Biodiversity

Sampling and Simpson's Index

Definitions

- **Ecosystem**
  - All **Biotic**(living) and **Abiotic** (non living factors)

- **Species**
  - Organisms with similar appearance, anatomy, physiology, biochemistry and genetics that can interbreed freely to produce **fertile offspring**

- **Habitat**
  - Where individuals of a species live
  - Specific locality, with specific conditions that species may be well adapted to

Biodiversity

- This includes all the different
  - plants,
  - animals,
  - fungus,
  - microorganisms.
  - Their genes
  - and the ecosystem that they form part of.
- Takes into account the number of different species and the numbers of individuals

Objectives

- explain the importance of sampling in measuring the biodiversity of a habitat
- describe how random samples can be taken when measuring biodiversity;
- describe how to measure species richness and species evenness in a habitat;

Objectives

- use Simpson's Index of Diversity (*D*) to calculate the biodiversity of a habitat, using the formula $D = 1-(\Sigma(n/N)^2)$ (HSW3);
- outline the significance of both high and low values of Simpson's Index of Diversity (*D*);
- discuss current estimates of global biodiversity.

Why sample?

- You can’t practically count every single organism
- Sampling provides a representation of the number and distribution of an organism
- There must be sufficient number of samples for the results to be representative of the situation

Equipment to survey Plants

- Tape measures
- Quadrats
- Collection/ trapping equipment
- Identification sheets/keys

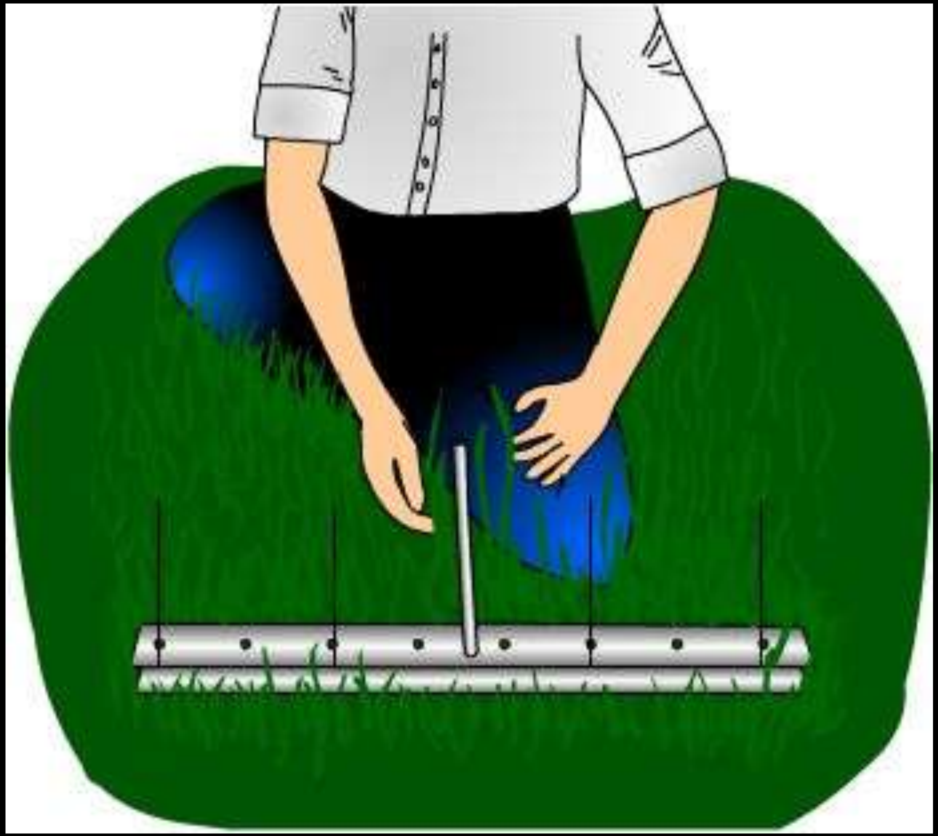
Types of quadrat

- Frame quadrat
  - Size
    - often $0.25m^2$
    - Sometimes $1m^2$ or $10cm^2$
- Point quadrat

Frame Quadrats

Point quadrat

- Particularly useful when sampling taller vegetation e.g. meadow



Point quadrats

p195

Method

- Pin dropped through holes in horizontal bar
- Each species the pin touches is recorded

Advantages

- Good for dense vegetation (e.g. grassland)

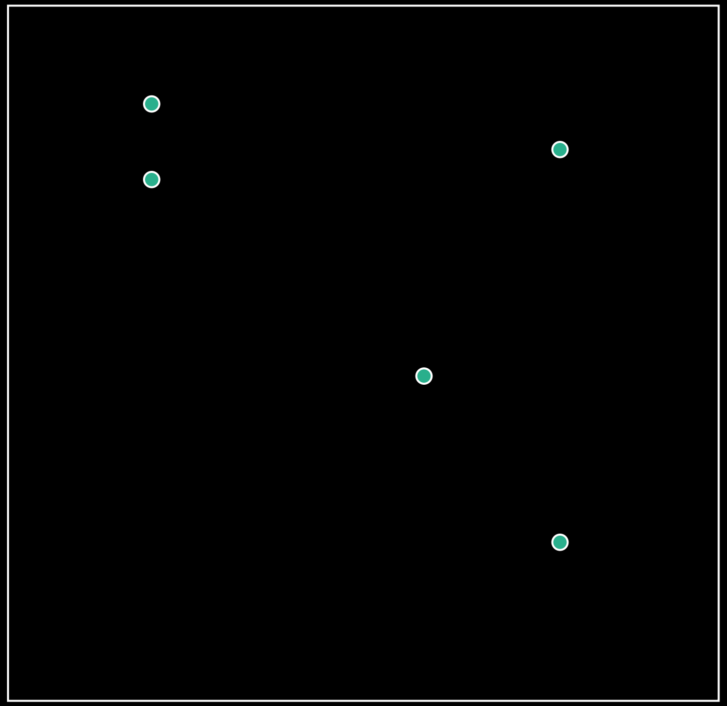
Disadvantages

- No good for plants taller than the frame
- Overestimates tall, thin leaved plants

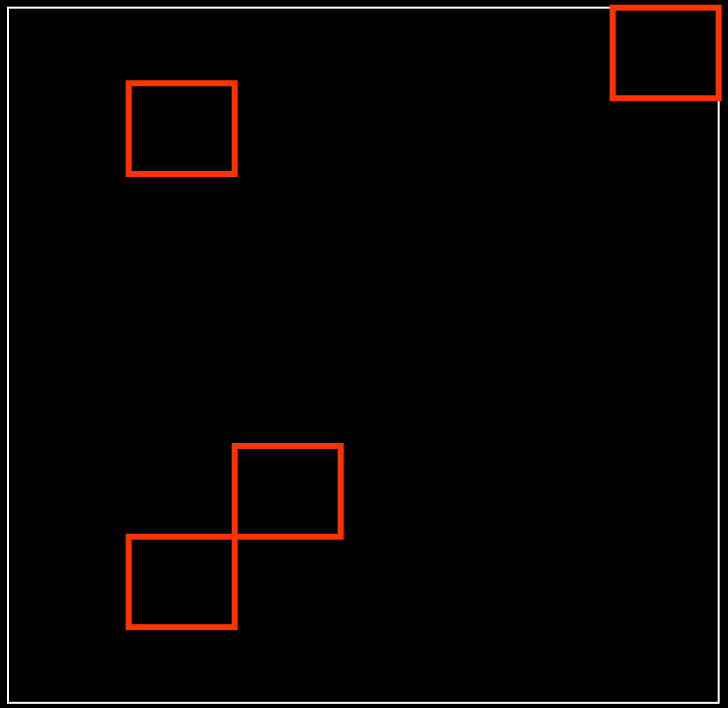
Avoiding Bias in Sampling

- **It helps to ensure the sample is representative of the habitat.**
  - Randomised sampling.
  - Systematic sampling e.g. transect

