The Ecosystem

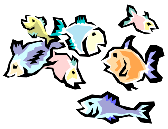
Measuring Components of the Ecosystem

THE ECOSYSTEM – Measuring Components of the Ecosystem

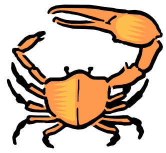
By the end of this topic you should be able to:-

N.B. Many practical aspects of this topic will be reinforced during practical work and field trips.

SYLLABUS STATEMENTS	ASSESSMENT STATEMENT	CHECK	NOTES
2.2	MEASURING ABIOTIC COMPONENTS OF THE SYSTEM		
2.2.1	List the significant abiotic (physical) factors of an ecosystem.		
2.2.2	Describe and evaluate methods for measuring at least three abiotic factors within an ecosystem (e.g. terrestrial – light intensity, wind speed, temperature, slope etc.).		
2.3	MEASURING BIOTIC COMPONENTS OF THE SYSTEM		
2.3.1	Construct simple keys and use published keys for the identification of organisms.		
2.3.2	Describe and evaluate methods for estimating the abundance of organisms.		
2.3.3	Describe and evaluate methods for estimating the biomass of trophic levels in the community.		
2.3.4	Define the term *diversity.*		
2.3.5	Apply Simpson's diversity index and outline its significance.		



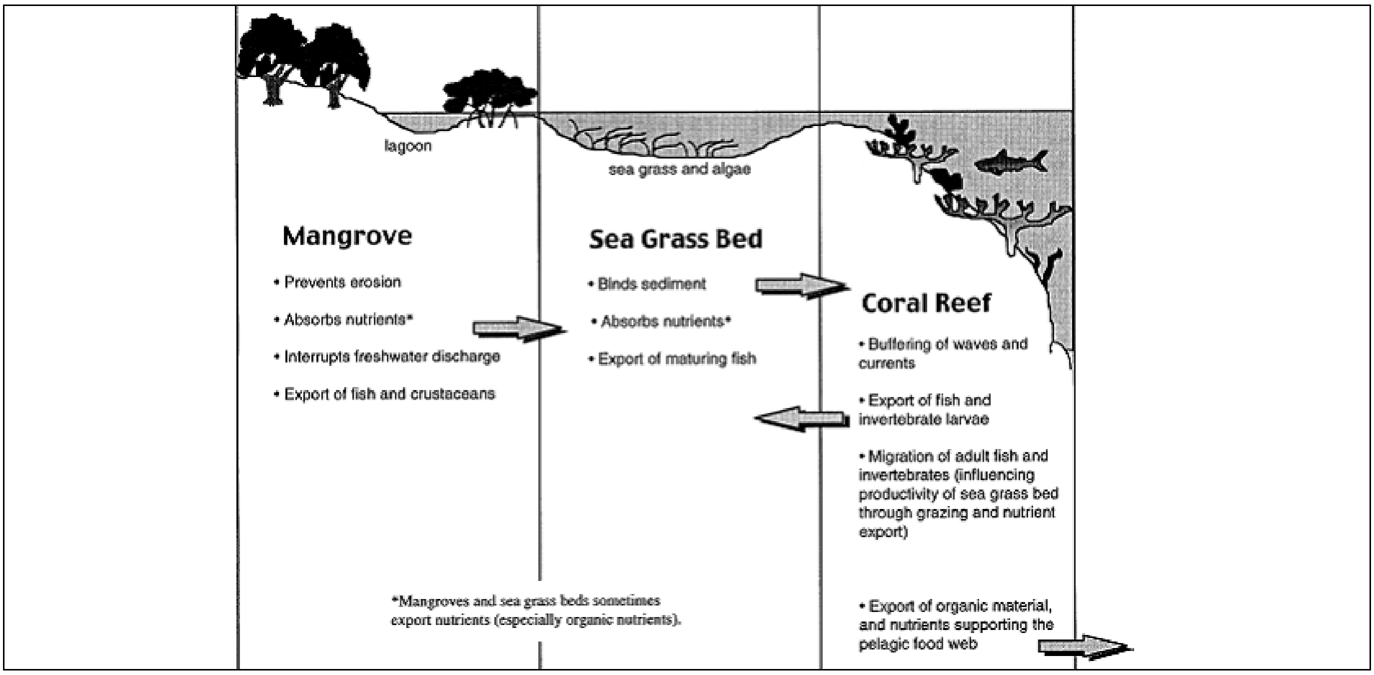
THE MANGROVE ECOSYSTEM.



The mangrove ecosystem is one that you can see around the coastal areas of parts of Hong Kong and you will visit one with the biologists within a few months of starting this course.

Mangrove ecosystems are so important because :-

- The tangle of aerial roots trap and **retain sediments** allowing the mangrove forest to expand seaward.
- The roots help to **diffuse wave action** which can threaten to uproot the trees and allow coastal erosion to occur.
- The roots help to **prevent** the floating seeds of **competing species** from getting established.
- Local people have long used leaves, fruits, bark and mosses for **medicinal uses.**
- Certain palm leaves have long been used for **roof thatching**, wrapping etc.
- Small scale fisherman rear groupers & sea bass in cages and oysters & green mussels from floats in backwater mangrove channels providing **food** and **financial stability** to local communities.
- Mangrove roots and foliage provides a superb **habitat and breeding ground** for many marine & terrestrial creatures:- fish, encrusting oysters, mangrove crabs, mudskipper, shrimps, prawns, fiddler crabs, snails and their predators e.g. monitor lizards, coral snake, mangrove viper, otters, fishing cats & many wading birds.
- **Reduce** coastal flood and storm damage.
- Help to **filter sediment** from **waterways**.
- Provide an important **en-route habitat** for migratory birds.
- Mangrove forests are a **buffer zone** between terrestrial and marine ecosystems.



Abiotic factors influencing the mangrove ecosystem.

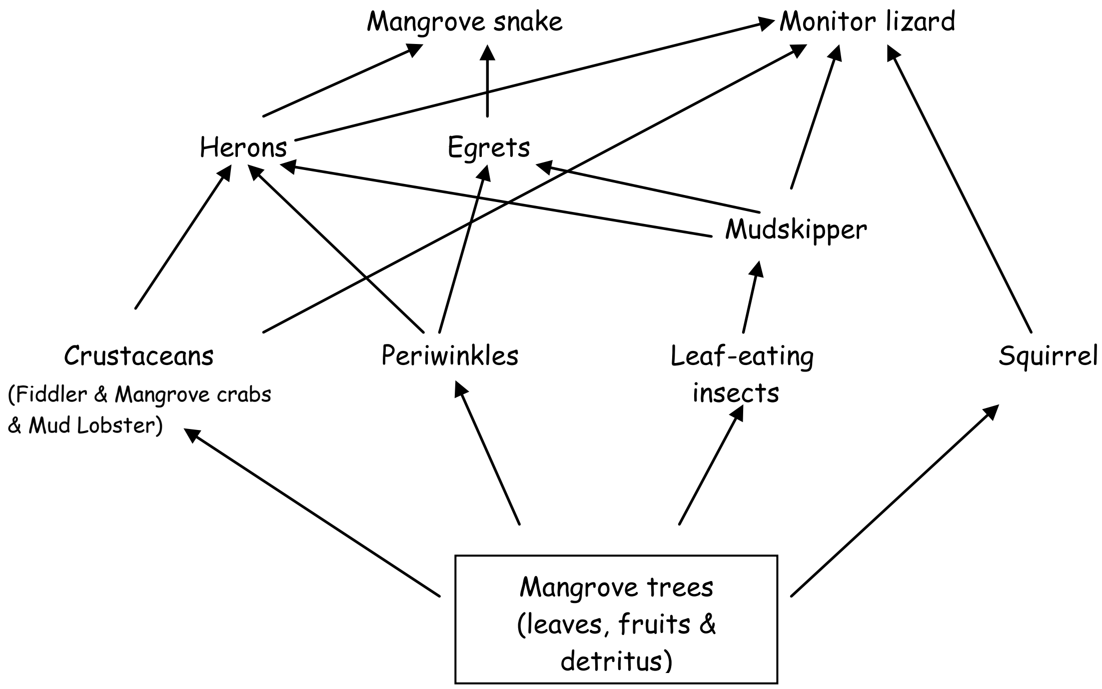
- **Mud** – **unstable, soft, waterlogged and anoxic** (∴slow decay & mineral recycling).
- **Salinity** and the **input of freshwater** i.e. salt content is high but **variable).**
- Exposure to **sunlight, wind, tides, waves**.
- **Submergence** by seawater and **exposure** to air due to continually changing water levels.
- **Pollution** i.e. effluent, chemicals, litter etc.
- **Temperature** i.e. warm mud.

