Chapter 13

The Line-Intercept Method: A Tool for Introductory Plant Ecology Laboratories

John Cummings and Denny Smith

John Cummings
cumminj@clemson.edu
Denny Smith
salton@clemson.edu
Department of Biology Instruction and Agricultural Education
Clemson University
Clemson, South Carolina 29634-1902

John Cummings received his BS and MS in Biology from Bowling Green State University. He is currently a lecturer and laboratory coordinator for introductory biology at Clemson University. His current interests include laboratory curriculum development, TA training, development of Web-based course management materials, and a long-term field project on barn owls.

Denny Smith received his BS in Biology from Mississippi College and his MS in Biology from East Texas State University. He is an Associate Professor of Biology at Clemson University, where he teaches introductory biology. His current interests include laboratory curriculum development, Web-based course management materials, and multimedia development.

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Introduction

This workshop took participants to a local granitic rock outcrop called Bogg's Rock. A brief tour of this area was provided to showcase this unique natural structure and to allow the participants to become familiar with the boundaries of the area. The commonly encountered plant species present on the rock were identified so that all participants would be using the same names during sampling.

Once familiar with the area and the plant species, participants were organized into small groups and assigned a portion of the rock to sample. The line-intercept method of sampling was employed. Data collected by all participant teams was summarized, and discussion reviewed the calculations necessary to determine the community structure present. Statistical method was then introduced to see if the plant species present were a function of the soil depths available on the different portions of the rock.

The line-intercept method was highlighted as a tool to 1) quickly determine community structure and 2) investigate the relationship between plant species and any independent variable present along a transitional zone. Thus, participants could take the method of sampling employed in this workshop back to their home institutions. The level of complexity is dependent on the objectives desired by each instructor, as both the sampling method and statistical method can be applied in a wide range of field applications.

Materials Needed

(Assuming 28 participants)

- Transportation to and from the field location
- 7 -- 100 m Tape measures or other linear measuring device (depending upon the area to be sampled)
- 7 Soil depth measuring devices (30 cm long dowels, sharpened to a point and graduated at 1 cm intervals) or other measuring device (depending upon the independent variable)
- 7 Silva student compasses, or something similar
- 28 Clipboards
- First aid kit
- Participants will need hand-held calculators

Student Outline

Introduction

Bogg's Rock is a granitic flatrock outcrop located 1.5 miles north of the town of Liberty in Pickens County, South Carolina. This site is currently privately owned, but it has been identified by the Nature Conservancy as a future acquisition, due to its unique plant community structure.

Bogg's Rock, like all granitic flatrock communities, is characterized by large expanses of bare granite. The area of exposed rock is approximately 7 acres and is composed of a granite-gneiss locally known as Beverly Granite Gneiss, the same bedrock that makes up the greater part of southeastern Pickens County. Erosion, as the result of winter freezes and thaws, is a major environmental influence. This action creates small pools that can hold early spring water. Thus, the rock outcrop contains many mats of aggregated plant species throughout its surface, which have become established through succession.

This field exercise employs the line-intercept sampling technique to determine the species composition of this plant community. Attempts are made to correlate species distributions with one of the many potential controlling factors present.

The Line-Intercept Sampling Technique

The plot, or quadrant, sampling method is generally the most common used for determinations of plant community structure. In this method, one takes a manageable area of known size and identifies, counts, and usually measures all individuals contained within it. This sampling procedure is then repeated (i.e., "replicated") for a number of plots to obtain an adequate representation of the community.

For accurate and unbiased application of plot sampling, samples must be randomly distributed. Further, the data collected and the calculations performed are long and tedious. For these reasons, this is not a preferred sampling technique for introductory biology students, nor is it applicable to most transitional environments.

Transects are advantageous and efficient in studies of communities at transition zones or in contiguous stages of ecological succession. One method of transect sampling, the line-intercept method, is especially efficient at determining relative estimates of plant density. In this method, data are tabulated on the basis of plants lying on a straight line cutting across the community under study. Because an area is not being sampled, only relative estimates of density can be calculated. This is advantageous when true estimates of absolute density either cannot be made or are difficult to interpret because of the problem of distinguishing among individual plants. Its advantages are emphasized when attempting to identify community structure in introductory biology courses, where the students' species-identification skills are weak.

Placement of transect lines is important. If the objective of the sampling is to determine species composition in a given habitat, then the directional orientation of the transect should be determined by connecting two randomly selected points in the community to be studied. If, however, the specific desire is to study a community transition or some ecological gradient, then the transect should transverse that transection or gradient. Several replicate transects should be used in the same study area.

Determining Species Composition On Bogg's Rock

This field exercise will begin with a quick walking-tour of Bogg's Rock. The boundaries of the rock will be identified, as well as preferred paths of travel (in attempts to limit the disturbance on the community). Many of the more common plant species will be identified on this tour.

Describe the general apparent community structure observed on the rock.

