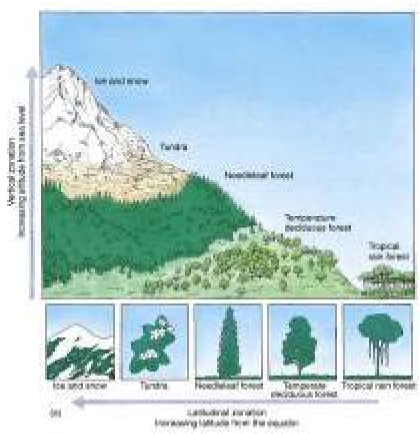
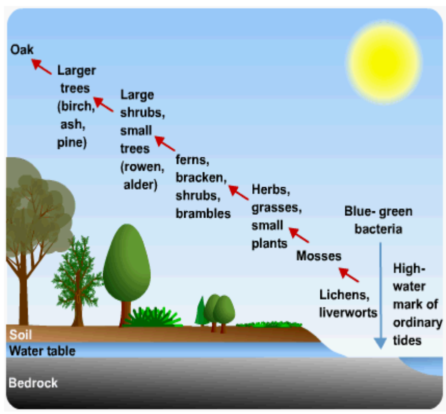
The Ecosystem





Changes in the Ecosystem

THE ECOSYSTEM – Changes in 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.

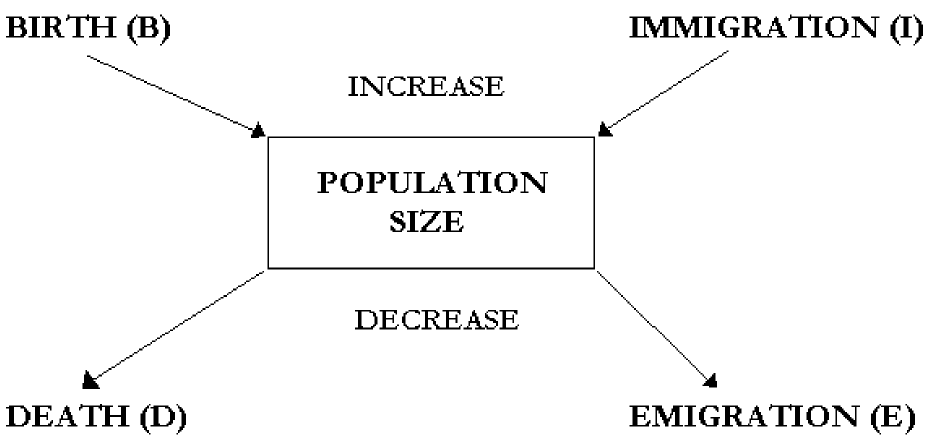
SYLLABUS STATEMENTS	ASSESSMENT STATEMENT	CHECK	NOTES
2.6	CHANGES		
2.6.1	Explain the concepts of limiting factors and carrying capacity in the context of population growth.		
2.6.2	Describe and explain "S" and "J" population growth curves.		
2.6.3	Describe the role of density-dependant and density-independent factors, and internal and external factors, in the regulation of populations.		
2.6.4	Describe the principles associated with survivorship curves including, K – and r – strategists.		
2.6.5	Describe the concept and processes of succession in a named habitat i.e. ______________________________		
2.6.6	Explain the changes in energy flow, gross and net productivity, diversity and mineral cycling in different stages of succession.		
2.6.7	Describe factors affecting the nature of climax communities.		

SYLLABUS STATEMENTS	ASSESSMENT STATEMENT	CHECK	NOTES
2.7	<u>MEASURING CHANGES IN THE SYSTEM</u>		
2.7.1	Describe and evaluate methods for measuring changes in abiotic and biotic components of the ecosystem along and environmental gradient.		
2.7.2	Describe and evaluate methods for measuring changes in abiotic and biotic components of the ecosystem due to a specific human activity.		
2.7.3	Describe and evaluate the use of environmental impact assessments (EIAs).		

POPULATION GROWTH

POPULATION – a group of organisms of the same species living in the same area at the same time, and which are capable of interbreeding.

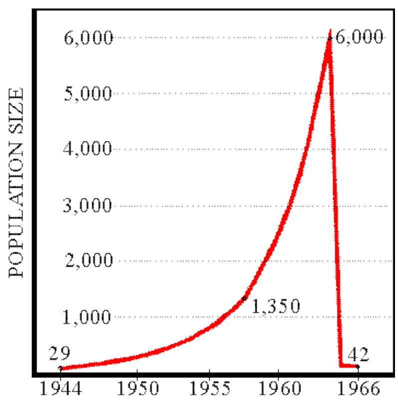
Population sizes are affected by **birth**, **death** and **migration**, which are in turn influenced by food supply, fertility, predation and disease.



The change in the size of any population over a period of time can be summarised as:-

Change in population size = B + I – D - E

An apparently **static** population occurs when these factors are **balanced**. If an imbalance occurs, there may be a **population explosion** (a very rapid growth) or a **population crash** (a very rapid decline).



Assumed population of the St. Matthew Island reindeer Herd. Actual counts are indicated on the population curve.

Label the population explosion and crash in the St. Matthew Island reindeer population as shown in the diagram on the left.

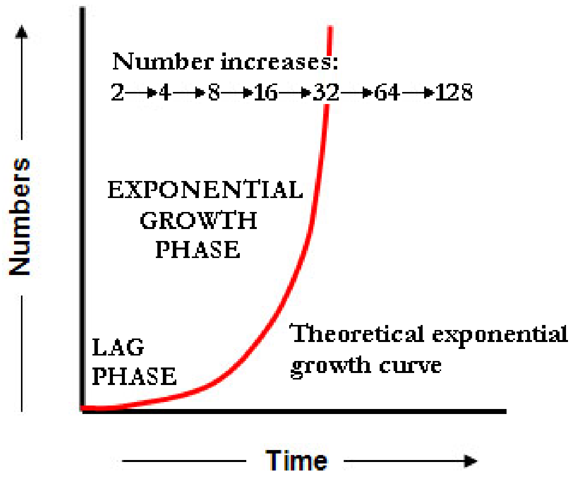
There is a limit to the size of a population that can be supported by any environment. This is called the carrying capacity (K).

CARRYING CAPACITY (K) – the maximum number of a species or "load" that can be <u>sustainably</u> supported by a given environment.

Under ideal conditions i.e. plenty of food, the correct temperature etc, a population can grow at its maximum rate, its **BIOTIC POTENTIAL**.
Such growth starts off slowly and then increases rapidly, producing an exponential, or J-shaped, growth curve.
i.e.

<u>The J-shaped growth curve</u>

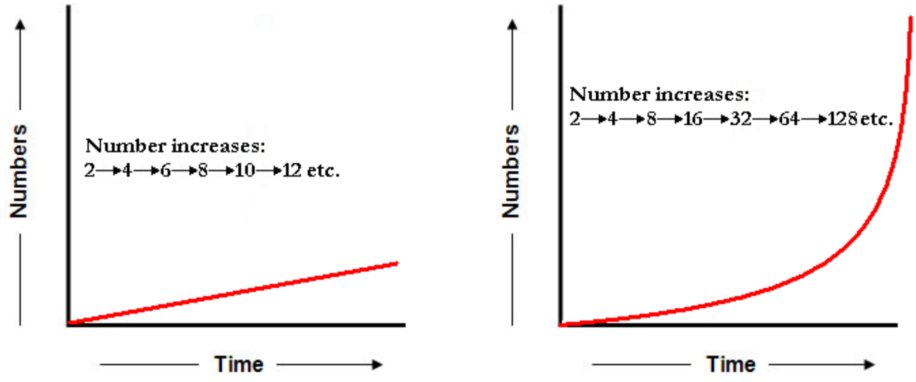
Imagine a population of two organisms (e.g. yeast cells) in ideal conditions (lots of space, food, ideal temperature etc). What would happen to their numbers if the cells divide every two hours.



- **Lag Phase** – slow initial increase as population begins reproduction.
- **Exponential Growth Phase** – the numbers double at regular time intervals = THE DOUBLING TIME

Q1. What features of the species will determine its BIOTIC POTENTIAL?

N.B. Exponential growth (also called logarithmic growth) is different from arithmetic growth (in which the rate of increase remains constant) and leads to much faster population growth.
i.e.

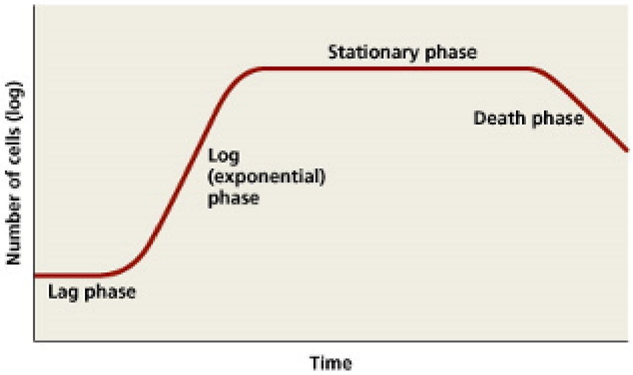


(a) arithmetic growth (b) exponential growth

Limits to population growth

Exponential growth cannot continue forever.

e.g. a typical bacterial growth curve.



The reason the bacterial population stopped increasing was that its environment could not support the vast number of new cells being produced. Before long, there would be a food shortage. In addition, many bacteria produce waste products which are toxic to themselves, so the number of births decreases and the number of deaths increases, causing a population decline.

Q2. List 4 important factors which set limits to population increase.

