SMITHSONIAN'S NATIONAL ZOO & CONSERVATION BIOLOGY INSTITUTE

Introduction to Distance Sampling for Wildlife Population Monitoring

Wildlife Tourism College
Pardamat Conservation Area
16 – 20 September 2024

MARA ELEPHANT PROJECT

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

ENARAU CONSERVANCY
Maasai Mara
Protecting unique habitats

NABOISHO

EARTHRANGER

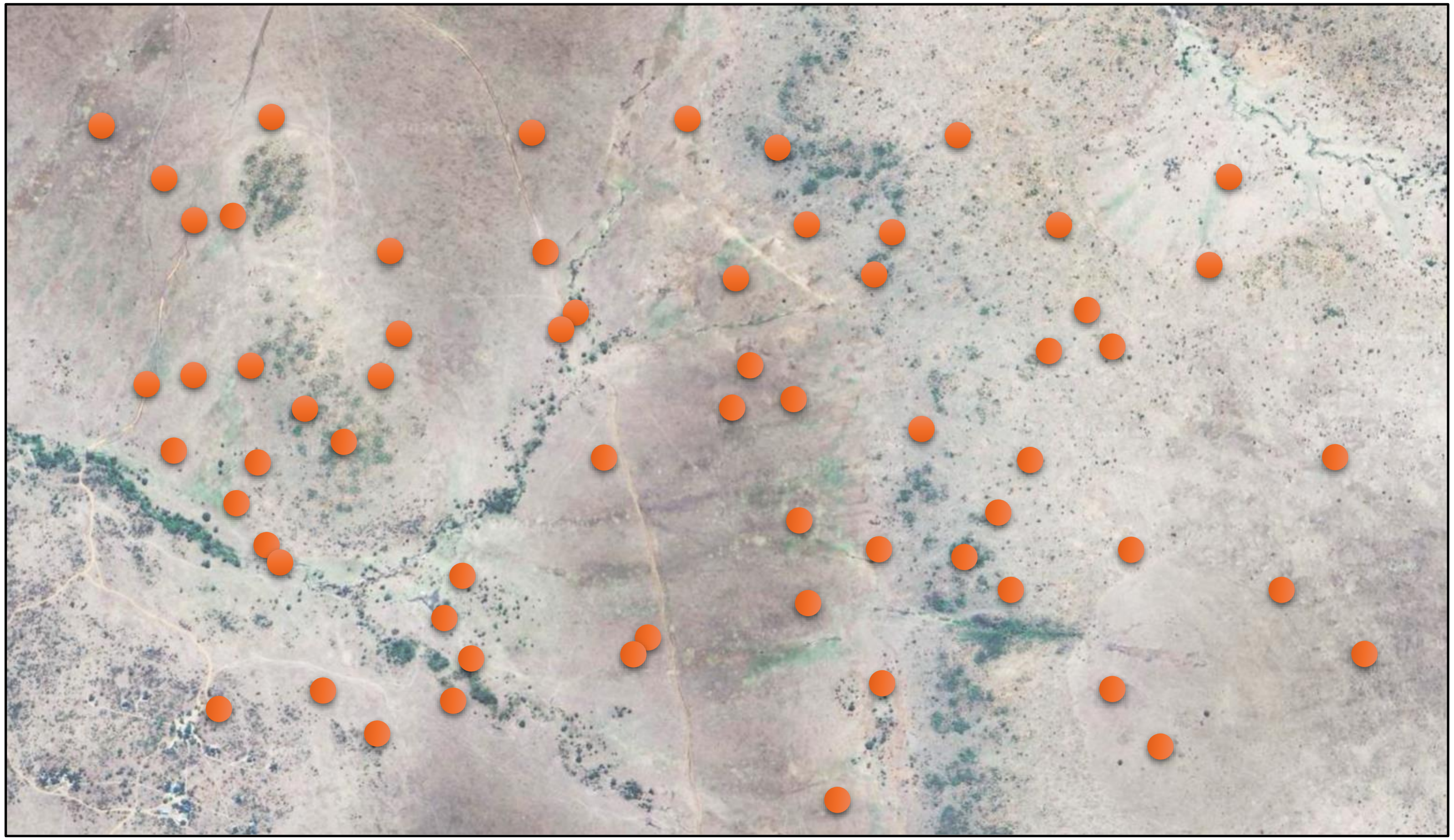
KWT
KENYA WILDLIFE TRUST

NASA
EARTH SCIENCE
APPLIED SCIENCES

Award: 80NSSC23K1537

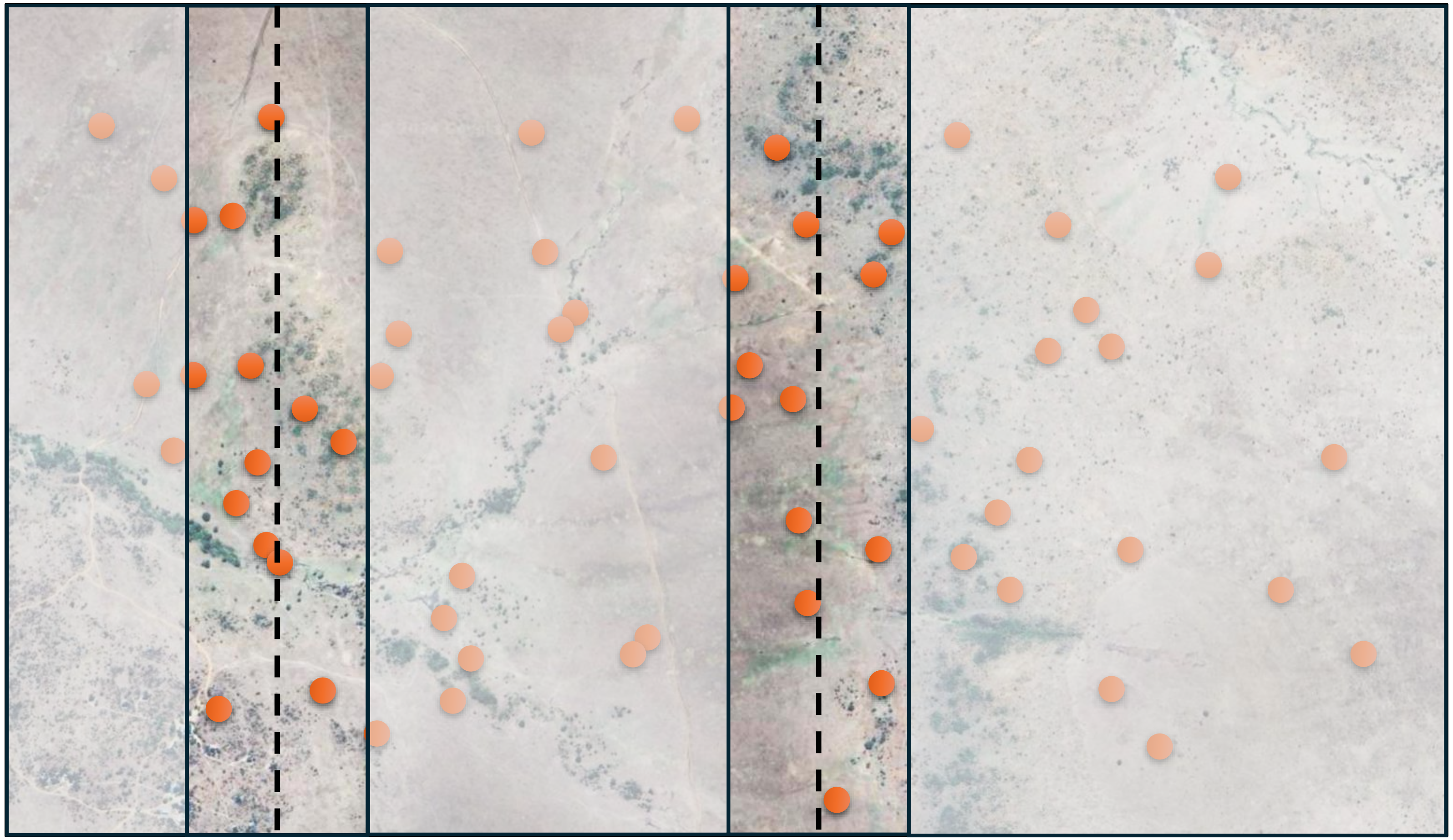
Q1: Why do we count wildlife?