Using the table on '**Abiotic Factors**' you should identify **THREE** key abiotic factors and understand how these may vary within the ecosystem with depth, time or distance.

Possible Feeding Relationships.

PRODUCERS	1° CONSUMERS	2° CONSUMERS	3° CONSUMERS
Mangrove trees (leaves, fruit & detritus)	Fiddler crab	Herons	Mangrove snake
Detritus from the sea	Mangrove crab	Egrets	Monitor lizard
	Periwinkle	Mudskipper	
	Mudskipper	Mangrove snake	
	Leaf-eating insects	Monitor lizard	
	Squirrel		
	Mud Lobster		

Possible Food Web.



The animals which live here have **adapted structurally** and in their **behavioral strategies.**

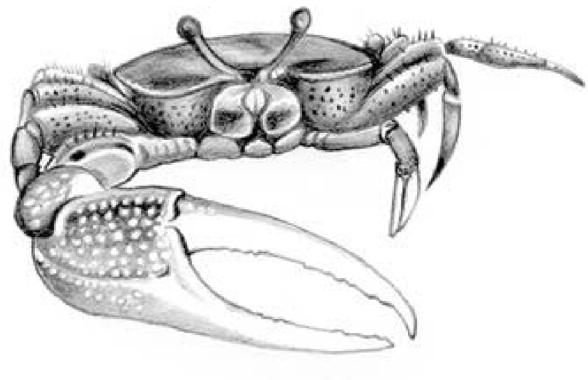
Information on key species.

Mangrove trees (*Rhizophora spp.*)

- Mangrove trees cannot maintain a hold on the shifting mud by sending down deep roots as the mud is anoxic and acidic only a few centimetres down from the surface. Consequently, they have a **broad, horizontal platform** that sits like a raft on the mud surface. These roots also obtain the nutrients required by the tree from the surface where they have been deposited by the tides.
- Added support gained by sending out curving aerial roots which act as struts (**PROP ROOTS**) from the trunk and other roots come down from the branches **(STILT ROOTS).**

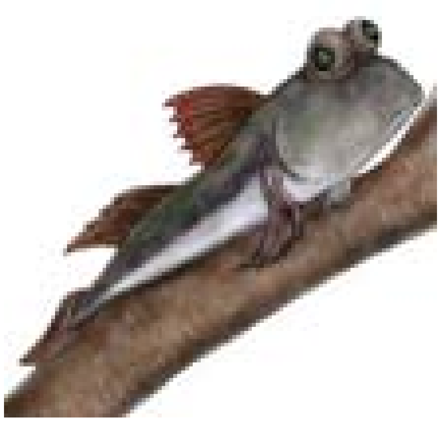
- Leaves have **thick waxy cuticle, sunken stomata** and a **thick epidermis** to reduce water loss.
- Ground roots grow up out of the mud in order to obtain oxygen from the air **(= PNEUMATOPHORES**).
- **Long, dagger-like fruits** which drop and stick firmly in the mud. The fruits **germinate while still on the tree** i.e. they are **VIVIPAROUS** in order that they can continue to grow as soon as they land so that they can establish themselves quickly (only plant in the world to do this).
- Gas exchange occurs through small pores on the trunk called **LENTICELS.**

Fiddler Crab (*Uca vocans*)



- One **giant pincer** (males only) for protecting territory, fighting competitors & attracting females by 'waving'.
- Feed by scraping mud into a ball, rolling it around their mouthparts to extract algae and then dropping the ball near its burrow as **pseudofaeces**.
- Pull **mud lid** over the top of their burrow when the tide comes in.
- **Eyes on long stalks** so it can peep out of its burrow and check for predators.
- N.B. All crab and lobster burrows help to **aerate the dense mud**.
- N.B. If there were no crabs, the mangrove ecosystem would become a foul-smelling, putrefying ooze of decomposing organic matter which would use up all the available oxygen → death of the nurseries.

Mudskipper (*Buliothalmis spp.*)



- When they get too dry, they **roll in puddles**, and wipe their faces with a wet fin.
- Large, rigid dorsal **fins raised** to warn off competitors.
- Uses the mangrove roots as a **refuge** to hide from predators.
- Give birth to **live young** in mud burrows.
- Can **breathe** through their **skin** as well as their **gills** (have an aqualung to extract oxygen from both water and air).
- When out of water, it keeps its **eyes moist by rolling** them back and forth into their sockets.

- **Mottled** colour for camouflage.
- Can walk, jump, swim and climb using its **powerful, stiff pectoral fins**.
- Shorter pelvic fins are joined together on the underside of the body to make a **'sucker'** to help it to cling on to the mangrove roots when it climbs.
- Protruding eyes allow the mudskipper a **360° view** and the ability to see above and below the water at the same time.
- When on land, the **gill covers shut tight** to store water inside the gill chambers.
- Eats insects (principal prey) as well as algae, detritus and small crabs.

The System.

INPUTS	**PROCESSES**	**OUTPUTS**
The sun	Energy flow within the food web	Heat
Sewage from nearby villages	Photosynthesis	New biomass
Freshwater streams	Respiration	Detritus
Detritus from the sea	Decomposition	Emigration of organisms
Litter	Death	
Sea water / Salt		
Immigration of organisms		
Wastewater from pipes / houses		

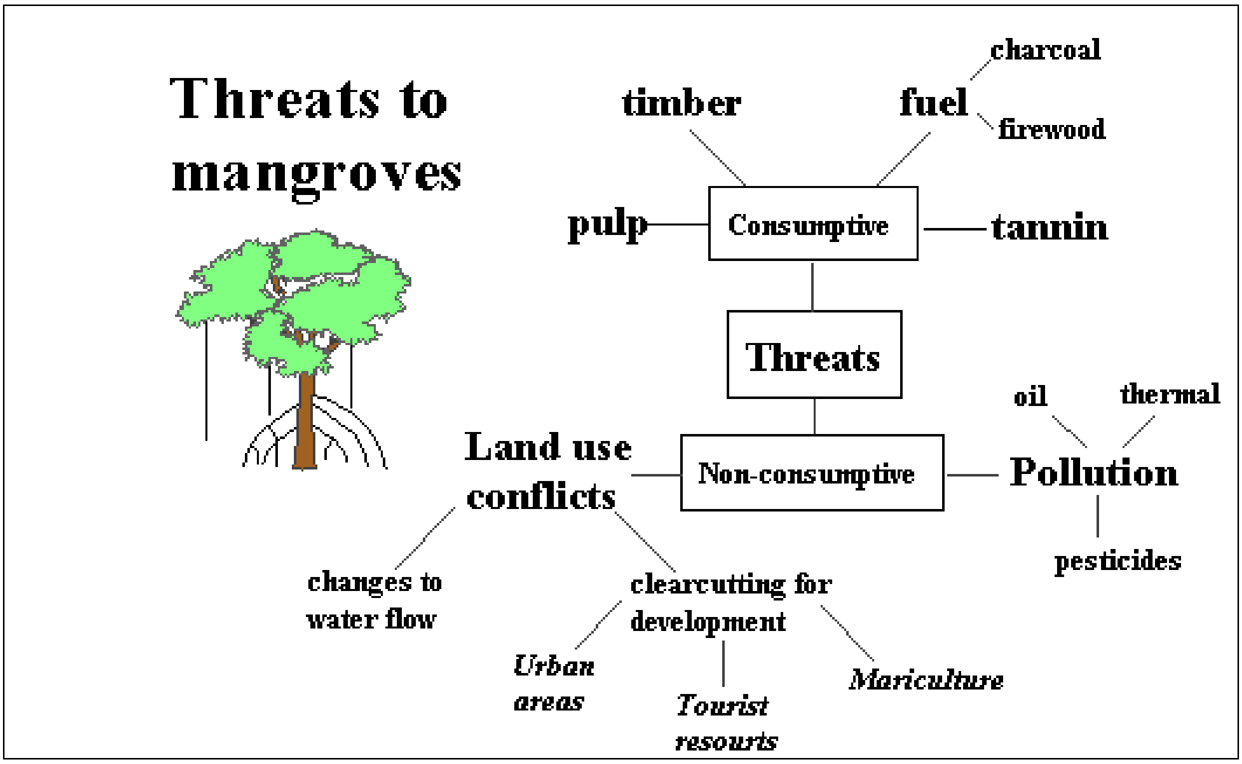
Human Impact on the Mangrove Ecosystems throughout Hong Kong.