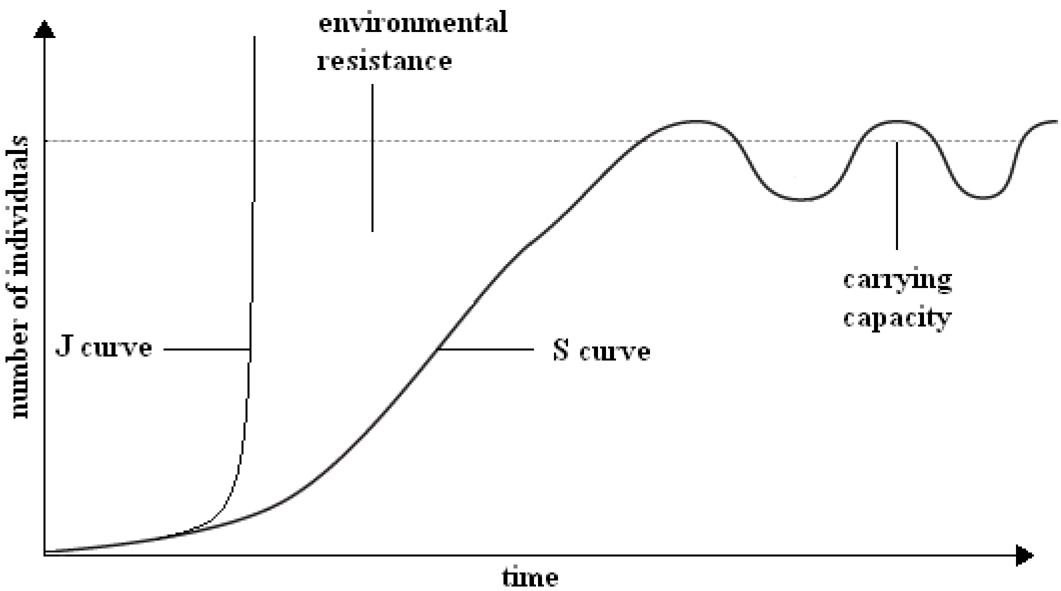
ENVIRONMENTAL RESISTANCE – environmental factors which reduce the population's growth rate.

It works against the organism's BIOTIC POTENTIAL.

Q3. What effect will environmental resistance have on:-

- Mortality (Death Rate)
- Natality (Birth Rate)
- Emigration

The S-shaped (Sigmoid Growth Curve)



The Lag Phase and the Exponential Growth Phase still exist on the S-curve but the exponential growth is soon reduced by environmental resistance. Eventually the population stops growing.

The S-shaped curve has FOUR phases:-

- **Lag Phase**
- **Exponential Growth Phase**
- **Transitional Phase** – growth **reduced** by environmental resistance
- **Plateau Phase** – growth **stopped**, population is stable and in equilibrium, the maximum population number for these conditions has been reached (carrying capacity).

Q4. What is the relationship between Natality/Immigration and Mortality/Emigration when the population has reached the Plateau Phase?

Q5. What determines the maximum population number reached in the Plateau Phase?

Q6. The carrying capacity (K) of a habitat for a particular population can change if the environment changes.

- What could happen to increase the carrying capacity (K)?

- What could happen to reduce the carrying capacity (K)?

Population Growth and Evolution

The exponential growth phase tells us that populations tend to produce more offspring than the carrying capacity of the environment can sustain. The result is that many offspring will die before becoming adults and reproducing. This is the STRUGGLE FOR EXISTENCE.

Q7. The offspring will vary in size, colour, shape, physiology etc. Which offspring will die and which will survive to reproduce?

This is called **NATURAL SELECTION**.

The theory of **Evolution by Natural Selection** suggests that this process has caused new species to evolve from ancestors. Changes in the environment which reduce the carrying capacity for a particular population will stimulate adaptation in the population.

Imagine a population of plants of varying heights in a field. The present population is at carrying capacity and is well adapted to the present environmental conditions. The environment suddenly changes so that the carrying capacity for this population is reduced and taller plants are much less likely to survive.

Q8. What change in the environment could cause this?

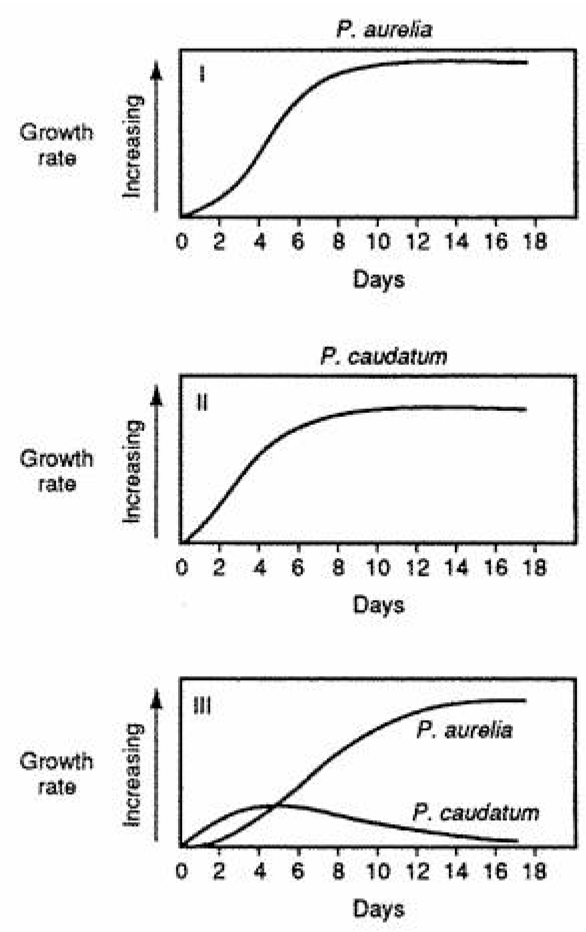
Q9. What would happen to the population in the future?

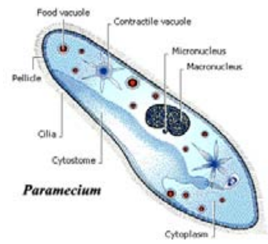
Population Growth Curves

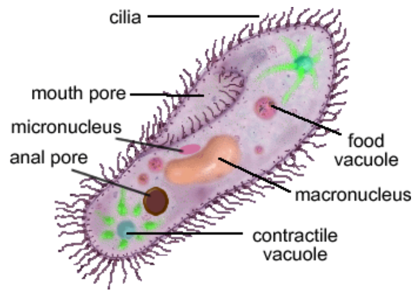
These are the results of a laboratory experiment in population increase. Twenty individuals of one species of *Paramecium* were put into a glass tube with a standard amount of bacteria as food. Each day the *Paramecium* were given food and every other day the mix was given a rinse to make sure that toxins did not build up in the tube.
The experiment was done with two different species of *Paramecium* i.e. *P. caudataum* and *P. aurelia*.

Paramecium multiplies by binary fission which is dividing into two without sexual reproduction.

Study the graphs below:-







Graphs to show the population growth curves for two species of *Paramecium*. The population numbers are means of three repeat experiments for each species (Data from Gause, 1984).

Q10. When was the highest number for each species reached when grown separately and together?

Q11. How long was the lag phase for each species when grown separately and together?

Q12. How long was the exponential phase for each species when grown separately and together?

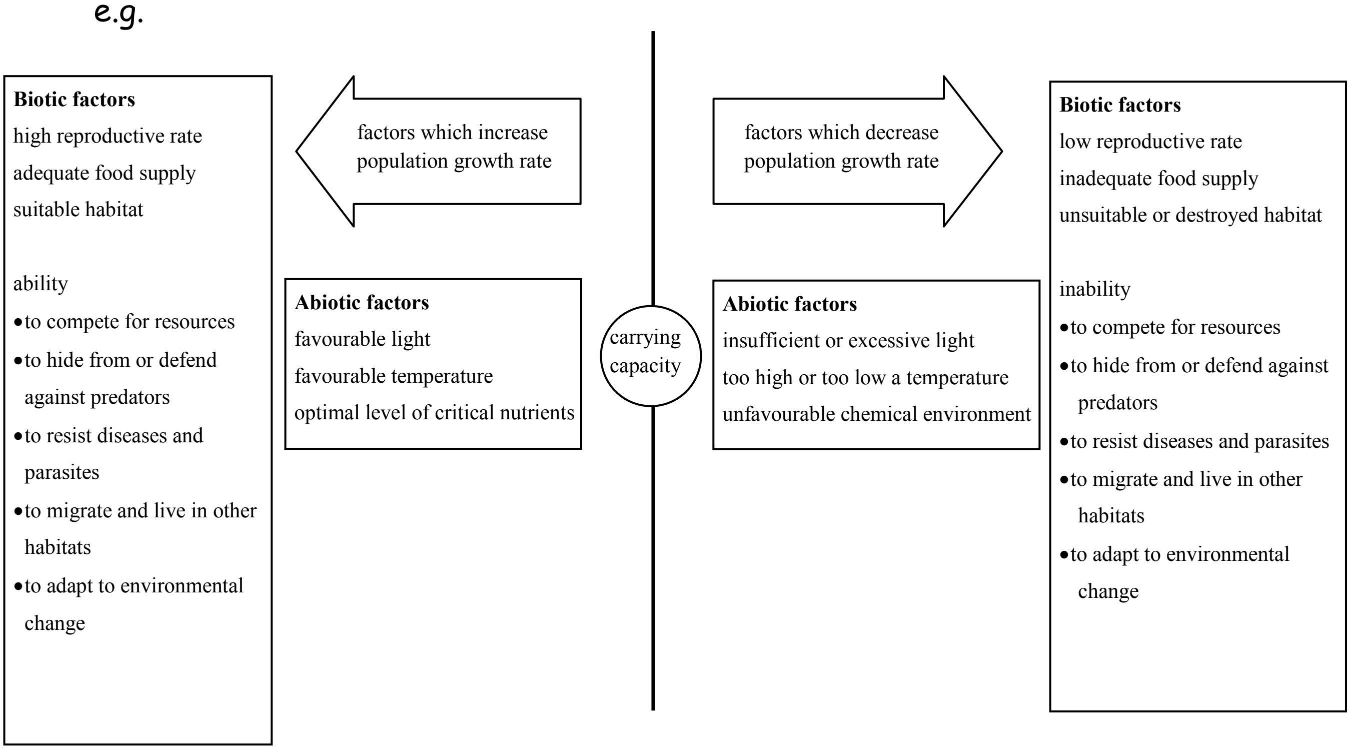
Q13. Which species had the larger carrying capacity?