Complete Census



N = Number of Animals Counted

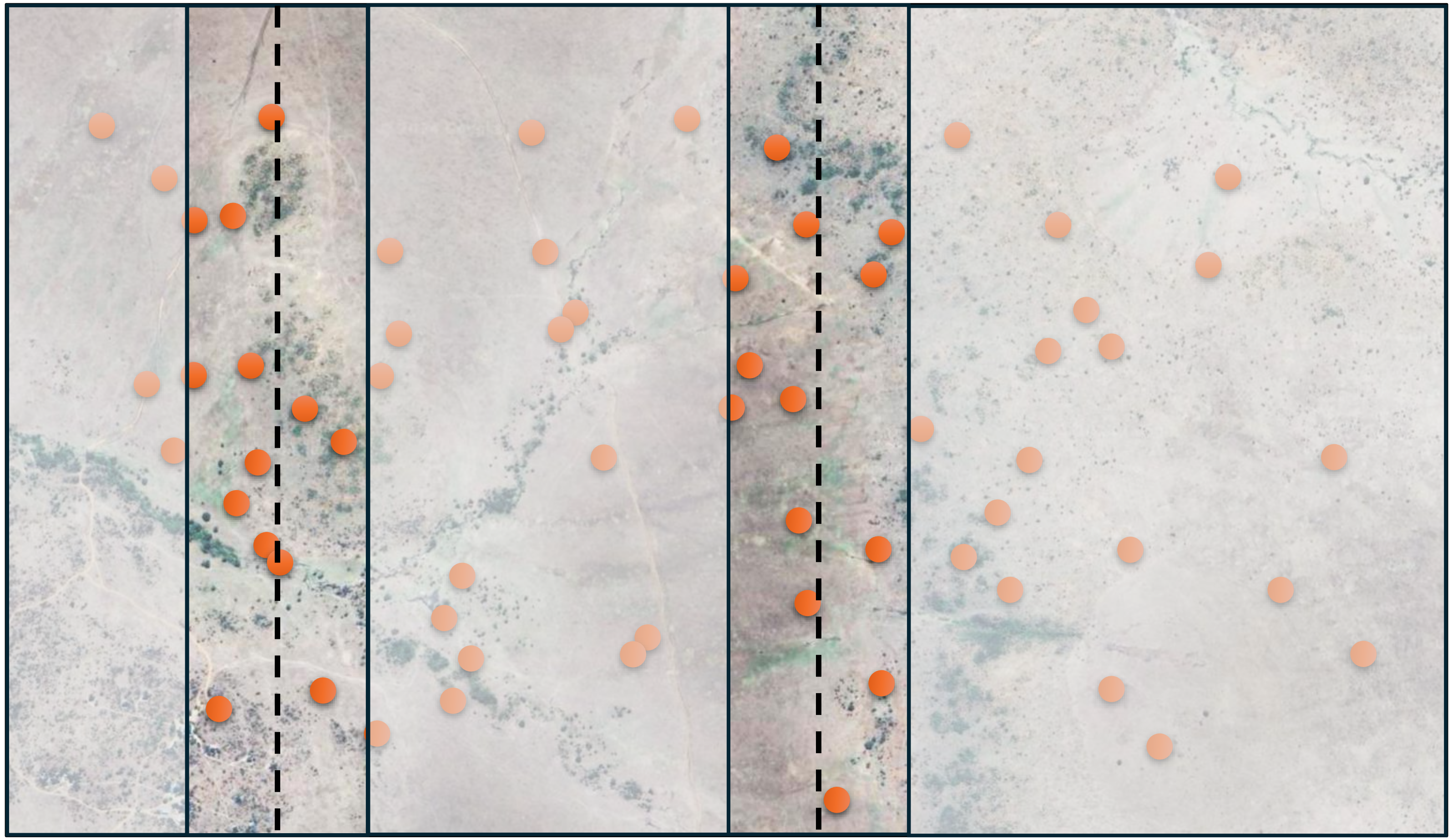
Strip Transects



N = ?

Strip Transects

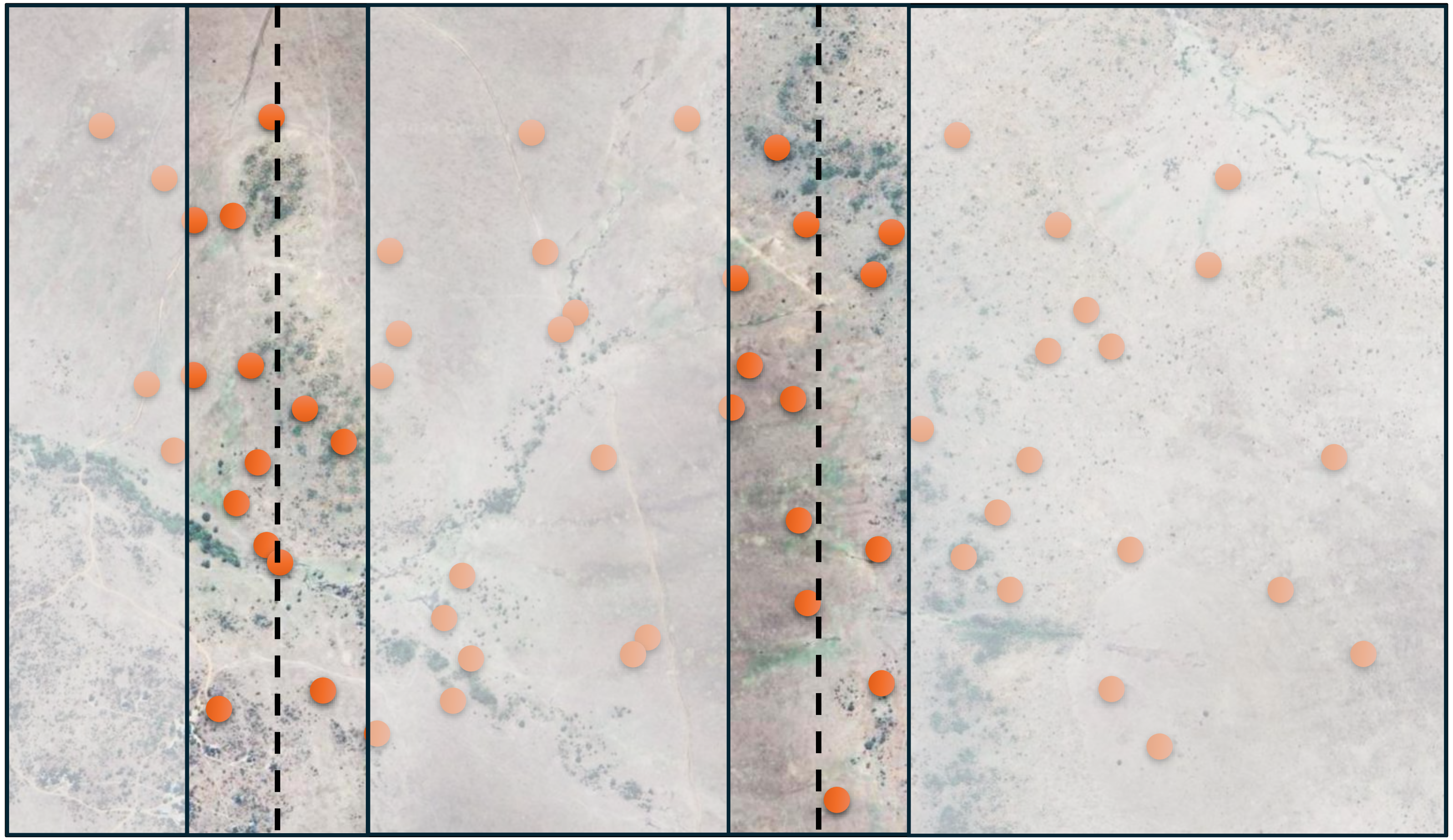
$$Density = \frac{\#\ Counted}{Area\ Surveyed}$$



Strip Transects

$$Density = \frac{\#\ Counted}{Area\ Surveyed}$$

$$\hat{N} = Density\ x\ Total\ Area$$

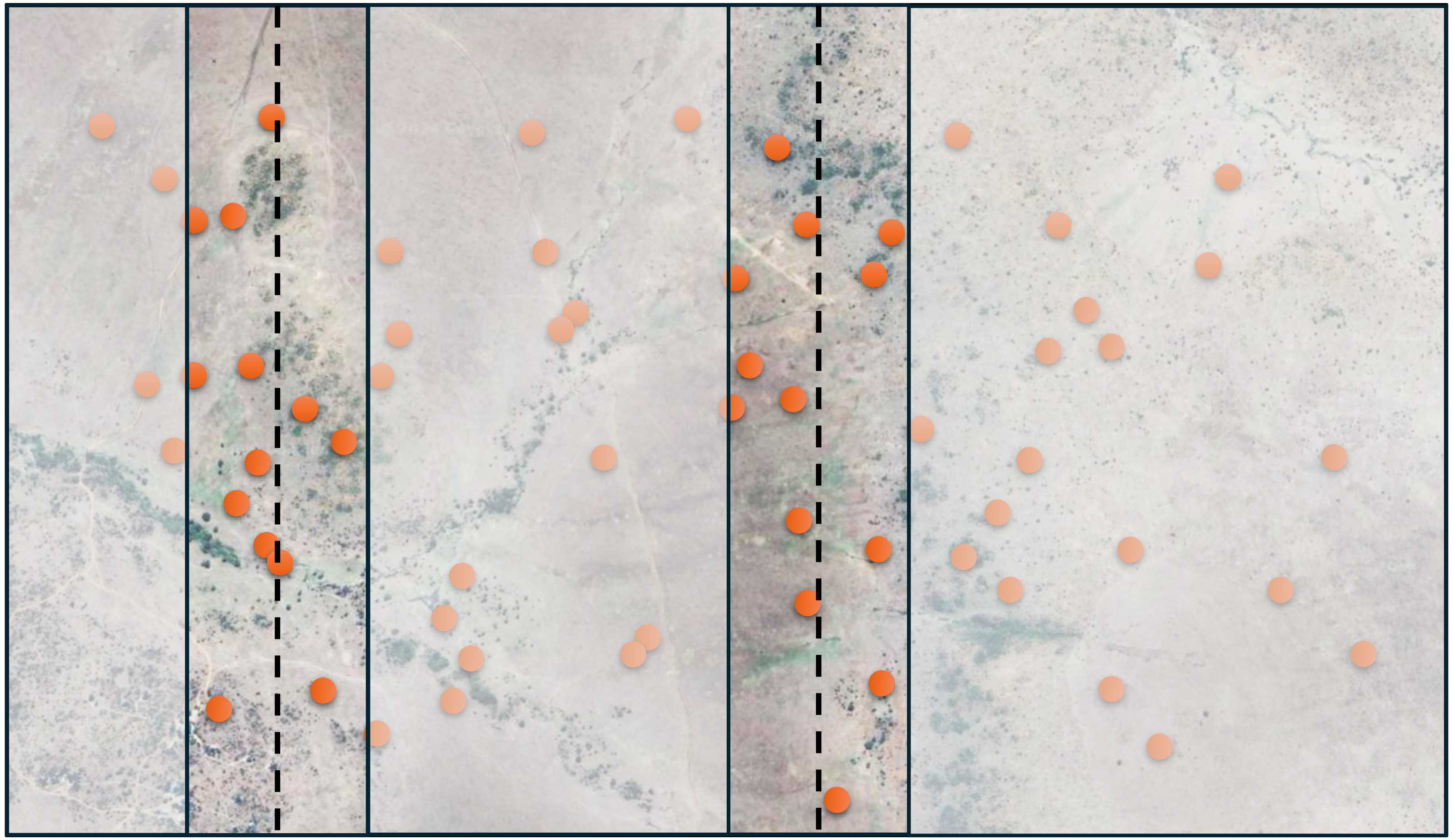


Strip Transects

$$Density = \frac{\#\ Counted}{Area\ Surveyed}$$

$$\hat{N} = Density\ x\ Total\ Area$$

Q2: If you surveyed 20 km^2 and your total area is 80 km^2, what is the density in your sampled area?



