FWF 410:
“Area, Distance and Plotless Sampling”

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Goal of the Lecture

To familiarize students with area, distance, and plotless sampling designs.

Reading Assignments:

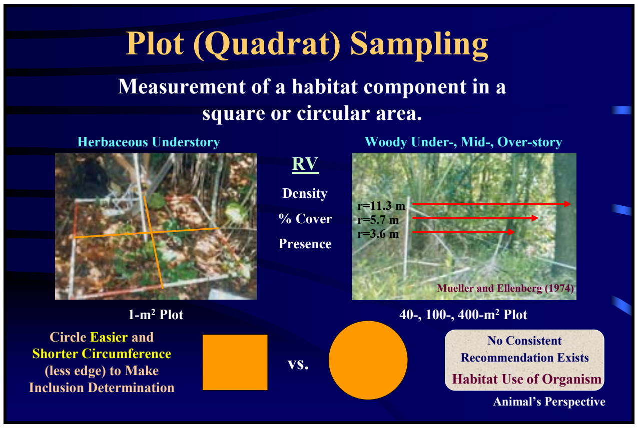
- **Chap 5: 124-126**
  - Line and Point Transects (Distance Sampling)
- **Chap 20: 530-532**
  - Quadrat and Plotless Methods
- **Handout**
  - Point- and Line- Intercepts (different than line and point transects!)

