PROTOCOL 2. PLOT SAMPLING—DENSITY AND PERCENT COVER

Sampling

Sometimes it is too time-consuming, expensive, or even impossible to collect data from your entire study area. Sampling allows us to gain information about a site without looking at every plant or animal. Sampling involves taking measurements on small plots that are representative of the larger study area and using the data to represent the entire study area. By locating quadrats using random or stratified sampling, you increase your chances of getting a representative sample. What might be the problem if you chose sampling locations without first setting up a sampling scheme (e.g., by choosing the first spot you encountered or by choosing sites that had lots of the plants you were interested in)?

Objective

To estimate population size or relative importance of invasive and other species in a study area.

Background

How do scientists measure the size of plant populations? Scientists could count every individual plant, but imagine how long this would take in large areas with many plants. When conducting plant ecology research, scientists often select smaller sample plots inside the larger study area. The scientists thoroughly study the plants in the sample plots and then use these results to make generalizations about the entire area.

For plants that are large, relatively easy to count, and not too numerous (less than 100 individuals per m^2), scientists count each stem in the plot to determine density (number of plants per area). When the plants are small and numerous (e.g., clovers, grass, or moss), it is extremely difficult to count each individual stem. In these cases, scientists estimate the percent of the ground covered by the species. In any one plot, you can measure density for plants with stems that are easy to count and percent cover for plants that are too hard to count. However, you must use the same method for the same species for all plots and you can't compare species measured using different methods.

In this protocol, we have included instructions for measuring density and percent cover in 1 m^2 plots. If plants are extremely dense so that it is difficult to count stems or estimate percent cover, you can decrease the size of the plots. For example, you may want to use 0.5 m^2 (0.5 m x 1.0 m) or 0.25 m^2 (0.5 m x 0.5 m) plots. If the plants are sparse and you are not getting a good sample, you can increase the size of the plots.

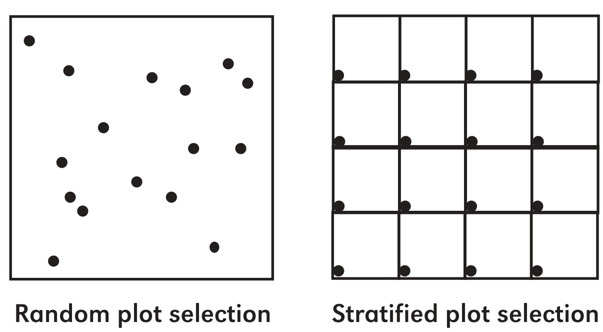
Prior to breaking into student groups to estimate density and percent cover, you should practice making these estimates as a larger class. There are several tricks that you can use to make these measurements easier. For example, you can start at one end of a plot and use a stick to separate stems you have already counted from those you haven't yet counted. To estimate percent cover, you can practice using a square quadrat frame with 10 cm intervals marked off (see below). Percent cover can be difficult to estimate at first, and getting practice beforehand will make things go more smoothly in the field.

When you practice the protocols with other students, you will likely come up with several different questions about exactly how to sample the plants. Making decisions about these details as a class will help standardize how different student groups collect data. This will allow you to combine data from different plots to get averages for the entire study area. It also will make it possible to compare results from different sites.

Prior to making measurements on plants, you will need to locate your study plots. There are many ways to locate small sample plots in a larger study area. Using an accepted method to locate these small plots can help to avoid bias. For example, imagine a research project on the side of a steep mountain. Getting to plots at the top of the mountain takes more effort than getting to plots closer to the bottom, so at the end of a long day of fieldwork, researchers might—perhaps unknowingly—select more plots near the bottom. To avoid this and other types of bias, scientists have developed several methods to locate plots in a larger study area.

Random sampling is one way to locate plots. To randomly select plots, scientists first determine how many plots they want, and then use random numbers to locate them. For example, scientists may first walk a random number of steps along the edge of their study area. Then they choose another random number and walk that many steps into the study area. The sample plot is located at the final step (see Figure 2.1).