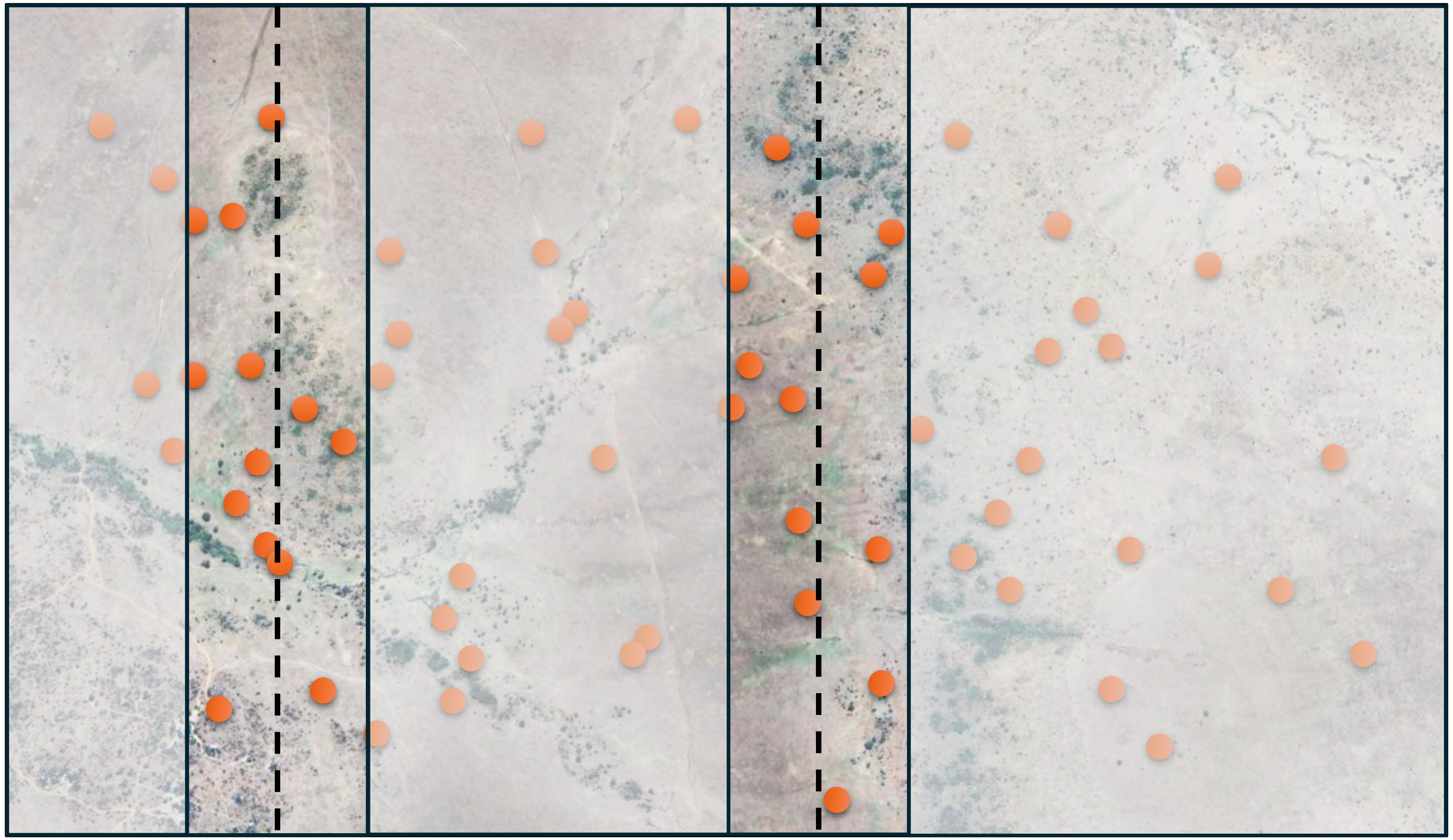
Strip Transects

$$Density = \frac{\#\ Counted}{Area\ Surveyed}$$

$$\hat{N} = Density\ x\ Total\ Area$$

Q2: If you surveyed 20 km^2 and your total area is 80 km^2, what is the density in your sampled area?

Q3: What is your estimated "$\hat{N}$" for the full area?



Strip Transects

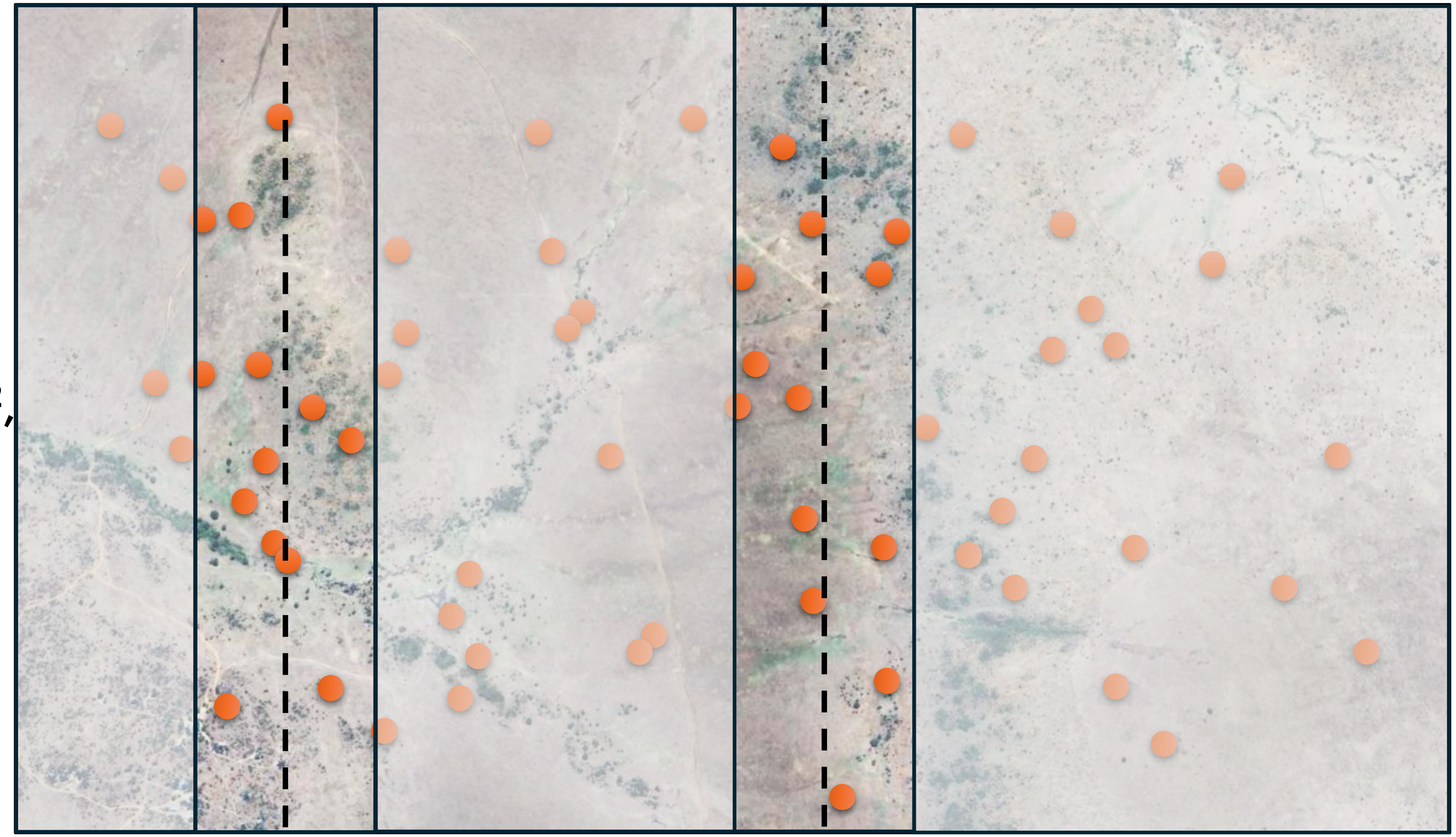
$$Density = \frac{\#\ Counted}{Area\ Surveyed}$$

$$\widehat{N} = Density\ x\ Total\ Area$$

Q2: If you surveyed 20 km² and your total area is 80 km², what is the density in your sampled area?

