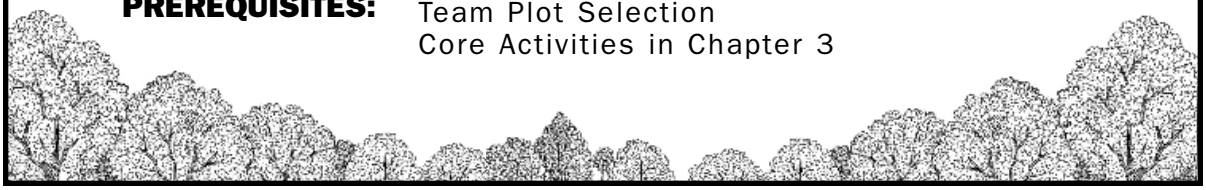
CHAPTER 4: PLANT ECOLOGY

"You just have to start at a particular point and count. Concentrate on what you're doing and try not to lose track."

—LIZ JOHNSON
(*Plant Inventory*, p.184)

TARGET QUESTION: **How many plants are in each plot? Why do different plants grow in different areas?**

PREREQUISITES: Team Plot Selection
Core Activities in Chapter 3



CORE ACTIVITIES:

LESSON 1

Why Count Plants?

LESSON 2

How Many Plants Are There in Each Plot?

LESSON 3

Comparing and Entering Data

Optional Activities

- Class Discussion: What Percentage of Each Plot is Covered by Vegetation?
- Field Trip: Calculating the Percentage Cover in Each Plot
- Data Analysis: Comparing and Transcribing Data
- Calculating a Biodiversity Index
- Calculating a Frequency Rate

ASSESSMENTS:

Refining the Explanation of Biodiversity

WEB COMPONENTS:

FOR TEACHERS

- How to Calculate a Biodiversity Index

FOR STUDENTS

- Plant Inventory*

* All Web reading selections for students are available as blackline masters.

OVERVIEW OF CHAPTER 4

Students speculate on why plants are more abundant in some areas of the site than others. They list factors that might account for the differences, such as temperature, humidity, light, soil, rainfall, wind, and human or animal activity, and figure out how they can collect more data on these factors.

They discuss why it might be important to take a count of all the individual plants in each plot and develop a plan for conducting the field study. A reading selection describes how scientists count plants and gives students tips for conducting their own survey. Students then count plants and record their data.

Several optional activities are provided. In the first, students discuss the idea that finding out what percentage of each plot is covered by vegetation would give them another way to compare the plots quantitatively. It would also help develop a composite picture of the whole site. They devise methods and tools to find out the percentages and then go out into the field to collect the necessary data. Later, they compare the percentage of vegetation in their plots.

The second optional activity teaches students to calculate a simple biodiversity index, a formula scientists use to quantify biodiversity in a given area.

The third optional activity encourages students to use their own data to calculate a frequency rate for the plants appearing in their plots.

BACKGROUND INFORMATION FOR THE TEACHER

Plants are remarkably adaptive organisms, inhabiting such diverse environments as tropics and tundra, desert and ocean, mountains and marsh. Yet each species has an optimal habitat. There can be many reasons why a plant flourishes in one plot and not in another. For example, because of the differences in slope, or because of the sheltering effect of a large tree, plots just a few feet apart could be receiving very different amounts of water and light. The same conditions of slope or shelter can also be responsible for differences in temperature and wind velocity.

Soil composition has a profound effect on plants. While many plants thrive in rich loam, only some specialized types can survive in sand or in compacted clay, and fewer still can find a foothold on rocky ledges. Each type of soil has a different capacity for retaining moisture, and each contains varying amounts of nutrients to give to the plant.

Human activity plays a large part in determining plant abundance and diversity. If an area is maintained as a park, or if it is farmed, then humans have played a large part in planting, fertilizing, and cultivating the plants. If an area is heavily traveled, paved, littered, exposed to a source of pollution, or clear-cut, then humans have played quite a different role.

TEACHING TIP: PROBLEM SOLVING

Taking an inventory of the plants in each plot may present students with new challenges. It is helpful to discuss some of the problems they will encounter before they actually go out into the field. Then the class as a group can decide how to deal with the situations in a consistent manner.

The reading selections provide some practical tips from field biologists. In general they recommend that the plant inventory be a count of all the whole, living plants. Although students may find plant parts, like acorns or fruits, and dead plant material, these should not be included in the count. Grasses and other ground cover that blanket an area should be estimated rather than counted plant by plant.

1

LESSON

LESSON 1 **WHY COUNT PLANTS?**

TIME 1 class period

MATERIALS ❑ Journals

WEB COMPONENT

Plant Inventory

1. Now that students have analyzed what kinds of plants are present in their plots, ask them to estimate how many plants are growing in their own plot. Have them record their estimate in their journals.