- Cutting for house posts and **charcoal burning.**
- Clearance for housing i.e. **urban expansion**.
- Introduction of **walkways** for access.
- Disposal of **rubbish**.
- **Introduction** of domestic animals.
- **External food** sources e.g. left over food, available to mangrove inhabitants.
- Input of **sewage / effluent** into coastal waters.
- **Construction** of roads, canals and ports.
- **Hunting** of larger predators leading to a lack of stability in the food web.
- Creation of **salt fields** for commercial use.

Mangrove forests felled to make way for the **prawn farm industry** – this particularly true in the mangrove forests of Thailand who are the largest producer of Black tiger prawns. These farms have a short life expectancy (3-5 years) before the soil becomes so contaminated with excreta, bacteria and toxic chemicals that a new site must be found. Surrounding mangroves also greatly impacted as nutrient-rich excreta is pumped into the mangrove channels as if they were sewers. Decomposition of this waste leads to anoxic conditions and the suffocation of species.

N.B. 32% of the total destruction of mangrove forests in Thailand is due to prawn farming!

Today, the total area of mangrove forest in Thailand has crashed from its original 2.3 million rai to less than 900,000 rai (* 1 rai = 1600m^2).



N.B. If properly managed, mangroves can provide timber for construction, pulpwood for paper and charcoal for energy. They can also provide food for livestock, shellfish for human consumption and more.

e.g.

In Matang, Malaysia, well managed mangroves produce fish and wood products worth more than $1000 per hectare per year and providing one job for every 3 hectare of land.

If all of S.E. Asia's mangroves were managed sustainably, they would provide $25 billion annually to the economy and create about 8 million new jobs!

*** Possible future saviour = ECOTOURISM → environmental awareness, as well as public education on conservation issues, more protective legislation, proper management and strict enforcement of existing regulations.**

Q1. List some of the activities which could be introduced to provide a sustainable source of income based on ecotourism. What kind of limitations / rules would most likely be enforced?

MEASURING ABIOTIC FACTORS

FACTOR	EQUIPMENT	NOTES
Temperature (°C)	Temperature Sensor Max. / Min. Thermometer Soil Thermometer	Ensure probe does not also measure body heat Measures diurnal range (can be reset with a magnet). N.B. Read minimum scale 'backwards'. . Ensure thermometer reading depth is consistent
Light Intensity (Lux)	Light Sensor	Probe should be one metre above ground and at the same angle for each reading
Wind Speed (m/s or km/hr)	Anemometer	Number of rotations are recorded for conversion via rotation / windspeed calibration chart (all tests to be conducted with the meter at the same height & away from body)
Wind Direction	Weather Vane Windsock Compass	
Humidity (% saturation)	Humidity Sensor Whirling Psychrometer (Wet/Dry Bulb Hygrometer)	Ensure sensor is not influenced by the operator's breath moisture or other moisture sources e.g. streams etc. Wet thermometer covered in muslin cloth. When whirled, temperature difference = % saturation N.B. no difference = 100 % saturated

Dissolved Oxygen (%)	Oxygen meter	Probe must be immersed in saturated oxygen gel to calibrated 100% saturation before use Probe must be placed at the same depth for each reading
Salinity (% salt)	Bunsen burner Evaporating dish Balance	Evaporation of a fixed amount of filtered water (100g) – weigh remaining salt (g) and calculate salinity value as a %
Flow velocity (m/s)	Flowmeter Time taken for an organic float (e.g. a dog biscuit) to travel a fixed distance	Number of rotations are recorded for conversion via rotation / velocity calibration chart (all tests to be conducted with the meter at the same depth) Float must be buoyant , flat to avoid wind exposure & biodegradable in case of loss.
Slope (degrees)	Clinometer (plus ranging poles) Gradometer (ranging poles plus spirit level)	Place clinometer at a fixed point on the lower ranging pole and aim at the corresponding point on the higher ranging pole to measure the angle String between two ranging poles is levelled and the increase in elevation is recorded

SOIL		
Particle Size (mm or cm)	Small particles (mm) = graduated sieves Large particles (cm) = calipers	Weigh individual sieves, place fixed amount of dry soil (i.e. no moisture or humus) into the top of the graduated sieve and shake. Re weigh each sieve and its contents Using calipers measure:- • Axis "A" – longest length • Axis "B" – width • Axis "C" – depth
Moisture Content (%)	Weigh ⇒ Heat in oven ⇒ re-weigh	**Moisture Content %** = $\frac{\text{(Initial mass(g) – final mass(g))}}{\text{Initial mass(g)}} \times 100$
Humus Content (%)	Weigh ⇒ Burn in oven ⇒ re-weigh	**Humus Content %** = $\frac{\text{(Initial mass(g) – final mass(g))}}{\text{Initial mass(g)}} \times 100$
Mineral Content (%)	NPK testing kit	See kit instructions
Drainage / Infiltration Rate (ml / sec)	Infiltrometer (Pour a fixed amount of water into the column and measure drainage time)	Ensure that column is firmly fixed in ground to avoid leakage
pH	pH kit Universal indicator	See kit instructions

EVALUATING THE TECHNIQUES USED FOR MEASURING ABIOTIC FACTORS

This activity is relevant to assessment statement 2.2.2. There is no formal assessment.

To do

1. Using a variety of apparatus, measure the following abiotic factors on campus:

    - Light intensity
    - Temperature
    - Relative humidity

    Consider these key terms before starting:
    - **REPRESENTATIVE SAMPLES**
    - **AVERAGING**
    - **RANDOM SAMPLING**

2. Return to the classroom and pool your results in order to obtain an **AVERAGE** figure for the school campus for each abiotic factor (**UNITS**!!).

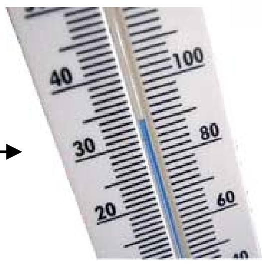
3. Present you data in an appropriate way.

4. Write a brief **EVALUATION** of your procedure in order to assess how reliable your final figures are.

5. Suggest some simple **IMPROVEMENTS** to your technique

You are provided with the following apparatus:

Light sensormeters →



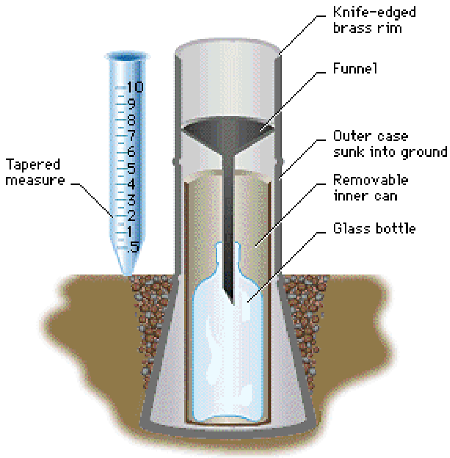
Thermometers →

Whirling psychrometers →

Temperature sensormeters →

Relative humidity sensormeters →

Q1. Below is a picture of a piece of apparatus used to measure precipitation i.e. a rain gauge



How could you attempt to measure the average precipitation (mm) falling on Sha Tin campus during a month?