Randomised quadrat sampling



Random point sampling



Random quadrat sampling

- Lay out a grid using tape measures.
- Use random numbers to plot coordinates within the grid.
- Sample at each point

Limitation

In a large grid of this method is that each point can be difficult to identify using 2 tape measures

Solutions

- Use more than 2 tape measures or laser
- In a very large area. Select coordinates from a map of the area and use a GPS to find the exact position

Systematic Sampling

- Take samples at regular distances across the habitat, or within a grid

Types of transect

Line – single tape stretched in straight line

Belt – a strip (e.g. 1m wide)

These can be:

- ***Continuous*** – sampling takes place over a short distance from one end to another
- ***Interrupted*** – over a longer distance, taken at intervals (e.g. every 10m)

Line transects

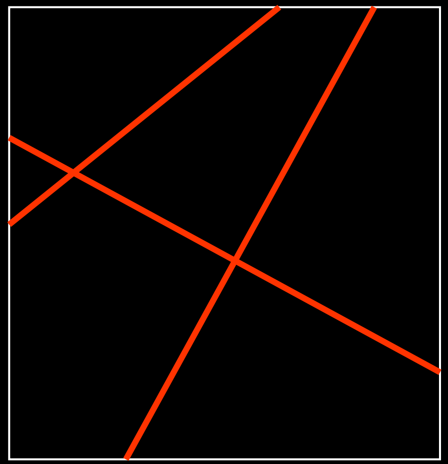
- Tape or rope sets out the line
- The species occurring on the line are recorded (usually at regular intervals)
- Lines can be chosen randomly

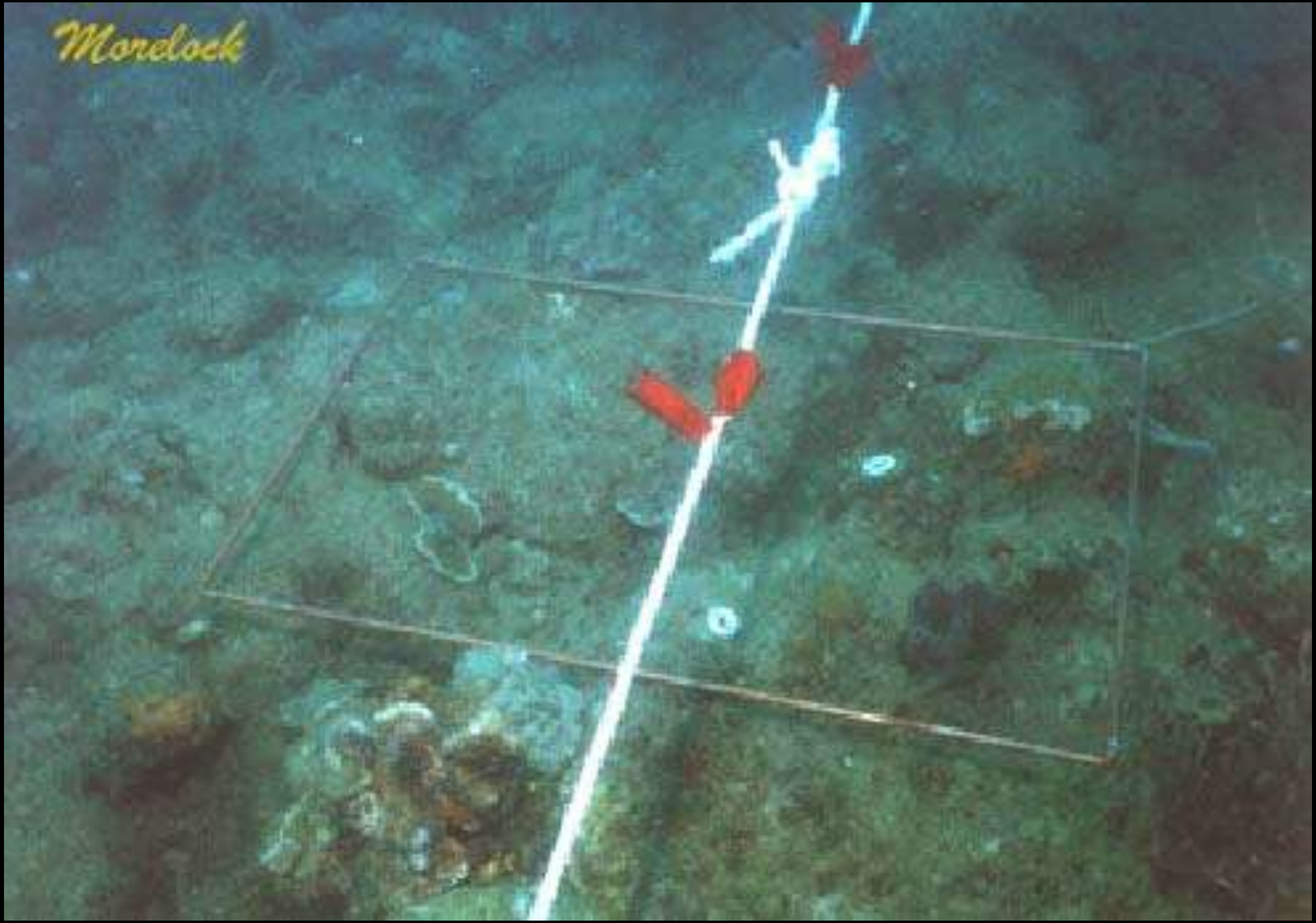
    (see diagram right)

