Plotless of Distance Techniques

Is a Quadrat Needed?

Counting the number of plants in a quadrat can be very time consuming. Therefore, alternative methods have been developed that are based on the distance between plants or the distance from a specific point and a plant.

One unavoidable truth when measuring vegetation density is that plant Density and Distance between Plants is inextricably linked:

High Density = Plants that are Close Together
or
Low Plant Density = Plants that are Far Apart

Techniques based on this premise are called plotless or distance-based techniques. The basic idea of these distance techniques is that density can be calculated if the average space occupied by individual plants can be determined. These techniques assume:

- Plants occupy circular areas
- Plants are randomly distributed

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

- Individual plants can be easily recognized (i.e., shrubland or bunchgrass communities)
- Space between plants is a measurable amount (i.e., relatively sparse comm.)

Plotless techniques can have several advantages over quadrat-based techniques:

- Usually faster (especially in sparse communities).
- Requires less equipment - just need a way to measure distance (e.g., meter stick, tape measure, or laser range finder).
- Does not require selection or adjustment in quadrat size.

Basic Distance Relationships

It is not surprising that the distances between plants or between a selected point and plants in the area are related by basic principles of geometry. Therefore, all distance based techniques are related by this general equation:

$$D = \frac{A}{(X \overline{d})}$$

- $D = \text{Density}$
- $A = \text{Area of interest (like meter squared)}$
- $\overline{d} = \text{Distance measured in the field}$

The term "$X$" in these equations varies depending on assumptions about distance between plants or points to a plant. Each technique or method includes some twist on the value for $X$. 
Three Basic Plotless or Distance Methods

About 8 to 10 methods have been developed to estimate and calculate density based on distances. However, we will outline just 3 methods here following Elzinga et al. 1998 (pages 172-173). In the examples below, focus on what is measured and become familiar with the equation of how distance is related to density.

1) Point-Centered Quarter

The distance from a sample point to the nearest plant in each of four quarters or quadrants.
- Choose a series of points in the sample area (at least 15).
- Place a “cross” or “plus” shaped guide/frame over the point.
- Measure the distance from the point to the nearest plant of interest in each of the quadrants outlined by the cross-shaped guide.

Estimate Density:

\[ D = \frac{A}{\bar{d}} \]

- \( D \) = Density or # of individual/specified area
- \( A \) = Specified area (i.e., 1 m\(^2\) or 1 hectare)
- \( \bar{d} \) = Average of 4 distances measured from center point to nearest plant in each quarter
- 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 = 0.5 meters
Quarter 2 = 0.35 meters
Quarter 3 = 0.4 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
\[ 1 \text{ m}^2/(.61)^2 = 2.7 \text{ plants/m}^2 \]

If you want to express density in number of plants per hectare in this example then:
There are 10,000 m\(^2\) in a ha so
\[ 10,000 \text{ m}^2/(.61)^2 = 27,027 \text{ plants/ha} \]

The technique assumes that the area around plants is roughly circular and points are far enough apart so that no plant is measured twice.

2) Nearest Neighbor

The distance from a selected plant to its nearest plant (neighbor) is measured.
- Choose a referent plant - (usually the closest individual to a selected point.)
- Identify the plant closest to the referent plant and measure the distance between these two plants.
Estimate density:
\[ D = \frac{A}{(1.67/d)^2} \]

- **D** = Density or # of individual/specif id area
- **A** = Specified area (i.e., 1 m^2 or 1 hectare)
- **d** = Distance measured from target plant to nearest plant (*Note: the target plant is the plant closest to the sampling point*)
- The 1.67 is a multiplier determined through field experiments that allows for accurate estimates of area covered
- The units of **A** and **d** must be the same. For example, if **A** is selected as m^2 then **d** should be expressed in meters for calculations.

**3) Closest Individual**

The distance from a sample point to the closest individual is measured.

- Choose a series of points in the sample area
- Measure the distance to the closest plant of interest

Estimate density:
\[ D = \frac{A}{(2d)^2} \]

- **D** = Density or # of individual/specif id area
- **A** = Specified area (i.e., 1 m^2 or 1 hectare)
- **d** = Distance measured from point to nearest plant in any direction.

- The units of **A** and **d** must be the same. For example if **A** is selected as m^2 then **d** should be expressed in meters for calculations.

**Reference**


**Note on calculations.** Calculations of density must be done for each sampling point and then averaged. Do not take an average distance for all points examined and then apply the calculation.

A standard deviation or standard error can also be calculated by using the above formulas. Calculate a density for each point, using **d** as the distance from each point to the closest point. Then an average and standard deviation (std dev) or standard error (std err) can be estimated. For Example, for closest individual method. \[ D = \frac{A}{(2d)^2} \]

1 hectare (abbreviated "ha") = 10,000 m^2 so A = 10,000

<table>
<thead>
<tr>
<th>Point</th>
<th>Closest Plant (m)</th>
<th>Calculated Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.0</td>
<td>100/ha</td>
</tr>
<tr>
<td>2</td>
<td>3.6</td>
<td>193/ha</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
<td>625/ha</td>
</tr>
<tr>
<td>4</td>
<td>12.5</td>
<td>16/ha</td>
</tr>
</tbody>
</table>
Average density of sample  = **233 plants per hectare**
Standard Deviation of 100, 193, 625 & 16 = **271**
Standard Error of 100, 193, 625 & 16 = **135**

**SUMMARY QUESTIONS**

1. Why can distances between plants be used to estimate density?
2. What kinds of communities and plants would plotless techniques work well for?