

## Exercise 4B

# Measuring Biodiversity — Arthropods

### Research Question

How diverse are the invertebrates on campus?

### Preparation

We will examine invertebrate communities from sites on campus. Each group will place three pitfall traps in the ground in different areas. The following lab period, we will collect the samples and identify distinct groups of animals and measure abundance of each group. We will not be identifying organisms to species — instead, we will work with larger taxonomic groupings (class, order, and family) using the keys provided or online.

Once organisms are identified, we will determine taxon (“species”) richness and evenness and calculate an index of biodiversity (the Shannon index). We will also construct species-accumulation and rank-abundance curves as described in the pre-lab.

### Materials (per laboratory team)

Containers for pitfall traps

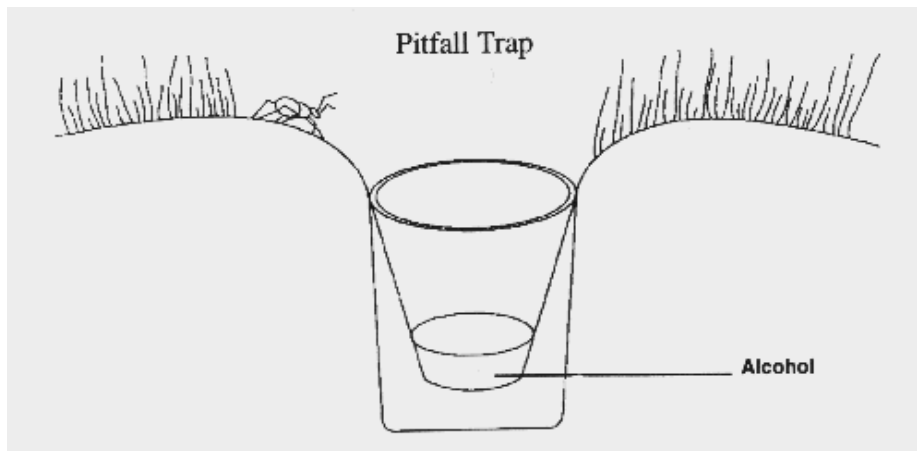
Hand trowel

Dissecting microscope

Guide to invertebrate identification

### Procedure

1. For each of the assigned sites, locate an area where your trap is unlikely to be disturbed over the sampling period (an area with little foot traffic). Mark the site with a survey flag.
2. With a trowel or other digging instrument, dig a hole large enough and deep enough so that your entire trap fits into the ground and the top of the trap is flush with or a little below the surface of the soil. If the top of the container is above the surface of the soil, you will not catch anything! Leave the traps until the next lab period.



3. The next lab period, collect the traps and return to lab. Examine your specimens using a dissecting microscope. Using the key provided, identify the organisms in your sample. Sort into families of like organisms and enter data into Table 4.3. Sum the number of individuals of each group, and include these totals in the right-hand column of the table.

4. Transfer these totals to the Shannon Calculation Table (Table 4.4). Calculate H, the diversity index for this sample, following the example from Exercise 4A [pre-lab].
5. Use your value of H to calculate species evenness (J), following the example in Exercise 4A.
6. Enter your data in the class spreadsheet.
7. Use class data to complete Table 4.5.  
Be sure the numbers entered reflect only the new groups of organisms observed (that is, those seen for the first time in each sample).
8. Using the class data, draw a species accumulation curve in Figure 4.5.
9. Using class data, complete Table 4.6.  
Be sure groups are ordered by rank (from most abundant to least abundant). Include the number of organisms observed for each family and sum to find the total number of organisms observed. To determine the proportional abundance for a group, divide the number of individuals in that group by the total number of organisms observed.
10. Using the data in Table 4.6, draw a rank-abundance curve in Figure 4.6.
11. Use the class data spreadsheet to calculate S, H, J, and  $s^2$  for the class data at the site.

To calculate variance for the H-value, use the equation:

$$s_H^2 = \frac{\sum p \cdot (\ln p)^2 - \left(\sum p \cdot \ln p\right)^2}{N} + \frac{S - 1}{2N^2}$$

This equation looks intimidating, but can be fairly straight-forward.