    or

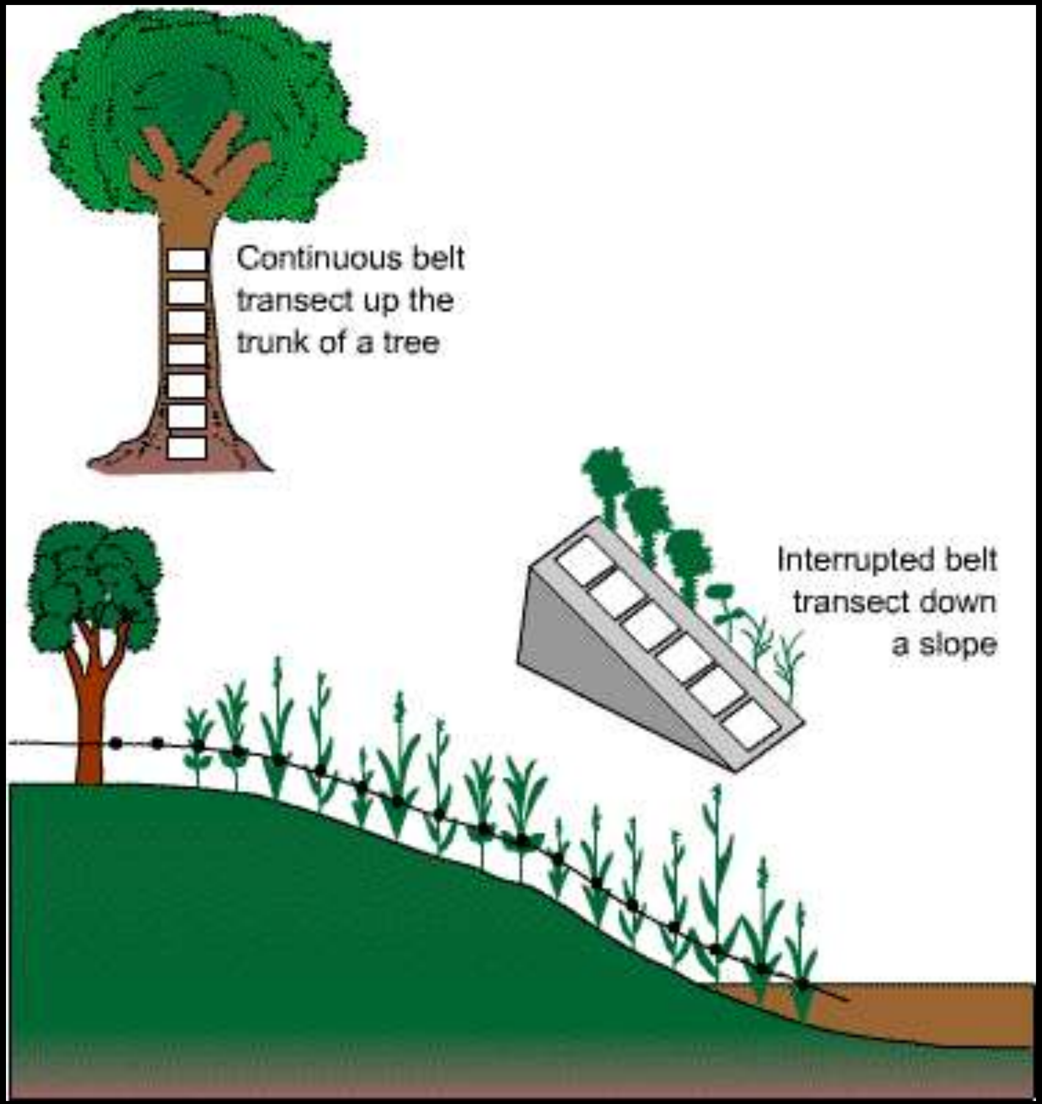
may follow an environmental gradient

such as a slope

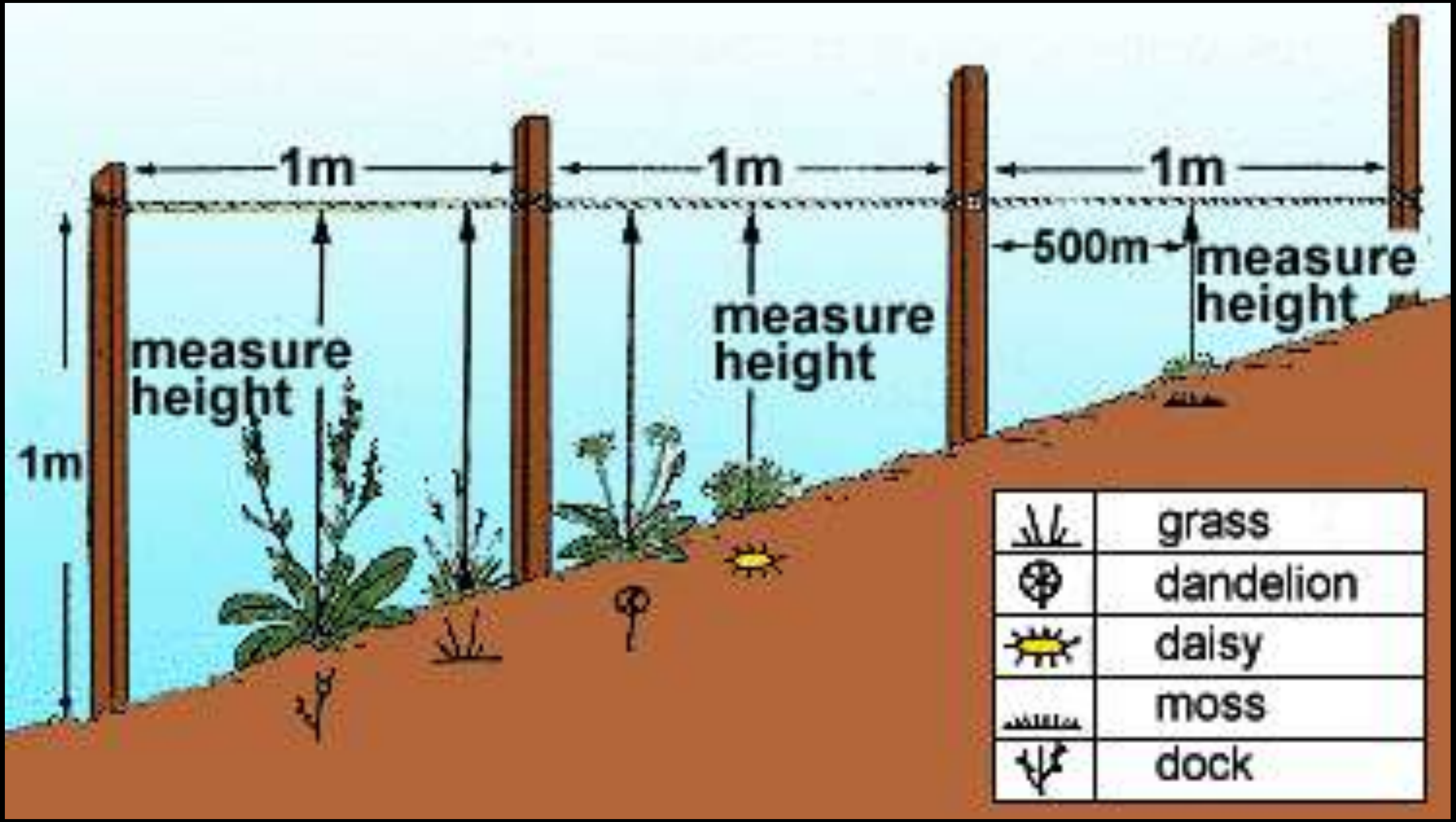



Morelock


5
4
3
2
1
Tape


Continuous belt transect up the trunk of a tree
Interrupted belt transect down a slope

Transect



This transect does not take into account the changes in height.

Number of Samples

- Sufficient to give a representative sample
- Wider the area the more samples should be done so no common plants are missed out.
- Repeat transect at several points across the area sampled

- Statistical analysis of the results will indicate if the results are significant

Measuring plant and immobile organism numbers (abundance)

- Counts
- Density
- Frequency
- Percentage cover
- Biomass
- Abundance scales

Density of a species

Method:

count no. of individuals in all quadrats, then calculate mean per unit area

Suitable for:

larger plants that are easy to identify as single individuals (e.g. yarrow)

Frequency of occurrence

Method:

e.g. if grass occurs in 15 out of 30 quadrats, the frequency of occurrence is 50%

Suitable for:

species that are hard to count. However, it ignores density & distribution.

Percentage cover

Method: estimate the area within a quadrat covered by a plant species

Suitable for:

areas where a species is abundant. Less useful if plants occur in overlapping layers.

Biomass

Method: Collect samples including roots of plants. Weigh to record their mass. Can be wet (or occasionally dry).

Suitable for:

constructing a pyramid of biomass/ best for simple food chains/not involving large animals

Abundance scales

Method: specific scale used – '**ACFOR**'

Abundant,

Common,

Frequent,

Occasional,

Rare

Suitable for:

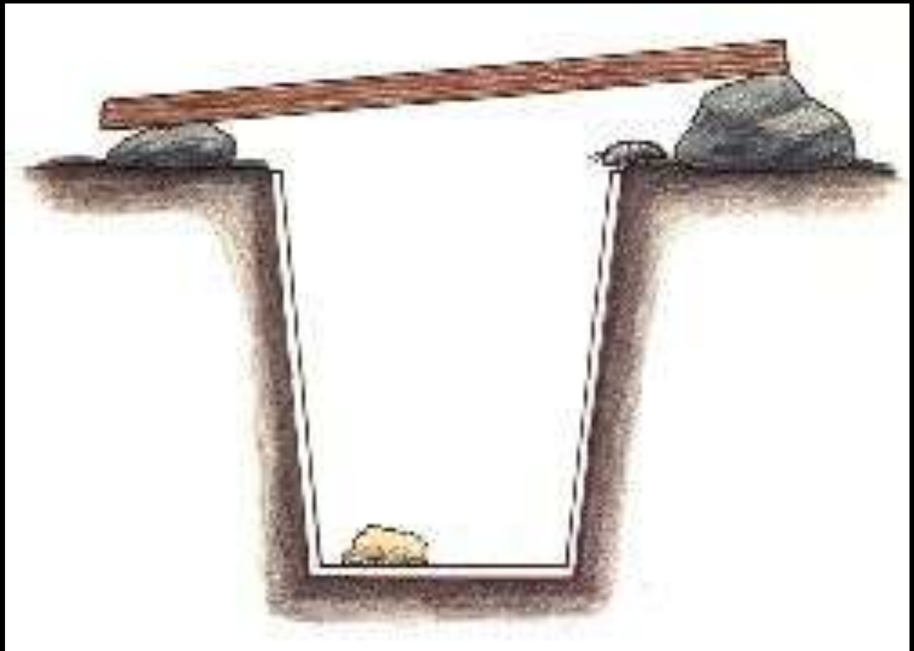
quick, easy sampling, but very subjective, not quantitative

