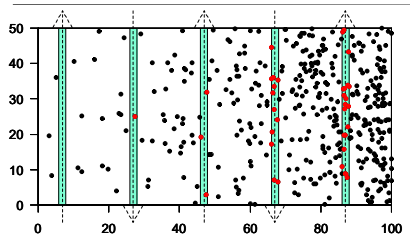
9. Line transect (distance) sampling: an introduction

Sampling area (not individuals)

- Strip transect
  - Sample a strip of defined width along a set of transects
- Line transect
  - Use additional data to estimate the width of the strip sampled
- Point "transect"
  - Sample the area around a set of points within fixed or estimated radius

Strip transect sampling



$$\hat{D} = \frac{n}{a} = \frac{36}{500} = 0.72$$

$$\hat{N} = \hat{D}A = 0.72 \times 5000 = 360$$

D = density
N = abundance

Size of study area (***A***) = 5000
Total transect length (***L***) = 50 x 5 = 250
Width of half the strip (***w***) = 1
Area sampled (***a***) = 2***wL*** = 2 x 1 x 250 = 500
Number of animals counted (***n***) = 36

$$\hat{N} = \frac{n}{a/A} = \frac{36}{0.1} = 360$$

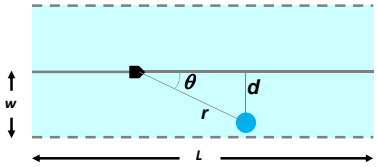
Line Transect Sampling

- Search along transects collecting data on:
  - Distance travelled (+ searching conditions)
  - Species and size of detected groups (+ observer, cue, etc)
- Cannot assume detection probability is 1, so …
  - Perpendicular distance (***d***)
  - Distance (***r***) and angle (***θ***) to detected groups ***d*** = ***r*** *sin(****θ****)*

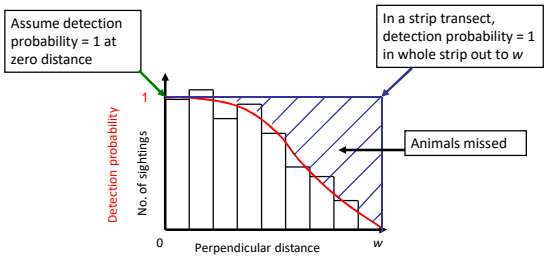
L = transect length

w = strip half-width

2***wL*** = nominal area searched



Estimating probability of detection



Average probability of detection: $\hat{p}_a = \frac{\text{area under curve}}{\text{area under rectangle}}$

Important assumption: animals are distributed uniformly between 0 and w

Line transect density/abundance estimate

- Strip transect density (*D*) is estimated as:

$$\hat{D} = \frac{n}{2wL}$$

n = number of animals seen
L = length of transect
w = strip half width

- Line transect density is estimated as:

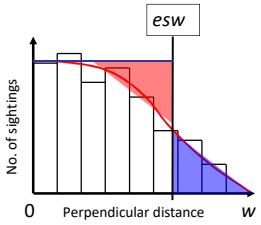
$$\hat{D} = \frac{n}{2wL\hat{p}_a}$$

p_a = average probability of detection

w x p_a = ***effective*** strip half-width (*esw*)

- And abundance (*N*) as: $\hat{N} = \hat{D}A$ *A* = size of survey area

Effective strip half-width (*esw*)



Assumptions of line transect sampling

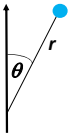
- Study area is sampled representatively
- All animals are detected on the transect line
- Animals do not move prior to detection
  - Animals in the vicinity of the transect line are distributed uniformly with respect to the line
- All measurements are accurate
- Observations are independent
  - To ensure an unbiased estimate of variance

➢ Violation of assumptions can cause bias …

All measurements are accurate

- Transect length
- Species identification
  - Inaccurate species identification
  - Sightings unidentified to species

- Perpendicular distances
  - Radial distances
    - Systematic under or over-estimation
    - Random error
  - Angles
    - Rounding to convenient values
    - Random error



- Group size
  - Systematic under or over-estimation
  - Bias may change with distance

All animals are detected on the transect line

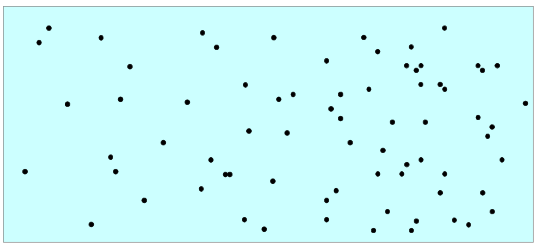
- Probability of detection at zero perpendicular distance = 1
  - Conventionally known as g(0) = 1
- If animals (or groups) on the transect line are missed
  - Density and abundance are negatively biased
- Two sources of bias
  - Availability
    - Not all animals on the transect line are at the surface
  - Perception
    - Animals on the line are at the surface but are missed by observers