Q3: What is your estimated "$\widehat{N}$" for the full area?

Q4: What assumptions are we making to find $\widehat{N}$?



Strip Transects

$$Density = \frac{\#\ Counted}{Area\ Surveyed}$$

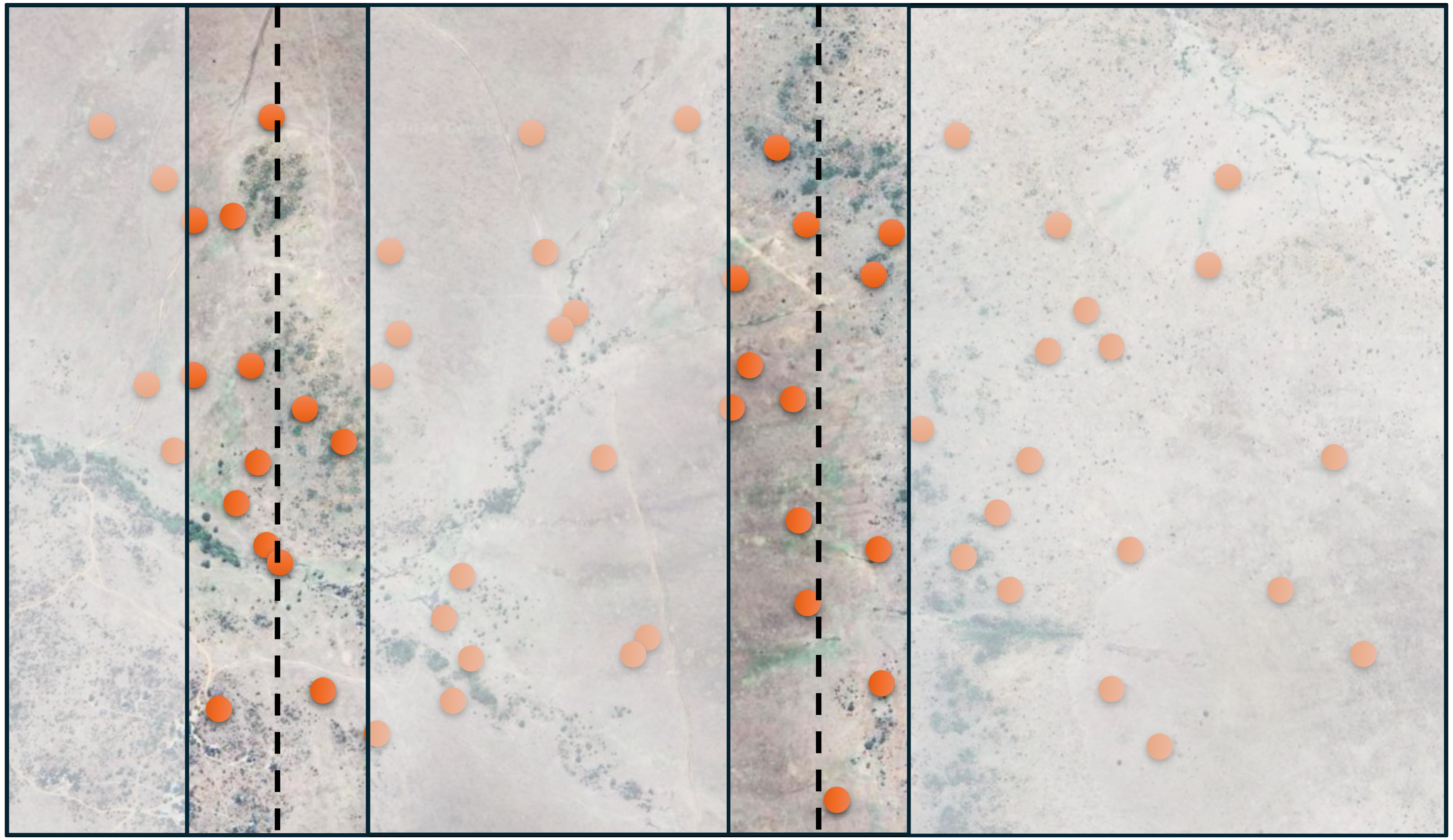
$$\hat{N} = Density\ x\ Total\ Area$$

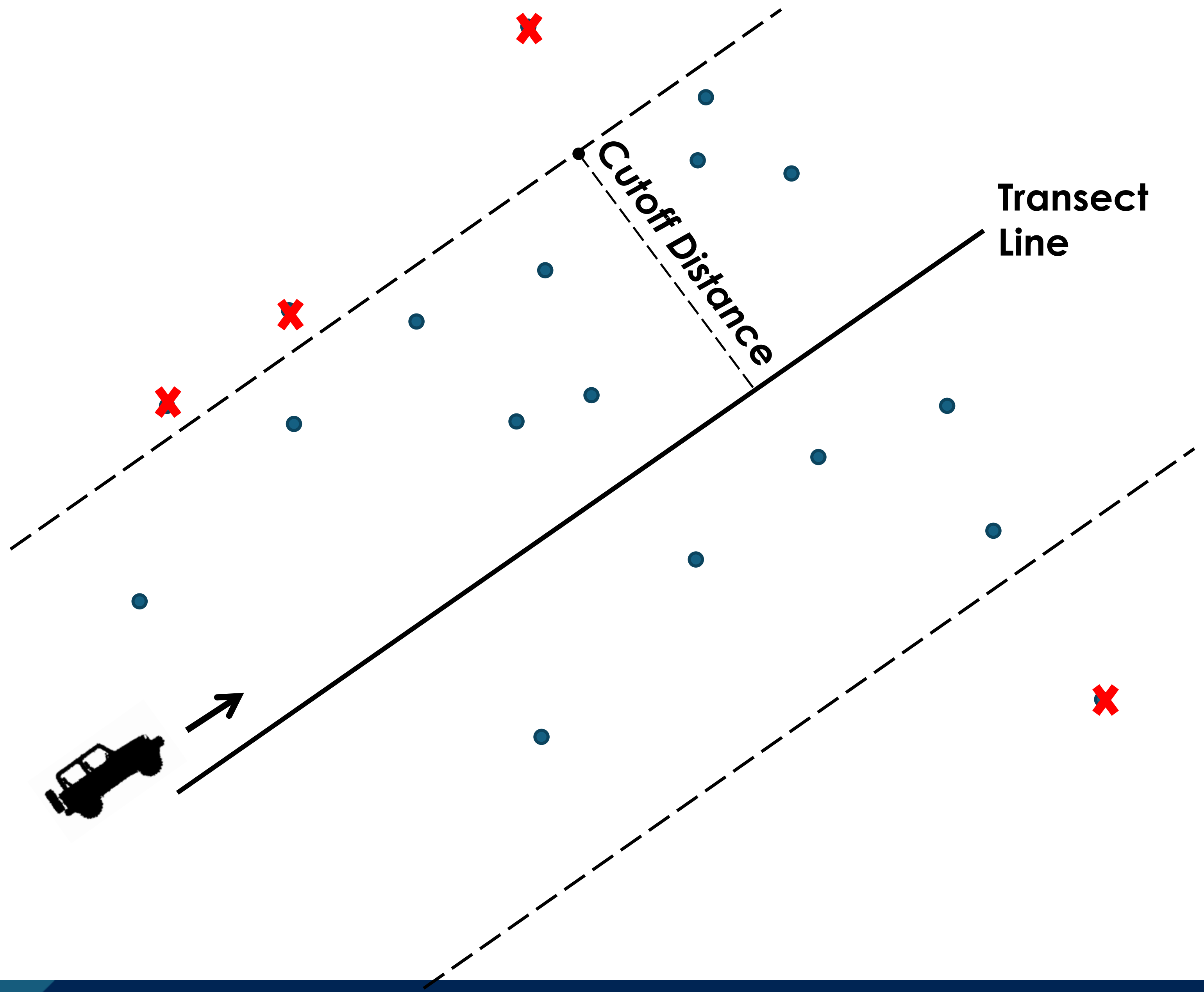
$$\hat{N} = 1.3\ x\ 80 = 104$$

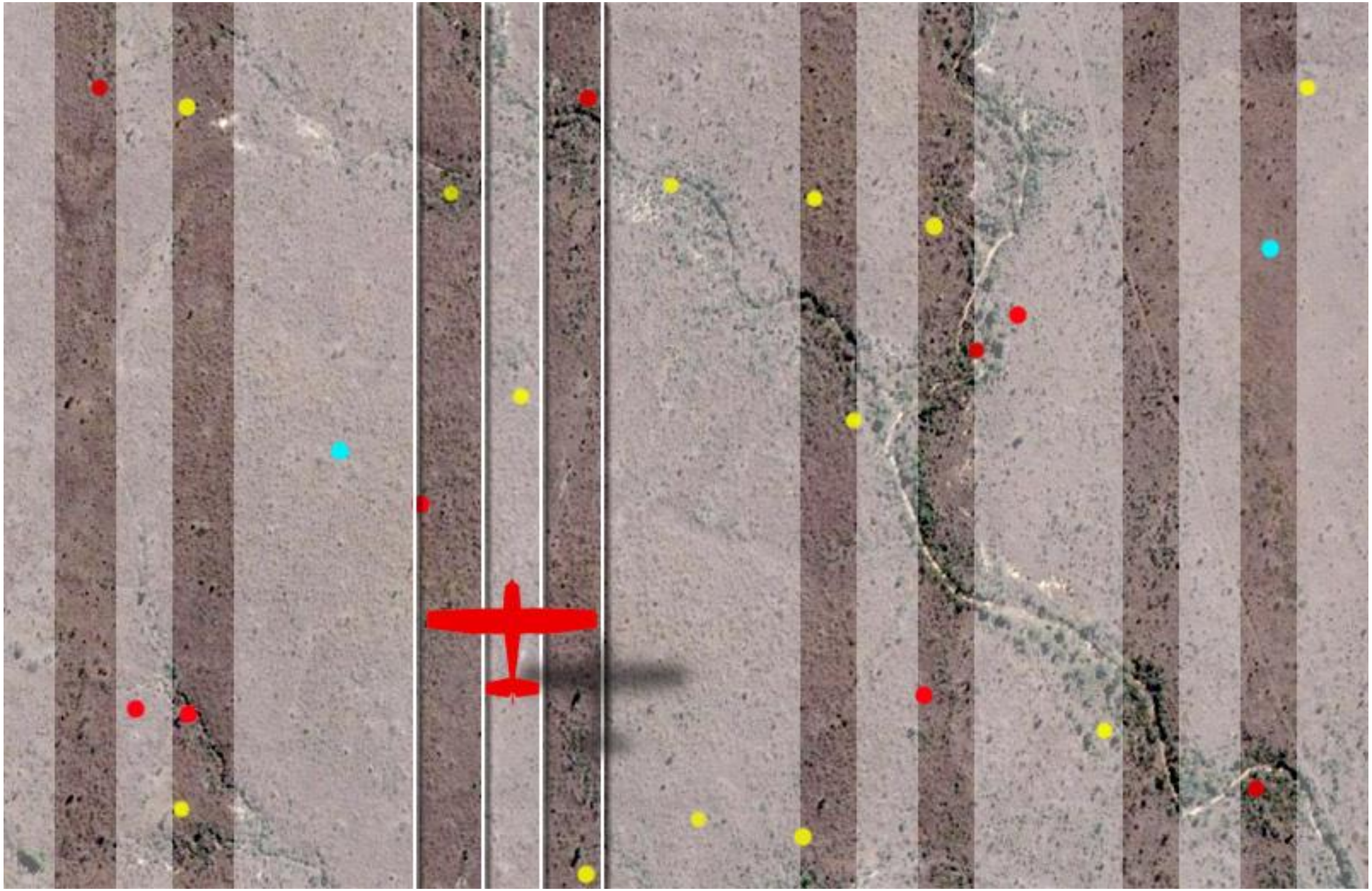
$$N = 64$$

True Abundance

Q5: How could design our study so that observed density is more "representative"?




Transect
Line
Cutoff Distance




© Petri Viljoen
P. Viljoen

What if we miss some animals?

Photo credit: Richard Costin

What if we miss some animals?

Photo credit: Richard Costin

What if we miss some animals?

Q6: What factors make animals hard to see?

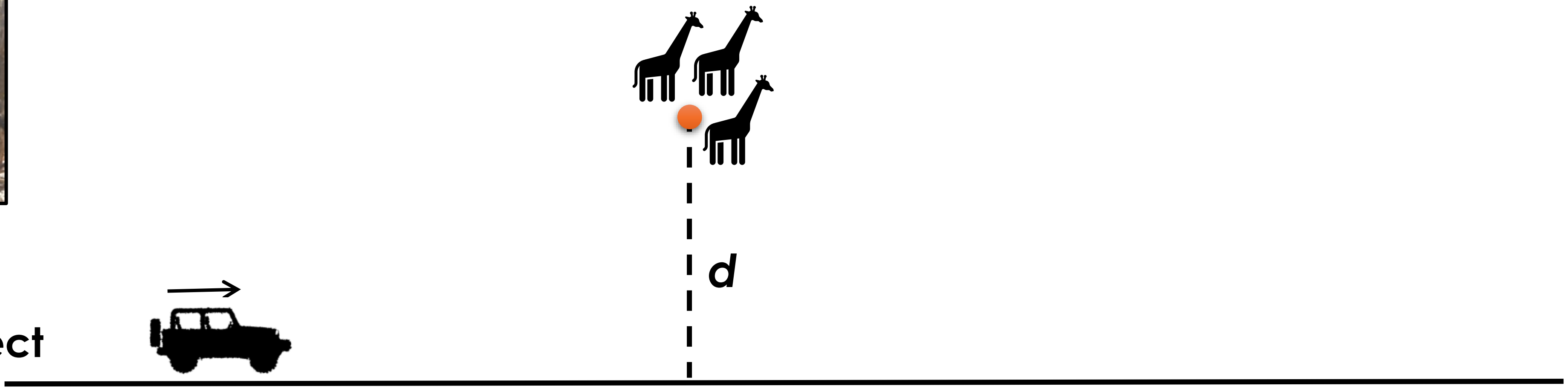
Q7: What happens to our estimates of *D* and $\hat{N}$ if we miss animals?