Sampling small animals

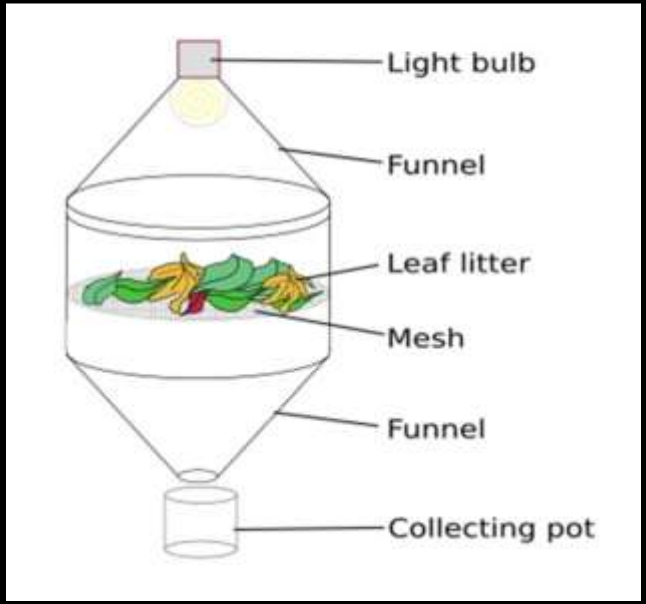
Collection methods – land or air

- Pitfall trap
- Tullgren funnel
- Beating tray
- Pooter
- Light trap
- Kite (butterfly) net
- Sweep net
- Humane trap

Pitfall trap



Tullgren funnel



Kite net

Poote

Light trap

Sweep Net

Humane small mammal trap

Beating tray

Sampling animals

Collection methods – in water

- Plankton net
- Dredge net
- Drift net

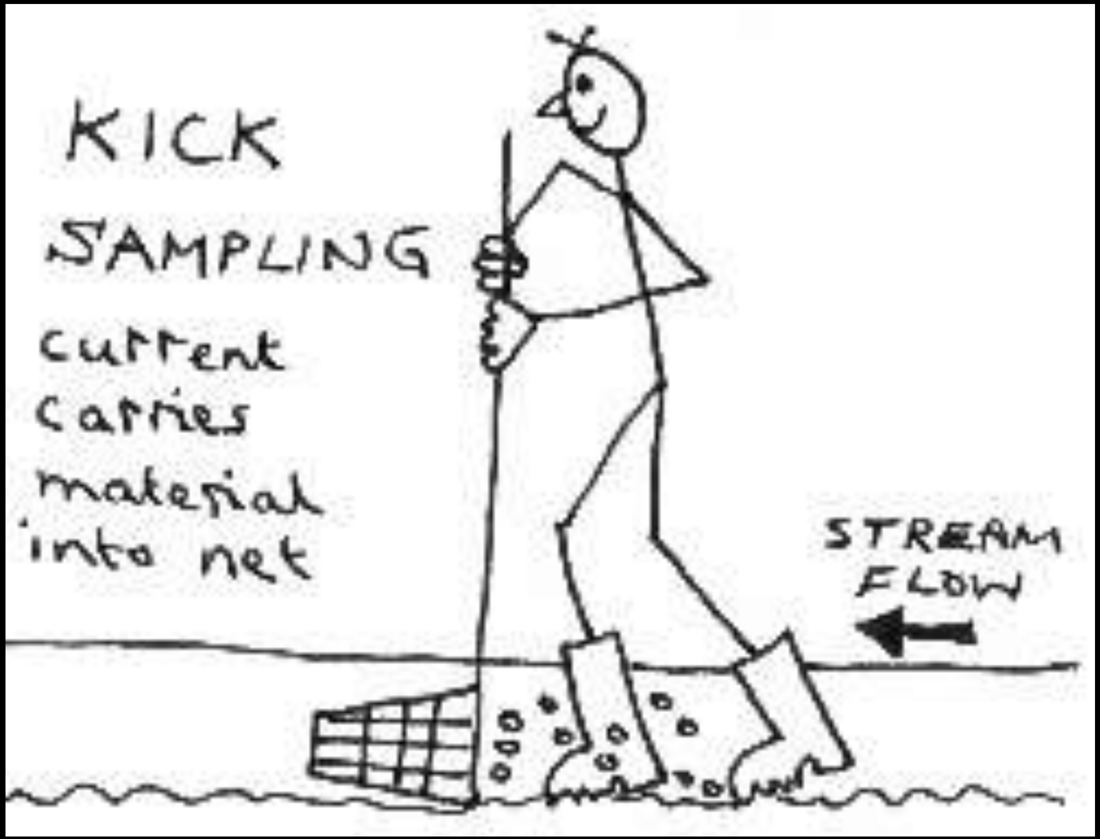
- ‘kick’ sampling

Plankton net

Dredge net

Drift net

Kick sampling



Results of kick sampling

Survey of a pond

A sample of a pond in October found these results.

Organism	Biomass (g/m²)
Algae	25
Mosquito Larva	46
Dragonfly Larva	23
Trout	10

What problems does this data suggest?
Suggest limitations with sampling that may have produced these results

Possible Sampling Limitations

- some species may be small therefore not easily counted/seen as they are covered by grass or larger plants

- similar species mis-identified

- plants counted even if only partially within the quadrat

Limitations of sampling, impact on results and modifications

Limitation

- Difficult to locate exact position of random number co-ordinates in the grid

Impact

- leads to biased / subjective data

Modification

- Use additional tape measures to locate position more accurately (by forming a grid)
  - OR sample the area systematically

Limitations of sampling, impact on results and modifications

Limitation

- If biomass is only measured in one quadrat this biomass value may not be representative

Impact

- The quadrat may have an unusually high or low biomass

Modification

- Do many measurements and calculate a mean per quadrat

Limitations of sampling, impact on results and modifications

Limitation

- experiment not replicated (in the same location)

Impact

- Data may not be representative of the whole area

Modification

- Should replicate the data at least 2 more times in the same area

Limitations of sampling, impact on results and modifications

Limitation

- grass/lichen/moss not identified to species level.

Impact

- Changes the calculations of species richness and diversity

Modification

- Use a key to identify plants to species level

Limitations of sampling, impact on results and modifications

Limitation

- only carried out at on one day or one point in time/season

Impact

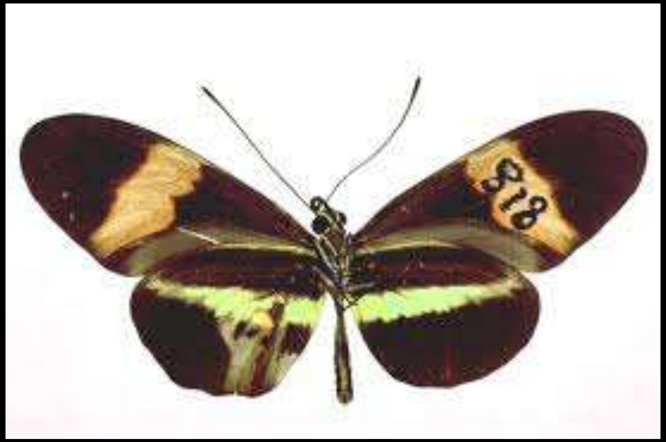
- Data is only representative of this moment in time

