Rangeland and Riparian Habitat Assessment

Measuring Plant Density

I. Definition = number of individuals per unit area

   A. What is an individual? - Need to define

      1.

      2.

      3.

   B. Also need to define the unit of area

      1.

      2.

   C. Often referred to as “abundance”

   D. Easy analytical concept to grasp and straightforward

II. When to measure density?

   A. Often used to monitor long-term vegetation changes because density is sensitive to changes in the adult population

   B. Can be useful in detecting plant response to management actions

   C. Also, can be used to monitor seedling emergence, survival and mortality

   D. Can be used to estimate cover or biomass

III. Advantages

   A. Straightforward and easy to grasp.

   B. Relatively quick and easy to measure compared to cover or biomass.

   C. Density (unlike estimates of cover or biomass) is quantifiable and absolute.

   D. Density of mature perennial plants is not affected by weather fluctuations as other attributes. This makes comparisons between years viable.

   E. Quick to measure for:

      1.

      2.

IV. Disadvantages:

A. Difficult to decide what is an individual. Difficult to count some life-forms:

1.

2.

3.

4. Can count a surrogate plant part (like culm) instead of a plant but the usefulness of such estimates is limited to the biological significance of changes in these surrogates.

B. Not a good indicator of relative dominance in a community when different life-forms are present (i.e., annual plants may have a much greater density than perennial shrubs in a community but may not dominate resource in the community)

C. Can be very time consuming in dense communities

D. May be difficult to select appropriate frame size and may need to select several sizes in order to adequately sample all plants in a community.

E. Because everything in a plot must be counted, errors can be made on whether a plant is “in” the plot. Depending on community, may need to make many borderline decisions.

V. There are 2 basic ways to measure density

A. Plotted or Quadrat Techniques - number of individuals in a quadrat

B. Plotless Techniques - estimates of density made based on space between plants

VI. Plotted or Quadrat Techniques:

A. Place a quadrat systematically or randomly as defined by protocol

B. Count and record number of individuals in quadrats or belt transects. Data are usually recorded by species.

1. If individuals are difficult to distinguish, write a clear guideline on what constitutes an individual or individual unit

2. If it is difficult to determine whether plants are in or out of the plot, write a guideline to use for border-line decisions

3. Written guidelines of what entities are counted in a plot are important because density is often measured over years to monitor community change

C. Shape of frame:

1. Frame can be circular, square or rectangular.

    a. Long, narrow quadrats often recommended because more species are recorded in vegetation that is clumped.

    b. However, rectangular quadrats may be difficult to use because they have a greater perimeter:area ratio than circular or square quadrats. This increases probability of borderline decisions.

D. Quadrat Size: Rules of Thumb

1. Quadrat should be larger than an average-sized plant

2. Quadrat should be larger than an average-sized space between plants

3. If there are more plots with “nothing” in them than there are plots with 1 plant, use a bigger quadrat. (*Some ecologists suggest that the optimum size will result in 20% of plots with nothing in them... seems a little high to me*).

4. Keep increasing plot size until the average density is 4-10 plants/plot of the plant of interest.

5. The proper quadrat size is strongly influenced by plant size (bigger plants require bigger quadrats to adequately sample). Therefore, nested techniques are often used when annual plants, perennial herbaceous plants, shrubs, or trees are all counted in differently sized plots.

VII. Plotless (or Distance) Techniques

A. Counting the number of plants in a quadrat can be very time consuming. Therefore, alternative methods have been used that are based on the distance between plants or the distance for a selected point and a plant. The basic premise of these distance techniques is that density can be calculated if the average space occupied by individual plants can be determined. These techniques assume:

1. Plants occupy circular areas

2. Plants are randomly distributed (may need to test this assumption)

B. Distance techniques were generally developed in forests, but they can be applied to grasslands if:

1. Individual plants can be easily recognized (i.e., shrubland or bunchgrass communities)

2. Space between plants is a measurable amount (i.e., relatively sparse comm.)

C. Plotless techniques can have several quadrat-based techniques:

1. Usually faster (especially in sparse communities)

2. Requires less equipment

3. Does not require selection or adjustment in quadrat size

D. About 10 different techniques have been outlined that use distances to estimate density. The most commonly used techniques in rangelands are:

1. <u>Closest Individual</u> - The distance from a sample point to the closest individual is measured.

   a. Choose a series of points in the sample area

   b. Measure the distance to the closest plant of interest

   c. Estimate density: $D = \frac{A}{(2\bar{d})^2}$

      (1) D = Density or # of individuals/specified area

      (2) A = Specified area (i.e., 1 m^2 or 1 hectare)

      (3) $\bar{d}$ = Average distance measured from point to plant

   d. The units of A and $\bar{d}$ must be the same. For example if A is selected as m^2 then $\bar{d}$ should be expressed in meters for calculations.