Photo credit: Janet Kavutha

~~Why~~ How do we count wildlife?

Basics of Distance Sampling

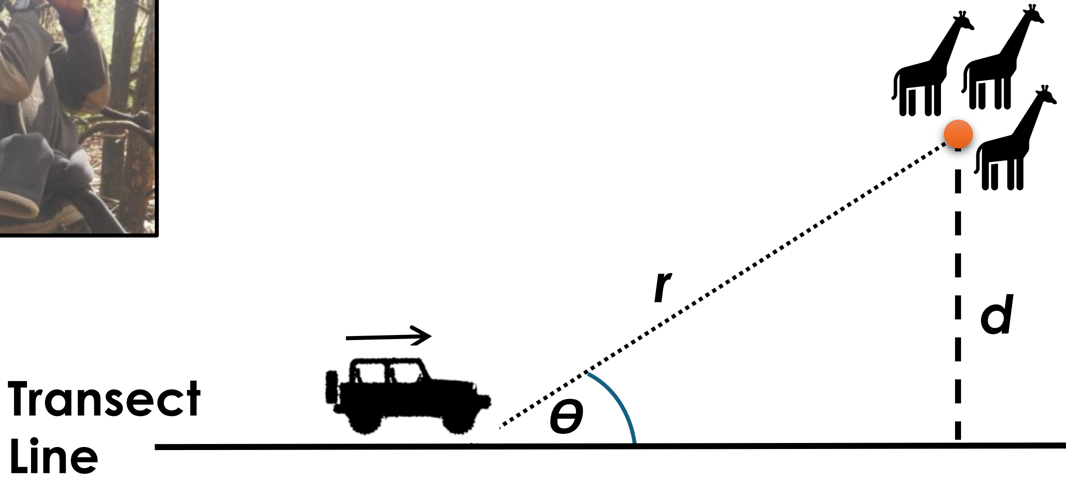
Estimating animal density by recording distances to fixed transect lines or points



Transect Line

Basics of Distance Sampling

Estimating animal density by recording distances to fixed transect lines or points



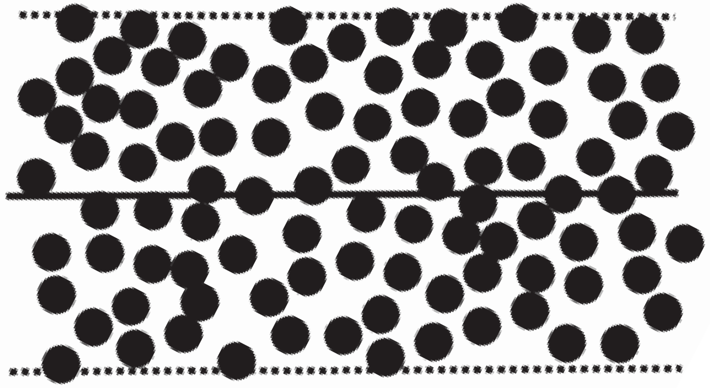
<u>Required data</u>

- Perpendicular distance (*d*)
  OR Radial distance (*r*) and angle (*θ*)
- Transect length
- Group size

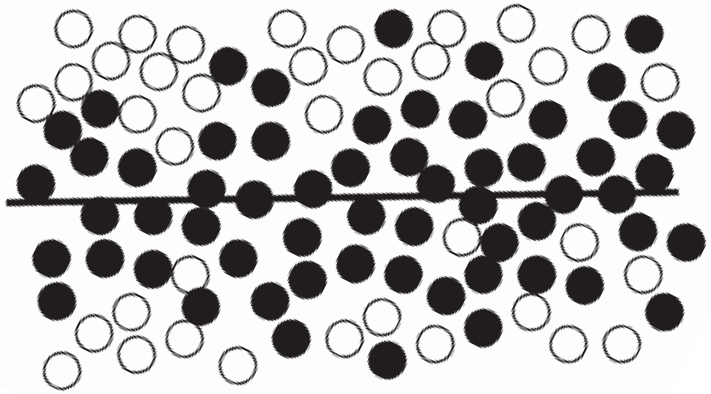
Because $d = r \times \sin(\theta)$

Why Bother with Distance Sampling?

Scenario A:
- **We detect every animal!**
- **Likely open habitat + highly visible species**

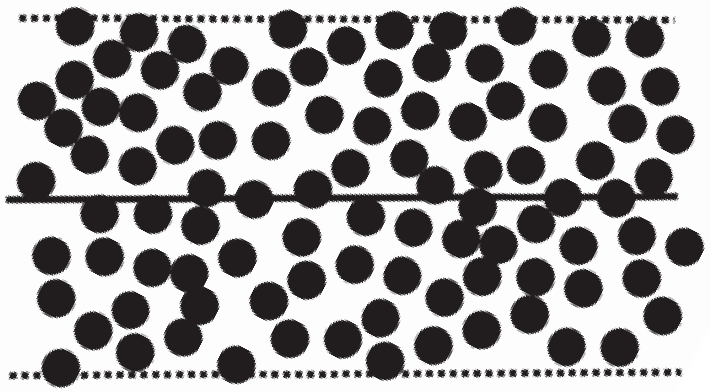


Scenario B:
- **Much more common!**
- **More animals seen close to our transect line**



Why Bother with Distance Sampling?