Q14. Which species do you think is larger in size? Give an explanation for your answer.

FACTORS THAT LIMIT POPULATION GROWTH

The factors that limit population growth affect the fertility or mortality rates. These factors may be classified as:-

- **BIOTIC** (caused by living organisms) or **ABIOTIC** (caused by non-living) components of the environment.
  e.g.



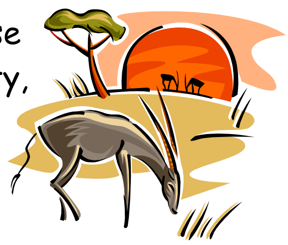
- **DENSITY – DEPENDENT** (effects are stronger as population density increases)

OR

- **DENSITY – INDEPENDENT** (the effect is the same whatever the population density)

Density-dependent factors

A density-dependent factor acts to decrease fertility of increase mortality as the population grows. The larger the population density, the greater the effect, e.g. the amount of fighting amongst prairie voles increases as the population density increases. Such fighting leads to an increase in the rate of emigration of these rodents from the area of prairie which they are inhabiting.



Examples of density-dependent factors include:-

- Predator-prey relationships
- Parasitism
- Disease
- Stress and crowding
- Food and water availability
- Availability of light
- Availability of oxygen
- Shelter
- Accumulation of toxic waste
- Interspecific competition
- Intraspecific competition

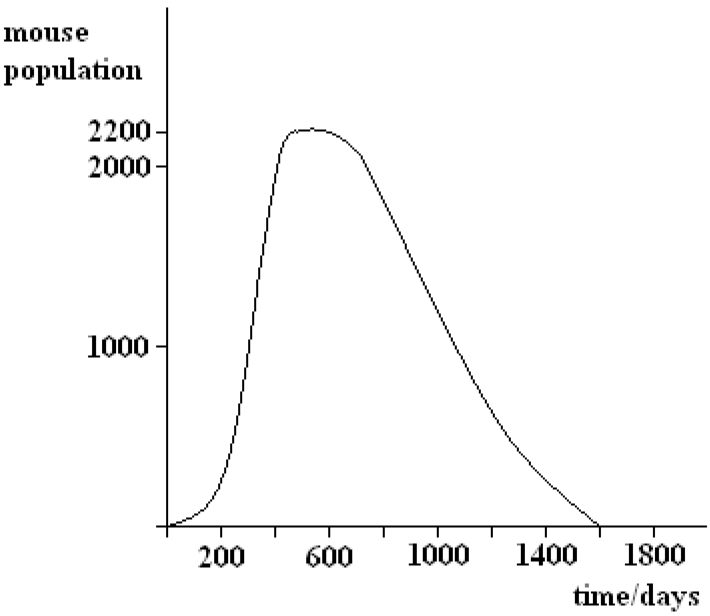
Density-independent factors

Density-independent factors are usually abiotic. The most important ones are:-

- Weather (conditions at a given time)
- Climate (long-term conditions)

Extreme or unseasonal heat or cold, drought, rain, floods and fire can all have a dramatic impact, irrelevant of population density. These changes, however, are not always negative.

Q10. The graph shows the growth curve for a population of mice reared in an enclosed environment.



a) Explain the shape of the curve between day 200 and day 600.

b) State two density-dependent factors which may have caused the population to crash.

c) State two environmental factors controlling wild population levels which do not operate in this case.

Survivorship Curves

Species differ in the rate at which their populations increase in numbers. As an extreme example, populations of bacteria increase in size rapidly, while populations of elephants increase in size much more slowly.

Population ecologists have identified **two** main strategies shown by organisms.

Small organisms, such as bacteria, **reproduce rapidly** and therefore use up the available resources of a habitat before other, competing species can exploit them. Because of their high rate of reproduction, such species have a **high value or *r***, the intrinsic rate of increase, and are said to be '**r-selected' or 'r-strategists'.**

r-strategists – species using r-strategies will tend to spread their reproductive investment among a large number of offspring so that they are well adapted to colonise new habitats rapidly and make opportunistic use of short-lived resources.

Other species **reproduce slowly** and have much **lower values of** ***r***. They spend much of their time in quite **stable habitats** and at **population levels near to the carrying capacity (K)**. Accordingly, they are said to be **'K-selected' or 'K-strategists'**.
K-selected species **show adaptations** that enable them to survive even when their population sizes are close to the maximum.

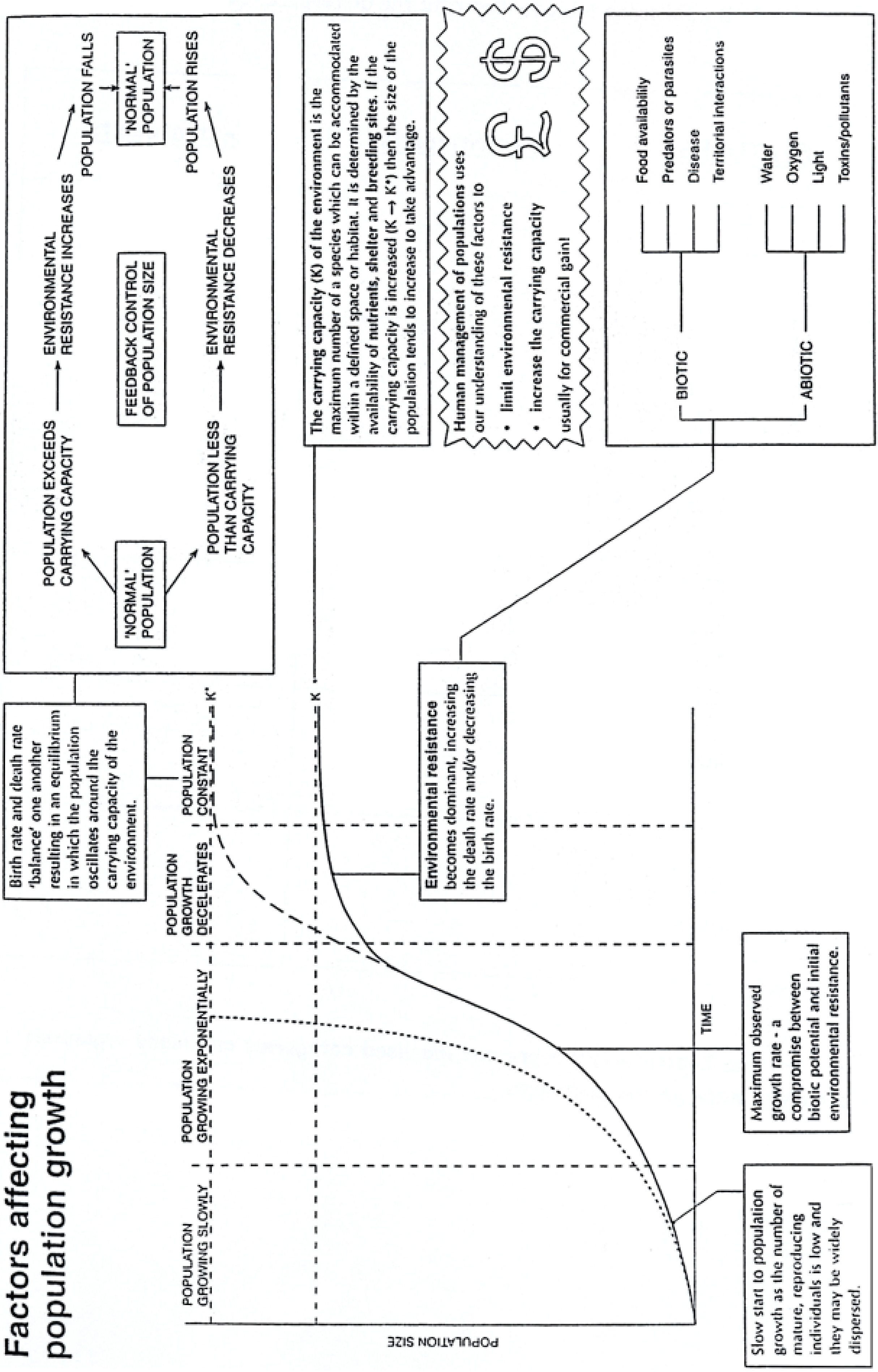
K-strategists – species using K-strategies will usually concentrate their reproductive investment in a small number of offspring thus increasing their survival rate and adapting them for living in long-term climax communities.

e.g.
An area of soil becomes cleared of vegetation, perhaps as a result of a fire. Within a short time plants start to grow as a result of seeds that arrive and germinate. Such seeds tend to have good means of dispersal and are often produced by annual weeds. These plants are r-strategists and are efficient at exploiting new habitats. However, eventually they lose out to more K-selected plants. These species take longer to colonise the area but are better adapted to it, competing more effectively for light and nutrients.

Q11. Complete the following table to illustrate the differences between r- and k-strategists.

FEATURES	r-strategists	K-strategists
Size		
Life span		
Colonising ability		
Number of offspring		
Care of the young		
Competitive ability		
Adaptability		
Reproductive episodes		
Reproductive cycle		
Dispersal		
Population density		
Examples of organisms		

N.B. r- and K-strategists between represent idealised categories and many organisms occupy a place on the continuum.


