3a

Plot Sampling

1. Introduction

The plot method is a basic and commonly used procedure for sampling many types of organisms. A **plot** generally is a rectangle or a square, but circles or other shapes can be used. The term **quadrat** often is used interchangeably with plot, but strictly speaking a quadrat is a square or rectangular plot.

In plot sampling, one takes a manageable area of known size and identifies, counts, and often measures all individuals within it. In sampling soil or aquatic organisms, a volume of the habitat often is sampled and analyzed. This sampling procedure is then repeated (i.e., replicated) for a number of plots (preferably of the same size) to obtain an adequate representation of the population or community.

The plot method is most widely used for sampling land plants, but may also be used for sampling relatively sessile or slow-moving animals (such as soil fauna), for benthos in aquatic environments, and for animal burrows, nests, hills, or other animal signs.

An accurate and unbiased application of plot sampling requires random samples (see Section 1A.2). If plot sampling is to be used for invertebrates, consult Sections 3D and 3E for specific sampling techniques.

2. Procedure

For sampling plants, rectangular plots have often been found to yield better results than other shapes; a rectangle with sides in a 1:2 ratio works well. For general class purposes, the following plot sizes are recommended: For closely spaced herbaceous vegetation, use a rectangular plot 1 m^2 in area on a scale of 1:2 (i.e., 0.71 × 1.41 m). For bushes, shrubs, and saplings up to 3 or 4 m tall, use 10-m^2 plots (2.24 × 4.47 m). For forest trees over 3 to 4 m high, use 100-m^2 sampling areas (7.07 × 14.14 m). Adjustment of these recommendations can be made by considering species-area curves and performance curves, as described in Section 1A.3.

For sampling soil macroinvertebrates or benthic invertebrates in a stream, it is common to use a square plot (quadrat) with an area of 0.1 m^2 (31.6 × 31.6 cm). This plot size should increase when sampling large organisms (see Sections 3D.2 and 3E.2.4, respectively). A circular plot is commonly used in pond benthos sampling (see Section 3E.2.1).

The location of each plot should be determined either by a systematic method such as a grid or by a standard random procedure (see Section 1A.2) such as using a randomly selected point as the center of the plot or using a set of random coordinates to define the plot boundaries. These methods of plot selection minimize bias by purposefully ignoring the nature of the vegetation and terrain; that is, one should not include or exclude any plants or animals that are subjectively deemed either good or poor representations of the community. If different strata in a forest community are being sampled, the three different plot sizes given above can be nested, the smaller plots lying within the larger ones. Nested plots are also useful for determining the most efficient plot size from species-area curves or performance curves (see Section 1A.3).

After the plots have been marked out, identify each species and count the number of individuals of each within each plot. If samples are to be analyzed in the laboratory, separate and label each sample. In plant sampling, also measure foliage coverage, basal coverage, or basal area of each individual, the measurement depending on the type of vegetation sampled (see Section 4 of the introduction to Unit 3).

3. Data and Calculations

For each plot, record the number of individuals, and for plants, the area covered for reach species, as on Data Sheet 3A.1. As soon as possible, enter the appropriate data for all plot samples on the class Data Sheet 3A.2. Data Sheet 3A.3 may then be used in performing the following calculations:

Density (D) is the number of individuals in a unit area:

$$D_i = n_i/A, \qquad (1)$$

where D_i is the density for species i, n_i is the total number of individuals counted for species i, and A is the total area sampled. **Relative species density** (RD) is the number of individuals of a given species (n_i) as a proportion of the total number of individuals of all species (Σn):

$$RD_i = n_i/\Sigma n, \quad (2)$$

or

$$RD_i = D_i/TD = D_i/\Sigma D, \quad (3)$$

where TD is the density for all species (which is equivalent to ΣD, the sum of the densities of all the species).

Frequency (f) is the chance of finding a given species within a sample:

$$f_i = j_i/k, \quad (4)$$

where f_i is the frequency of species i, j_i is the number of samples in which species i occurs, and k is the total number of samples taken. Frequency is highly dependent on the size and shape of the plots used. If plots are too large, then one is almost certain to find most of the species in a given sample plot. On the other hand, if plots are too small, then the same species will seldom be encountered in more than one plot.

Realtive frequency (Rf) is the frequency of a given species (f_i) as a proportion of the sum of the frequencies for all species (Σf):

$$Rf_i = f_i/\Sigma f. \quad (5)$$

Coverage (C) is the proportion of the ground occupied by a vertical projection to the ground from the aerial parts of the plant:

$$C_i = a_i/A, \quad (6)$$

where a_i is the total area covered by species i (estimated by basal area, foliage area, or basal coverage), and A is the total habitat area sampled. The **relative coverage** (RC_i) for species i is the coverage for that species (C_i) expressed as a proportion of the total coverage (TC) for all species:

$$RC_i = C_i/TC = C_i/\Sigma C, \quad (7)$$

where ΣC is the sum of the coverages of all the species.

The sum of the above three relative measures for species i is an index called the **importance value** (IV_i):

$$IV_i = RD_i + Rf_i + RC_i. \quad (8)$$

The value of IV may range from 0 to 3.00 (or 300%). Dividing IV by 3 results in a figure that ranges from 0 to 1.00 (i.e., 100%), and this is referred to as the **importance percentage.** The importance value, or the importance percentage, gives an overall estimate of the influence or importance of a plant species in the community. Although such an estimate has the advantage of using more than one measure of influence, it has the disadvantage of giving equal weight to each and yielding similar values for different combinations of the three relative values. Also, the term importance is confusing since it means different things to different ecologists. It also involves summing three different yet not independent measures, which is difficult to defend mathematically.

4. Suggested Exercises

1. Sample a forest or grassland community using plots.
   a. Determine the density, relative density, frequency, relative frequency, coverage, and relative coverage for the species sampled in given strata.
   b. Calculate importance values for the predominant species; interpret these measures.
2. Sample a benthic or soil habitat for macroinvertebrates using plot sampling with the techniques given in Section 3D or 3E. Determine the density, relative species density, frequency, relative frequency, and/or biomass (Section 6A).
3. Compare two similar community types (e.g., two forests, two prairies, or two benthic communities). Analyze the data collected according to one or more of the following considerations:
   a. Species diversity (Section 5B)
   b. Community similarity (Section 5C)
   c. Species-area curve (Section 1A.3)
   d. Relative-abundance curve (Section 5A.7.1)
   e. Statistical significance (by Mann-Whitney testing, Section 1B.3.4) of the difference in density (or coverage) of the major species
4. Compare plot sampling results to those obtained from the point-quarter (Section 3C) or transect (Section 3B) methods.
   a. Compare species-sample size curves and performance curves (Section 1A.3).
   b. Evaluate the precision of the methods by determining the standard error for the density of a few of the more important species (see Sections 1B.2.2 and 1B.2.3). Which method has greater precision? Which has less bias? Which is more efficient in terms of the amount of data collected per time and effort sampling?

5. Selected References

Barbour, M. G., and W. D. Billings (eds.). 1987. North American terrestrial vegetation. Cambridge University Press, New York.

Becker, D. A., and J. J. Crockett. 1973. Evaluation of sampling techniques on tall-grass prairie. J. Range Management 26:61–65.

Bonham, C. D. 1989. Measurements for terrestrial vegetation. John Wiley & Sons, New York.