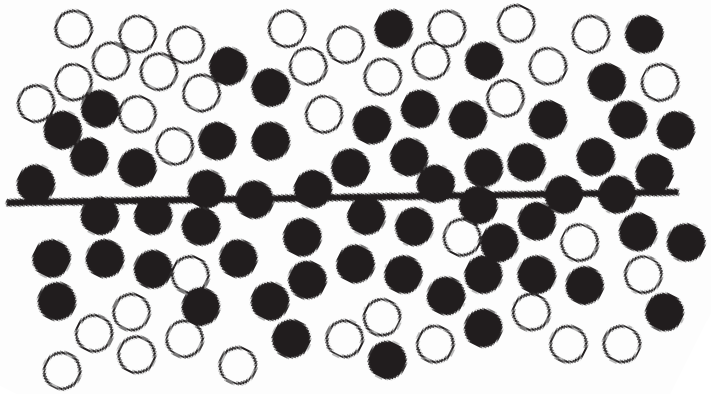
Scenario A:
- We detect every animal!
- Likely open habitat + highly visible species



Detection probability (p) = 1

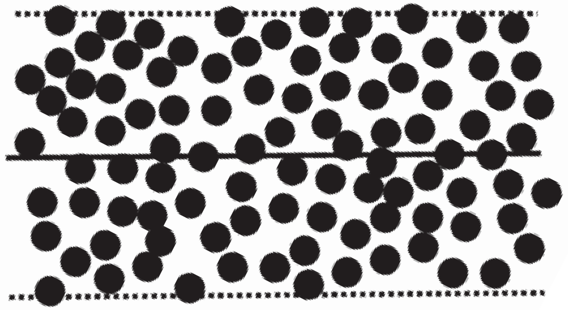
$$Density = \frac{\#\ Counted}{Area\ Surveyed}$$

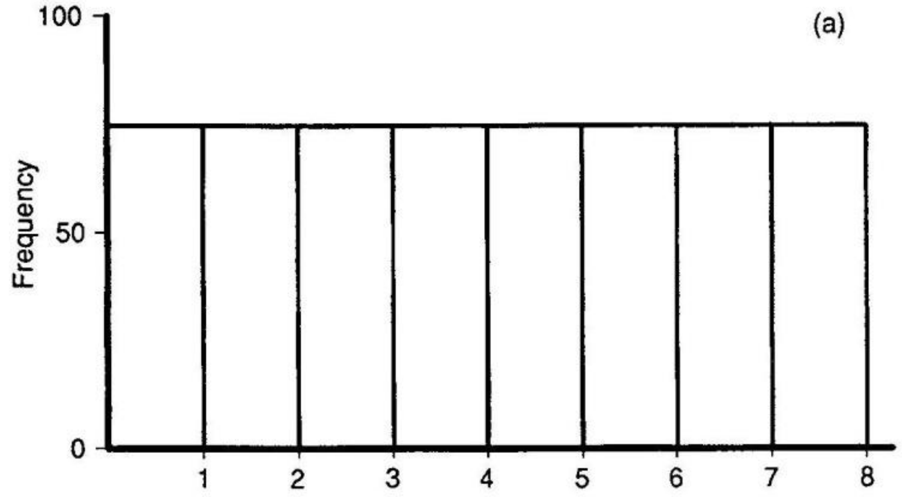
Scenario B:
- Much more common!
- More animals seen close to our transect line



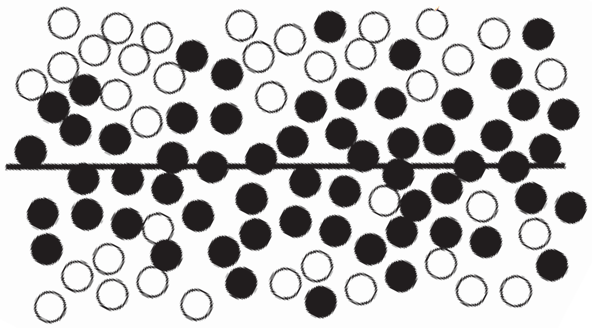
Detection probability (p) < 1

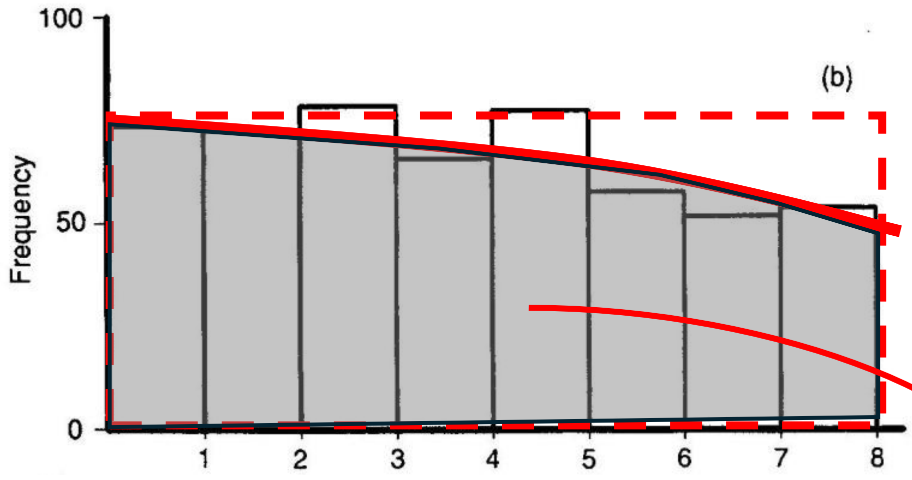
$$Density = ???$$





Detection probability (p) = 1





Detection probability (p) < 1

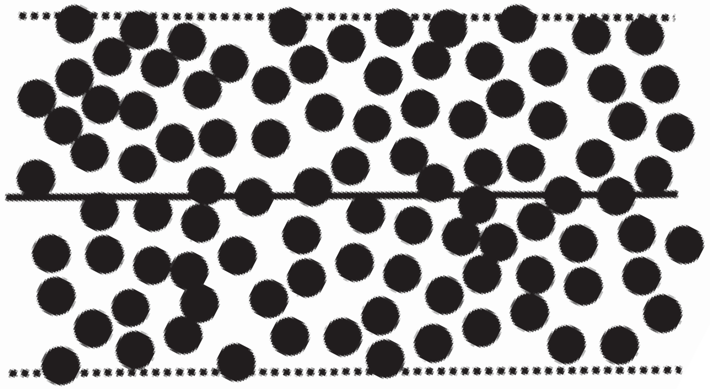
Estimated detection prob. ($\hat{p}$) = 0.65

$\hat{p}$ = Area under curve

Distance sampling model

Why Bother with Distance Sampling?

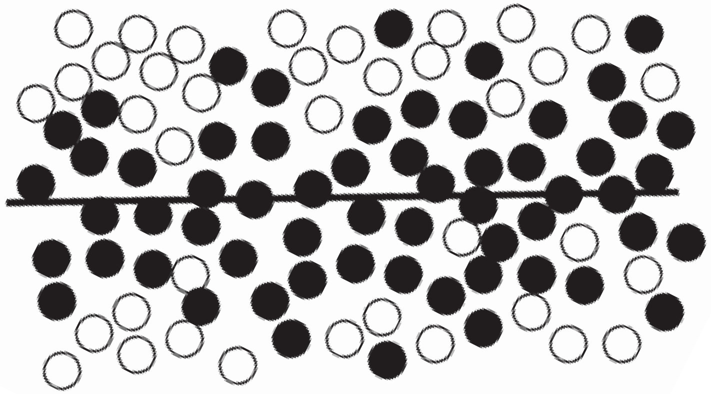
Scenario A:



Detection probability (p) = 1

$$Density = \frac{\#\ Counted}{Area\ Surveyed}$$

Scenario B:



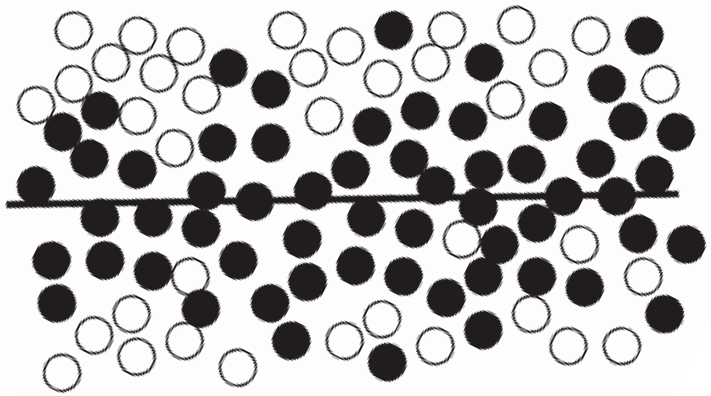
Detection probability (p) = 0.65

$$Density = ???$$

$$Density = \frac{\#\ Counted}{Area\ Surveyed * p}$$

Distance Sampling Example

Scenario B:



Q8: What is your estimate of *D* if you have the following data?