2. <u>Nearest Neighbor</u> - The distance from a selected plant to its nearest plant (neighbor) is measured.

   a. Choose a referent plant - usually the closest individual to a selected point.

   b. Identify the plant closest to the referent plant.

   c. Estimate density:

$$D = \frac{A}{(1.67\bar{d})^2}$$

      (1) D = Density or # of individual/specified area

      (2) A = Specified area (i.e., 1 m^2 or 1 hectare)

      (3) $\bar{d}$ = Average distance measured from point to plant

      (4) The 1.67 is a multiplier determined through field experiments that allows for accurate estimates of area covered

   d. The units of A and $\bar{d}$ must be the same. For example if A is selected as m^2 then $\bar{d}$ should be expressed in meters for calculations.

3. Point-Centered Quarter - The distance from a sample point to the nearest plant in each of four quarters or quadrants around the point is measured.

   a. Choose a series of points in the sample area (at least 15).

   b. Place a "cross" or "plus" shaped guide over the point.

      (1) Lay a line or bar across the point in a specified compass direction.

      (2) Lay another line or bar perpendicular to the first through the point.

   c. Measure the distance from the point to the nearest plant of interest in each of the quadrants outlined by the cross-shaped guide

   d. Estimate density: $D = \frac{A}{\bar{d}^2}$

      (1) D = Density or # of individual/ specified area

      (2) A = Specified area (i.e., 1 m^2 or 1 hecater)

      (3) $\bar{d}$ = Average the 4 distances each point.

      (4) Density is estimated for each point then averaged over all points.

   e. The units of A and $\bar{d}$ must be the same. For example if A is selected as m^2 then $\bar{d}$ should be expressed in meters for calculations. For example:

      Distance of point to shrub
      Quarter 1=.5 meters
      Quarter 2 = .35 meters
      Quarter 3 = .4 meter
      Quarter 4 = 1.2 meters
      The average distance to a plant ($\bar{d}$) = .61 meters
      If we want to express density in number of plants/m^2 then

      $1\ m^2/(.61)^2 = 2.7$ plants/m^2

      If you want to express density in number of plants/ha then:

      There are 10,000 m^2 in a ha,

      so $10{,}000\ m^2/(.61)^2 = 27027$ plants/ha

   f. The technique assumes that area around plants is roughly circular and points are far enough apart so that no plant is measured twice (in different point-centered quarters).

4. Angle-Order Method - the distance from a selected point to the third nearest plant in each of four or more pie-shaped sections around the point is measured.

   a. This technique is designed for use in highly clumped communities where plants are not randomly distributed. This technique assumes that if A is divided into smaller sections then the distribution of plants becomes random.

   b. Randomly or selectively select a series of points = N points

   c. Divide area around point into equi-angular sections = *k* sections

   d. In each section measure distance to 3rd nearest plant = $\bar{d}$

   e. Calculate Density (D) as follows:

      (1) $D_1 = 2/N * \sum 1/\bar{d}^2$

      (2) $D_2 = (3k-1)/N * \sum k/\bar{d}^2$

      (3) If $D_1 < D_2$ then average D_1 and D_2

      (4) If $D_1 > D_2$ then use D_1

Important References for Estimation of Density

Bonham, C.D. 1989. Density. pp. 137-197. *In*: Measurements for Terrestrial Vegetation. John Wiley & Sons, New York.

Cottom, G. and J.T. Curtis. 1956. The use of distance measures in phyto-sociological sampling. *Ecology* 37:451-460.

Dix, R.L. 1961. An application of the point-centered quarter method to the sampling of grassland vegetation. *Journal of Range Management* 14:63-69.

Hutchings, S.S. and M.J. Morris. 1959. Use of distance measures for determining plant density in semi-arid vegetation. Proc. 9th Intl. Bot. Cong. Vol 2:174.

Laycock, W.A. 1985. Density as a method for monitoring rangeland vegetation. Symp. on Rangeland Monitory. Soc. for Range Manage. Ann. Meeting. Salt Lake City, UT.

Lyon, J.L. 1968. An evaluation of density sampling in a shrub community. *Journal of Range Management* 18:205-211.

Mueller-Dombois, D. and H. Ellenberg. 1974. The count-plot method and plotless sampling techniques. pp. 93-135. *In*: Aims and Methods on Vegetation Ecology. John Wiley & Sons, New York.

Oldenmeyer, J.L. and W.L. Regelin. 1980. Comparison of 9 methods for estimating shrub density and saplings in Alaska. *Journal of Wildlife Management* 44:662-666.