Modification

- Data should be collected at different points in the day/year

Mark/release/recapture

- First capture and mark



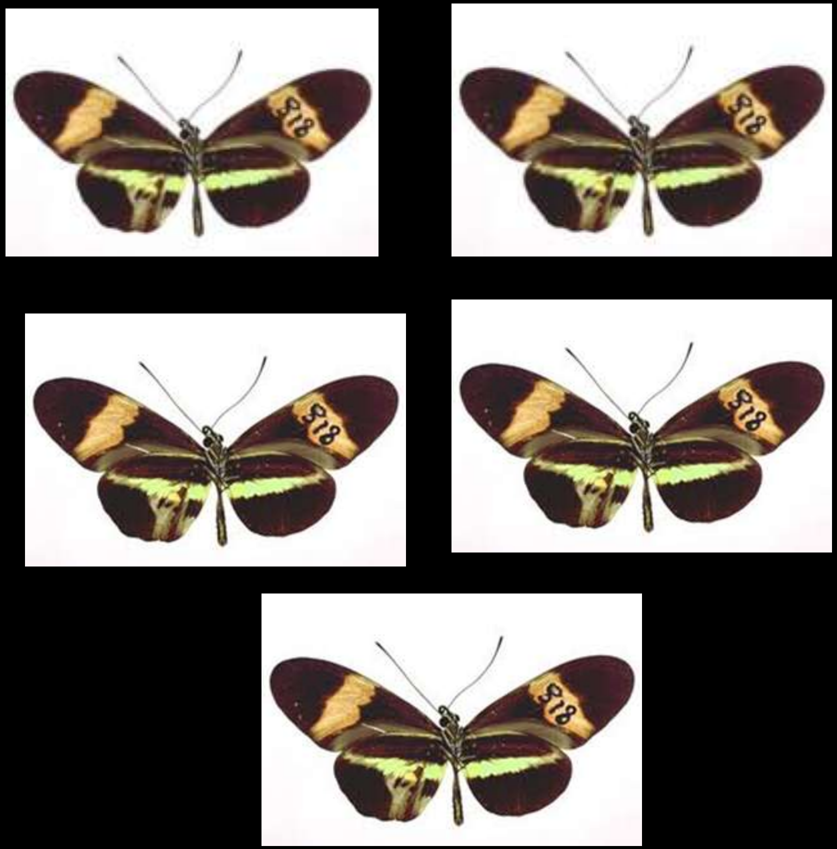
In the first capture

Each animal that is captured is marked in a distinctive way

Mark/release/recapture

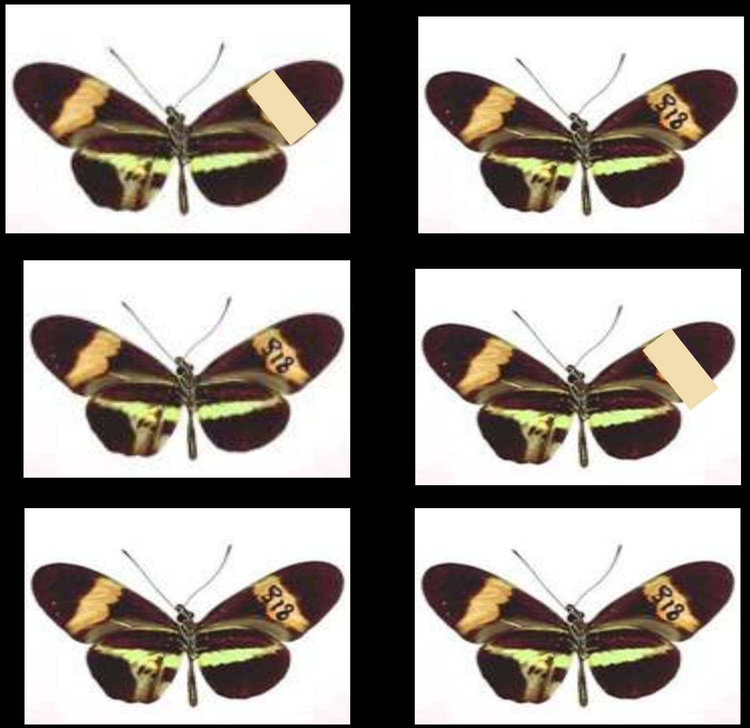
- Release the marked sample back into the population

The marked animals from first capture are released back into the natural population and left for sufficient time to mix with the unmarked individuals



Mark/release/recapture

- Second capture and count marked



Only some of these animals from the second capture will have marks on (the re-captured)

Record numbers of each

Mark/release/recapture

1. The population is sampled by capturing as many of the individuals as possible and practical
2. Each animal is marked in a way to distinguish it from unmarked animals
3. Return the animals to their habitat and leave them long enough to allow reintegration with the rest of the population.
4. Take another sample of the population (sample size can vary but should be large enough to be valid)
5. Record the numbers of marked and unmarked animals in this second sample.
6. Use the equation to estimate the size of the overall population.

Mark/release/recapture

$$\text{Total population} = \frac{\text{No. of animals in 1}^{st}\text{ sample} \times \text{total no. of animals in 2nd sample}}{\text{Number of marked animals in the second sample (recaptured)}}$$

This is sometimes called the **Lincoln Index**

Mark/release/recapture

6 Assumptions when using this technique

1. The marked animals mix evenly with the unmarked

2. The marks are not lost between marking and recapture

3. The marked animals behave in the same way as the unmarked and suffer no ill effects from the mark (e.g. the marks don’t make them more obvious to predators)

4. Being caught the first time does not increase or decrease the likelihood of an animal being caught the second time

5. There are no births or immigrations between marking and recapture

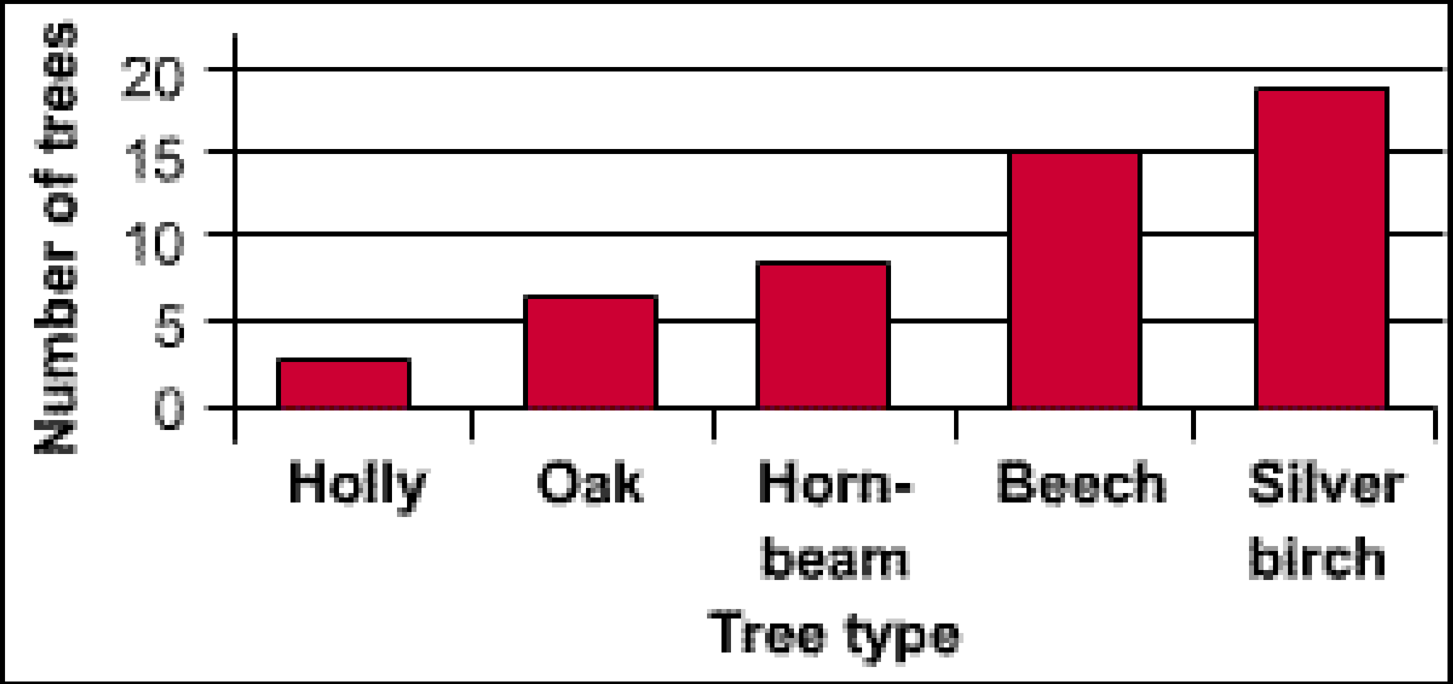
6. After release the catch is repeated after allowing sufficient time for the marked animals to mix with the rest of the population