Factors affecting population growth
POPULATION GROWING SLOWLY
POPULATION GROWING EXPONENTIALLY
POPULATION GROWTH DECELERATES
POPULATION CONSTANT
POPULATION SIZE
TIME
K
K'
Birth rate and death rate 'balance' one another resulting in an equilibrium in which the population oscillates around the carrying capacity of the environment.
'NORMAL' POPULATION
POPULATION EXCEEDS CARRYING CAPACITY
ENVIRONMENTAL RESISTANCE INCREASES
POPULATION FALLS
FEEDBACK CONTROL OF POPULATION SIZE
POPULATION LESS THAN CARRYING CAPACITY
ENVIRONMENTAL RESISTANCE DECREASES
POPULATION RISES
The carrying capacity (K) of the environment is the maximum number of a species which can be accommodated within a defined space or habitat. It is determined by the availability of nutrients, shelter and breeding sites. If the carrying capacity is increased (K → K') then the size of the population tends to increase to take advantage.
Human management of populations uses our understanding of these factors to
• limit environmental resistance
• increase the carrying capacity
usually for commercial gain!
£ $
BIOTIC
Food availability
Predators or parasites
Disease
Territorial interactions
ABIOTIC
Water
Oxygen
Light
Toxins/pollutants
Environmental resistance becomes dominant, increasing the death rate and/or decreasing the birth rate.
Maximum observed growth rate - a compromise between biotic potential and initial environmental resistance.
Slow start to population growth as the number of mature, reproducing individuals is low and they may be widely dispersed.

SUCCESSION

SUCCESSION – the orderly process of change over time in a community.

OR

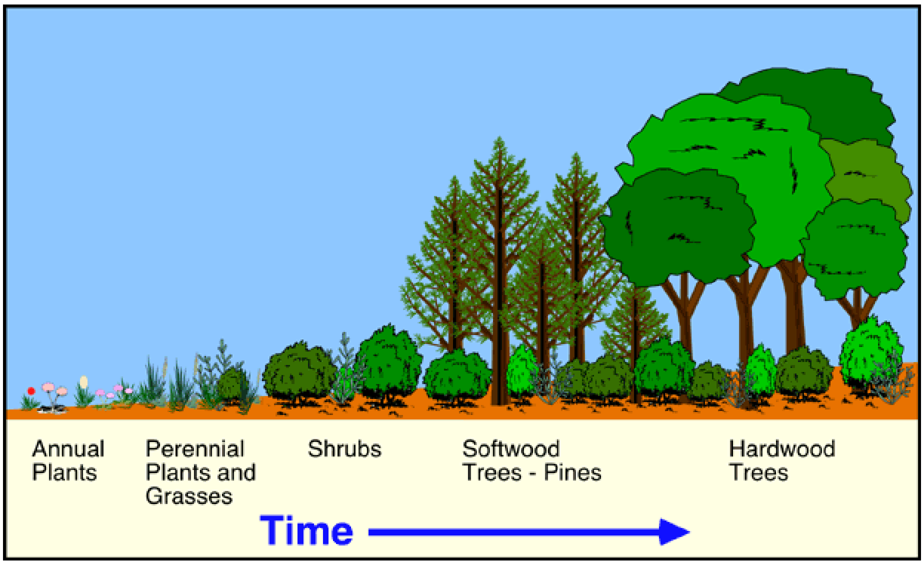
SUCCESSION – a predictable sequence of changes, caused by the living things themselves, where an ecosystem develops from a simple coloniser community to a complex climax community.

Changes in the community of organisms frequently causes changes in the physical environment that allow another community to become established and replace the former through competition. Often, but not inevitably, the later communities in such a sequence or sere are more complex than those that appear earlier.

It is clear that the physical characteristics (e.g. light availability, temperature etc.) or chemical characteristics (e.g. soil pH, salinity etc), of a habitat influence the species of plant or animal that live there. For example, a canopy of beech trees may drastically reduce the amount of light reaching the soil surface, and this may, in turn, affect the water content and temperature of the soil. Also, by absorbing particular nutrients from the soil or by adding leaf litter, the trees could change the soil pH.

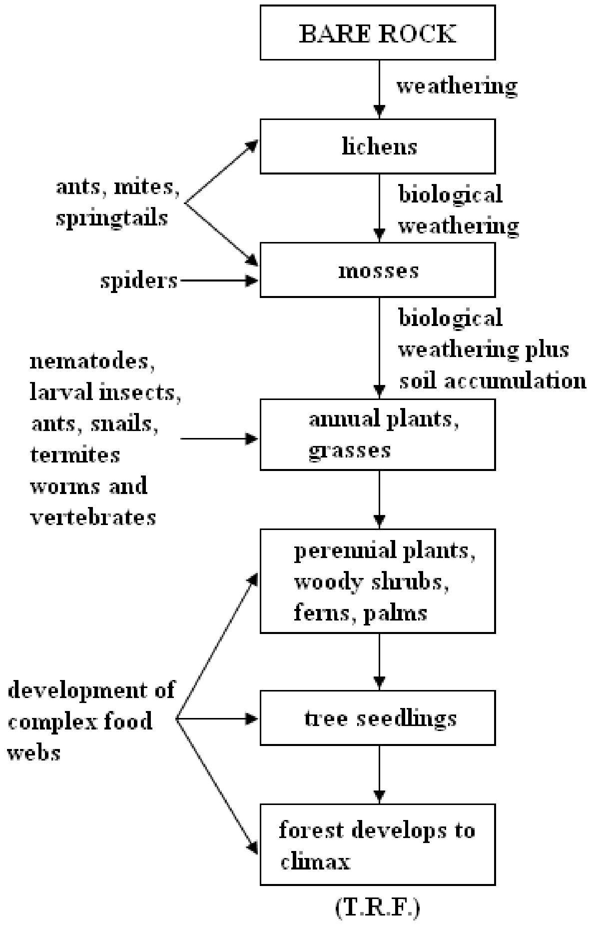
Such changes may allow species that were previously excluded from that habitat to invade. These new species may then change the habitat, making conditions less favourable for the species already there, the populations of which might then decline.

In this way, there may be a gradual progression from one community to another, and this progression is called **NATURAL SUCCESSION**.



PRIMARY SUCCESSION – this involves the introduction of species into an area that has never previously been colonized e.g. bare rock, a manufactured pond etc. The first species to enter an area are called PRIMARY COLONISERS and form a PIONEER COMMUNITY.

<u>Primary succession of a bare rock surface</u>



Q1. Distinguish between physical and biological weathering of the rock surface.

Q2. How does soil form?