We already made a column to calculate and sum ( $P_i \cdot \ln P_i$ ) to find the H-value. Now we just add another column to calculate and sum ( $P_i \cdot [\ln P_i]^2$ ).

Note in the equation that  $s^2$  is variance, but **S** is species richness, not standard deviation!

Also note that **N** is total number of individuals of all species; *not* number of samples!

For additional explanation, see:

"Computing variance for the Shannon diversity index" at

<http://www.dataanalytics.org.uk/Publications/S4E2e%20Support/exercises/Comparing%20shannon%20diversity.htm#intro>

**Table 4.3** Data Table for Ground Invertebrates

Trap Sample #	Species Identified	Number of individuals (Tally Marks)	Total number of individuals
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			
25.			
Total Number of individuals in the sample:			

**Species Richness (S) =**

**Table 4.4** Shannon Calculation Table for Ground Invertebrates

Species in Samples	$N_i$	$P_i$	$\ln P_i$	$-(P_i \cdot \ln P_i)$	$(P_i \cdot [\ln P_i]^2)$
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
<b>SUM</b>	<b>N=</b>			<b>H=</b>	

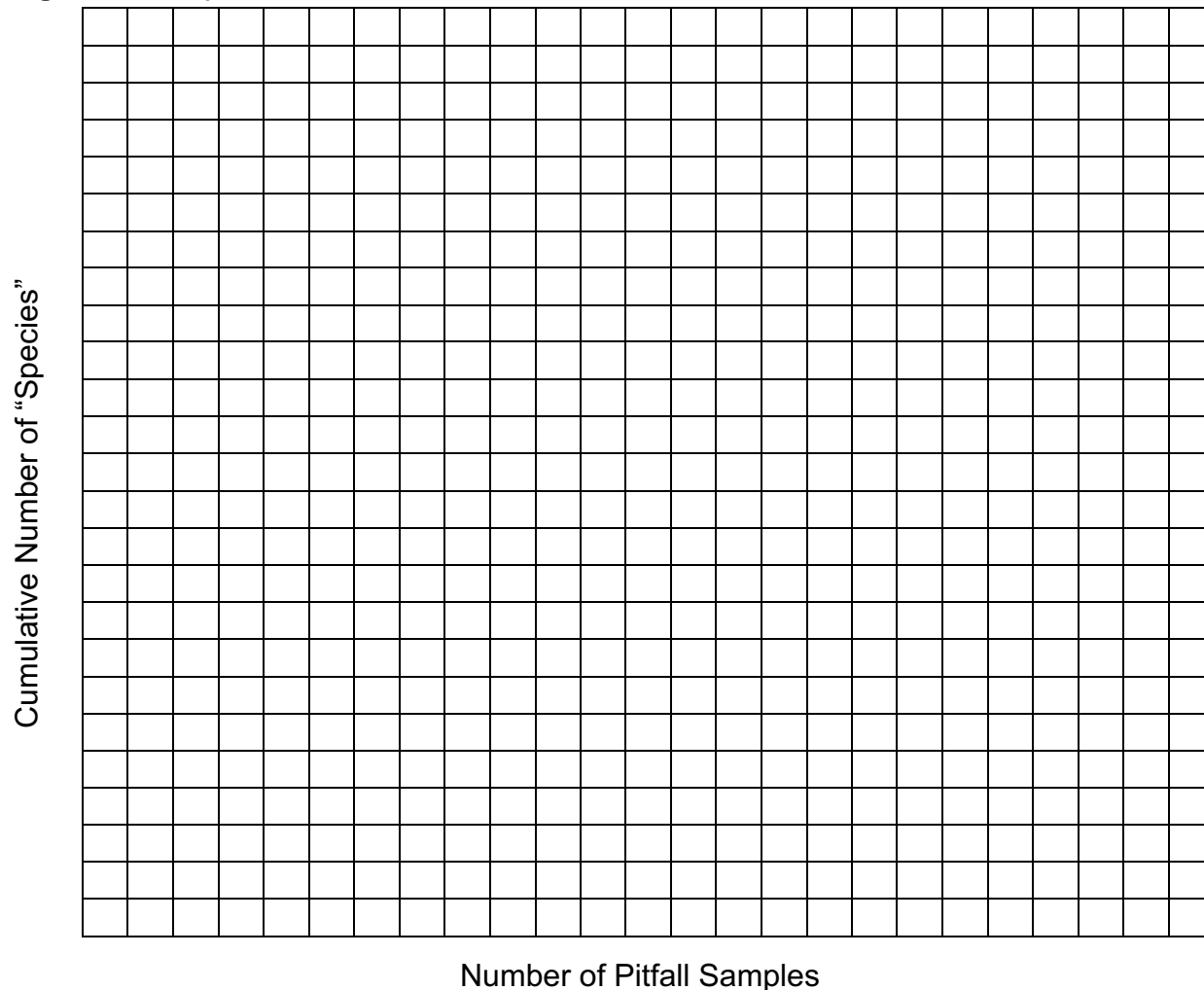
**Species Evenness (J) =**

**H-value variance ( $s^2_H$ ) =**

**Table 4.5** Species Accumulation Data for Ground Invertebrates

		<b>Cumulative “Species” Number</b> (only include new species for each sample)					
<b>Group</b>	<b>Sample Number</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>
	1						
	2						
	3						
	4						
	5						
	6						
	7						
	8						

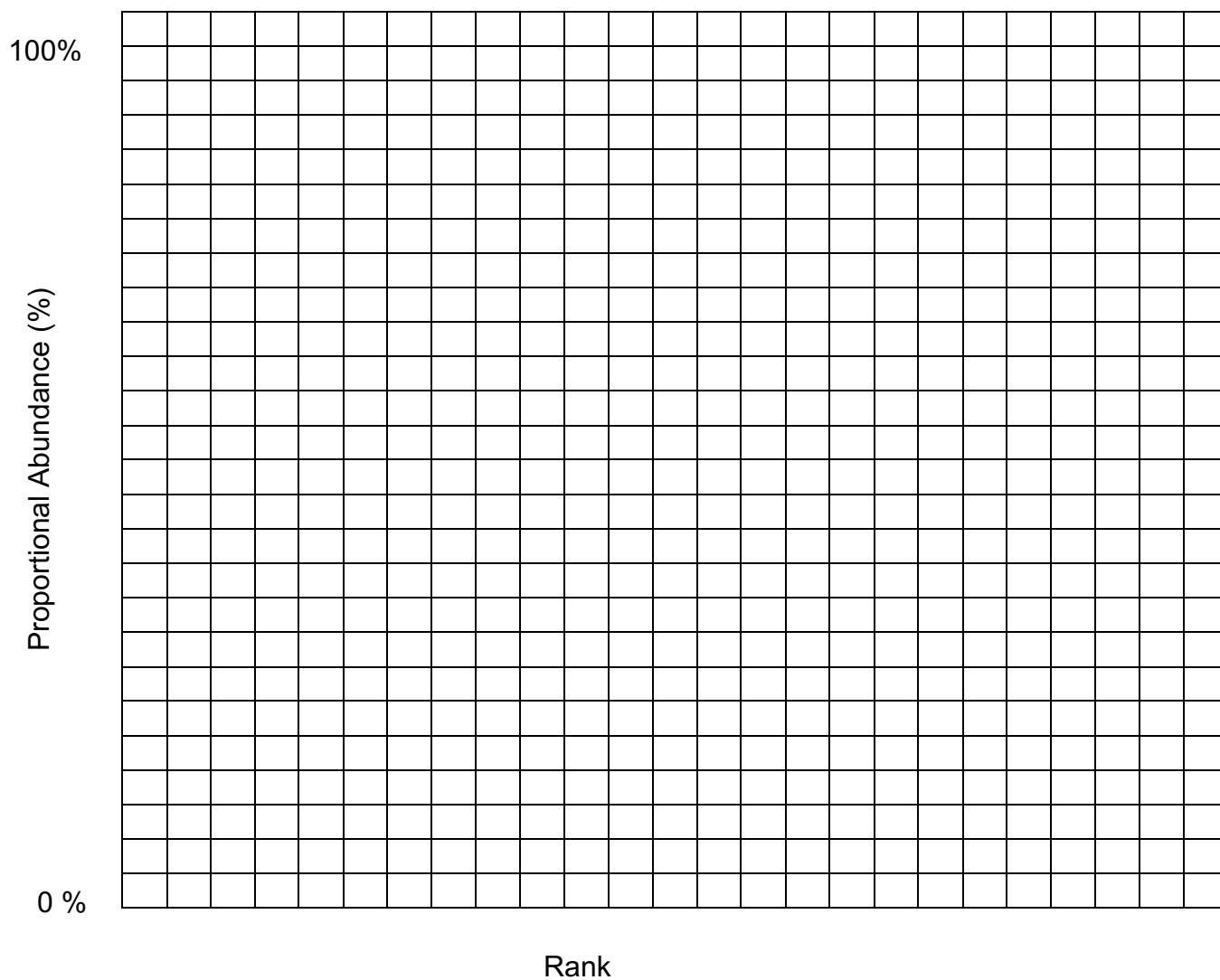
**Figure 4.5** “Species” Accumulation Curve for Ground Invertebrates



