Estimation of a Plant Density
Exercise 4

Density from Quadrats or Plots

When monitoring for ecosystem change, especially for change in rare or endangered plant species or for the increase of potentially dangerous invasive species, an estimate of standing biomass may not be the most important parameter to measure. We may be far more interested in whether the population is increasing or decreasing and if reproduction is successfully occurring. To determine population dynamics it is necessary to measure the number of individuals at several points in time, usually yearly, to determine the trend. You should bear in mind that two or three data points do not necessarily make a trend and those of us that quantitatively study plant population dynamics have been fooled many times by a short series of points showing either increase or decrease in numbers.

Plant density is the number of individuals per unit area. We don't really care if plants are large or small, just how many of them are present on a defined plot of land. If we are measuring annual grasses on the foothills of the Sierra Nevada range, our sample plot has to be quite small or we will be counting for a very long time. I have sampled some plots with well over a thousand individuals of a species per square meter. On the other hand, if we are counting trees we may need to have a very large plot in order to obtain samples that meet the criteria of ratio data. Ratio measurements have difference between two values that is meaningful, as well as a meaningful 0. The difference between a 100 trees per ha and 90 trees is the same difference as between 100 trees and 110 trees, ten trees. A ratio variable also has a clear definition of 0. When there are 0 trees per acre, there are none and the zero is meaningful.

If our plot size is small and we obtain numbers for sequential observations like 1, 0, 0, 1, 2, 1, 0, 0, 0, the data takes on the characteristics of ordinal data and loses some resolution and meaning. For this reason, when sampling for density, we generally would like to have counts between 30 and 300 per observation. We can adjust the size of the quadrat or plot area to ensure that there are enough individuals to count but not so many that the task become onerous.

In our annual grass communities, we may use a quadrat 15 cm on a side while on a tree site the plot might be 100 m by 100 m. Sometimes only seedlings will be counted. Obviously, if we were counting maple tree seedlings in the spring under a large prolific adult, another size plot would be in order.

Another issue that arises with plant density measurements is what constitutes and individual. Some plants like aspen or sod forming grasses are root sprouters (or have rhizomes) and a whole series of what appears to be individuals above ground may be linked via their roots below ground. In most cases, if the root connection is broken for some reason, both plants get along just fine as two separate individuals. In any case, it is wise to identify what you are calling an individual. You may also wish to count stems or define how far apart stems or culms must be to constitute a separate individual. When counting grasses, I often count plants as different individuals if they are separated by 2.5 cm, which is the width of my thumb.

Density measurements are collected in a process very similar to biomass as we studied in the last lesson. A random plot is identified, and the number of individuals is counted. Counts are then tallied and a mean, variance, standard deviation or standard error is calculated. Well designed data forms speed the collection of data in the field and simplify the process of analysis in the lab and office.

Recently people have begun using electronic data loggers in the field to reduce both transcription error and data handling time. However, many of us still like to have information collected on data sheets written in pencil or permanent ink. There is security in knowing that the data is in a form that is easily retrievable without electronics.

Shrub and Tree Density

Shrubs and trees, because of their size, pose a special problem when density values need to be calculated. Plots are often large enough that they must be "staked out" using surveyor pins or wooden stakes. If the shrubs are short enough to allow measuring tapes to pass over their tops, circular quadrats can be quite useful. We hold the end of a fiberglass measuring tape at the center of the plot (usually on a pole with a point to hold it in place and bubble level to ensure that it remains vertical) while a second individual stretches the tape to the proper distance and revolves around the circle counting individual shrubs. The table below provides the radius values for circular plots of varying areas.

Area (m^2)	Diameter (m)	Radius (m)
10	3.57	1.78
20	5.05	2.52
30	6.18	3.09
40	7.14	3.57
50	7.98	3.99
60	8.74	4.37
70	9.44	4.72
80	10.09	5.05
90	10.70	5.35
100	11.28	5.64
110	11.83	5.92
120	12.36	6.18
130	12.87	6.43
140	13.35	6.68
150	13.82	6.91

If trees or tall shrubs that are higher than 1.5m, circular plots can be used with some difficulty by threading the tape through the plants. Alternatively, we can use square or rectangular plots that are marked on the ground with surveyor's pins. To create square corners on the plots, we use the principle of the 3m, 4m, and 5m right triangle. Three measuring tapes are used to create the necessary right triangles. The corners of the plot are marked with surveyor's pins and trees or shrubs rooted in the plot counted.