FIGURE 2.1.
Random and Stratified Sampling



Each of the study areas has 16 plots represented by the black dots.

The biggest drawback to random plot selection is the possibility that, by chance, all the plots will be clumped or located near each other. Selecting plots using *stratified sampling* is a way of avoiding clumping. When using stratified sampling, scientists randomly locate a starting point and then divide their study area into a certain number of equal boxes. They next locate a plot at the corner of each box.

After locating your sampling plots, you will need to build quadrat frames. Then you will count stems and estimate percent cover of different species on your sampling plots.

PART 1. LOCATING SAMPLE PLOTS—RANDOM AND STRATIFIED SAMPLING

Random Sampling

Materials

Stakes and flagging

Random number table *or* stopwatch *or* phone book

Procedure

1. Locate the corner of the study area in which you will sample (e.g., a wetland).
2. Orient yourself so that you will walk along the longest edge of your study area.
3. Choose a random number using one of the methods described below. If the edge of your study area is less than 99 paces, you will need a random number between 00 and 99. If the number you choose is larger than the maximum number of steps you can take along the edge of your study area, choose the next random number. For example, if your study area is 60 paces long and you choose random number 71, select the next number.
   a. *Random number table.* Locate a random number table, often located in ecology or biology laboratory textbooks. Pick any number on the page, and for each subsequent number you need, choose the next number below.
   b. *Stopwatch.* Using this method you only will be able to generate random numbers with two digits. Obtain a digital stopwatch that measures to the nearest one hundredth of a second. Press the start button, wait a while, and press the stop button. Your two-digit random number is determined by using the digits in the tenth and hundredth places.
   c. *Phone book.* If you do not have access to a random number table or a stopwatch, you can use the white pages (not the pages that contain advertisements) of a phone book. Flip the book open, and choose a name at random. Your random number is determined by choosing the last digits of the phone number. For each subsequent random number you need, choose the next number below.
4. Beginning at your starting point and continuing along the edge of your study area, walk the number of steps indicated by your random number.
5. Turn 90 degrees towards the plot. Choose another random number (use the next number in the table or phone book, or use the stopwatch method again), and walk the number of steps indicated by this second number. You should be walking into your study area in a direction that is perpendicular to the edge of the plot. Walk in a straight line. Try not to veer to the right or left to avoid shrubs or wet spots.
6. The corner of your first sampling plot is located where your foot lands on the last step. You may want to permanently mark the corners of your plot with stakes and flagging. Avoid trampling plants in the plots. Repeat steps 3–6 to locate additional plots.

Making Decisions

Whenever someone measures plants in the field, questions are bound to come up about how to conduct the measurements. Should I stretch out the plant when I am measuring its height or just measure it as is? What do we mean by "stem" when the plant branches part way up? Should I measure percent cover at ground level or as seen from above the plants?

The answers to these questions will vary, depending on why you are measuring something. Ask yourself why you are taking a certain measurement. Are you measuring percent cover to get an idea of the amount of bare soil surface that might be available for a seed to sprout? Or is percent cover important as a measure of how shaded smaller plants might be. Depending on your objectives, would you want to measure percent cover at ground level or higher up?

For some questions there may not be one good answer. However, regardless of the question, the class will need to come to a consensus so that all measurements are collected in the same way. The class should write down all these questions and the decisions that were made, so that next year's students will be able to continue the study in the same way. This will allow you to make comparisons from one year to another.

Making decisions like this is part of conducting research.

Stratified Sampling

Materials

Stakes and flagging

Map of site

Surveyor's tape (100 m or 50 m) or nonstretch string

Procedure

1. Obtain or make a map of your study site and determine the outside dimensions.
2. Decide how many sample plots you will need. Later on, you will divide the study area into a grid of equal-sized squares. You will locate one sample plot in each square.
3. Choose a random number and walk that many steps to start the grid. Next divide your study area into a grid of equal-sized squares, one for each sample plot. You may want to first draw out the grid on a map of the site. Then using a survey tape, nonstretch string, or pacing off the correct distances, mark the edges of the squares with stakes and flagging. Avoid trampling and disturbing the study area as much as possible.
4. Locate a sample plot at the corner of each of the sections of your study area.