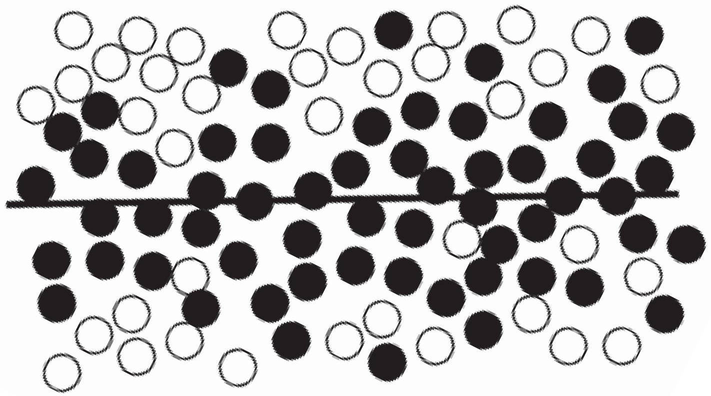
- Transect area = 20 km^2
- # Counted = 61
- Estimated detection = 0.65
- Total area = 80 km^2

Q9: How many animals would you guess are in the transect area?

Q10: How many animals would you guess are in the total area?

Distance Sampling Example

<u>Scenario B</u>:



Q8: What is your estimate of *D* if you have the following data?

- Transect area = 20 km^2
- # Counted = 61 Topi
- Estimated detection = 0.65
- Total area = 80 km^2

$$D = \frac{61}{20} = 3.05\, Topi/km^2$$

Q9: How many animals would you guess are in the transect area?

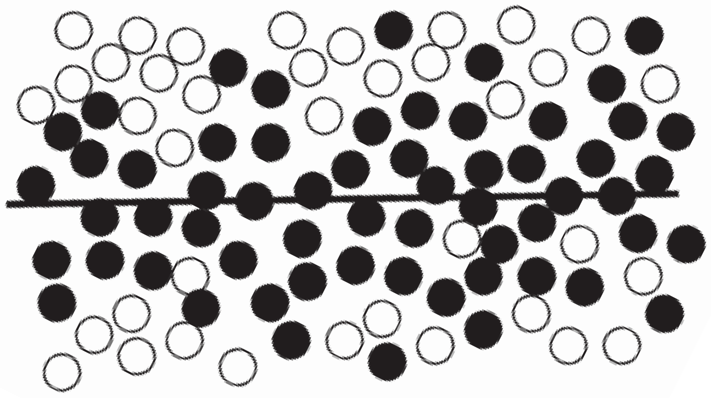
$3.05\, Topi/km^2\ x\ 20\ km^2$ = *93.8 Topi (Truth = 100)*

Q10: How many animals would you guess are in the total area?

<u>Estimated N</u> = $3.05\, Topi/km^2\ x\ 80\ km^2$ = *244 Topi*

Distance Sampling Example

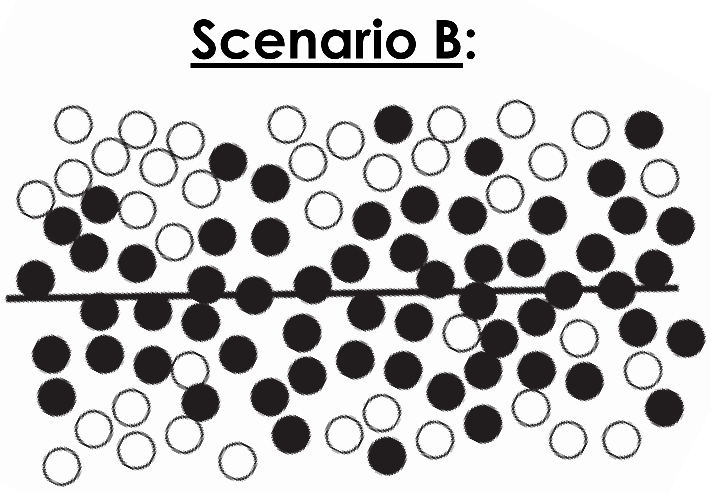
Scenario B:



Q11: Now imagine that each dot in Scenario B represents a group of Topi, not a single individual. If the average (mean) group size is 3.8 individuals, how many Topi would you estimate for your 80 km^2 area?

- Transect area = 20 km^2
- # Counted = 61 Topi Groups
- Mean Group Size = 3.8
- Estimated detection = 0.65
- Total area = 80 km^2

Distance Sampling Example

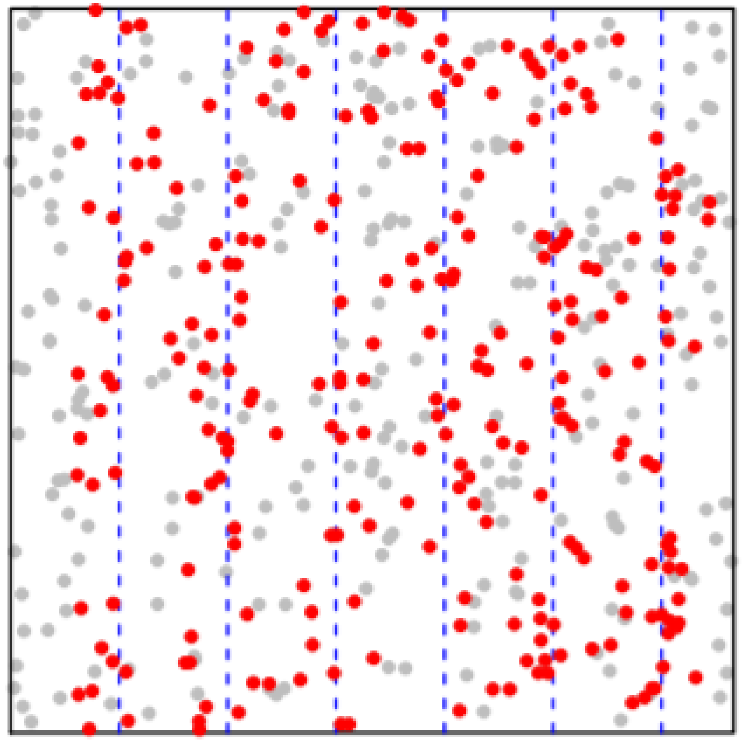


Q11: Now imagine that each dot in Scenario B represents a group of Topi, not a single individual. If the average (mean) group size is 3.8 individuals, how many Topi would you estimate for your 80 km^2 area?

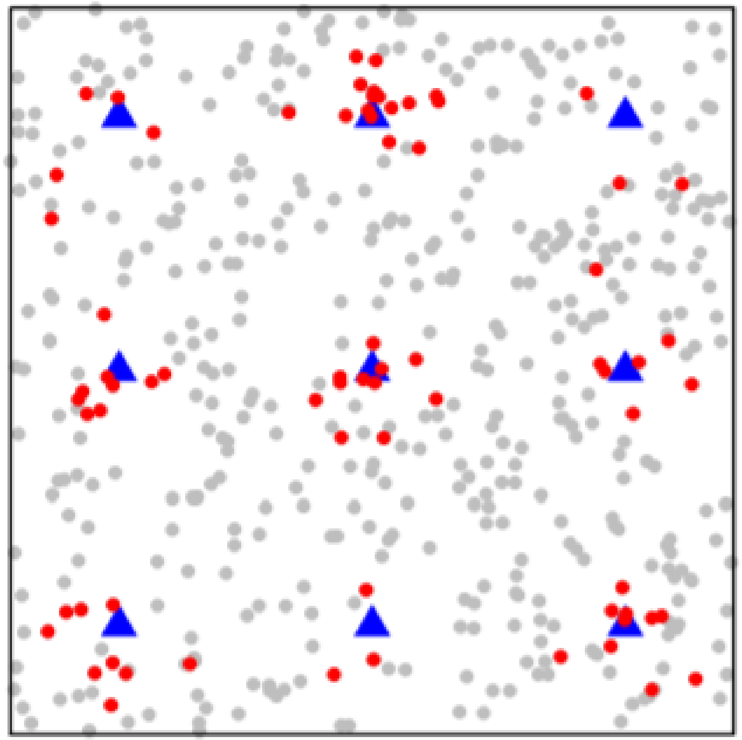
- Transect area = 20 km^2
- # Counted = 61 Topi Groups
- Mean Group Size = 3.8
- Estimated detection = 0.65
- Total area = 80 km^2

Estimated N = $3.05 \frac{Groups}{km^2} \, x \, 80 \, km^2 \, x \, 3.8 \frac{Individuals}{Group}$ = 927 Topi

Line Transects



Point Transects

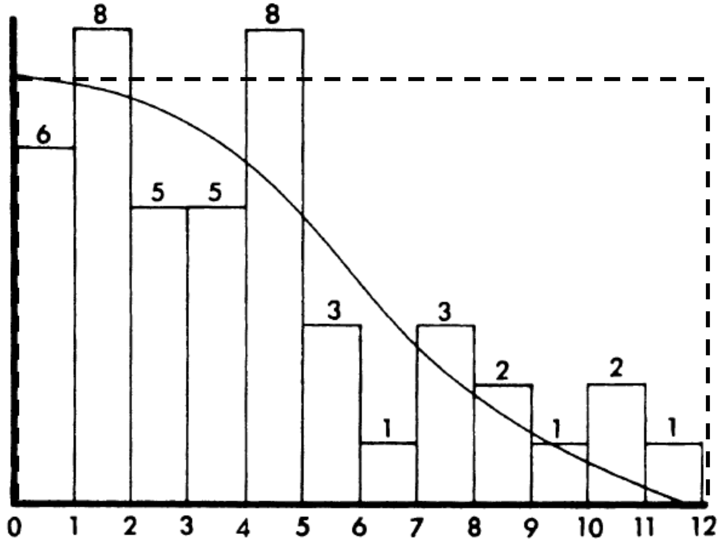


Miller et al 2019

Summary of Distance Sampling Concepts

1) Number of animals seen/heard decreases at greater distances from the observer

2) If we understand how detection probability changes with distance, we can get much more reliable density/abundance estimates than we do with simple counts