Q3. During this ecological succession, explain how:-

- The minerals accumulate

- Erosion is reduced

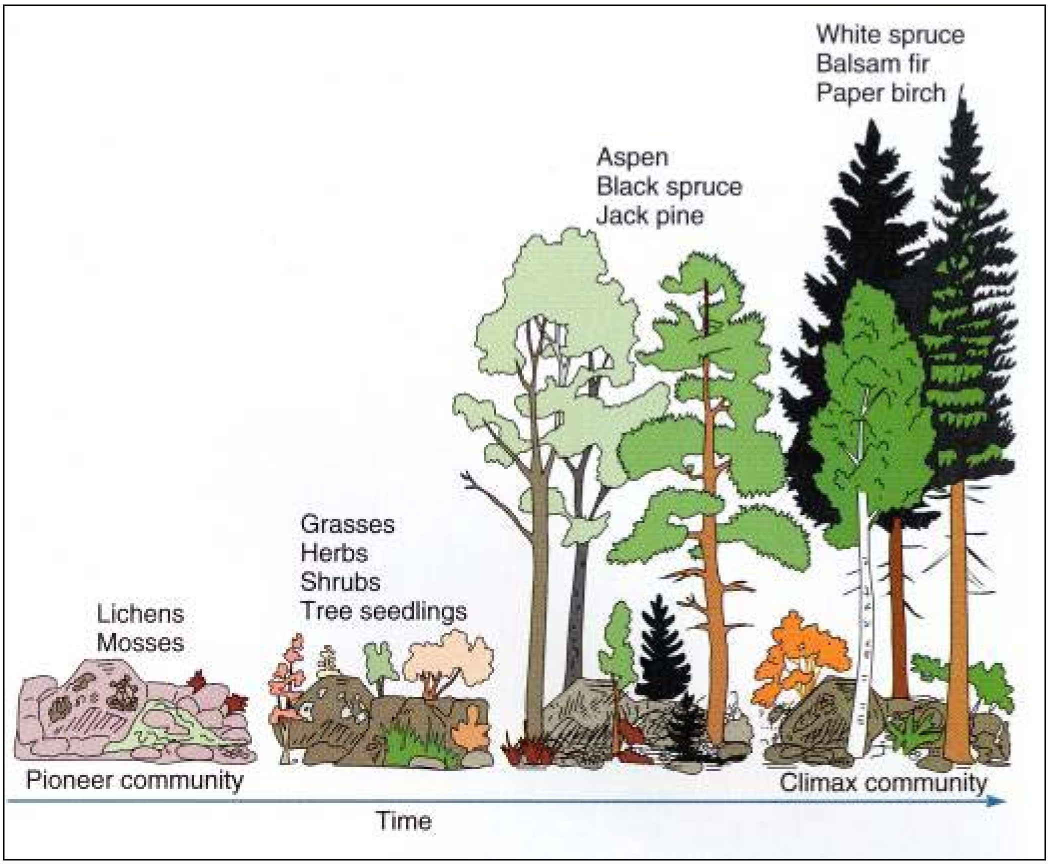
- Drainage may be affected

- Rainfall may increase

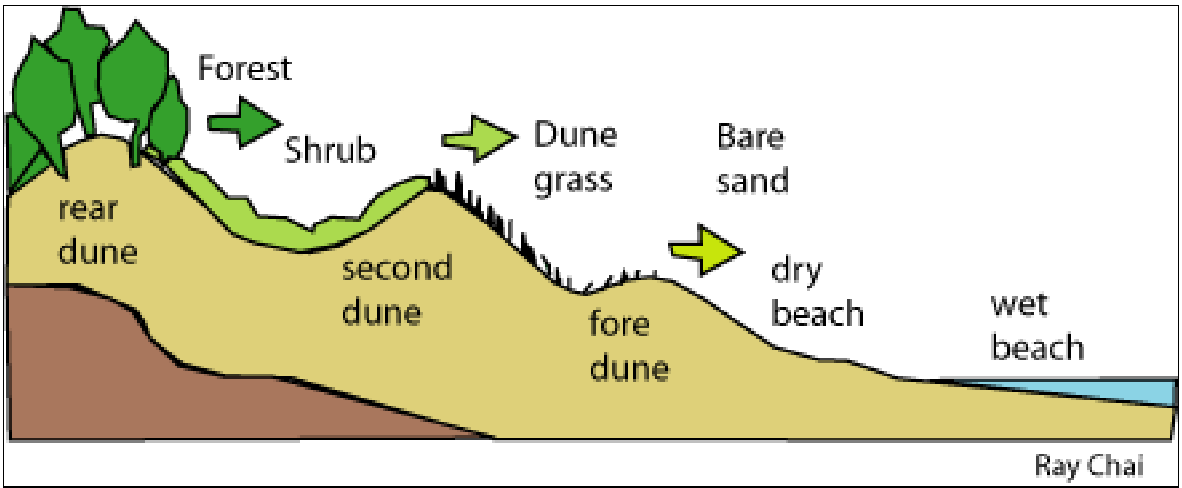
Q4. The earlier species (colonisers) changes the conditions. Suggest some examples of how this occurs.

As succession continues, the number of different species in the ecosystem increases, and the food webs become more complex. Eventually a stable ecosystem develops which is in equilibrium with its environment and which normally undergoes little further change. This is called the **CLIMAX COMMUNITY**. In equatorial regions the climax community is tropical rainforest.

Examples



The example above is referred to as a **XEROSERE** i.e. from bare rock



The example above is referred to as a **PSAMMOSERE** i.e. from bare dune

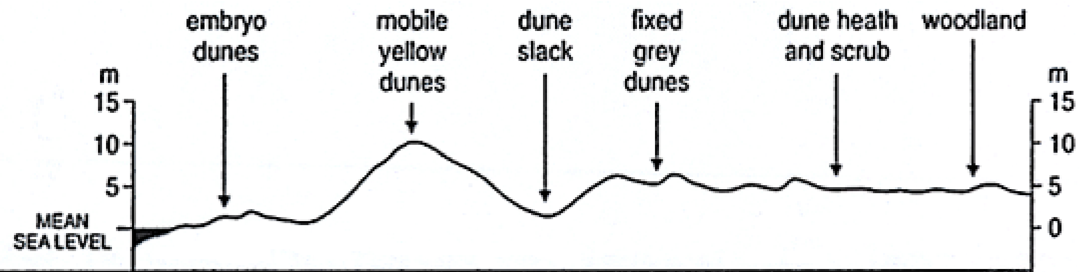
SERE – the set of communities that succeed one another over the course of succession at a given location.

Summary of the changes that occur during succession:-

SERE	SPECIES DIVERSITY	NO. OF INTERACTIONS BETWEEN ORGANISMS	RESISTANCE OF COMMUNITY TO ENVIRONMENTAL CHANGE
Pioneer community	Few species	Few	Susceptible
↓	↓	↓	↓
Sub-climax community			Resistant
↓			↓
Climax community	Many species	Many	Resistant

CLIMAX COMMUNITY – a community of organisms that is more or less stable, and that is in equilibrium with natural environmental conditions such as climate; the end point of ecological succession.

Q5. The diagram below shows a transect across an area of coastal san dunes.



SITE	1	2	3	4	5
pH	7.6	7.5	7.0	6.7	6.5
PERCENTAGE ORGANIC MATTER	0.8	1.74	3.59	9.31	12.61
PERCENTAGE VEGETATION COVER	3	30	90	100	100
No. of SPECIES PER UNIT AREA	18	73	143	161	105

a) Explain the conditions which:-

- Inhibit the number of plant species at site 1.

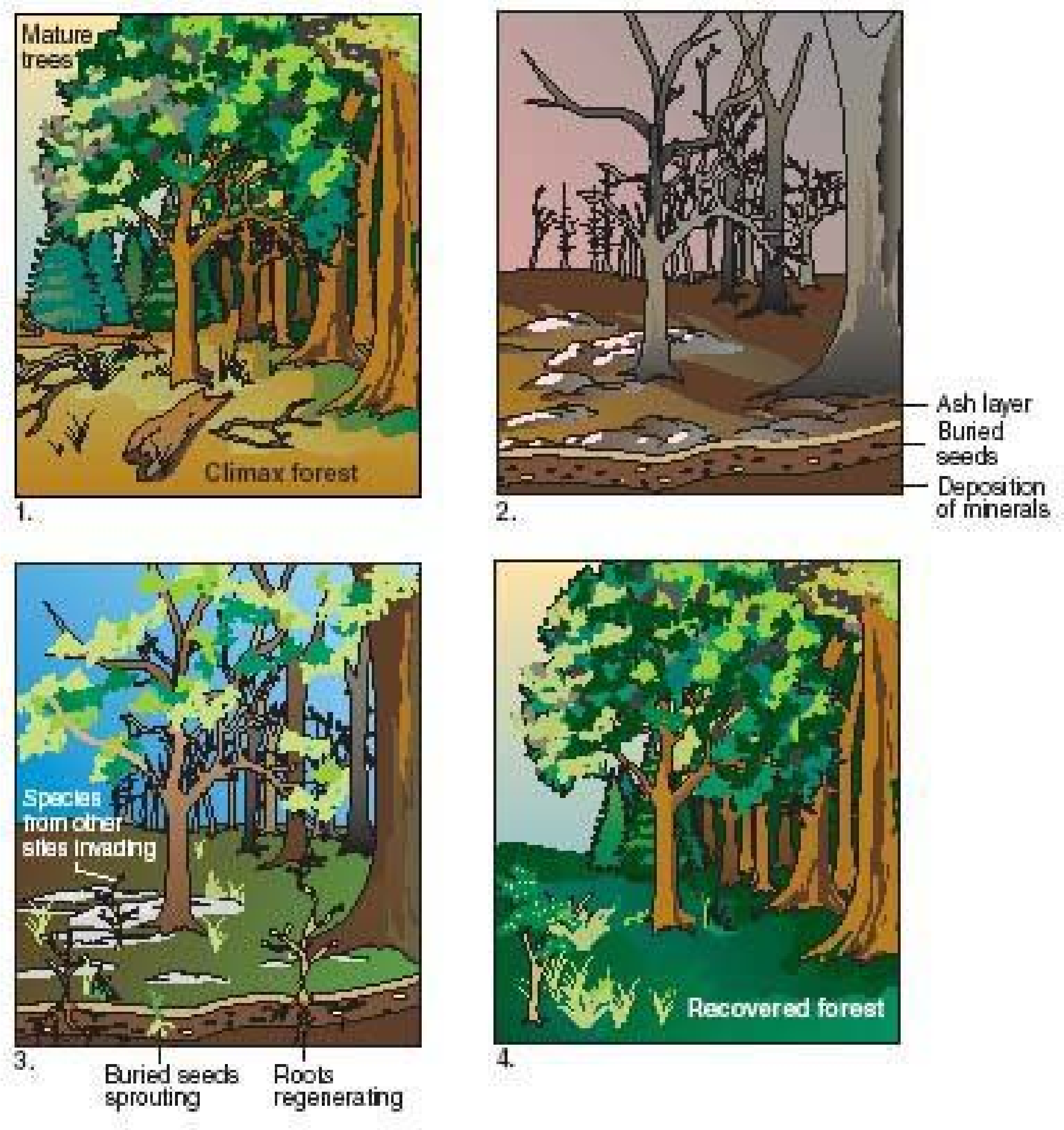
- Encourage a variety of plant species at site 4.

b) How could you account for the decline in the number of plant species from site 4 to site 5?

c) Suggest the effects that recreational activity might have on the succession shown.

SECONDARY SUCCESSION – this involves the re-establishment of species into an area that once contained populations of plants and animals, but which have been disturbed.

For example:-



Such disturbances may be natural e.g. a hurricane, flooding or fire, or they may be a result of human activities e.g. forest clearance for house or road building. The common factor is that the existing vegetation and most of the animal species living in and on it are removed or destroyed. However, the soils of these areas are often fertile and contain many seeds, spores and eggs, which then allow very rapid re-colonisation.