Observer Bias

If several different groups of students estimate density or percent cover of the same species on the same plot, do they get different results? You might want to try this in your class and see how close the results are for density and percent cover. Whenever someone measures plants in the field, there is bound to be some error due to differences in the way different researchers take their measurements. When several people are working on the same research project, they often train together so that their measurements are more standardized.

PART 2. BUILDING QUADRAT FRAMES

Materials (per student group)

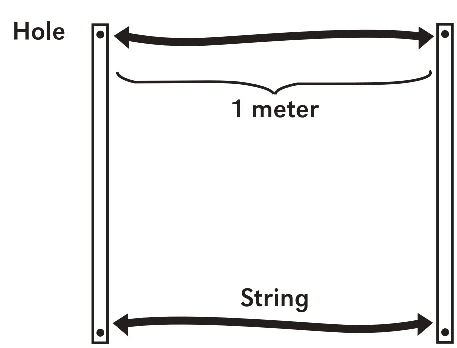
½ in PVC tubing, elbows, and sleeves *OR*

Meter sticks, or other sticks 1 m in length and screws or nonstretch string

Procedure

1. A quadrat frame will mark the outer edges of your plot. You can build a square quadrat frame out of PVC tubing or meter sticks. One method involves fastening sections of PVC tubing using elbows. To make the quadrat frame easier to slide under vegetation, you can construct the two halves separately using PVC tubing and sleeves. Both halves are in the shape of a square "C." Using right-angle elbows, attach both ends of a 1 m piece of tubing to 0.5 m long pieces of tubing. Place sleeves at the end of the 0.5 m pieces so they can be joined in the field to form a square. Another method used to construct quadrats is tying 1 m long pieces of string between both ends of two meter sticks (Figure 2.2). This method is best for short vegetation as the strings may get caught on taller plants. Another method is to fasten meter sticks to each other using screws.
2. Regardless of the method used to construct the quadrats, make sure they can be taken apart or folded up for carrying. It is best to leave one corner of the quadrat unattached so you can unfold the quadrat and slide it under the vegetation into place. If all four sides are fixed, you must place the quadrat over the vegetation, which can be difficult with tall plants such as purple loosestrife.
3. Mark 10 cm intervals on your quadrat frame in black and the 50 cm point in red to help you estimate percent cover. For example, by marking off every 10 cm, you can visualize a square 10 cm x 10 cm, which is the same as 1% cover for a 1 m^2 plot. A rectangle that is 50 cm x 10 cm is 5% cover, a square 50 cm x 50 cm is 25% cover, and so on.

FIGURE 2.2
Quadrat Construction



Cut string into two 130 cm lengths. Firmly tie string to the holes in the ends of the meter sticks. Be sure your final string length is 1 m. Leave one string end untied so you can place the quadrat around tall vegetation.

PART 3. PLOT SAMPLING

Materials (per student group)

Quadrat frame

Copies of Plot Sampling Data Form 1: Density and Percent Cover (one for each plot) (p. 78)

Copy of Plot Sampling Data Form 2: Summary (p. 79)