MEASURING BIOTIC FACTORS

CLASSIFICATION KEYS

A classification key is used to identify an unknown organism and assign it to a genus and species. Typically keys use a series of linked questions highlighting contrasting characters. The key is followed until an identification is made.

RULES FOR MAKING KEYS

1. **The first clue should be one that either :-**

   - **Divides the whole group into two.**

   OR

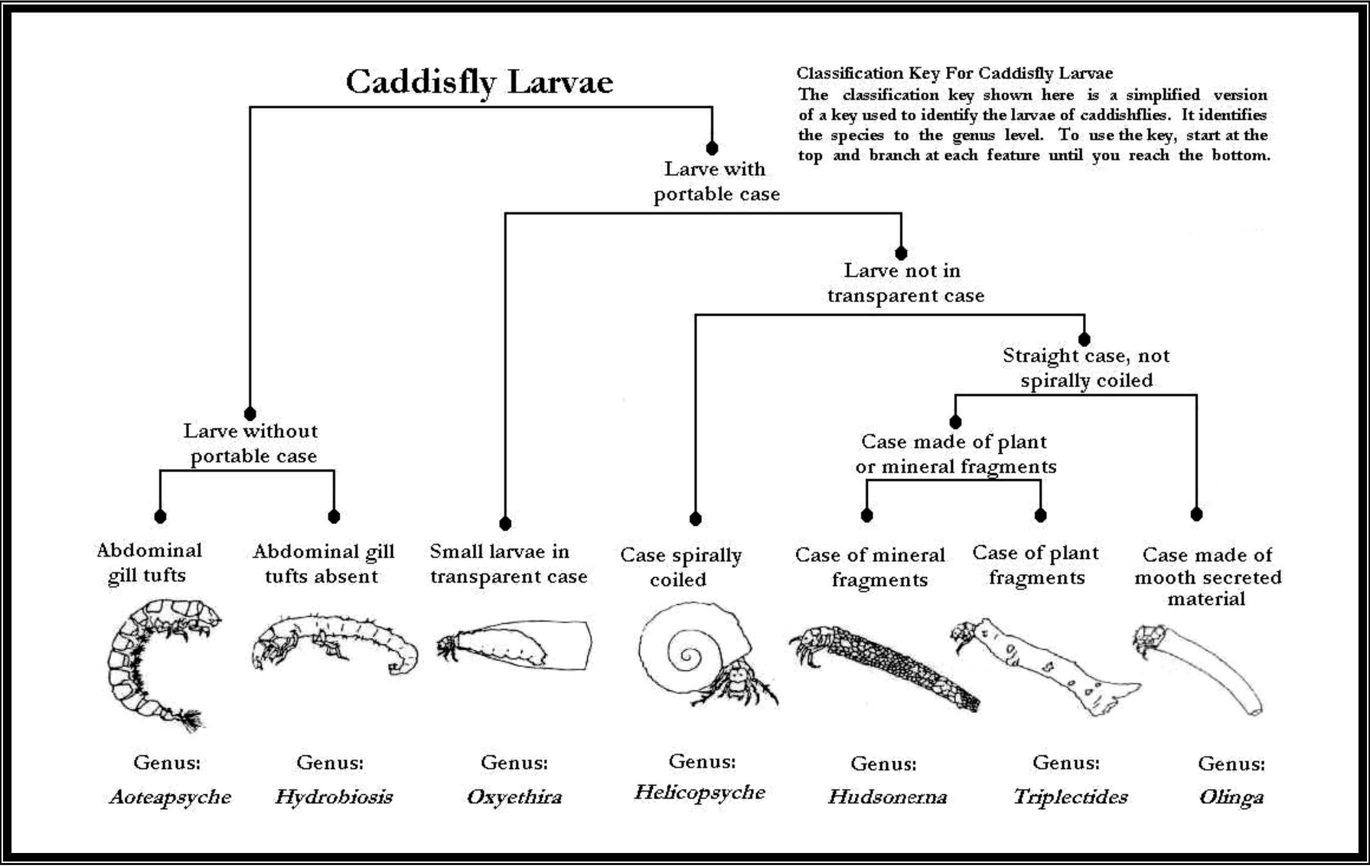
   - **Splits off one organism and leaves the rest.**

2. **Only use characteristics that you can SEE.**
3. **Don't use one characteristic more than once as a clue.**
4. **Make sure BOTH statements in a clue refer to the SAME characteristic………**

   e.g.
   Has jointed legs …………………… = CORRECT
   Does not have jointed legs ………………

   Has jointed legs ……………………. = WRONG!
   Has wings …………………

Complete the questions below:



1. In the key above, name the main feature that has been used to distinguish the different genera of caddis larvae:

____

2. Use the simplified key on the next page to identify each of the orders of aquatic insects (in bold) illustrated below. The key does not include all of the diagnostic features normally used by an entomologist (a person who studies insects):