2. Then ask:

- Why might it be important to know how many plants are in your plot?
- What might that number tell you about your plot? About the whole site?
- How could you use those numbers to compare plots at our site and with other sites participating in the project?

3. Discuss the factors that influence the numbers and kinds of plants in each plot. Give students a few minutes to retrieve the data from their journals that relate to the measurements they made of the environmental factors at the site. Have them draw up a two-column chart that lists possible reasons why there may be different numbers of plants in each square and ways they are measuring those differences.

WHY ARE THERE DIFFERENT NUMBERS OF PLANTS IN EACH PLOT?

Possible reasons for differences	Ideas on how to measure
Temperature	Thermometer
Moisture	Rain gauge, humidity indicator
Sunlight/shade	Timed observations, light meter
Soil	Tests for pH, particle size, and color
Foot traffic	Observations, soil test for compaction
Fertilizer	Ask groundskeepers what they use, how much, and where

4. Analyze the quality of the data students already collected on the factors they listed. Ask students how they think they could collect more evidence. Encourage them to continue collecting evidence on the effects of environmental factors in future field trips.

5. Then help students develop a plan for how they will go about taking a plant inventory. Ask:

- What will you observe? Count? Measure?
- How many different ways will you record the data?
- What tools will you need?
- What are some of the problems you might have? Describe some scenarios and ask the class to problem-solve. For example: What will you do if you

find an acorn (or some other plant part)? What if you find dead plant parts? What if you have a lot of grass in your plot? Should you count every blade?

Help students come to some agreements so that the entire class deals with the same problem in the same way.

6. Direct students to the reading selection, "Plant Inventory." Later, discuss the information. Ask students to summarize the different methods the two scientists used to take a plant inventory. Point out some of the problems the scientists faced in the field and ask how they resolved them.

2

LESSON

LESSON 2

HOW MANY PLANTS ARE THERE IN EACH PLOT?

TIME 1 or more field sessions

MATERIALS

- ❑ Journals
- ❑ Hand lenses
- ❑ Frames or markers for team plots
- ❑ Compasses
- ❑ Equipment for measuring environmental factors

1. ***At the site, check that students are clear on the key questions. Remind them of their safety rules and then send them off to begin the plant count.***

2. ***Circulate among the teams as they work and use some of these questions to help them stay on task:***

Tasks	Focus Questions
To count all the plants in each plot	How are you counting? How has your team divided up the task?
To solve problems as they arise	What problems have you encountered about what or how to count? How did you solve them? Should we discuss the problems as a group?
To record new questions	What new questions arose today? Where did you record them?
To collect data on environmental factors	How are you measuring and recording the environmental factors that influence your plot? What tools are you using?

3. ***If students are not able to complete the plant count in the allotted time, have them mark precisely where they left off. Plan to return to the site within the next few days to finish the count.***

LESSON 3

LESSON 3 **COMPARING AND ENTERING DATA**

TIME 1 class session

MATERIALS ❑ Journals

1. Back in the classroom, give teams time to go over their data, making sure that each team member has a complete set of notes in his or her personal journal.

2. Discuss what students found out. Ask:

- How did your predictions of numbers of plants compare with the data you collected?
- Were there considerable differences in the numbers of plants from one plot to the next?
- What might those differences mean? What do the numbers of plants tell you about the plot you are examining?
- Have students again speculate on what factors might account for the differences. Are there any other factors they want to add to the list? Record their ideas.

OPTIONAL ACTIVITY 1a

CLASS DISCUSSION	**WHAT PERCENTAGE OF EACH PLOT IS COVERED BY VEGETATION?**
TIME	1 class session and 2 or more field sessions

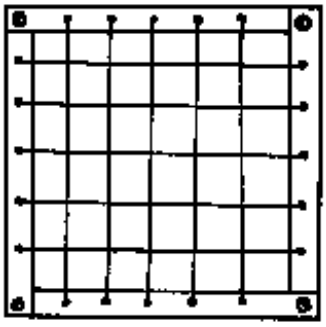
Discuss how vegetation is distributed over each plot. Ask students to estimate what percentage of their plot is covered by vegetation and to record that number in their journals. Use some of these questions to prepare them for the fieldwork:

- Why would it be useful to look at the percentage of vegetation in each team plot? What would those numbers tell you about the plots? About the site?
- What could you invent to mark off your plot into equal sections to make calculating percentages easier? How many sections would you use in your plot?