Mark/release/recapture

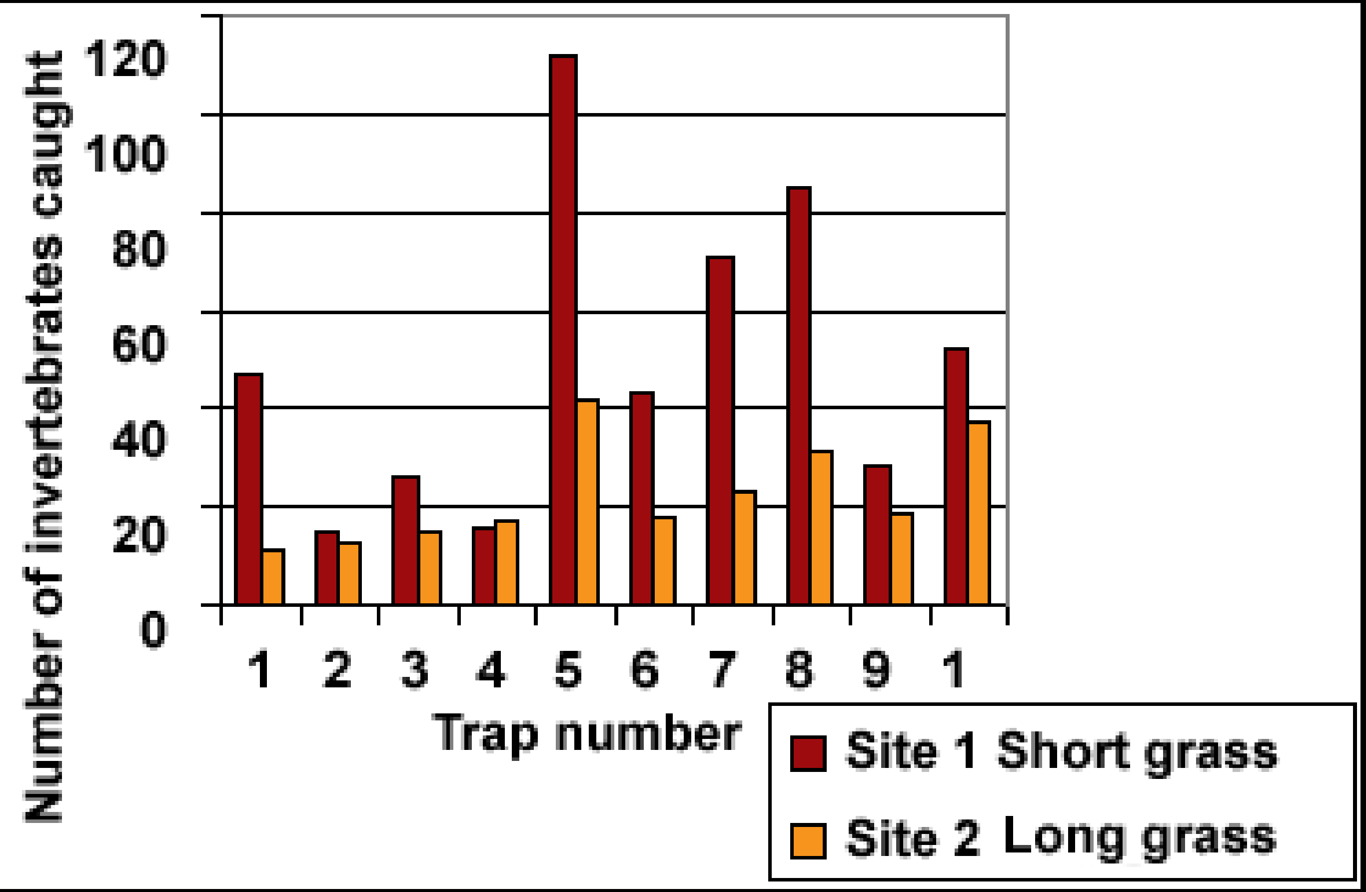
$$\text{Total population} = \frac{\text{No. of animals in 1}^{st}\text{ sample X total no. of animals in 2}^{nd}\text{ sample}}{\text{Number of marked animals in the second sample (recaptured)}}$$