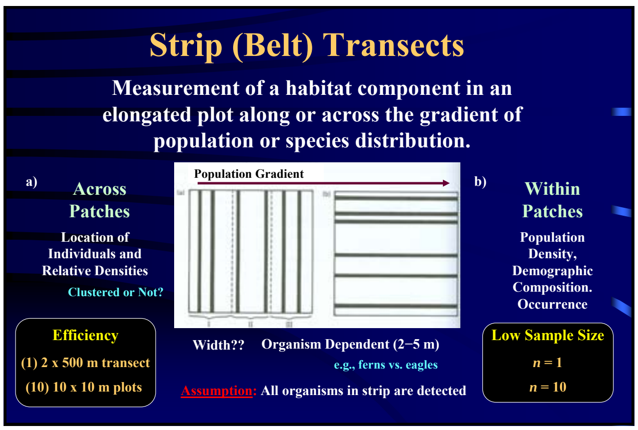
Lecture Structure

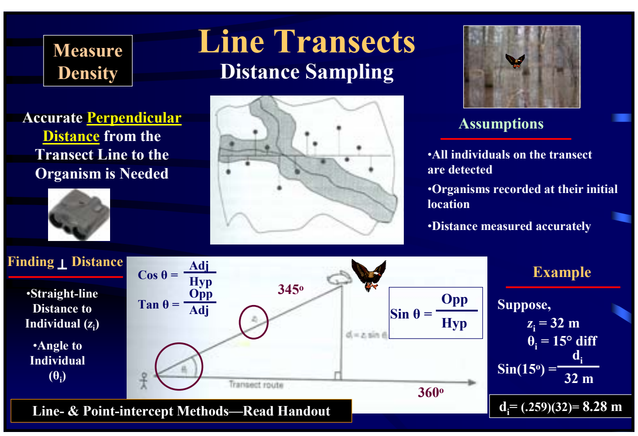
I. Area Sampling

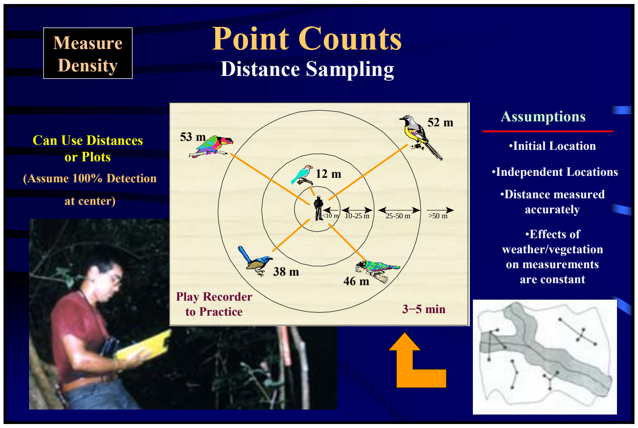
II. Distance Sampling

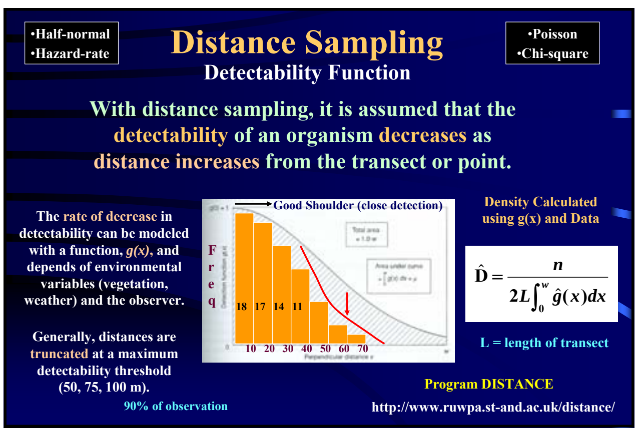
III. Plotless Sampling

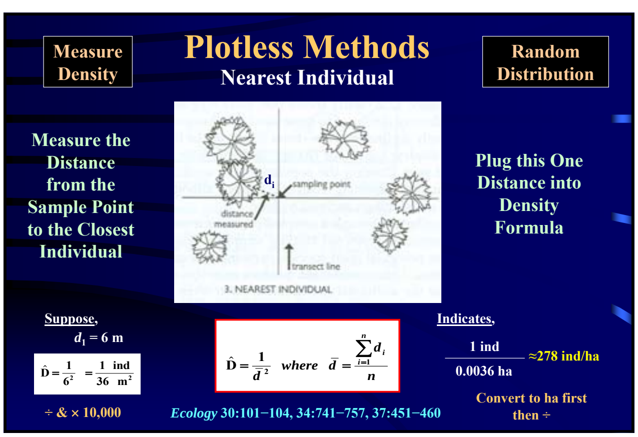

Plot (Quadrat) Sampling
Measurement of a habitat component in a square or circular area.
Herbaceous Understory
Woody Under-, Mid-, Over-story
RV
Density
% Cover
Presence
r=11.3 m
r=5.7 m
r=3.6 m
Mueller and Ellenberg (1974)
1-m² Plot
40-, 100-, 400-m² Plot
Circle Easier and Shorter Circumference (less edge) to Make Inclusion Determination
vs.
No Consistent Recommendation Exists
Habitat Use of Organism
Animal's Perspective

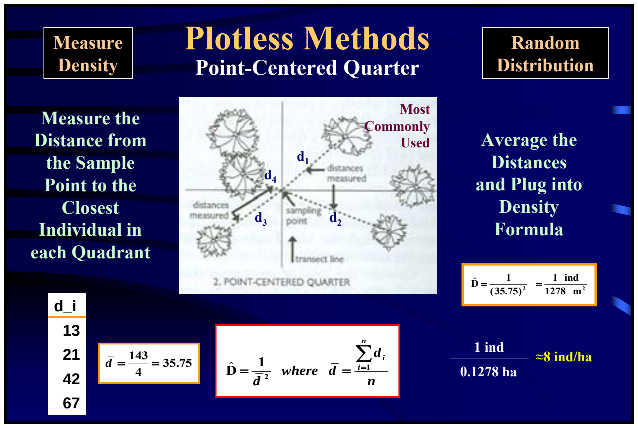

Strip (Belt) Transects
Measurement of a habitat component in an elongated plot along or across the gradient of population or species distribution.
a)
Across Patches
Location of Individuals and Relative Densities
Clustered or Not?
Population Gradient
b)
Within Patches
Population Density, Demographic Composition. Occurrence
Efficiency
(1) 2 x 500 m transect
(10) 10 x 10 m plots
Width?? Organism Dependent (2–5 m)
e.g., ferns vs. eagles
Assumption: All organisms in strip are detected
Low Sample Size
n = 1
n = 10