Order of insect A: ________________

Common Name: ________________

Order of insect B: ________________

Common Name: ________________

Order of insect C: ________________

Common Name: ________________

Order of insect D: ________________

Common Name: ________________

Order of Insect E: ________________

Common Name: ________________

Order of insect F: ________________

Common Name: ________________

Order of insect G: ________________

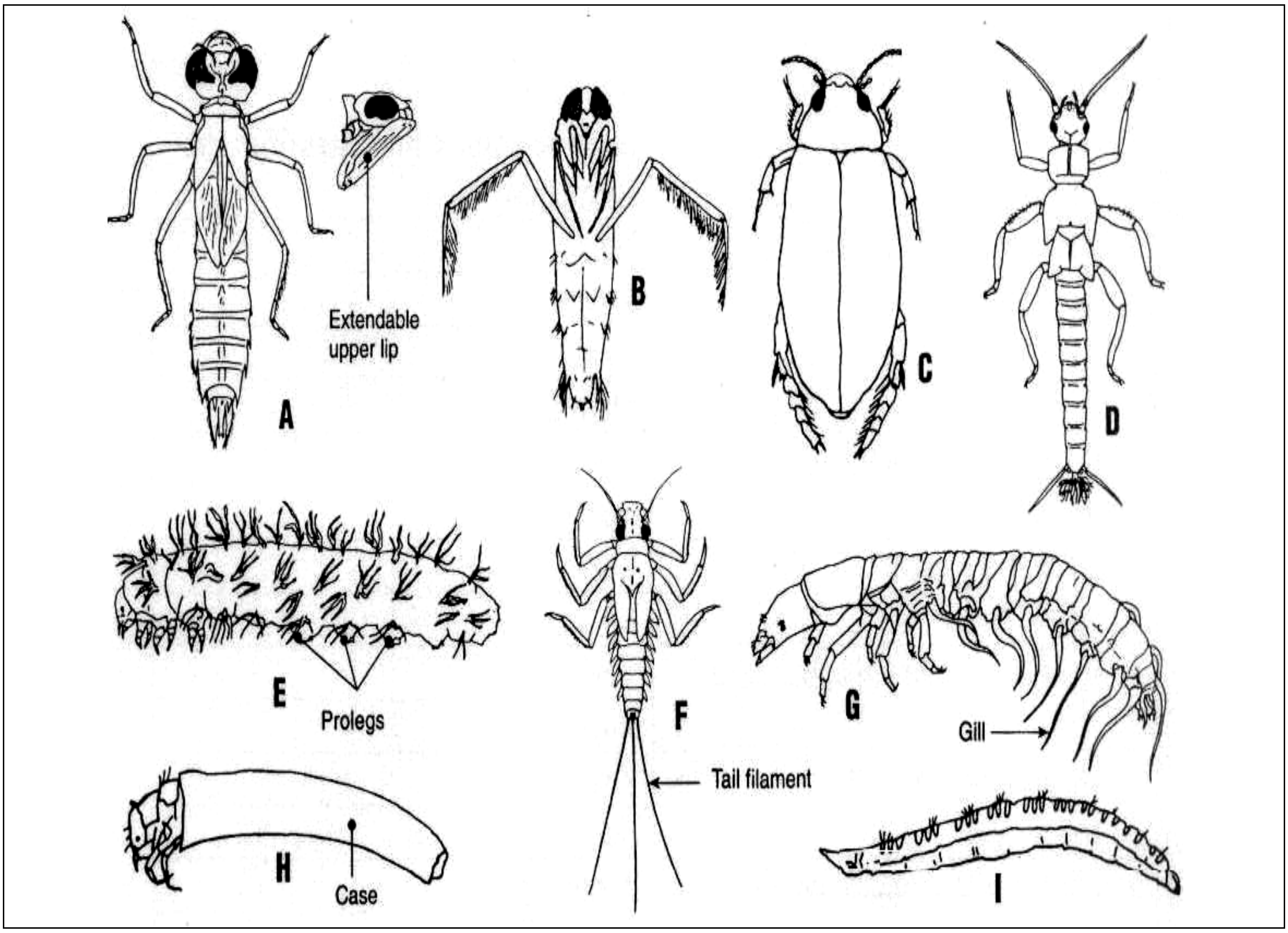
Common Name: ________________

Order of insect H: ________________

Common Name: ________________

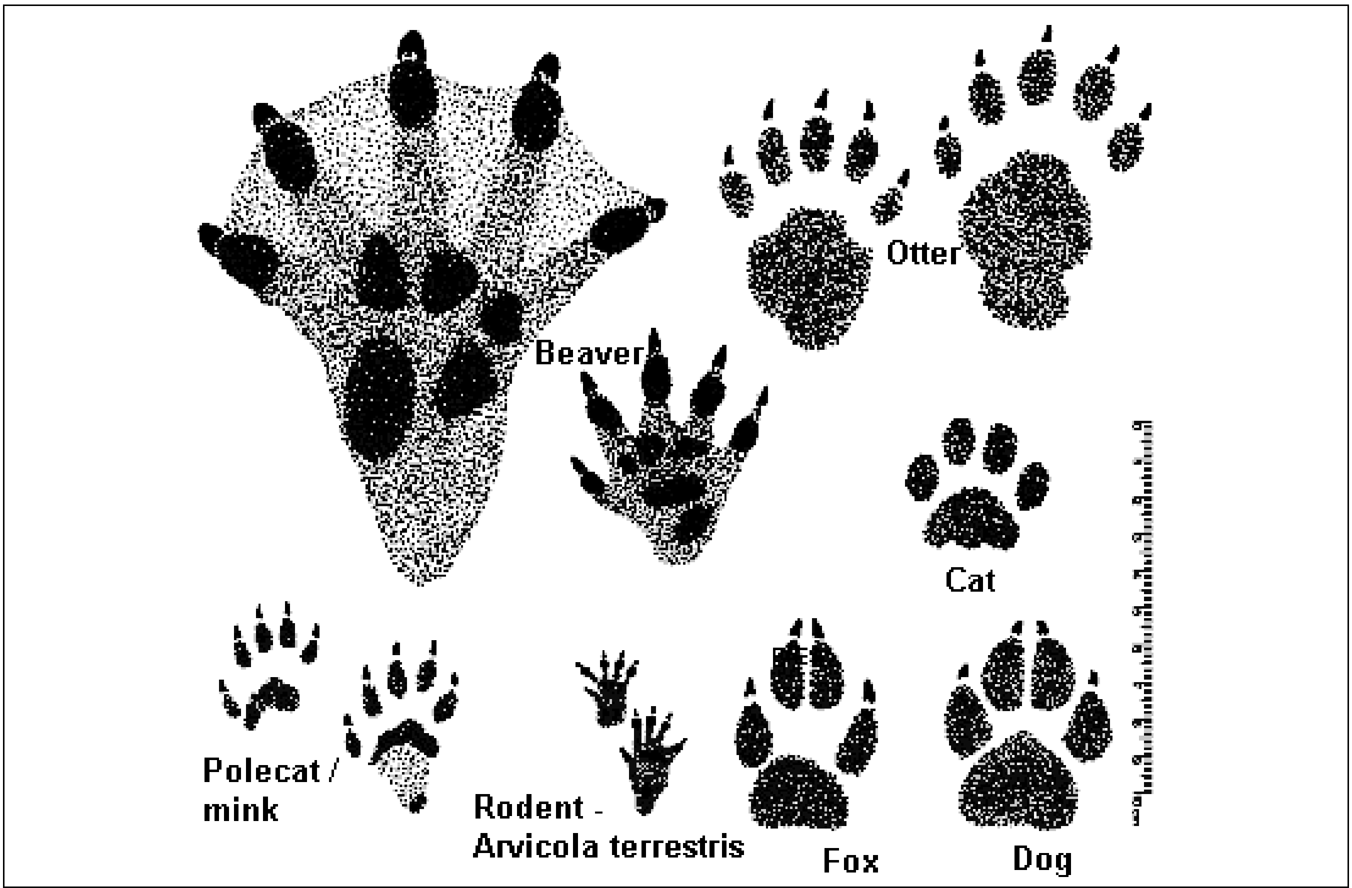
Order of insect I: ________________

Common Name: ________________



Key to Orders of Aquatic Insects			
1	Insects with chewing mouthparts; forewings are hardened and meet along the midline of the body when at rest (they may cover the entire abdomen or be variably reduced in length)	**Coleoptera**	Beetles
	Mouthparts are of the piercing and/or sucking type and form a pointed cone	Go to 2	
2	Mouthparts form a short, pointed beak; legs may be fringed for swimming or long and well-spaced apart for suspension on water	**Hemlptera**	Bugs
	Mouthparts do not form a beak, legs (if present) not fringed or long, spaced apart	Go to 3	
3	Prominent upper lip (labium) extendable, forming a food capturing structure longer than the head	**Odonata**	Dragonflies Damselflies
	Without a prominent, extendable labium	Go to 4	
4	Abdomen terminating in 3 tail filaments which may be long and thin, or with fringes of hairs	**Ephemeroptera**	Mayflies
	Without 3 tail filaments	Go to 5	
5	Abdomen terminating in 2 tail filaments	**Plecoptera**	Stoneflies
	Without long tail filaments	Go to 6	
6	With 3 pairs of jointed legs on thorax	Go to 7	
	Without jointed, thoracic legs (although non-segmented prolegs or false legs may be present)	**Diptera**	True flies
7	Abdomen with pairs of non-segmented prolegs bearing rows of fine hooks	**Lepidoptera**	Moths & butterflies
	Without pairs of abdominal prolegs	Go to 8	
8	With 8 pairs of finger-like abdominal gills; abdomen with 2 pairs of posterior claws	**Megaloptera**	Dobsonflies (toebiter)
	Either, without paired, abdominal gills, or if such gills are presant, without posterior claws	Go to 9	
9	Abdomen with a pair of short or long posterior prolegs bearing claws with subsidiary hooks; sometimes a portable case	**Trichoptera**	Caddisflies

Designing Keys



Keys are usually designed for use in a particular area to identify organisms.

Design a key for the identification of mammals through their footprints, shown above.