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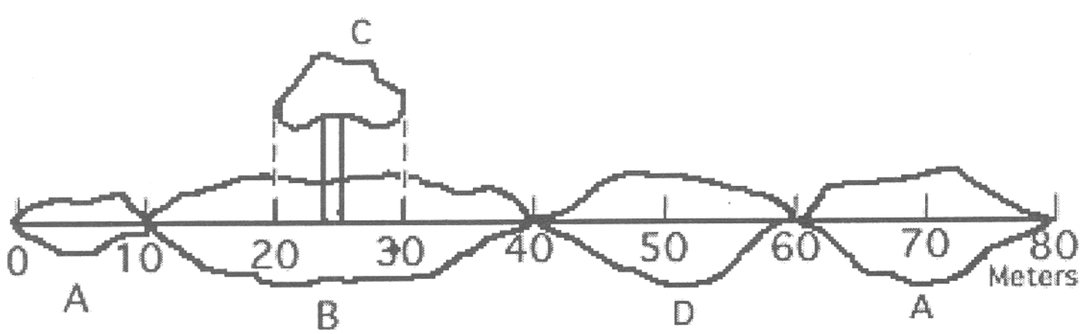
Once the tour is complete, you will be divided into groups of four for sampling. Each group will be provided with a tape measure, a soil depth measuring device, and a compass. All groups will be taken to a starting point (a different point for each group), and each group will be given a randomly generated compass heading.

Procedure

1. Extend the tape measure for 100 meters in the direction specified. Keep the line as straight as possible.
2. Determine the intercept length for each plant species that touches or comes within one centimeter of the transect line. *Intercept length* is that portion of the transect length intercepted by the plant measured at or near its base or clump of plants or by a perpendicular projection of its foliage intercepted by the line. See diagram below. Record intercept length to the nearest cm in Table 13.1.



Species	Starting Point (cm)	Stopping Point (cm)	Distance (cm)	Soil Depth (cm)
A	0	100	100	0
B	100	400	300	4
C	200	300	100	4
D	400	600	200	1
A	600	800	200	0

3. For each species intercept, determine the depth of the soil at the midpoint of the intercept. Insert the depth gauge, and continue to apply force until it reaches an obvious stop. Record the soil depths, to the nearest centimeter, for each intercept in Table 13.1 also.

Table 13.1. Intercept lengths from individual transects.

Species	**Starting Point (cm)**	**Stopping Point (cm)**	**Distance (cm)**	**Soil Depth (cm)**

4. Summarize the data in Table 13.1 by tallying the total number of patches in which a species appears and the cumulative length of transect covered by each species. Record these values in Table 13.2. (*Note:* Since more than one stratum was sampled, total length may exceed 100% of length sampled.)

The summary for the data from the diagram is presented for illustration purposes.

Species	**Number of Patches**	**Total Length Covered (cm)**
A	2	300
B	1	300
C	1	100
D	1	200

Table 13.2. Summarized coverage data from individual transects.

Species	**Number of Patches**	**Total Length Covered (cm)**

5. Combine your data with that from the other groups, and determine the total number of patches in which a species appears and the total length covered by that species. Record these values in Table 13.3.

Table 13.3. Summarized coverage data from *all* transects.

Species	Number of Patches	Total Length Covered (cm)

6. Rank order the species based on their total length of coverage, and present that data in order in Table 13.4. This is a description of the community composition of Bogg's Rock.

   Again, the diagram data are presented for comparison.

Species	Rank
A	1
B	1
D	3
C	4

Table 13.4. Rank of species density present on Bogg’s Rock.

Species	Rank
	1
	2
	3
	4
	5
	6
	7
	8
	9
	10
	11
	12

Does the calculated community structure agree with the general description you wrote earlier? Explain any differences.

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Determining Species Distribution On Bogg’s Rock

Now that you have defined the species composition of the Bogg’s Rock community, we will attempt to assess the role of one factor important to species distribution.
What factors could be regulating species distribution?

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The list that you generated should be quite extensive. Any of the items you listed could be, and probably is, affecting species distribution on the rock. All of these factors are testable, but we will only investigate soil depth, as this is most likely the easiest to quantify.

Soil depth measurements were already collected and are recorded in Table 13.1.

Procedure

1. Refer back to Table 13.1, and use this data to determine the frequencies of occurrence for each species in each of the soil depth categories listed in Table 13.5.
   Data from the original diagram are presented below.

	Soil Depth Interval (cm)					
Species	**0**	**1**	**2**	**3**	**4**	**5+**
A	2	0	0	0	0	0
B	0	0	0	0	1	0
C	0	0	0	0	1	0
D	0	1	0	0	0	0

Table 13.5. Frequency of occurrence of each species as a function of soil depth.

	Soil Depth Interval (cm)					
Species	**0**	**1**	**2**	**3**	**4**	**5+**

2. Once you have determined your species' frequency of occurrence, combine your results with the rest of the class to fill in the observed values in Table 13.6.

Table 13.6. Contingency table of species occurrence at various soil depths.

(Obs. = Observed; Exp. = Expected)

	Soil Depth Interval (cm)											
	0		1		2		3		4+			
Species	**Obs**	**Exp**	**Obs**	**Exp**	**Obs**	**Exp**	**Obs**	**Exp**	**Obs**	**Exp**	**Total**	
Total												**Grand Total**

3. You will perform a *contingency chi-square* to test the independence of the two variables: species presence and soil depth. This statistical analysis is actually testing the null hypothesis that the two variables are independent: species distribution is not related to soil depth. Rejecting this null would indicate that soil depth in some way controls species distribution.