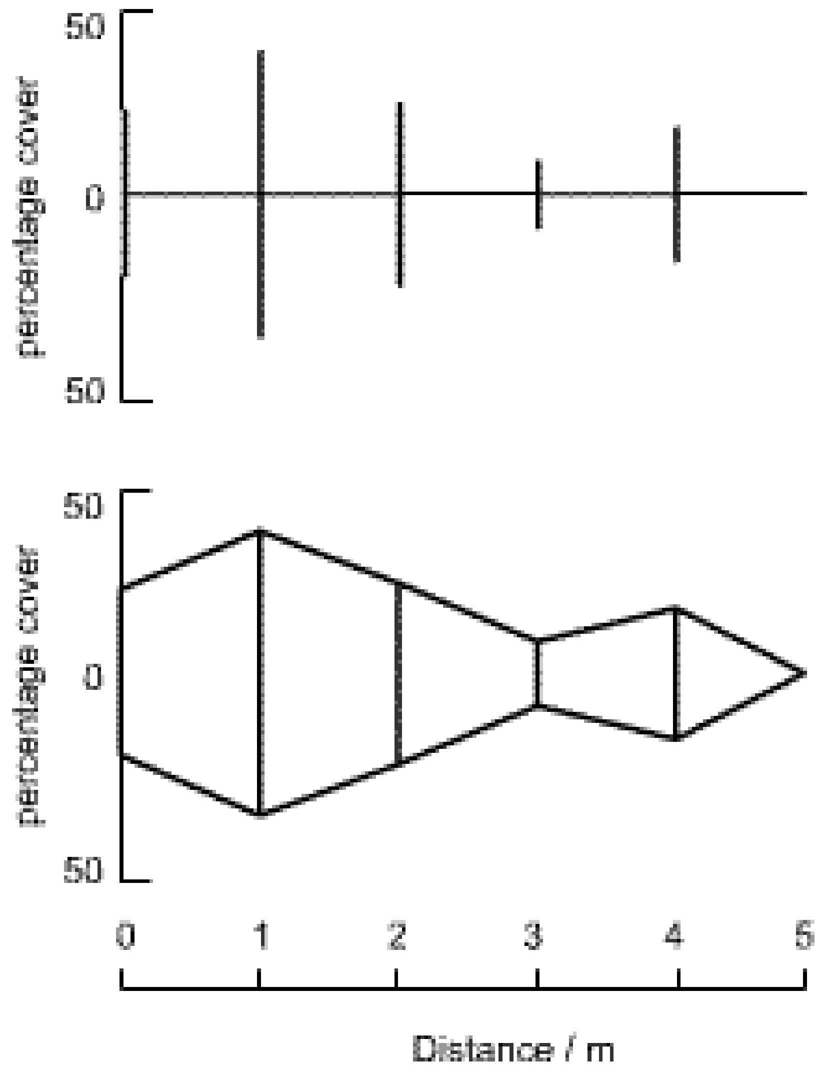
Displaying the data

Bar chart to show abundance of trees in a small woodland site

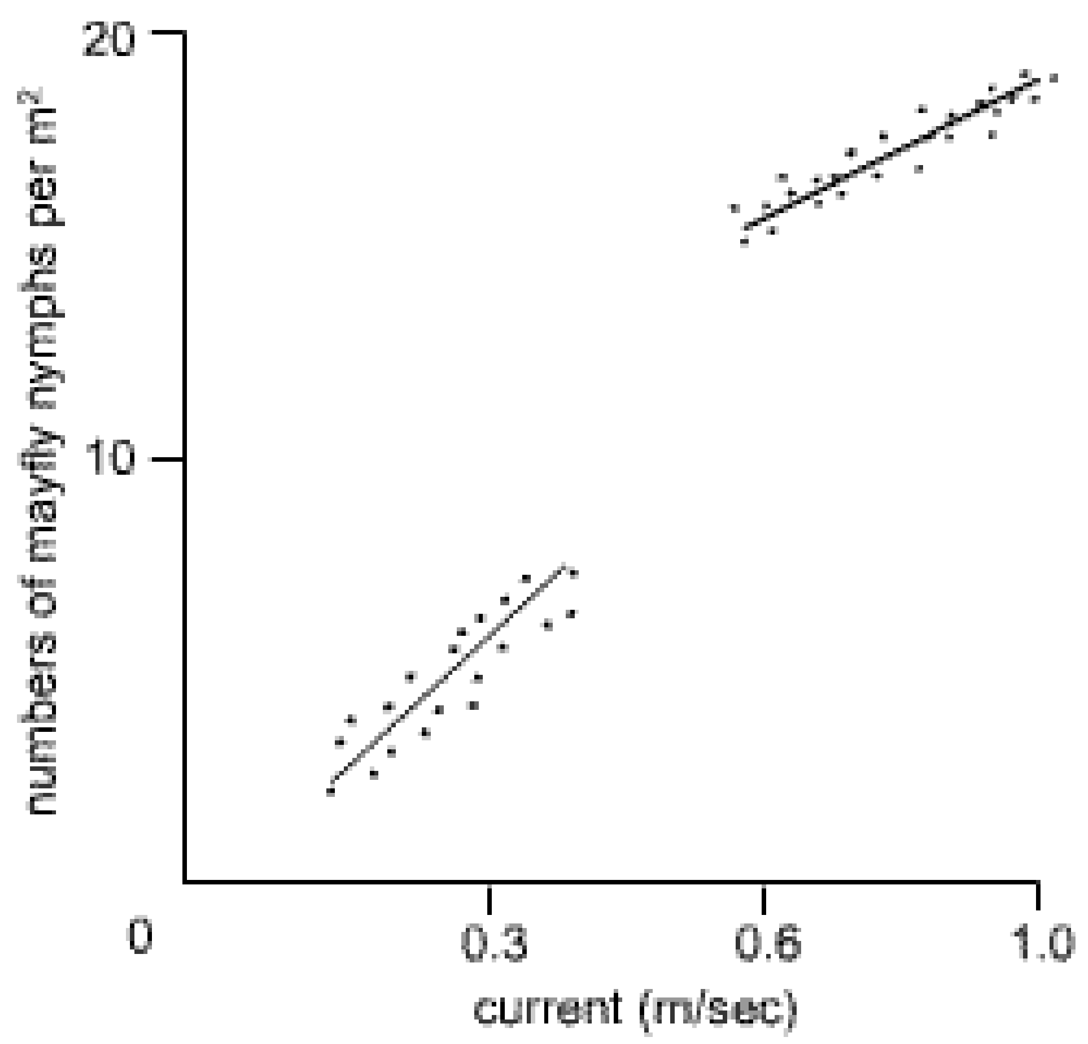


A bar graph comparing the invertebrate abundance in long and short grass





50
percentage cover
0
50
50
percentage cover
0
50
0
1
2
3
4
5
Distance / m



numbers of mayfly nymphs per m²
20
10
0
0.3
0.6
1.0
current (m/sec)

Factors affecting plant distribution

- Soil moisture/water availability
- Light/shading from other plants (trees)
- Temperature
- Slope
- Soil pH
- Grazers
- Humidity
- Soil minerals
- Contamination/pollution

Seasons can have a big impact on plant populations

Sampling should take this into account by measuring at different times of the year

Factors affecting animal distribution

- Food availability
- Predators
- Shelter
- Temperature
- Water availability

Seasons/time of day also affect animal numbers so should be taken into account when sampled

Objectives

- explain the importance of sampling in measuring the biodiversity of a habitat
- describe how random samples can be taken when measuring biodiversity;

Measuring biodiversity

Objective

Describe how to measure

- species richness
- species evenness in a habitat;

Species richness

- This is the number of species in a habitat
- The more species the richer the habitat
- However this doesn’t give us the full picture of biodiversity – what if there are only a few individuals of a couple of a species – that habitat doesn’t have a high biodiversity

Estimating species richness

- Use a **QUALITATIVE** sampling technique appropriate to the habitat and record all the species seen.
- (Don’t necessarily have to identify the different species)
- The number of different species in two areas can be compared. This data tells us nothing about which ones are present or their relative abundance

Species evenness

- This is a measure of the abundance of individuals in a species.
- This is a **QUANTITATIVE** assessment as it gives relative numbers of each species present

Estimating species evenness

Plants

- Select an appropriate sampling method
- Count the no. of plants per unit area
- Or percentage cover
- For larger plants a direct count will be possible

Animals

- Direct count for larger animals
- For smaller animals – mark/release/ recapture
- Soil organisms – sample, sift and count
- Aquatic organisms - netting

Investigating the effect of mowing and grazing on species richness (FSC Nettlecombe)

Grassland plots were treated as follows:

1. Untouched
2. Mowed weekly cuttings left
3. Mowed weekly cuttings removed
4. Mowed annually

1	2	3	4
2	1	4	3
3	4	1	2
4	3	2	1

Sample each area and find out the species richness.

Suggest ways to keep this survey valid:

Controls. Much more difficult

How can the data collected be kept reliable?

Displaying Data

Calculations

Mean averages
Ranges (difference between min and max)

Type of graph

Bar graph
Include range bars

How is the significance of the mean affected by the following results?

- A small range of values
- A wide range of values
- Overlapping ranges in data sets

Results of the sample

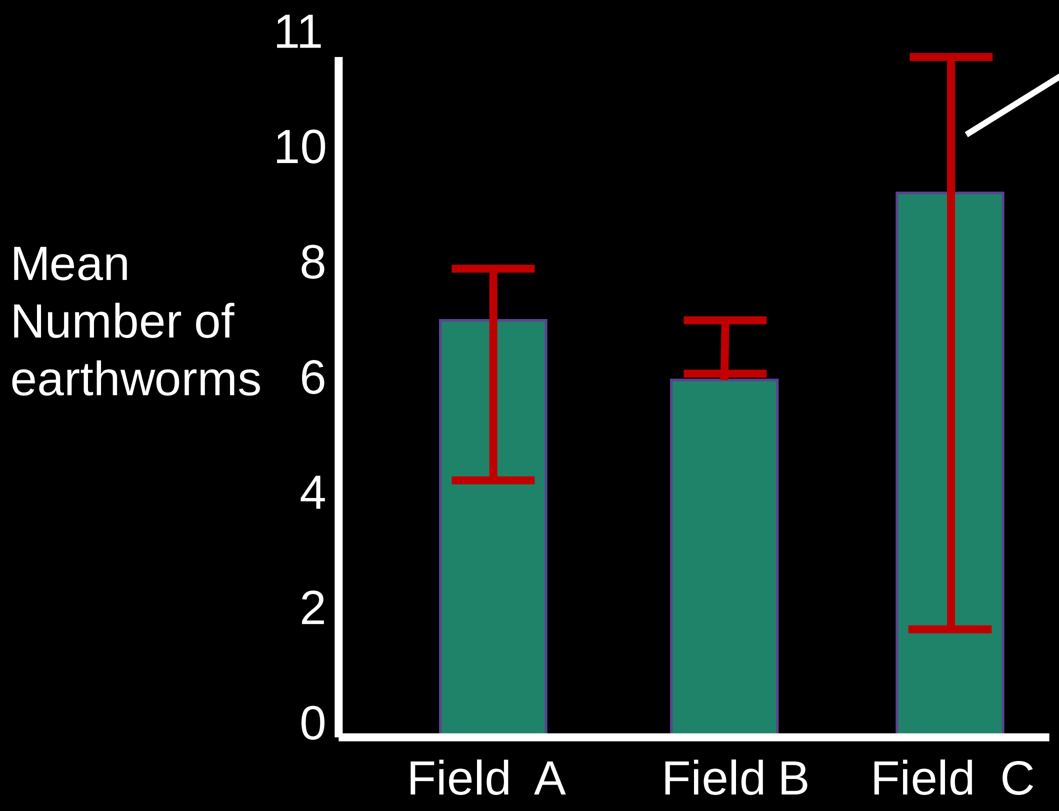
Mean Species richness	**Untouched**	**Mowed left**	**Mowed removed**	**Grazed by sheep**
At start	13	12	13	14
After 5 years	9	12	11	13
After 10 years	6	13	10	12

Why has the species richness changed in this way?