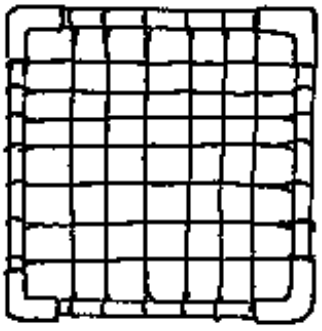
TEACHING TIP: CONSTRUCTING GRIDS

To make it easier to determine what percent of a plot is covered in vegetation, students may want to construct grids to fit inside their frames. Dividing the team plot into four equal parts is perhaps the easiest way, but students may elect to divide their plots into larger or smaller parts if the area is better handled that way.

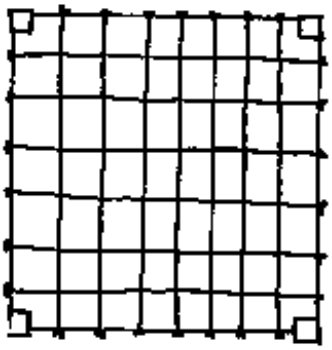
Here are some suggestions for ways to construct grids:



WOOD FRAME WITH TACKS AND TWINE



PVC PIPE WITH TWINE



STAKES AND TWINE

- How are percentages calculated? (Depending on the skill level of the class, you may want to give a brief review of calculating percentages.)
- To prepare students to categorize their data, introduce the scale below and discuss it with the class. Ask them to predict the percent coverage of their own team plot.

SCALE FOR CATEGORIZING PERCENT COVERAGE

Percent Vegetation	Coverage
0%	bare, no vegetation
0 to 20%	sparsely covered
20 to 40%	lightly covered
40 to 60%	half covered
60 to 80%	mostly covered
80 to 90%	almost blanketed
>90%	blanketed

OPTIONAL ACTIVITY 1b

FIELD TRIP	**CALCULATING THE PERCENTAGE COVER IN EACH PLOT**
TIME	2 or more field sessions
MATERIALS	❑ Equipment students bring in or invent for measuring factors that influence plant abundance, such as rain gauge, thermometer, soil test kit, light meter ❑ Frames or other markers, plus materials for marking these off into grids (twine, wire, metersticks) ❑ Calculators

1. Before going out, check that students have constructed or brought in all the equipment they need. Remind them of their tasks at the site. Outdoors, go over the safety rules and then set them off to work. Circulate to check on progress. Use some of these questions:

Tasks	*Focus Questions*
To determine what percentage of the plot is covered by vegetation	How have you subdivided the plot? Into how many divisions? How will you calculate the percentage coverage?
To measure environmental factors that influence the plot	What factors are you measuring? What tools are you using to measure?
To record data	How are you recording the data?

2. If students cannot complete the tasks in the allotted time, have them make note of exactly where they left off and plan to return soon to finish.

OPTIONAL ACTIVITY 1c

DATA ANALYSIS	**COMPARING AND TRANSCRIBING DATA**
TIME	1 class session
MATERIALS	❑ Journals ❑ Map Number Two

1. Discuss the new data that students collected. Ask:

- What percentage of your plot was covered by vegetation? How did you figure that out? How did your estimation compare with the data you collected?
- What covered the rest? (bare ground, rock, pavement, mud, human made structure, water)
- How do plots in different locations compare? Here it might be useful to use a class chart to categorize the percent of coverage (as described in Optional Activity 1a).
- Which plots have the highest percentage of plants? Do you think that will affect the numbers and kinds of arthropods you might find there?

2. If you are doing the optional mapping activities, show Map Number Two and have students transcribe their new data onto it. Save the map and the new data for future use.

3. Discuss the factors affecting plant growth that students measured. Ask:

- What do you think are the most important factors determining the numbers of plants in your plot? What evidence do you have to support your theory?
- What measurements did you take of these factors? Describe the equipment you used to take measurements. What worked and what did not?
- For how long should you continue to collect data on these factors to make the data meaningful? How many readings do you think it takes to collect enough data to draw a valid conclusion?

OPTIONAL ACTIVITY 2

ACTIVITY	**CALCULATING A BIODIVERSITY INDEX**
TIME	1 class session
MATERIALS	❑ White pages of a discarded phone book, 1 page per student or pair of students
WEB COMPONENT FOR THE TEACHER	How to Calculate a Biodiversity Index

1. Explain to students that this activity illustrates how to determine the biodiversity index of a particular area. Scientists calculate a biodiversity index when they want to quantify diversity in a given area. The index is a kind of mathematical shorthand. The number of species in an area is divided by the total number of all individuals in that area, and the result is called the biodiversity index of that area. Please see *How to Calculate a Biodiversity Index* on the Web for an example.