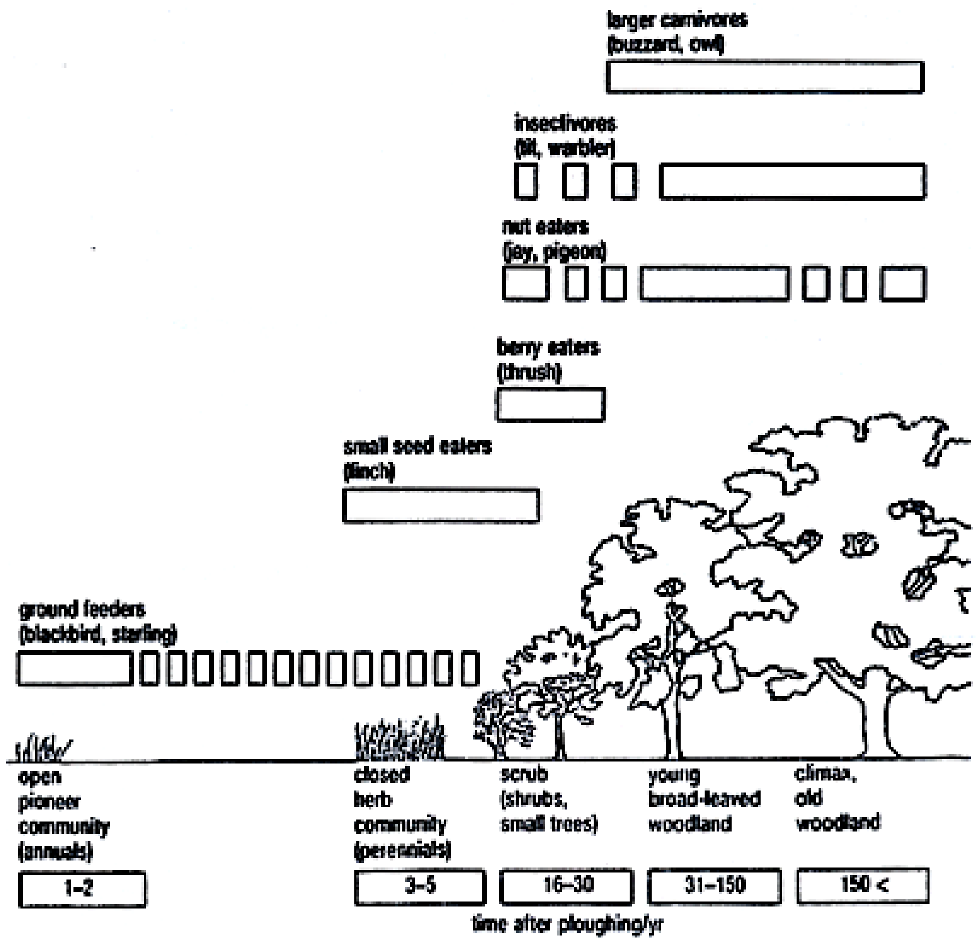


Fig 2.22 Secondary succession in an abandoned ploughed field. The climax community is woodland. The animal community changes with the plant community as illustrated by the birds in the diagram

A climax community produced by the action of humans is called a **PLAGIOCLIMAX**. This may occur for the following reasons:-

- The introduction on non-native species
- The effects of acid rain
- The effects of global warming
- Deforestation
- The planting of crops
- The grazing of cattle
- Agricultural operations
- Forestry
- Deliberate maintenance of grasslands, heathlands and coppice woodlands
- Land clearance
- Fire

Effect of grazing on succession

Summary

In the early stages of succession, **gross productivity is low** due to the initial conditions and **low density of producers**. The proportion of **energy lost through community respiration is relatively low** too, so **net productivity is high**, i.e. the system is **growing** and **biomass is accumulating**. In later stages, with an increased consumer community, **gross productivity may be high in a climax community**.

However, this is balanced by respiration, so **net productivity approaches zero** and the production : respiration (P : R) ratio approaches **1**.

Q6. Suggest, with reasons, whether each of the following will (i) increase, (ii) decrease or (iii) stay the same as succession proceeds:-

- Nutrient content of the soil or water

- Productivity

- Number of species (species diversity)

- Biomass

- Rate at which populations replace each other

Read the following extract:-

Krakatoa – an example of primary succession (a Lithosere).

Extract taken from "The Living Planet" by David Attenborough

It was one of the Indonesian volcanoes that produced the most catastrophic explosion yet recorded. In 1883, a small island named Krakatau, 7 kilometres long by 5 kilometres wide, lying in the straits between Sumatra and Java, began to emit clouds of smoke. The eruptions continued with increasing severity day after day. Ships sailing nearby had to make their way through immense rafts of pumice that floated on the surface of the sea. Ash rained down on their decks and electric flames played along their rigging. Day after day, enormous quantities of ash, pumice and lava blocks were thrown out from the crater, accompanied by deafening explosions. But the subterranean chamber from which all this material was coming was slowly emptying. At 10 a.m. on 28 August, the rock roof of the chamber, insufficiently supported by lava beneath, could bear the weight of the ocean and its floor no longer. It collapsed. Millions of tons of water fell on to the molten lava in the chamber and two-thirds of the island tumbled on top of it. The result was an explosion of such magnitude that it produced the loudest noise ever to echo around the world in recorded history. It was heard quite distinctly over 3000 kilometres away in Australia. Five thousand kilometres away, on the small island of Rodriguez, the commander of the British garrison thought it was the sound of distant gunfire and put out to sea. A tempest of wind swept away from the site and circled the earth seven times before it finally died away. Most catastrophic of all, the explosion produced an immense wave in the sea. As it travelled towards the coast of Java, it became a wall of water as high as a four-storey house. It picked up a naval gunboat, carried it bodily nearly 2 kilometres inland and dumped it on top of a hill. It overwhelmed village after village along the thickly populated coast. Over 36,000 people died.

Krakatau shows how complete a recovery can be. Fifty years after the catastrophe, a small vent spouting fire arose from the sea. The people called it Anak – the child – of Krakatau. Already it has thickets of casuarina and wild sugar cane growing on its flanks. A remnant of the old island, now called Rakata, lies a mile or so away across the sea. The slopes that a century ago were bare are now covered by a dense tropical forest. Some of the seeds from which it sprang must have floated here across the sea. Others were carried by the wind or brought on the feet or in the stomach of birds. In this forest live many winged creatures – birds, butterflies and other insects – that clearly had little difficulty in reaching the island from the mainland a mere 40 kilometres away. Pythons, monitor lizards and rats have also arrived here, perhaps on floating rafts of vegetation that frequently get swept down tropical rivers. But evidence of the newness of the forest, and the cataclysm that preceded it, is easy to find. The tree roots cover the surface of the ground with a lattice that clasps the earth together, but here and there, a stream has undermined them, and a tree has toppled to reveal the still loose and powdery volcanic dust beneath. Once the plant cover has been broken in this way, the loose ash is easily eroded by the stream and a narrow gorge, 6 or 7 metres deep, appears beneath a roof of interlaced roots. But these breaks are the exception. The tropical forest has, within a century, reclaimed Krakatau. Without much doubt, the coniferous forest, in another century, will have reclaimed Mount St. Helen's.

RESEARCH – Complete the research task on page 274 of your Environmental Systems & Societies textbook about Mount St. Helens.

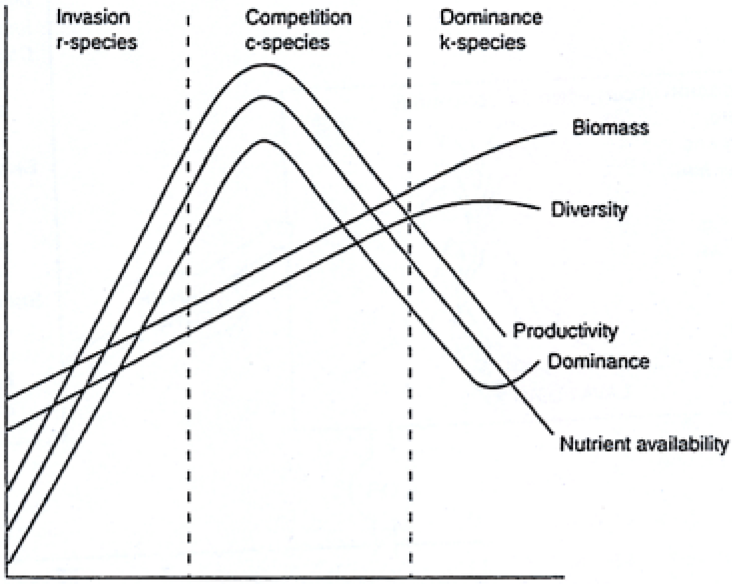
Succession

Succession, or prisere, is the sequential change in species in a plant community as it moves towards a seral climax. Each sere is an association or group of species, which alters the micro-environment and allows another group of species to dominate. The **climax community** is the group of species that are at a **dynamic equilibrium** with the prevailing environmental conditions - in the UK, under natural conditions, this would be oak woodland. On a global scale, climate is the most important factor in determining large scale vegetation groupings or **biomes**, e.g. rainforest, temperate grassland, and so on. However, in some areas, vegetation distribution may be influenced more by soils than climate. This is known as **edaphic** control. In savanna areas forests dominate clay soils, grassland sandy soils. Soils may also affect plant groupings on a local scale, within a climatic region, e.g. on the Isle of Purbeck grassland is found on limestone and chalk rendzina soils, forest on the brown earths, and heathland on the podzols associated with sands and gravels.

SUCCESSION AND SPECIES SELECTION

r-species are the initial colonisers - large numbers of a few species. Highly adaptable, rapid development, early reproduction, small in size, short life, highly productive.