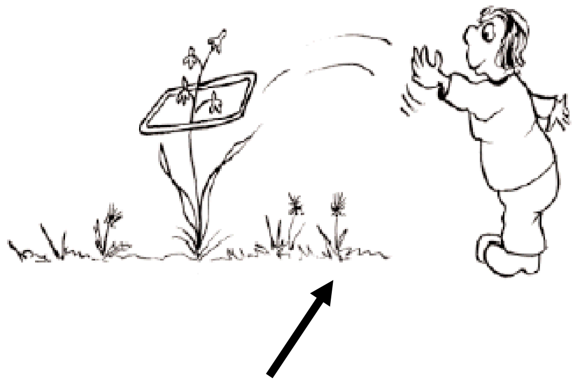
MEASURING THE ABUNDANCE OF ORGANISMS

ESTIMATING THE POPULATION OF A SESSILE ORGANISM USING QUADRATS

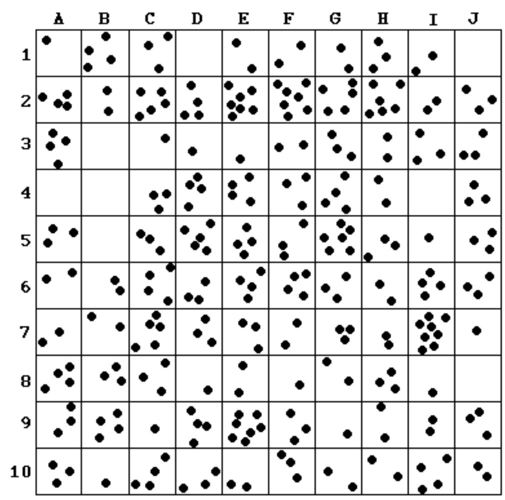
SESSILE ORGANISM – An organism which is permanently attached to a substrate or is not free moving e.g. barnacles, plants, coral polyps etc.

QUADRAT - A square frame (usually 1m2 or 0.25m2) made from string, wood, metal or 4 posts which is used for ecological or population studies.

RANDOM SAMPLING - i.e. without definite aim, direction, rule or method



Cheating!

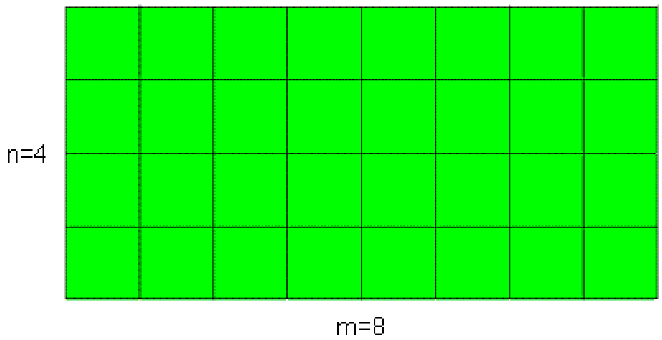


Random co-ordinates

HOW DO YOU ESTIMATE THE POPULATION OF TWO PLANT SPECIES?

- Count the number of individuals in Species A and Species B NOT count the number of species in each quadrat selected
- Use random sampling i.e. generate co-ordinates within the chosen overall area
- Keep repeating until the RUNNING AVERAGE stabilises (this tells you the average number of individuals of each species are found in one quadrat
- Use this figure to calculate the ESTIMATED number of individuals in the the whole area

e.g.



Area = Length X Width
= 8 X 4
= 32m^2

- Multiply the running average per unit area by the whole area
e.g. 10 individuals in 0.25m^2 quadrat X (32 x 4)
= 1280 individuals (approx.)

What sort of people would want to estimate and when?

- Biologists can study breeding patterns i.e. before season and after → birth rate
- Scientists from a variety of fields can assess the impact of an industry on an area i.e. how the population is affected by building, commissioning, production etc. = monitoring for an E.I.A.

N.B. Quadrats can be used to estimate population density, percentage frequency and percentage cover.

ESTIMATING THE POPULATION NUMBER OF AN ANIMAL SPECIES BY THE CAPTURE – MARK – RELEASE – RECAPTURE METHOD (LINCOLN INDEX).

This a technique used for **MOBILE ORGANISMS** e.g. birds, snails, tigers etc – How can the population be estimating as they do not stay still?

1. Randomly **capture** a group of representative organisms from the population being studied. Capture technique depends on organism being caught e.g.

SWEEP NETS

PITFALL TRAPS

TRANQUILISER DARTS

Q1. What is meant by a random sample?

Q2. Which organisms might be caught using the above capturing techniques?

2. **Mark** the organisms in a way that is not detrimental to their health or makes them easier for predators to spot e.g.

LEG RING

TAIL/ FIN NICK

PAINT (non-toxic)

RADIO COLLAR

3. Randomly **<u>release</u>** and allow organism to reintegrate for a period of time (organism dependent)

4. **<u>Catch</u>** a second sample and count the total number and the number which are marked

5. **<u>Calculate</u>** the estimated population using the **<u>LINCOLN INDEX</u>** equation :-

$$\text{POPULATION SIZE} = \frac{\text{NUMBER MARKED AND RELEASED IN THE FIRST CAPTURE} \times \text{TOTAL NUMBER IN THE SECOND CAPTURE}}{\text{NUMBER OF MARKED RECAPTURES IN THE SECOND CAPTURE}}$$

Q3. 625 trout were caught by drag netting a small lake. They were all marked by injecting a red dye beneath a scale near their tail. They were released. One month later, the lake was netted again and 873 trout were caught. 129 had marks. Estimate the population size.

Q4. It is important to capture, mark and release enough in the first capture so that there is a reasonable chance you will get some <u>marked recaptures</u> in the second capture. There are many other potential sources of error in this method. Discuss these and make notes below.

Q5. In 1919 a researcher by the name of Dahl wanted to estimate the number of trout in a Norwegian lake. The trout were subject to fishing so it was important to know how big the population was in order to manage the fish stock. He captured and marked 109 trout in his first sample. A few days later, he caught 177 trout in a second sample, of which 57 were marked. Use the **Lincoln Index** to estimate the total population size.

Q6. Describe some of the problems with the mark and recapture method if the second sampling is:-

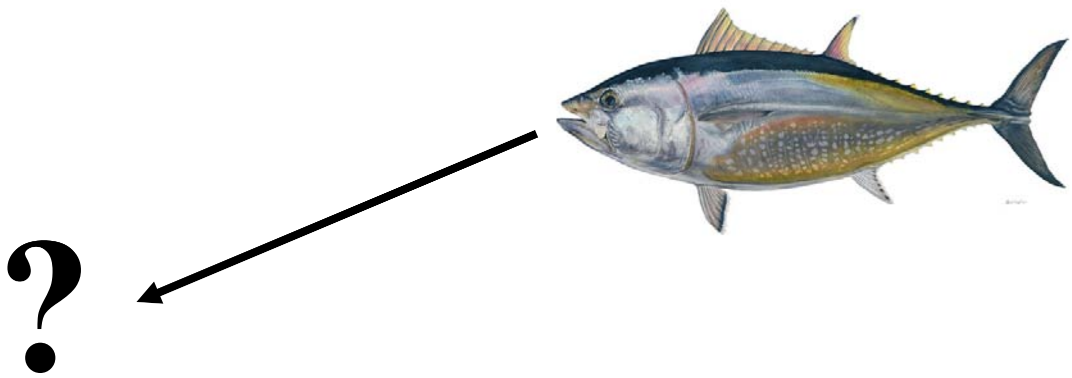
a) Left too long a time before being repeated:

b) Too soon after the first sampling:

Q7. Describe **TWO** important assumptions being made in this method of sampling that would cause the method to fail if they were not true.

Q8. Some types of animal would be unsuitable for this method of population estimation. Name an animal for which this method of sampling would not be effective and give a reason for your answer.

Q9. Scientists in Australia are involved in a computerized tagging programme for southern bluefin tuna (a species also found in New Zealand waters). Describe the type of information that could be obtained through this tagging programme.



MEASURING BIOMASS – A summary

BIOMASS – The mass of organic material in organisms or ecosystems, usually per unit area.
(Sometimes the term "dry weight biomass" is used where mass is measured after the removal of water. Water is not organic material and inorganic material is usually relatively insignificant in terms of mass).

Units of biomass = g m^{-2}

- Usual method for measuring is to dig up/scrape off organisms in $1m^2$, **dry** them out in a warm oven and multiply by the area of the study site.