   Using pages from a phone book, students can figure out the diversity of surnames on a given page and then compare the diversity found on different pages. The surnames may be thought to represent species, and the page can represent an area.

2. Distribute one page of the white pages section of a discarded phone book to each student or each pair of students. Explain that they will use the listings to figure out the diversity of surnames on one page. Use examples like the following to illustrate the technique.

   Examples

   A. One page contains 300 names and they are all the same name, Smith. To calculate the diversity of names on the page, use this formula:

$$\frac{\text{1 surname (numerator)}}{\text{300 individuals (denominator)}} = 1/300$$

   or 0.003 (index of diversity). This is a very low index.

B. Another page of 300 names lists 200 Smiths, 70 Smithsons, 26 Smitthers, and 4 Smitts. Here the index would be:

$$\frac{\text{4 surnames}}{\text{300 individuals}} = 4/300$$

or 0.013 (index of diversity), a higher index than the first example. The higher number indicates greater diversity.

It is also useful to look at the relative contribution the individuals to the total. Here Smiths represent 200/300 or 2/3 of the group; Smithsons represent 70/300 or 7/30 of the group, and so on.

3. Ask students to calculate the diversity of surnames on their white page. Discuss their findings and compare indexes of different pages.

4. Then ask students to apply the idea to species. Ask:

- What if you were talking about plant species, not names in a phone book? How would you calculate a biodiversity index? What would be the numerator? The denominator? What would the index tell you about an area?
- Which area do you think would have a higher biodiversity index: a rain forest or a cornfield? Explain.
- Which area do you think would be more at risk if the environment changed? Why?

OPTIONAL ACTIVITY 3

ACTIVITY	CALCULATING A FREQUENCY RATE
TIME	1 class session
MATERIALS	❑ Journals ❑ Calculators

1. Have students review their data to find a plant that appears frequently at the site, that is, it is present in many of the plots. Let's use the dandelion (*Taraxacum*) to illustrate. Ask:

- In how many of the plots does the dandelion occur?
- How could you express that as a percentage to state how frequently dandelions occur in your plots?

If dandelions appear in all of the plots and there are ten plots total, then you can use the following formula:

$$\frac{\text{number of plots containing dandelions}}{\text{total number of plots}} \times 100 = \text{frequency rate of dandelions}$$

or $\frac{10}{10} = 1 \times 100 = 100\%$

The dandelion appears in 100% of the plots.

Contrast the frequency of the dandelion with another plant that occurs in only one out of the ten plots. It might be a scarlet oak (*Quercus coccinea*), for example.

$$\frac{1}{10} = 0.1 \times 100 = 10\%$$

This tells us that the scarlet oak occurs in only in 10% of the plots.

2. Then ask students to suggest a way to show the comparative frequency rate of all the plants in their plots. (Simply repeat the above calculation for each plant represented in the plots.)

3. How could students then arrange the resulting frequency rates for all of the plants so that they have an organized picture of all the plants represented in the plots? (They could organize the data on a bar graph or pie chart showing plants ranked in order from those that occur most frequently to those that occur least frequently.)

4. Another way to look at frequency of species in their plots is for students to develop a scale that ranges from rare to common. For example, they might formulate a scale like this:

   If a species occurs in 1% to 20% of the plots, it is rarely present.

   If it occurs in 21% to 40% of the plots, it is seldom present.

   If it occurs in 41% to 60% of the plots, it is often present.

   If it occurs in 61% to 80% of the plots, it is mostly present.

   If it occurs in 81% to 100% of the plots, it is commonly present.

   Caution students not to jump to the conclusion that a species is rare if it occurs rarely in their plots. A scarlet oak is a common enough tree, but it is not commonly present in their plots. They need to look for reasons why there are fewer oaks, or why there are more of some other plant. Mention that one of the principles of biodiversity is that in nature, the larger the organism, the less frequently it occurs. They might create a graph to illustrate this principle.

5. Later in the unit, it is interesting to look for correlations between the frequency of plant and animal species in different plots. To do this, students carry out the same calculations for arthropods as they did for plants above. Then they could ask, for instance:

   - What arthropod appears frequently when there is a high frequency of dandelions?
   - How are the two species connected?
   - How does sunlight, soil composition, or temperature factor in?
   - What would happen if you removed all the dandelions?

ASSESSMENT: REFINING THE EXPLANATION OF BIODIVERSITY

1. Ask students to summarize what they learned from their experiences in taking a plant count. What can you learn from counting plants? Why do you think different numbers of plants grow in different areas?

2. Review the collaborative explanation of biodiversity that students recorded after they completed Chapter 3. Have them critique their earlier thinking and decide if they want to improve their statement, add to it, or make changes.

3. Record their new explanation on the class chart or concept web.