Procedure

1. Decide how many plots (also called quadrats) you will sample. A rule of thumb is either a minimum of ten plots or one 1 m^2 plot per 100 m^2. Divide into groups of 3–4 students for 1 m^2 plots. Each student group should be responsible for one or more plots. Students in each group should take on roles as data gatherers and data recorders.
2. Locate the sampling plot using either the random or stratified selection methods described above.
3. Lay out the 1 m^2 quadrat on the ground at the first sampling point you have chosen. Be careful not to step in the quadrat while laying it out.
4. For species that are easy to count and that are tall, count the number of stems in the plot. Record this number separately for each species on the Plot Sampling Data Form 1: Density and Percent Cover. If the stems are numerous, you can avoid double counting by starting at one corner of the plot and moving systematically across the plot. You also can hold or mark stems you have counted, or place a plastic wand or thin stick between the counted and uncounted stems.
5. If the species is very numerous and not too tall, estimate what percent of the area of the plot it is covering (its percent cover), rather than count individual stems. Record the percent cover separately for each species on the Plot Sampling Data Form 1: Density and Percent Cover. For any one species, be sure to use the same method (density or percent cover) on all plots so you can make comparisons. You can use percent cover for smaller species and density for larger species in the same plot but you will not be able to compare species that are measured using different methods.
6. Repeat steps 2–5 for each plot you are responsible for sampling.
7. If you encounter species you cannot identify, (a) describe the species (e.g., 1 m tall, purple flowers), (b) collect a sample from outside your plots, (c) try to identify the species using identification keys or by asking experts, and (d) press the specimen for use as reference for future surveys.

DATA ANALYSIS AND INTERPRETATION

You can use the data from your plot surveys to make generalizations about density and percent cover in the larger study area. To do this, you will need to compile the results for all the plots in a particular area. You can determine the average density or percent cover for each of the species you measured for all your plots.

After gathering together all the plot sampling data forms, calculate the average density or percent cover for each species found in your large study area using the formula below.

(You may substitute percent cover for density where appropriate but don't mix cover and density.)

$$\text{Average species density} = \frac{(\text{density in plot 1}) + (\text{density in plot 2}) + (\text{density in plot X})}{\text{total number of plots}}$$

For example, consider a series of 5 plot surveys conducted in a schoolyard. Purple loosestrife was found in 4 of the plots.

Plot #	Species	Density (#/m^2)
1	Loosestrife	85 stems/m^2
2	Loosestrife	53 stems/m^2
3	Loosestrife	64 stems/m^2
4	Loosestrife	33 stems/m^2
5	Loosestrife	0 stems/m^2

$$\text{Average species density} = \frac{85 + 53 + 64 + 33 + 0}{5} = \mathbf{47\ stems / m^2}$$

On the Plot Sampling Data Form 2: Summary, record the average density or percent cover for each of the species you found in your study area. You can use the average density to compare different species, to compare the same species from several different sites, and/or to compare sites where control measures have and have not been implemented. You can use average percent cover in the same ways. However, you cannot compare species measured using density with species measured using percent cover.

PLOT SAMPLING DATA FORM 1: DENSITY AND PERCENT COVER

Complete one form for each plot.

Name(s) ________________________________ Date ______________

Description of study area (e.g., wetland) ______________________

____

____

Plot ID number/label ____

Description of sample plot (e.g., standing water, shady) ____________

____

____

Method used (density, percent cover, or both) ___________________

____

Species name (or description)*	Density (# of individuals in plot)	Percent cover (% of plot covered by species)

**If you don't know the name of the species, you can describe it and give it a name. You may want to take a sample of the species to later determine its name by asking an expert or using a field guide.*

PLOT SAMPLING DATA FORM 2: SUMMARY

Use one form to compile the results from all individual plot surveys for each study area (e.g., schoolyard or wetland).