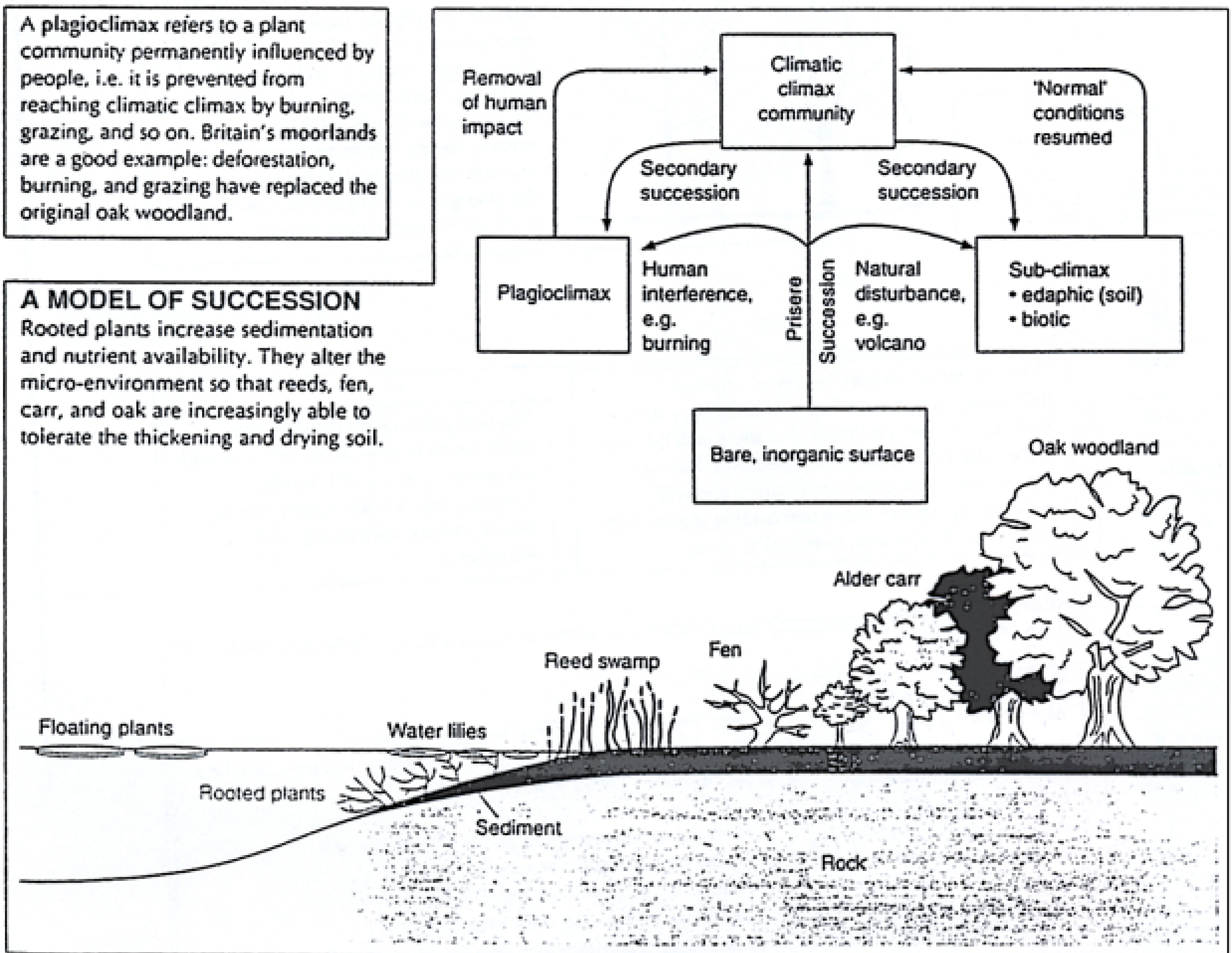
k-species are diverse, and are specialists - a few of many species. Slower development, delayed reproduction, larger size, longer living, less productive.



A **plagioclimax** refers to a plant community permanently influenced by people, i.e. it is prevented from reaching climatic climax by burning, grazing, and so on. Britain's **moorlands** are a good example: deforestation, burning, and grazing have replaced the original oak woodland.

A MODEL OF SUCCESSION

Rooted plants increase sedimentation and nutrient availability. They alter the micro-environment so that reeds, fen, carr, and oak are increasingly able to tolerate the thickening and drying soil.



Ecological succession proceeds via *several stages* to a *climax community* and is characterized by:
1. an increase in *species diversity* and in *complexity of feeding relationships;*
2. a progressive increase in *biomass;*
3. completion when *energy input (community photosynthesis) = energy loss (community respiration).*

A COMMUNITY (all the species present in a given locality at any given time), is the group of interacting populations (all the members of a species in a place at a given time) which represents the biotic component of an ecosystem, and is seldom static. The relative abundance of different species may change, new species may enter the community and others may leave. There are reasons for these changes.

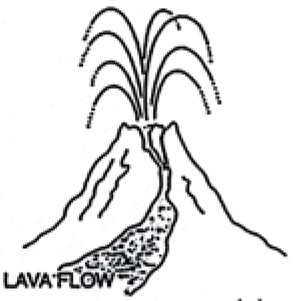
Catastrophes: may be natural (e.g. flooding, volcanic eruption) or caused by people (e.g. oil spill, deforestation).

Seasons: changes in temperature, rainfall, light intensity and windspeed, for example, may alter the suitability of a habitat for particular species.

Succession: long-term directional change in the composition of a community *brought about by the actions of the organisms themselves.*

CAN BE EITHER

Primary succession occurs when the community develops on bare, uncolonized ground *which has never had any vegetation growing on it*, e.g. mud in river deltas, lava flows, sand dunes, artificial ponds and newly erupted volcanic islands.



OR

Secondary succession occurs on ground *which had previously been colonized* but is now available because the community has been destroyed, typically by fire, flood or as a result of human agricultural or industrial activities. Such ground will not be 'virgin' but will include remnants of soil, organic debris, seeds and even resistant animals and plants which have survived the changes, e.g. fire debris may be rich in minerals, particuarly phosphate.

... BUT ALWAYS PROCEEDS VIA A SERIES OF STAGES

BARE GROUND ⟹ PIONEER COMMUNITY (COLONIZERS) ⟹ SECONDARY COMMUNITY ⟹ CLIMAX COMMUNITY

Migration: the arrival of seeds and spores. If conditions are suitable immigrant species may become established.

The number of species has risen – further stabilizing soil and adding nutrients. May still be an input of new species so that there will be both *intra-* and *inter-specific competition.* Pioneer species are often poor competitors and will be replaced by higher, more demanding plants such as grasses, shrubs and, eventually, trees.

The end point of succession: the community is now in equilibrium with the environment and is stable. Composition is often determined by one dominant species e.g. *oak woodland.*

During succession each species modifies the environment, making it *more* suitable for new species and *less* suitable for those already there.

These species are simple plants, e.g. lichens and algae with minimal environmental demands. May show symbiotic relationships to aid their establishment. The community is *open,* i.e. space for further colonizers.

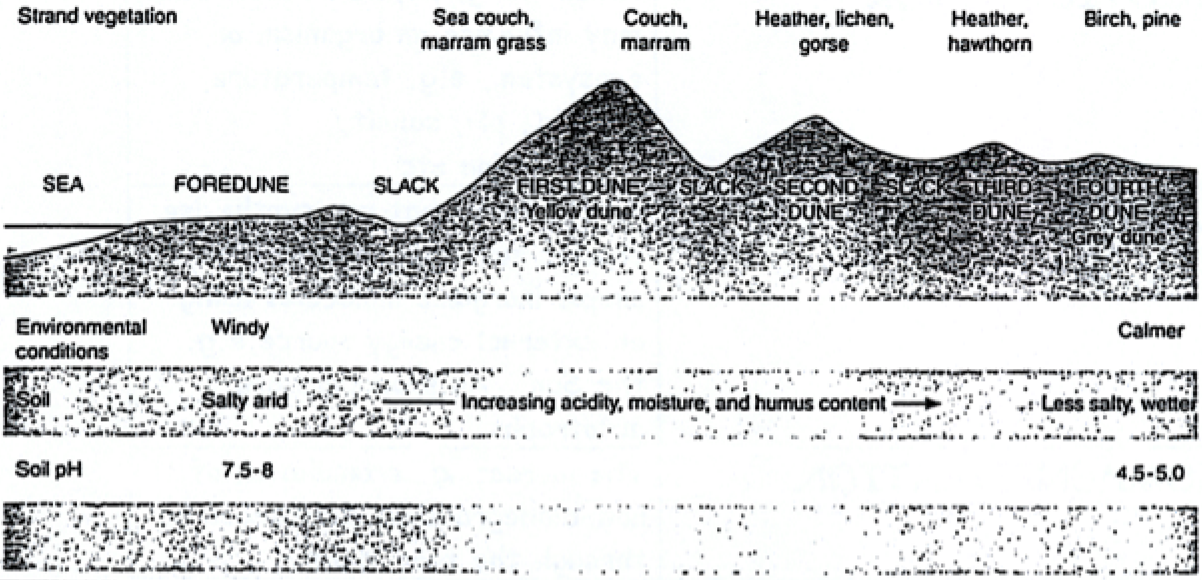
Each of these stages is called a *seral stage* and the complete succession is called a *sere.*

Hydrosere: succession in an aquatic environment.
Xerosere: succession on dry land.
Hàlosere: succession in a salty environment.
Lithosere: succession on a rocky surface.

Coastal ecosystems

An ecosystem is a set of inter-related plants and animals with their non-living environment. Coastal ecosystems include sand dunes, psammoseres, and salt marshes, haloseres. These change spatially and temporally. The changes in micro-environment which allow other species to invade, compete, succeed, and dominate is termed succession.

SAND DUNE SUCCESSION - STUDLAND BEACH, ISLE OF PURBECK



SALT MARSHES

Examples include Scolt Head Island in East Anglia and Newtown on the Isle of Wight.

Salt marshes are very productive and fertile ecosystems because of their high oxygen content, nutrient availability, and light availability, and because of the cleaning action of the tides.

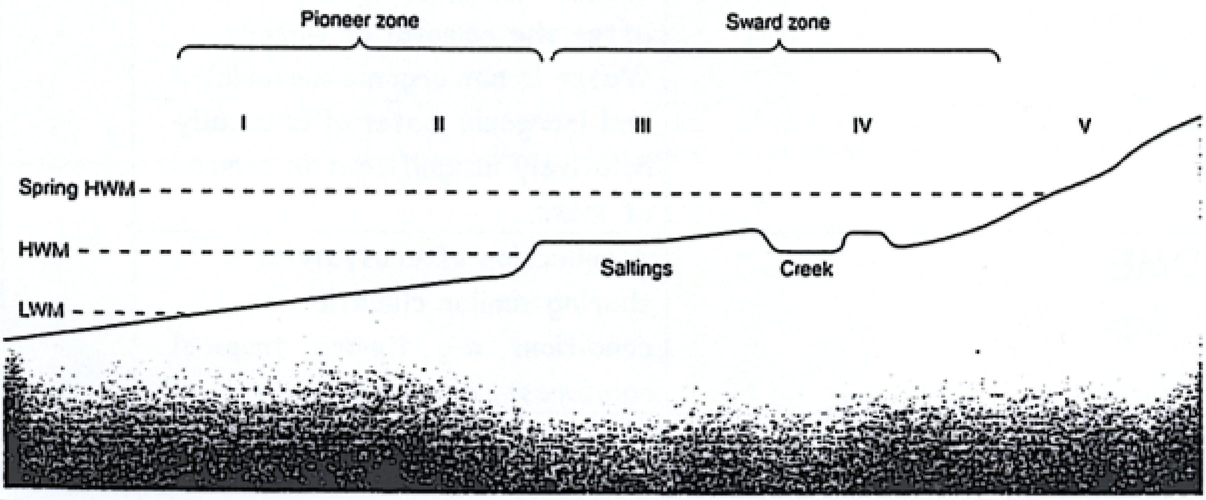
I Colonisers on bare mud flats: algae (enteromorpha), eel grass, and marsh samphire (salicornia) increase the amount of deposition of silt. These plants can tolerate alkaline conditions and regular inundation by sea-water.