The Effect of Grazing

- Grazing animals will keep grasses and other vegetation short
- Grasses are less able to compete with other species as they are continually removed
- Allows more light so smaller species can thrive.
- Less competition for light/space/water/ or minerals
- Grazing removes minerals so plants adapted to low soil fertility compete well.
- Animals may be selective and remove some plants more than others.

A bar chart with range bars



Range bar connecting the maximum value to the minimum value

- Bar do not touch
- Bar graph fills more than 50% of available space
- Means calculated to whole numbers as cannot have less than a whole (living)organism

Results of a field survey.
Ten quadrat samples per field

Objectives

- Use Simpson's Index of Diversity (*D*) to calculate the biodiversity of a habitat, using the formula $D = 1-(\Sigma(n/N)^2)$
- Outline the significance of both high and low values of Simpson's Index of Diversity (*D*);
- Discuss current estimates of global biodiversity

The Effect of Mowing

- Similar to the effect of grazing
- Plant removal is not selective.
- If cuttings are removed it will also reduce soil fertility, if not they will be recycled by decomposition
- Mowing allows light and space in so more plants thrive.

Simpson’s Diversity Index

- This takes into account:
  - the species richness
  - the species evenness
- A higher value means a more diverse habitat

If asked to explain the value of using Simpson’s Diversity Index, explain the above and make sure you explain what is meant by species richness and evenness

Simpson's Diversity Index

- A more diverse habitat should be less susceptible to change if one species is affected, than a less diverse ecosystem which is dominated by one or two species

Simpson’s Diversity Index

- The formula is

$$D = 1 - [\Sigma(n/N)^2]$$

- n= no. of individuals of a particular species
- N= total no. of individuals of all species
- Σ means ‘sum of’

Simpson's Diversity Index – order of steps

Species	n	n/N	$(n/N)^2$
A	Step 1 – gained from sampling	Step 3	Step 4
B			
Sum (Σ)	Step 2 $\Sigma n = N$		Step 5
1- Σ			Step 6

See your textbook p199 for two worked examples

Worked Example

Species	Number of birds in this species encountered
Magpie	11
Black headed gull	4
Carrion crow	4
Blackbird	1
Starling	37
House sparrow	7
All species	64

The working…

$$D = 1-[\Sigma(n/N)^2]$$

Step one:

n = no of individuals in each species

N = 64. (total number of individuals)

For each species, divide the number of individuals by 64 (N)

Place this into a separate column on your table

Step two

Add another column for you table for the $(n/N)^2$ calculation.

Square the result for each species for n/N and add this detail to your table

Step three:

For all of the species add up the total (sum of) for the $(n/N)^2$ calculation

Add this to you table.

Final step:

Take this figure away from 1. this is your diversity index

The higher the number, the more diverse the habitat.

Species	n	n/N	$(n/N)^2$
Magpie	11		
Black headed gull	4		
Carrion crow	4		
Blackbird	1		
Starling	37		
House sparrow	7		
	N	Sum $(n/N)^2$	
	Diversity index		

The importance of D

You will probably be asked to compare it to another ecosystem.

Values closer to 1 are the most biodiverse
This indicates that they have high species richness and evenness.
They are more stable and cope better with change

Measuring Genetic Biodiversity

- This includes all the different
  - plants,
  - animals,
  - fungus,
  - microorganisms.
  - their genes
  - and the ecosystem that they form part of.

Genetic Biodiversity

- Species need variation within their genes.
- These differences are called alleles
  - E.g tongue rolling and non tongue rolling
- Variation improves a species likelihood of adapting if the environment changes
  - Individuals cannot adapt but the species can.
- Lack of variation makes the species vulnerable to extinction if conditions change

Factors that change the genetic variation

Increasing genetic biodiversity

- Mutation is the main way of increasing genetic biodiversity
- Interbreeding will spread these mutations between different populations of the species

Factors that change the genetic variation

Decreasing genetic biodiversity

- Artificial selection/ rare breeds have very reduced variation due to their low numbers and inbreeding that results
- Natural selection
- Founder Effect
- Genetic drift
- Genetic bottlenecks after a catastrophic event

All American bison today are descended from 12 survivors after overhunting. They have very limited variation

There may have been a human genetic bottleneck about 70000 years ago after the Toba eruption

Measuring Genetic Biodiversity

- This means that we are measuring how many alleles there are of each gene.

<u>MONOMORPHIC</u>

- Many genes have only one version e.g a gene that codes for an enzyme like amylase or a protein like collagen

<u>POLYMORPHIC</u>

- Some genes have different alternatives such as eye colour or blood groups or genetic diseases such as sickle cell anaemia

Measuring Genetic Biodiversity

- The more polymorphic genes there are, the more genetically biodiverse a species is.
- It can be calculated as follows

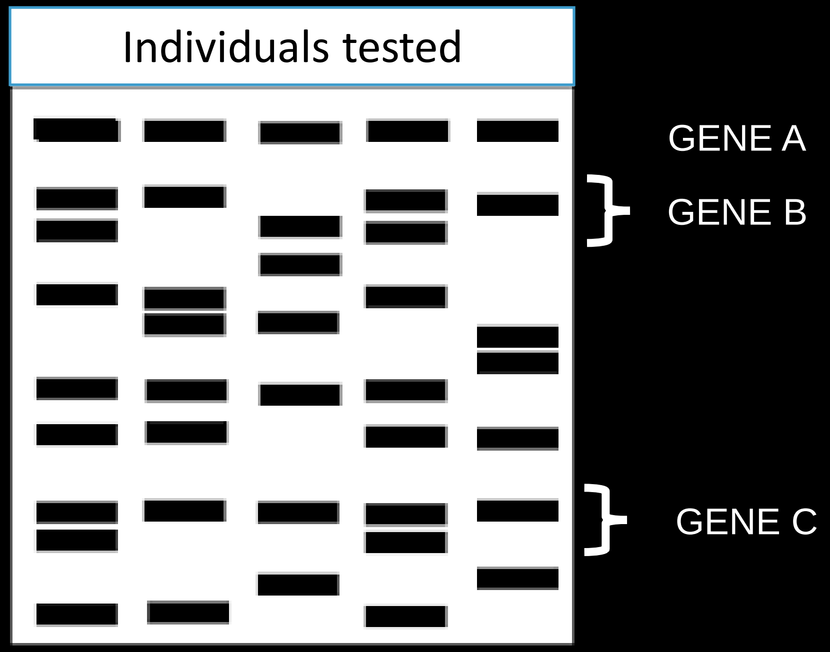
$$\text{Proportion of polymorphic gene loci} = \frac{\text{Number of polymorphic gene loci}}{\text{Total number of gene loci}}$$

A gene locus is the gene's position on the chromosome

How can we work out the number of alleles?

A technique called gel electrophoresis can separate out the DNA after it has been chopped up using an enzyme.

The gene can be identified on the strands and it is possible to see if it is the same in everyone or different, by comparing its position.



We have 3 loci and 2 of them are polymorphic

2/3 = 0.67 or 67% of the genes are polymorphic