plant Community Sampling

Mean

The mean is simply the average. If you find that there is a significant p value ($p < 0.05$), then the next step is to look at the means (Fig. 1). If the mean is larger for the "Plant Community 1" group, this means that this community has higher diversity (either α or β).

RESULTS

In a t test, it is customary to report the mean (m) of the sample, as well as the p value. You will report your results like the example in fig 2).

☒ Below (Fig. 3) construct a bar graph for each test.

- Be sure to include the p value of each test.
- Be sure to record the mean of your plant communities above or inside its corresponding bar.
- Be sure to provide numerical values on the y axis.
- Be sure to label your plant community types below the x -axis.

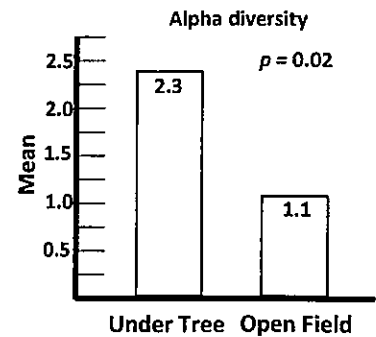


Figure 2. Example of a bar graph.

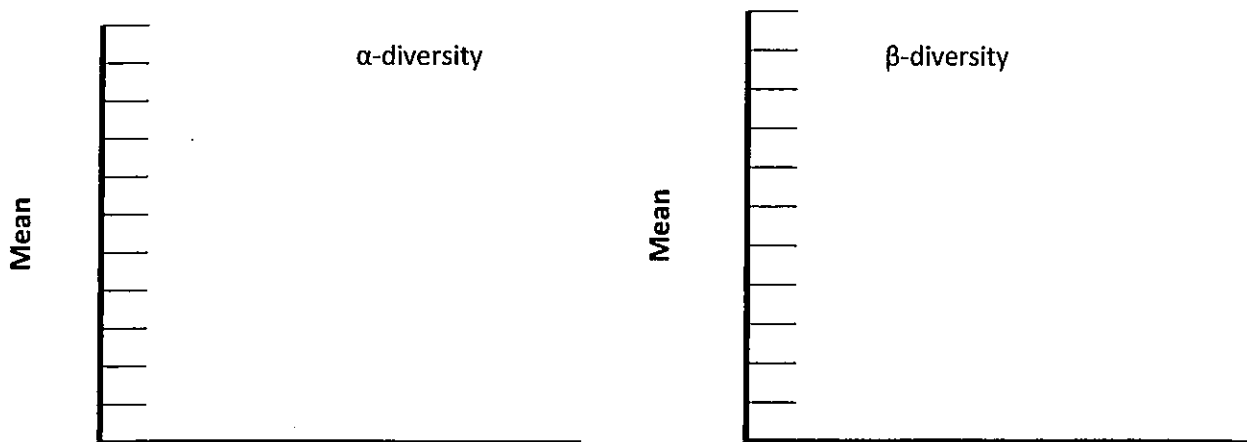


Figure 3. A comparison of α - and β -diversity between two plant communities.

Was α -diversity between your two plant communities different? If so which was higher?

Was β -diversity between your two plant communities different? If so which was higher?

Lab 1: Plant Community Sampling

Interpret the differences in α -diversity and β -diversity between your two plant communities. What do your findings mean?

If you had a plant community (Plant Community 1) that statistically higher α -diversity and statistically lower β -diversity than a comparative community (Plant Community 2), what could you infer about make up of species from plot to plot in Plant Community 1 (relative to Plant Community 2).