**Table 4.6** Rank Abundance Data for Ground Invertebrates

<b>Rank</b>	<b>Species</b>	<b># individuals</b>	<b># individuals / total # observed</b>
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
<b>Total =</b>			

**Figure 4.6** Rank- Abundance Curve for Ground Invertebrates



## Part I — Conclusions

For any given population, the highest possible value of  $H$  is equal to the natural logarithm of the number of species in the sample. Both for your sample and for the class data, how does  $H$  compare with its theoretical upper limit? Explain what this means.

How does the slope of your rank-abundance curve relate to your calculated  $J$  value?

What conclusions can you draw about species richness of your sample sites? Do you think your collection of samples includes more than half of all species present at each site, or not? Explain, using your species accumulation curve.



## Part II — Comparing two locations

We can use the analyses described in Part I to compare different locations, seasons, or habitats. We'll describe here using the Aquatic Invertebrate data we collected at different sites in Stevens Creek from our Stevens Creek fieldtrip.

1. Draw species accumulation curves for the class data at each site as separate curves on the same graph.
2. Draw a bar graph of the number of pollution-sensitive taxa, of pollution-moderately tolerant taxa, and of pollution-very tolerant taxa observed only at Site 1, observed both at Site 1 and at Site 2, and observed only at Site 2.
3. Draw rank abundance curves for the class data at each site as separate curves on the same graph. Make sure each line clearly indicates its respective site.
4. For these rank abundance graphs, also color code the specimen data points as to their pollution tolerance indication:
  - Green = pollution-sensitive (Taxon Group 1)
  - Yellow = pollution-moderately tolerant (Taxon Group 2)
  - Red = pollution-very tolerant (Taxon Group 3)
5. Calculate S, H, J and  $s^2$  for class data from each creek site separately.
6. Use the H values and variances to perform a Hutcheson  $t$ -test to determine if there is a significant difference in aquatic invertebrate diversity between the two creek sites. [NOTE: the Hutcheson  $t$ -test uses different calculations than the Student  $t$ -test done in Exercise 1c.]
  - To Calculate the  $t$ -statistic ( $t_{stat}$ ), use the formula:

$$t = \frac{H_a - H_b}{\sqrt{S_{H_a}^2 + S_{H_b}^2}}$$

- To Calculate the *degrees of freedom*, use the formula:

$$df = \frac{(S_{H_a}^2 + S_{H_b}^2)^2}{\left( \frac{(S_{H_a}^2)^2}{N_a} + \frac{(S_{H_b}^2)^2}{N_b} \right)}$$

- Use  $df$  to find the **critical  $t$ -value** from **Table 1.8** in Exercise 1c.
- Compare your  $t_{stat}$  to the **critical  $t$ -value** as done for the Students  $t$ -test in Exercise 1c.

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Again refer to: "**Comparing the Shannon diversity index of two samples using a t-test**"

<http://www.dataanalytics.org.uk/Publications/S4E2e%20Support/exercises/Comparing%20shannon%20diversity.htm>

7. Answer the "Conclusions" questions from Part 1 for each of these sites in Part 2. Then compare and contrast these conclusions for the two sites.
8. Discuss all the above results comparing and contrasting the two sites with respect to the points discussed on the Stevens Creek field trip.