- Problems
  - **No account of depth** ∴ plants roots, tubers etc. are omitted
  - Organisms being studied often have a **season** where they are prevalent
  - **Mobile organisms** can leave the study area ∴ **snapshot**
  - **Distribution of organisms** can be variable, so would have to repeat
  - **Generation times** of some organisms is very short therefore results often unreliable e.g. pyramid of biomass for phyto and zooplankton appears incorrect
  - **Not a very environmentally friendly/ethical** sampling technique particularly if species are well established or slow growing
  - Sampling technique can cause **permanent damage**
  - **Cannot measure in the field**

- A more accurate method would be to dig up $1m^3$ if studying plants in order to incorporate the roots, but this still leaves the problems of seasonality, distribution etc.

- **PRODUCTIVITY** is therefore a more reliable and accurate measurement although it is time consuming i.e. not a snapshot but a study of biomass production in an area over **TIME = g m^2 yr^{-1}**

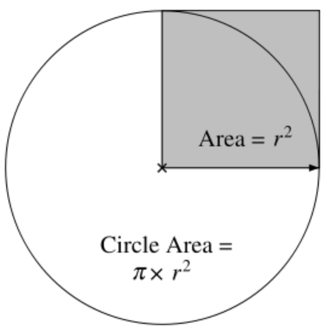
- If you were to **estimate** the biomass of a large area e.g. a forest, the following would have to calculated:
  - estimate size of area from a map, remote sensing or a scaled aerial photo (m^2 or km^2)
  - randomly select a testing area (must be appropriate size compared to study area and relatively 'typical'
  - count no. of trees in sample site BUT what is a tree?; are they all the same species?; above what height is it classed as a tree?; above what girth is it classed as a tree?; what if it bifurcates (splits)

- In order to calculate the mass of a tree, the VOLUME must be calculated:- **VOLUME OF TRUNK = AREA x HEIGHT**

- **To calculate area** –
  Area = Πr^2
  Area is measured from the circumference/girth
  Circumference = Πd
  $\therefore$ **c = $2\Pi r$** (we need r to calculate the area)
  $\therefore$ **r = $\frac{c}{2\Pi}$**

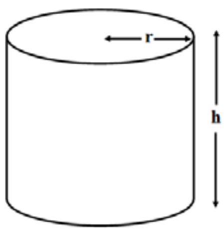
  Area = Πr^2

N.B. A decision must first be made as to what will be classed as a tree and where the measurement should be taken i.e. not forked, trunk thicker than an arm, circumference measured 1m above the ground, not on a slope etc etc.



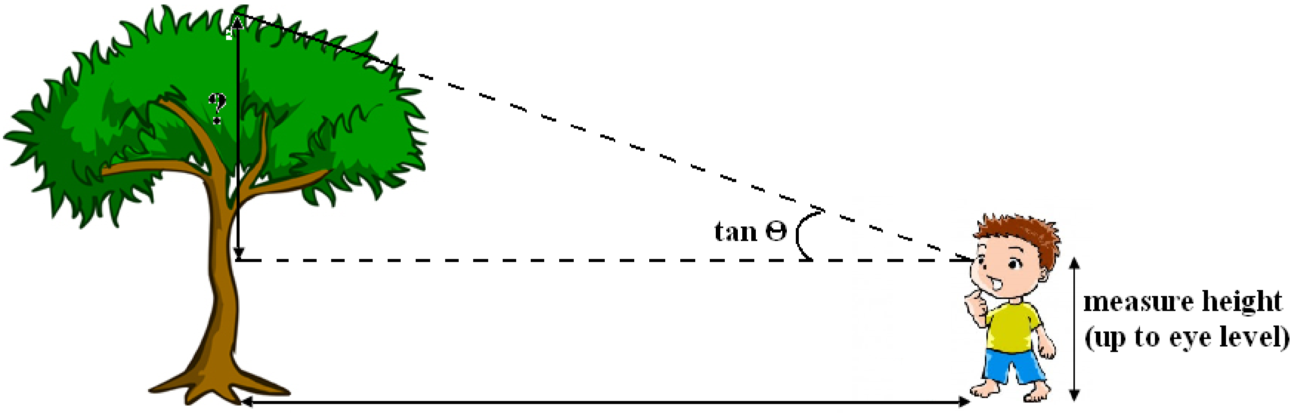
Volume = Πr2h

$$V = \pi r^2 h$$



$\therefore$ we need to find h

- **<u>To calculate height</u>** –



From trigonometry → ***SOHCAHTOA***

Where

Tan θ = $\frac{?}{10m}$

∴ ? = 10 x tan θ

So, for height of tree we need →
? + height of measurer to eye level

A CLINOMETER IS USED TO MEASURE THE ANGLE FROM EYE LEVEL TO THE HIGHEST BRANCH

- We use volume because :
  DENSITY = $\frac{\text{MASS}}{\text{VOLUME}}$

  → **MASS = DENSITY X VOLUME**

  If density of wood is constant i.e. they are the same species/ family of trees we can assume that <u>MASS = VOLUME</u>

  (If done more accurately, then would have to multiply each volume by the specific density of that particular wood type – conversion factor of 0.6 has been suggested by Edwards & Grub, J. of Ecology 1977 but would still have to incorporate leaves, branches etc. so a further conversion factor would have to be applied – 1.1 according to paper written above)

- So, need to measure the volume of all the trees in the sample area (mark each tree to avoid repetition) = mass (if density is a constant)
  → total mass in sample area e.g. 10m2
  If total study area was 1km2 then multiply by this factor i.e.100
  → **TOTAL MASS OF TREES IN THE FOREST**

- **BUT:**
  - **Not biomass as have not included all producers** / living organisms depending on what is being studied i.e. trophic level, ecosystem etc.
  - Not biomass as still contains water ∴ **not dry mass**
  - If done properly, would have to dig up entire sample site and heat until dry ∴ unrealistic so only a vague estimate is possible
  - **Ignores branches, leaves, roots** etc. which are part of the mass of the tree/plant
  - **Ignores variation** in the area i.e. spacing, gradient etc.
  - **Ignores animals** (particularly mobile ones) if relevant to biomass study
  - **Ignores variation between trees** i.e. deep roots, surface roots, different species having different density wood etc.

Q1. What strategies could be employed in order to try and mitigate (lessen) some of these problems?

MEASURING SPECIES DIVERSITY OF AN ECOSYSTEM USING THE SIMPSON'S INDEX.

DIVERSITY – A generic term for heterogeneity (variety). This term needs to be divided further for its clear meaning to be understood
i.e.

GENETIC DIVERSITY – The range of genetic material present in a gene pool or population of a species.

HABITAT DIVERSITY – The range of different habitats or number of ecological niches per unit area in an ecosystem, community or biome. Conservation of habitat diversity usually leads to the conservation of species and genetic diversity.

SPECIES DIVERSITY – The variety of species per unit area. This includes both the **number of species** present and their **relative abundance**.

A simple count of species number is misleading.

Consider the plant diversity within two ecosystems:-

Ecosystem A is an agricultural monoculture (one species), a field of maize. However, there are weeds as well. In total, there are 20 species present but 19 weed species are uncommon and the maize plant is very dominant.

Ecosystem B is an alpine meadow. It contains many species of grasses and flowers. In total there are 20 species present but all species are approximately equally common.

Q1. Which one would have greatest diversity?

Q2. Explain why number of species is not a good indicator of diversity. What else needs to be taken into account?

The Simpson's Diversity Index.

This is a measure of **species richness** which allows for **relative abundance**.

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

where **D** = diversity index

N = total number of organisms

n = number of individuals in each particular species

A high value of D indicates a high species diversity.

It can be used for plants, animals or both in a particular ecosystem.

Q3. The maize ecosystem and the alpine meadow can be compared with this formula.

- The maize ecosystem contained 105 maize plants and 5 individuals of all the other 19 weed species.
- The alpine meadow contained 10 individuals of each of the 20 species.

Calculate the Simpson's Index for each ecosystem using the **help sheet** for guidance.

SIMPSON'S INDEX (help sheet)

NAME OF ECOSYSTEM :- ________________________

Total no. of organisms (N) = ___________

N – 1 = __________

N (N-1) = __________ (This is the top part of your equation)

SPECIES	n (no. of individuals)	n - 1	n(n-1)	SPECIES	n (no. of individuals)	n - 1	n(n-1)
1							
2							

$\sum n(n-1)$ = _____
(This is the bottom part of your equation)

Calculation.