   HO: Species distribution is not related to soil depth.
   HA: Soil depth affects species distribution.

   The first step in calculating a contingency chi-squire is to determine the expected values for each of the cells in the table. To do this, you must first calculate the totals for each row and for each column. Do this, and enter these values in Table 13.6. The grand total of all rows should equal the grand total for all columns. Use this as a check on your math.

4. Once the row and column totals and the grand total have been determined, the expected values for each cell in the table can be calculated. Use the following formula to calculate the expected values.

$$\textbf{Cell}_{\text{row i, column i}}\ \textbf{expected} = \frac{\textbf{(row}_{\,i}\ \textbf{total) X (column}_{\,i}\ \textbf{total)}}{\textbf{grand total}}$$

   Fill in the expected values in the contingency table.

5. There are certain restrictions when using contingency chi-square. Those that apply in this case are related to the expected values present in the contingency table. None of the expected values may be less than one, and there may not be more than 20% of the expected values below five. Review your contingency table to determine if either of these restrictions has been violated. If so, your instructor will help you reconfigure the contingency table by lumping some of the categories. Use the blank contingency table attached at the end of this lab to make a new contingency table if necessary.

6. Once you have an acceptable contingency table, calculate the chi-square value. The formula for this number is:

$$\mathbf{X^2 = \sum [(O\text{-}E)^2/E]}$$

   For each cell in the contingency table, subtract the expected value from the observed value. Square this value, and then divide it by the expected value. Add the resulting values from each of the cells in the table. This is your chi-square value. Record it here:

   X^2 = __________.

7. Chi-square tests the probability that the distribution of observed values is the result of chance. Chi-square values for all distributions of numbers and for all sizes of contingency table have been calculated. Scientists use these values to determine whether to accept or reject their null hypothesis. Biologists are willing to reject a null hypothesis if the probability of chance occurrence is 0.05 or less. The chi-square values that result in a 0.05 probability for all sizes of contingency table are presented in Table 13.7 at the end of this handout. You must compare your calculated chi-square value against that presented in this table (referred to as a **critical value**) to determine if you can reject your null hypothesis. First you must determine which critical value is appropriate for your situation. This is determined by calculating the degrees of freedom appropriate for your contingency table.

   Degrees of freedom (df) = (# rows –1)(# columns –1)

   Record your degrees of freedom here:

   df = ___________.

8. Find the critical value from Table 13.7 for your df. Record that value here:

Critical value = __________.

9. If the chi-square value you calculated is greater than or equal to the critical value, you may reject your null hypothesis.

Do you accept or reject your null? ____________________

What conclusions can you make concerning the effect of soil depth on plant distributions on Bogg's Rock?

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If you conclude that there is a relationship, review the distributions of observed values in your contingency table, and describe any associations between plant species and soil depth.

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Table 13.7. Critical chi-square values at p =0.05.

df	**X^2**
10	18.307
11	19.675
12	21.026
13	22.362
14	23.685
15	24.996
16	26.296
17	27.587
18	28.869
19	30.144
20	31.410
21	32.670
22	33.924
23	35.172
24	36.415
25	37.652

df	**X^2**
26	38.885
27	40.113
28	41.337
29	42.557
30	43.773
31	44.985
32	46.194
33	47.400
34	48.602
35	49.802
36	50.998
37	52.192
38	53.384
39	54.572
40	55.758
41	56.942

Table 13.6. Contingency table of species occurrence at various soil depths. (Obs. = Observe; Exp. = Expected)

	Soil Depth Interval (cm)									
Species	**Obs.**	**Exp.**	**Obs.**	**Exp.**	**Obs.**	**Exp.**	**Obs.**	**Exp.**	**Total**	
Total										**Grand Total**

Notes for Instructors

The scale of the area to be sampled will vary, dependent upon the transitional zone and plant species being investigated. As such, the linear distance assigned to each student-team must be pre-determined. This will alter the sizes of the data collection tables necessary in the lab handout, since proper space should be allotted.

Prior student experience with chi-square calculation and statistical theory, while not necessary, will facilitate data manipulation and calculations.

Transitional zone communities are much more prevalent than one might initially suspect. Unique nature preserves are not required. Even things as simple as the distance away from a highly traveled campus street have the strong potential to show a shift in community structure. Thus, the independent variable for hypothesis testing can be soil depth, moisture, light, distance from woods, etc. This lends itself to applying this technique to student-generated investigations.

Specific care should be taken to identify any potential safety concerns associated with the area to be sampled. As with any field exercise, a good first-aid kit and bee-sting pen should be readily available. Parking and other traffic related concerns should be evaluated. Seasonality can have a tremendous influence over the validity of any investigation. Further, the instructor should be cognizant that the students have a tremendous potential to disrupt or alter the area simply through their presence. Areas should be chosen where this will not have a significant effect.