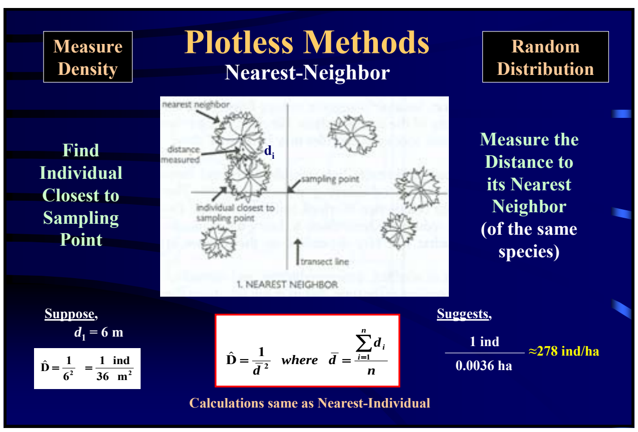

Measure Density
Line Transects
Distance Sampling
Accurate Perpendicular Distance from the Transect Line to the Organism is Needed
Assumptions
•All individuals on the transect are detected
•Organisms recorded at their initial location
•Distance measured accurately
Finding ⊥ Distance
•Straight-line Distance to Individual (zi)
•Angle to Individual (θi)
Cos θ = Adj / Hyp
Tan θ = Opp / Adj
345°
Sin θ = Opp / Hyp
Transect route
360°
Example
Suppose,
zi = 32 m
θi = 15° diff
Sin(15°) = di / 32 m
Line- & Point-intercept Methods—Read Handout
di = (.259)(32) = 8.28 m

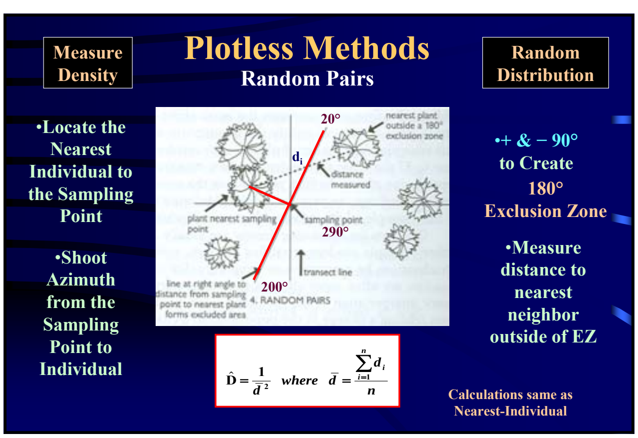

Measure Density
Point Counts
Distance Sampling
Can Use Distances or Plots
(Assume 100% Detection at center)
53 m
52 m
12 m
38 m
46 m
Play Recorder to Practice
3–5 min
Assumptions
•Initial Location
•Independent Locations
•Distance measured accurately
•Effects of weather/vegetation on measurements are constant


•Half-normal
•Hazard-rate
Distance Sampling
Detectability Function
•Poisson
•Chi-square
With distance sampling, it is assumed that the detectability of an organism decreases as distance increases from the transect or point.
The rate of decrease in detectability can be modeled with a function, g(x), and depends on environmental variables (vegetation, weather) and the observer.
Generally, distances are truncated at a maximum detectability threshold (50, 75, 100 m).
90% of observation
Good Shoulder (close detection)
F r e q
18 17 14 11
10 20 30 40 50 60 70
Density Calculated using g(x) and Data
$\hat{D} = \frac{n}{2L\int_0^w \hat{g}(x)dx}$
L = length of transect
Program DISTANCE
http://www.ruwpa.st-and.ac.uk/distance/


Measure Density
Plotless Methods
Nearest Individual
Random Distribution
Measure the Distance from the Sample Point to the Closest Individual
d_i
sampling point
distance measured
transect line
3. NEAREST INDIVIDUAL
Plug this One Distance into Density Formula
Suppose,
$d_1 = 6$ m
$\hat{D} = \frac{1}{6^2} = \frac{1}{36}\frac{ind}{m^2}$
÷ & × 10,000
$\hat{D} = \frac{1}{\bar{d}^2}$ where $\bar{d} = \frac{\sum_{i=1}^{n} d_i}{n}$
Ecology 30:101–104, 34:741–757, 37:451–460
Indicates,
$\frac{1 \text{ ind}}{0.0036 \text{ ha}}$ ≈278 ind/ha
Convert to ha first then ÷


Measure Density
Plotless Methods
Point-Centered Quarter
Random Distribution
Measure the Distance from the Sample Point to the Closest Individual in each Quadrant
Most Commonly Used
d_1
d_4
d_3
d_2
distances measured
sampling point
transect line
2. POINT-CENTERED QUARTER
Average the Distances and Plug into Density Formula
$\hat{D} = \frac{1}{(35.75)^2} = \frac{1 \text{ ind}}{1278 \text{ m}^2}$
d_i
13
21
42
67
$\bar{d} = \frac{143}{4} = 35.75$
$\hat{D} = \frac{1}{\bar{d}^2}$ where $\bar{d} = \frac{\sum_{i=1}^{n} d_i}{n}$
$\frac{1 \text{ ind}}{0.1278 \text{ ha}}$ ≈8 ind/ha