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

D = ____________________ ∴ D = _______

SIMPSON'S INDEX (help sheet)

NAME OF ECOSYSTEM :- ________________________

Total no. of organisms (N) = ___________

N – 1 = __________

N (N-1) = __________ (This is the top part of your equation)

SPECIES	n (no. of individuals)	n - 1	n(n-1)	SPECIES	n (no. of individuals)	n - 1	n(n-1)
1							
2							

$\sum n(n-1)$ = _____
(This is the bottom part of your equation)

Calculation.

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

D = ――――――――――― ∴ D = _______

Q4. Which system is more diverse?

Q5. Differences in diversity can be for many reasons. Can you suggest two hypotheses to explain the differences between the maize and the alpine meadow's diversity.

Certain biomes have high diversity and others have low diversity.

Q6. Comment on the relative biodiversity of Tropical Rainforest, Tropical Grassland (Savannah), Desert, Temperate Forest and Tundra.

Example questions

1. Give TWO assumptions that must be made when using the mark, release and recapture method to estimate population size.

2. In a survey of a deer population, 80 deer were marked and released. Two weeks later a second sample was captured. Of these deer, 17 were seen to be marked and 3 were unmarked. Calculate the estimated population size.

3. A record of the flower populations of a meadow were recorded using random quadrat sampling.
   i.e.

SPECIES	NUMBER
Festuca	54
Buttercup	17
Sheperd's Purse	12
Species 'A'	5
Dandelion	3

Using the results in the table, calculate the Simpson's Index for the meadow.

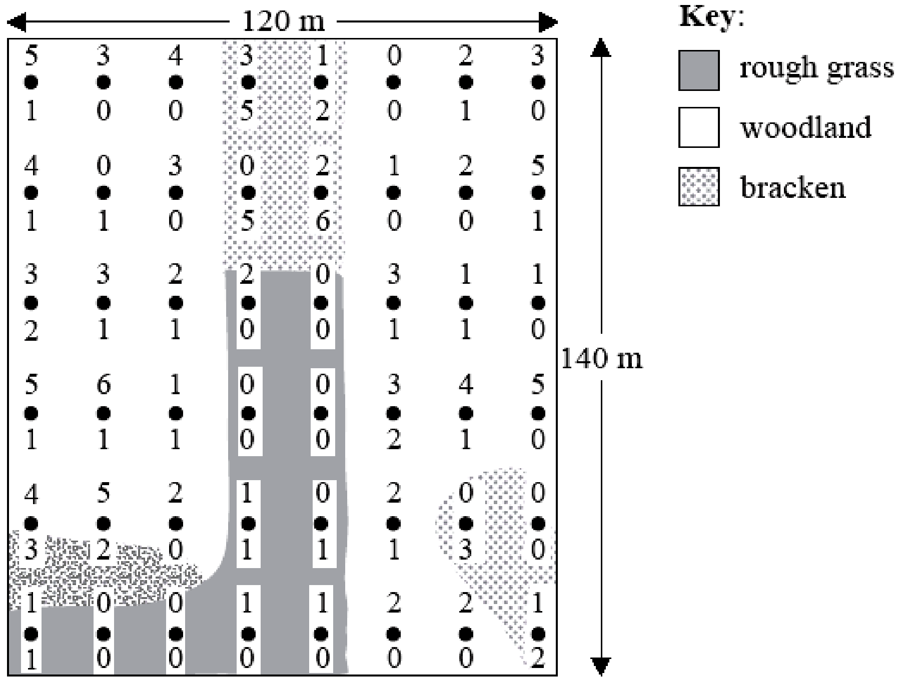
4. Name three ecosystems where you would expect to find a high diversity index.

5.

Figure 3(a) shows the numbers of wood mice and bank voles collected from traps.

The number above the trapping point (•) represents wood mice and the number below the trapping point (•) represents bank voles.

Figure 3(a)



[Source: A Cadogan and G Best, *Environment and Ecology*, page 51, Blackie and Sons Ltd, 1992]

Figure 3(b)

	Rough grass	Woodland	Bracken
Wood mice	6	50	
Bank voles	3	15	

(This question continues on the following page)

(i) Complete **Figure 3(b)** by calculating the numbers of wood mice and bank voles found in bracken. *[1]*

(ii) Suggest **two** reasons for the relationship between rodent numbers and habitat shown in **Figure 3(a)** and **Figure 3(b)**. *[2]*

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(iii) Explain why the rodents were marked and released after capture. *[1]*

. . . .

. . . .

. . . .

N07/4/ECOSO/SP1/ENG/TZ0/XX

KEY WORDS

TERM	DEFINITION
ABIOTIC FACTOR	A non-living, physical factor that may influence an organism or ecosystem, e.g. temperature, sunlight, pH, salinity, precipitation etc.
BIODIVERSITY	The amount of biological or living diversity per unit area. It includes the concepts of species diversity, habitat diversity and genetic diversity.
BIOMASS	The mass of organic material in organisms or ecosystems, usually per unit area. Sometimes the term "dry weight biomass" is used where mass is measured after the removal of water. Water is not organic material and inorganic material is usually relatively insignificant in terms of mass.
BIOTIC FACTOR	A living, biological factor that may influence an organism or ecosystem, e.g. predation, parasitism, disease, competition.
COMMUNITY	A Group of populations living and interacting with each other in a common habitat.
DIVERSITY INDEX	A numerical measure of species diversity that is derived from both the number of species (variety) and their proportional abundance e.g. The Simpson Index.
ECOSYSTEM	A community of interdependent organisms and the physical environment they inhabit.
ENVIRONMENT	An organism's physical and biological surroundings.
FOOD CHAIN	The transfer of energy and matter in a sequence of trophic levels in which organisms of a lower trophic level become the food of organisms in a higher level.

FOOD WEB	The interconnection of organisms within several food chains.
HABITAT	The environment in which a species normally lives.
KEY	A classification key is used to identify an unknown organism and assign it to a genus and species. Typically keys use a series of linked questions highlighting contrasting characters. The key is followed until an identification is made.
LIMITING FACTORS	Various factors which limit the distribution or numbers of an organism.
LINCOLN INDEX	A formula used to estimate the population of a mobile organism. Sometimes referred to as the capture-mark-release-recapture method. $N = \frac{n1 \times n2}{m}$ N = estimated population n1 = total no. in first capture n2= total no. in 2nd capture and m = total no. in 2nd capture that were marked
PHOTOSYNTHESIS	The process by which autotrophs (plants) make their own food by converting light energy into chemical energy.
POPULATION	A group of organisms of the same species living, in the same area at the same time, and which are capable of interbreeding.
PRODUCTIVITY, GROSS PRIMARY (GPP)	The quantity of organic matter produced, or solar energy fixed, by photosynthesis in green plants per unit area per unit time.

PRODUCTIVITY, NET PRIMARY (NPP)	Gross primary productivity less the biomass or energy lost by plants through respiration (R): NPP = GPP – R. The quantity of biomass potentially available to consumers in an ecosystem is indicated by NPP. It is measured in units of mass or energy per unit area per unit time.
PRODUCTIVITY, SECONDARY	The biomass gained by heterotrophic organisms, through feeding and absorption, measured in units of mass or energy per unit area per unit time.
QUADRAT	A sample area enclosed within a frame, usually a square, within which a plant community (or sometimes an animal community) is analysed.
RESPIRATION	The breakdown of food to release energy.
SIMPSON'S INDEX	A formula used to calculate the species diversity of a certain area i.e. $D = \frac{N(N-1)}{\sum n(n-1)}$ where **D** = diversity index, **N** = total number of organisms, **n** = number of individuals in each particular species
SOIL	The loose aggregate of mineral and other particles that covers the land, and in which terrestrial plants generally grow.
SPECIES	A group of organisms that interbreed and produce fertile offspring.