Class ____________ Teacher _____________________ Date ________________

Description of study area (e.g., wetland) _______________________________

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____

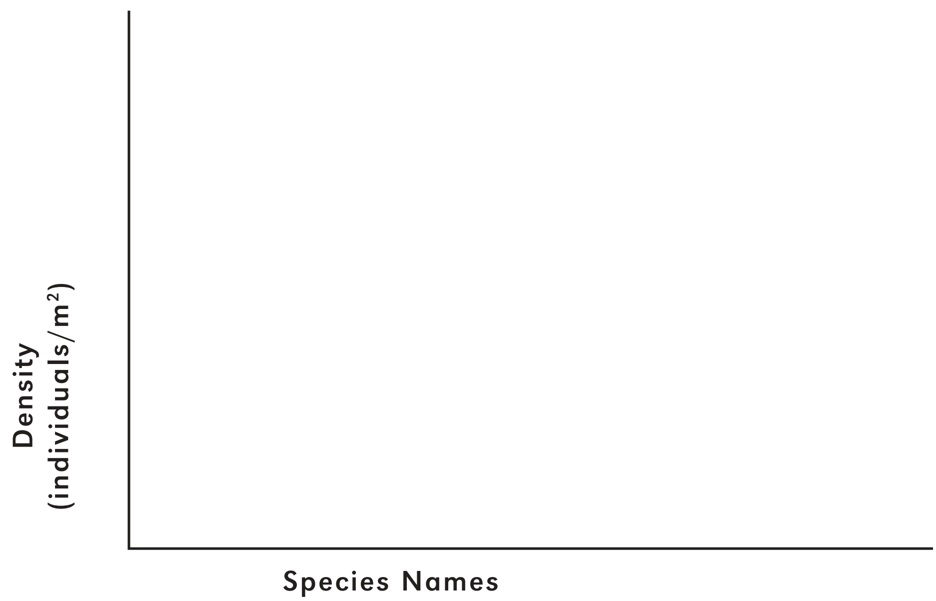
Number of plots surveyed ____

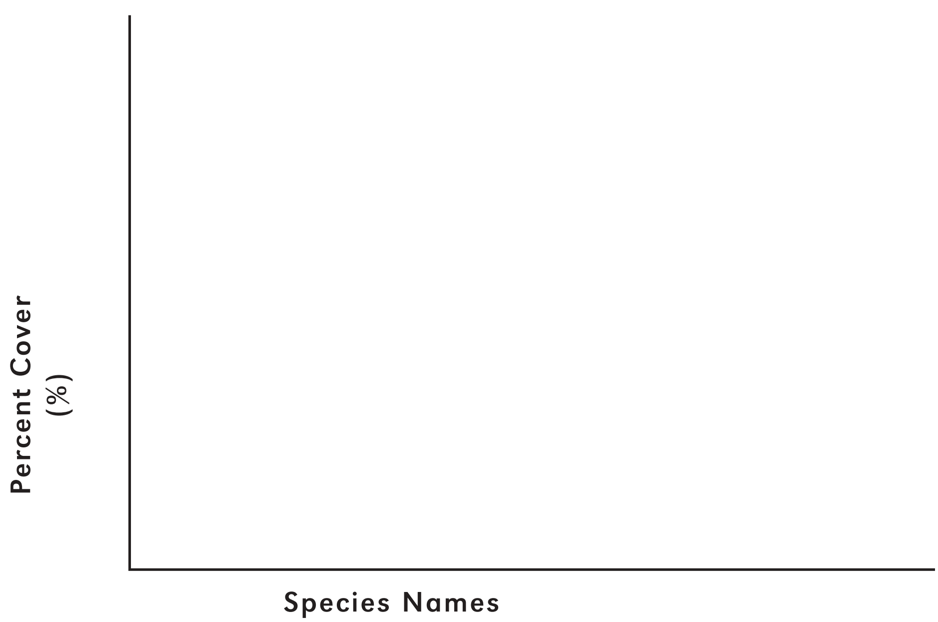
Determine the average density *or* percent cover for each species using the formula in **Data Analysis and Interpretation** (p. 77).

Species name (or description)	Average density	Average percent cover

PLOT SAMPLING DATA FORM 2: SUMMARY *(continued)*

Draw a bar graph showing the average density or percent cover of the different species.





PLOT SAMPLING: QUESTIONS

Name ____ Date________________

(Please use complete sentences.)

1. Did you find any species that were present in all plots or had very high densities? Give some reasons that might explain this.

2. Did you find any species that were not present in all plots or had very low densities? Give some reasons that might explain this.

3. How did the density (or percent cover) of the invasive species compare with the other species in the study area?

PLOT SAMPLING: QUESTIONS *(continued)*

4. Do you think the combined results of all your plot surveys accurately represent the larger study area? Please explain. What might be some problems with the data you collected?

5. If you were to do your sampling again, what things might you change? Why might you make these changes?

6. Do you think plot sampling is a good way to study large areas? Why or why not? Explain.