Animals do not move prior to detection

- Animals do move …
  - If movement is after detection – no problem
  - Movement prior to detection can be
    - Random
    - In response to the survey vessel
- Random movement is generally not a problem
  - Unless speed of movement is high relative to survey platform
  - Causes positive bias in abundance
- Responsive movement is a problem
  - Avoidance causes negative bias in abundance
  - Attraction causes positive bias in abundance
    - This bias can be severe

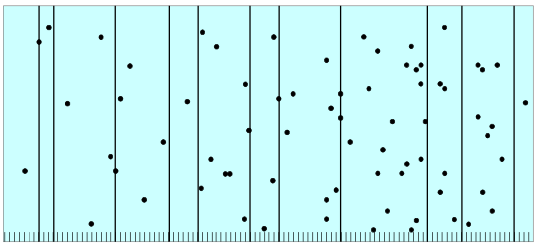
Study area is sampled representatively

- Animals are not distributed randomly in space
- Sampling must be random/systematic
  - To achieve equal coverage probability



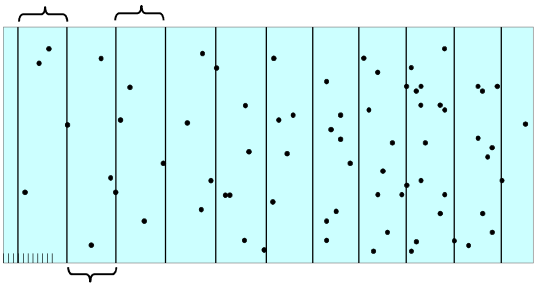
Survey design

- Randomly spaced parallel lines
  - Give equal coverage probability



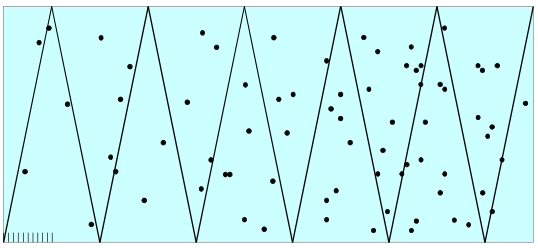
Survey design

- Evenly spaced parallel lines
  - With a random starting point
  - But time wasted in transit …



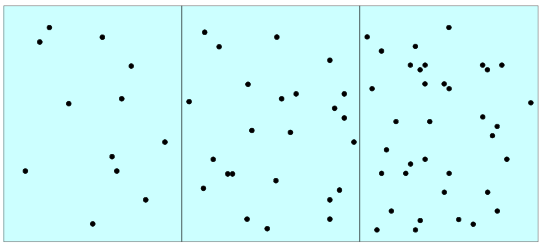
Survey design

- Systematic zig-zag lines
  - With a random starting point
  - Appropriate for large areas
    - Potential problem at ends of lines in small areas



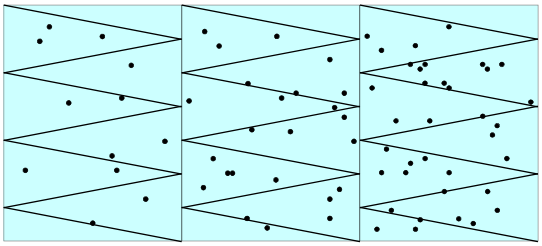
Stratification of survey area

- Two purposes for stratification
  - Logistical reasons
  - To reduce overall variance
    - If density is known/expected to vary



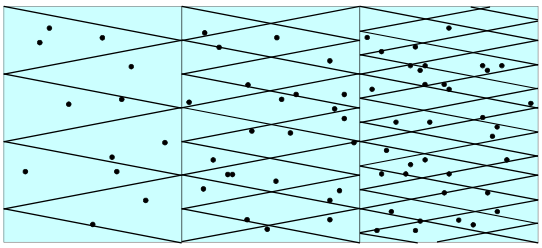
Stratified survey design

- Stratified design (with zig-zag lines)
  - Survey lines placed perpendicular to density contours
    - Generally desirable feature of survey design
  - Inter-transect variability is less within strata than for the whole area



Stratified survey design

- Stratified design with uneven effort
  - Increase survey effort in relation to expected density
    - Reduce variance even more
    - But then strata must be analysed separately



Line transect sampling in practice

- Define the area within which abundance is to be estimated
- Design survey and select transect lines
- Search along transect lines for animals
  - Searching in front and to either side of the transect
- When an animal (group of animals) is encountered:
  - Identify species
  - Determine group size
  - Measure perpendicular distance from animal/group to transect line
- Continue searching along transect lines
- When finished:
  - Number of animals encountered is known (n)
    - Or number of groups and mean group size
  - Length of total transect is known (L)
  - Use distance data to estimate average probability of detection (p_a)