Measure Density
Plotless Methods
Nearest-Neighbor
Random Distribution
Find Individual Closest to Sampling Point
nearest neighbor
distance measured
d_i
sampling point
individual closest to sampling point
transect line
1. NEAREST NEIGHBOR
Measure the Distance to its Nearest Neighbor (of the same species)
Suppose,
$d_1 = 6$ m
$\hat{D} = \frac{1}{6^2} = \frac{1 \text{ ind}}{36 \text{ m}^2}$
$\hat{D} = \frac{1}{\bar{d}^2}$ where $\bar{d} = \frac{\sum_{i=1}^{n} d_i}{n}$
Calculations same as Nearest-Individual
Suggests,
$\frac{1 \text{ ind}}{0.0036 \text{ ha}}$ ≈278 ind/ha


Measure Density
Plotless Methods
Random Pairs
Random Distribution
•Locate the Nearest Individual to the Sampling Point
•Shoot Azimuth from the Sampling Point to Individual
20°
nearest plant outside a 180° exclusion zone
d_i
distance measured
plant nearest sampling point
sampling point
290°
transect line
line at right angle to distance from sampling point to nearest plant forms excluded area
200°
4. RANDOM PAIRS
•+ & − 90° to Create 180° Exclusion Zone
•Measure distance to nearest neighbor outside of EZ
$\hat{D} = \frac{1}{\bar{d}^2}$ where $\bar{d} = \frac{\sum_{i=1}^{n} d_i}{n}$
Calculations same as Nearest-Individual

Measure Density

Plotless Methods

Wandering Quarter Distance

Non-Random Distribution

•Establish a Transect

•Find First Individual

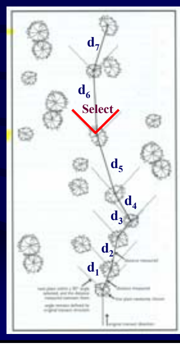
•Establish a 90° Zone of Selection

+ & − 45°

360°

315° 45°

Original Transect Direction



•Measure the Distance to the Nearest Neighbor in 90° Zone

•Continue until the end of your sampling area is reached

$$\hat{D} = \frac{1}{\bar{d}^2} \quad where \quad \bar{d} = \frac{\sum_{i=1}^{n} d_i}{n}$$

Calculations same as Point-Centered Quarter

Measure Density

Plotless Methods

T^2-Method

Non-Random Distribution

•Establish Random Sampling Points (n=10)

•Measure Distance to Nearest Individual (x_i)

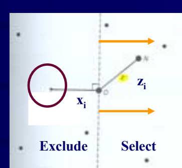
•Measure Distance to Nearest Neighbor (z_i) in 180° Zone of Selection

Calculate Density

	x_i	z_i
1	70.56871	72.86309
	58.92468	42.11325
	20.61602	46.58666
	49.42305	34.42808
	35.58351	43.29432
	26.68249	20.96942
	32.68853	40.7564
	22.59545	16.04923
	41.61153	36.92389
10	70.81591	71.90725
Σ =	429.5099	425.8916

$$\hat{D} = \frac{10^2}{\left[2.828(429.51)(425.89)\right]} = 0.000193$$

per m^2



$$\hat{D} = \frac{n^2}{\left[2.828\left(\sum_{i=1}^{n} x_i\right)\left(\sum_{i=1}^{n} z_i\right)\right]}$$

×10,000 =1.93 ind/ha

Plot vs. Plotless Methods

Simulations and empirical studies have shown that plot methods are more accurate (unbiased + precise) than plotless methods in estimating population density.

Ecology 75:1769−1779, JRM 26:61−67, Proc. Grassl. Soc. South. Afr. 12:109−113

Plotless methods are recommended only when individuals are randomly distributed and individual spacing (e.g., >20 m) prevents detection in randomly or systematically placed plots.

(trees spaced far apart)

Recommendation:	•Point-centered Quarter	(overestimated)	(random)
	•T^2 Method	(underestimated)	(non-random)