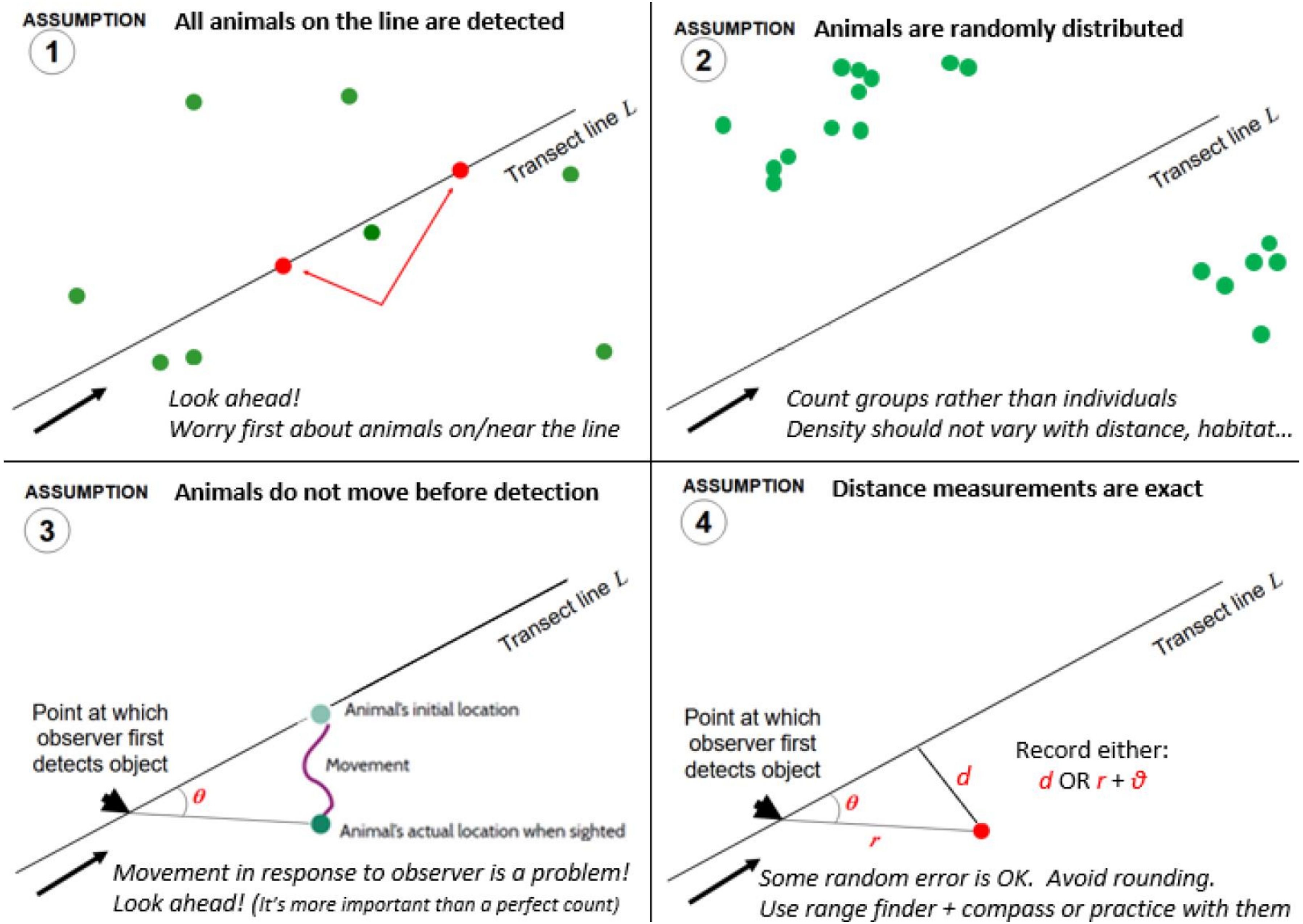
Detection Probability =

$$\frac{Area\ Below\ Curve}{Total\ Area\ of\ Rectangle}$$

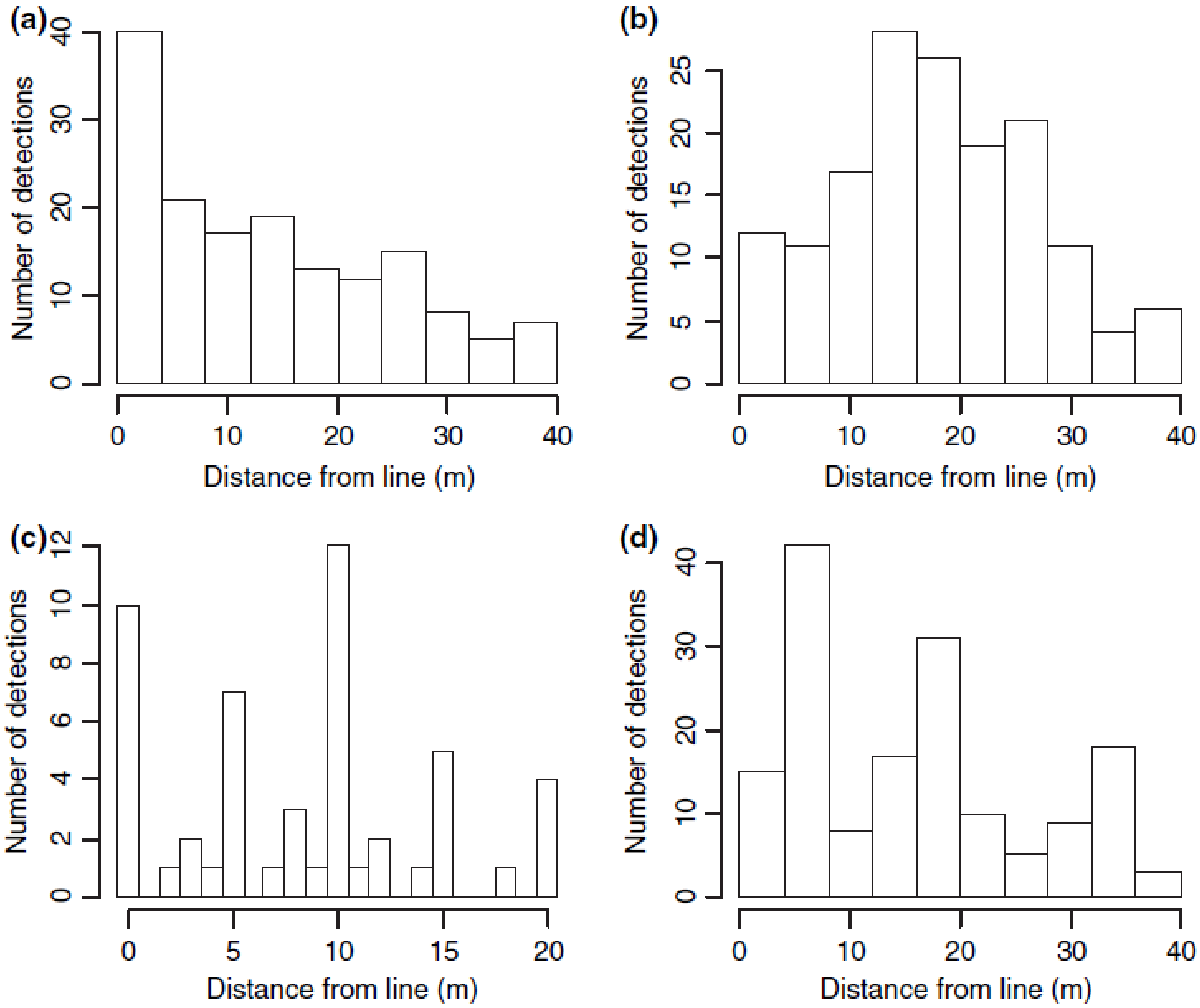
Study Design

- Assumptions and Limitations
  a) **Objects on or near transects are detected with certainty**
  b) **Objects should be measured from their initial location**
  c) **Measurements should be exact**
  d) **Sufficient sightings are recorded to estimate detection function**
  e) Sightings should be independent
  f) Observer must walk faster than the animals
  g) Transects should be placed at random with respect to the distribution of animals

Buckland et al. 1993, 2001, Burnham et al. 1980


ASSUMPTION 1 All animals on the line are detected
Transect line L
Look ahead!
Worry first about animals on/near the line
ASSUMPTION 2 Animals are randomly distributed
Transect line L
Count groups rather than individuals
Density should not vary with distance, habitat...
ASSUMPTION 3 Animals do not move before detection
Transect line L
Point at which observer first detects object
θ
Animal's initial location
Movement
Animal's actual location when sighted
Movement in response to observer is a problem!
Look ahead! (It's more important than a perfect count)
ASSUMPTION 4 Distance measurements are exact
Transect line L
Point at which observer first detects object
θ
d
r
Record either:
d OR r + ϑ
Some random error is OK. Avoid rounding.
Use range finder + compass or practice with them

Distance Sampling Practice!



(a)
Number of detections
0
10
20
30
40
Distance from line (m)
(b)
0
5
10
15
20
25
(c)
0
2
4
6
8
10
12
(d)