Tree and shrub density can also be obtained from high resolution aerial imagery that has been geographically rectified and properly scaled. This process, while conceptually identical to the one outlined above, employs different technologies and protocols. We will examine this process in a later exercise.

Plot-less Methods

Closest Individual Estimate of Plant Density

Because the inverse of density is the mean area of a plant, there have been attempts to measure the distance between plants to obtain an estimate of the mean area of an individual of a plant species. The simplest method to measure mean area is called the "Closest Individual Method". It is a point to plant measurement in which random points are found on the landscape and the distance from that point to the nearest plant of the species being monitored is measured. The mean area for a species is calculated by the formula:

$Mean\ Area = (2\mathrm{d})^2$ Where d is the mean distance from the random point to a plant of that species

This technique is accurate only for randomly distributed populations and has a large bias for clumped distributions. **Very few plant populations are truly randomly distributed on the landscape. This technique is therefore NOT recommended.** Other plot-less techniques, such as the Point-Centered Quarter Estimate of Plant Density (Cottam and Curtis 1956), have been used for trees and was applied to herbaceous vegetation by R.L. Dix in 1961. Again these techniques assume that individuals are randomly scattered on the landscape, which is rarely the case. Thus, these techniques can lead to substantial errors and should not be generally used. We mention them here because, in spite of this limitation, data collected using "Distance Measure" techniques have been widely reported.

Equipment

Each sampling crew will require:

1. Surveyor Pins
2. 2 Measuring Tapes
3. Compass and Abney Level or a Smartphone equipped with a compass app such as Smart Compass or Compass pro that provides direction and a Level/Inclinometer app (Bubble or Clinometer + slope finder + bubble level) to determine the slope and aspect
4. Random Number Table
5. Data Forms
6. Notebook

Figure 1. General survey equipment for Plant Density measurements. Clockwise from upper left: 1) surveyor pins, 2) metric fiberglass tape, 3) Brunton-type compass (pocket transit), 4) Abney level.

Assignment

We will choose two areas to sample; one with herbaceous vegetation and the other with shrubs or trees. For the herbaceous plant community, choose an appropriate quadrat size and sample 15 randomly selected quadrats within a single plant community or ecological/range site. Record your data on the data forms provided. Repeat this process for another site or plant community. After you have finished the field portion of this exercise, calculate the mean density, standard deviation, and standard error of the mean for the plants encountered in the survey.

On the area with shrubs or trees, decide on an appropriate quadrat (plot) size. Measure the density of the shrubs or trees on 5 quadrats (plots). When you have finished sampling, calculate the tree/shrub density for the sampled community.

Calculations

Please calculate the following, showing your work:

a) Density of plant species found in each community by each method
b) Standard deviation
c) Standard error of the density estimates

Questions

1. How do you deal with plants that are only partially in the quadrat or plot?
2. When should you use more than a single quadrat size in a vegetation type?
3. Your supervisors want you to make a recommendation for future surveys. They want you to tell them which method was easiest to use, gave the best data, and has straight-forward interpretation? Write a brief professional report of your evaluation.

References

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Plant Density Data Form

Name: ___________________________
Date: ___________________________
Location: ___________________________ Long._________________ Lat. _______________
Quadrat Size: ___________________________ Quadrat Shape ____________________________

Sample	Plant Species												
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
Mean													
Standard Deviation													

Notes: ____

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Plant Density Data Form

Name: ________________________
Date: ________________________
Location: ________________________ Long.________________ Lat. ______________
Quadrat Size: ________________________ Quadrat Shape __________________________

Sample	**Plant Species**												
1													
2													
3													
4													
5													
6													
7													
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11													
12													
13													
14													
15													
Mean													
Standard Deviation													

Notes: ____

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