II Halophytic vegetation such as rice grass and spartina (cord grass) build up the salt marsh by as much as 5 cm per annum. Their roots anchor into the soit mud; the vegetation is taller and longer living than salicornia but not as salt tolerant.

III Sea lavendar grasses: inundated only at spring tides. Less salt tolerant.

IV A raised salt marsh with creeks may be formed, including turf grasses such as fescue and rushes (juncus). Inundation is rare.

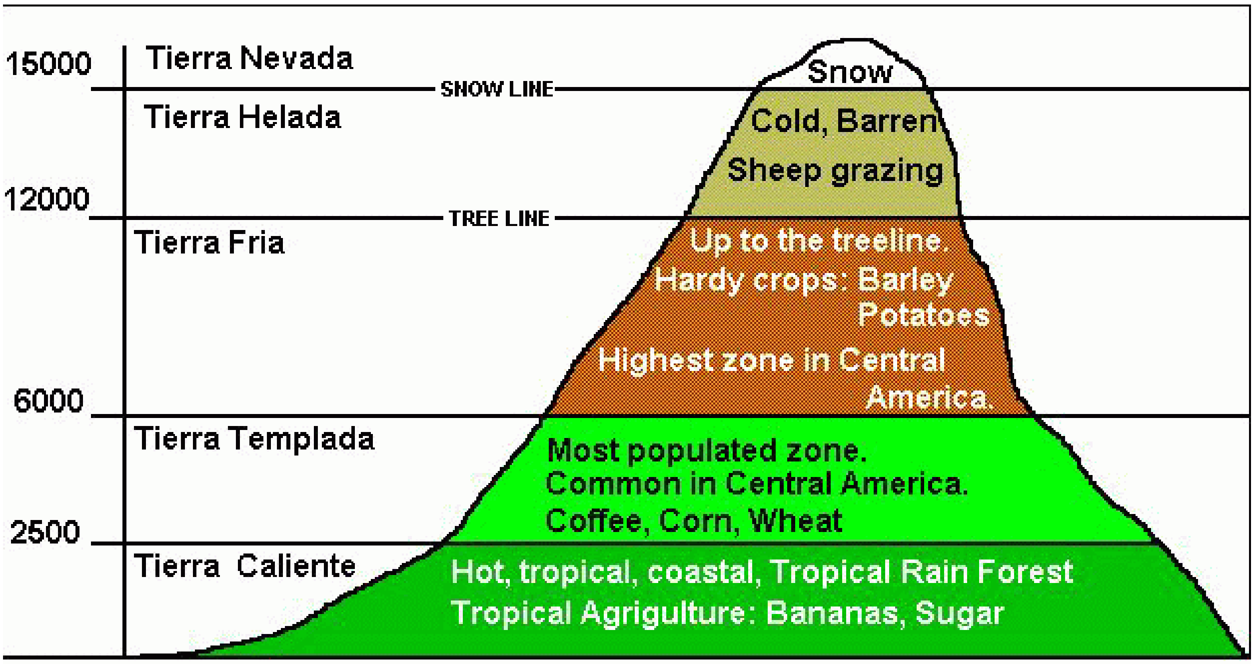
V Inundation absent: ash and alder.



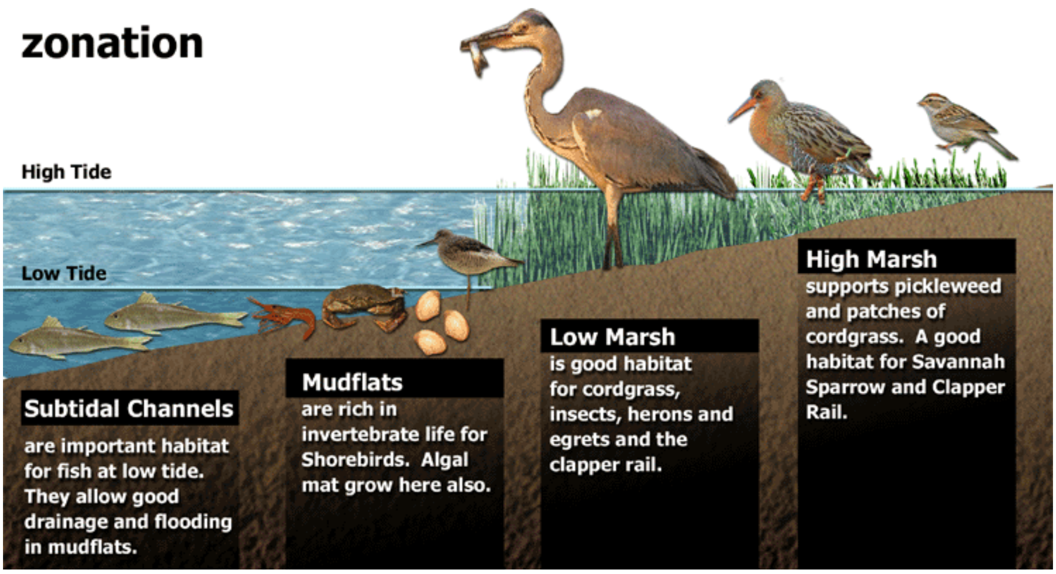
N.B. The concept of succession i.e. change over time, must not be confused with ZONATION.

ZONATION - a change through space e.g. the global biomes display zonation in relation to latitude and climate; rocky shores display zonation where plants and animals are separated into zones according to their ability to withstand changes in salinity and exposure to the air etc.

For example:-



OR



MEASURING CHANGES IN THE SYSTEM

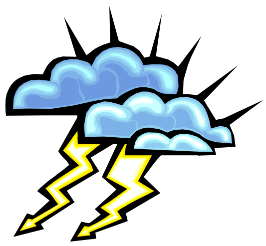
An environmental gradient is a trend in one or more abiotic and/or biotic components of an ecosystem. These can be spatial and static i.e. **ZONATION** or dynamic and taking place over long periods of time i.e. **SUCCESSION**.

Place the following examples into their correct place in the table (some examples can fit into both categories although this is unusual):-

1. **ROCKY SHORES** i.e. populations of organisms changing from salt-resistant species to more common inland species with increasing distance from the sea.
2. **TROPICAL RAINFORESTS** i.e. the formation of a tropical rainforest over thousands of years after a volcanic event.
3. **ABANDONED FARMLAND** turning slowly into lowland scrub due to lack of management.
4. The transition of a **SHALLOW POND** into oak woodland.
5. The transition from **DECIDUOUS WOODLAND to ALPINE FOREST / HIGHLAND SCRUB** when hiking up a large mountain.
6. **SAND DUNE COLONISATION** i.e. the change in the populations of plant species found with increasing distance from the sea as the dunes stabilise over time to create distinct vegetational zones at various points along the dune transect.

SUCCESSION	ZONATION

MONITORING ABIOTIC (PHYSICAL) FACTORS



Ecosystems can be roughly divided into:-
- **Marine**
- **Freshwater**
  and
- **Terrestrial systems**.

Each of these is influenced by many abiotic factors which can be measured using a variety of equipment and can be monitored on a regular basis to observe changes over time and space. The equipment that can be used to measure these factors and techniques to eliminate inconsistency in measuring have already been highlighted in '**THE ECOSYSTEM – Measuring Components of the Ecosystem**' booklet on pg 10-13.

If you were studying the following ecosystems, which key abiotic factors would you focus on measuring and what equipment would you require?

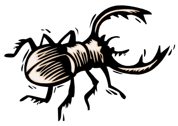
N.B. the three most significant / influential abiotic factors should be chosen and how these may vary with depth, time or distance should also be stated.

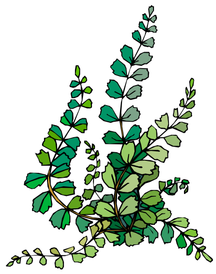
ECOSYSTEM	Significant Abiotic Factors	Equipment required	Possible variation in time, depth or space (choose one)?
TROPICAL RAINFOREST	1		
	2		
	3		
ESTUARINE MUDFLAT (i.e. near the mouth of a river)	1		
	2		
	3		
A POND	1		
	2		
	3		
DEEP OCEAN	1		
	2		
	3		
ROCKY SHORE	1		
	2		
	3		
A STREAM	1		
	2		
	3		
MOUNTAIN SUMMIT	1		
	2		
	3		
CONIFEROUS FOREST FLOOR	1		
	2		
	3		

MONITORING BIOTIC (LIVING) FACTORS

Once the abiotic conditions within an environmental gradient have been measured, we can begin to ask questions about the distribution of organisms within the study area. This can be done in many ways depending on what needs to be measured i.e.

- **Which species are present**
- **The size of a particular population of organisms**
- **The productivity in a particular area**
- **The diversity of a particular area**





Complete the following table to remind you of some of the measuring techniques discussed in **'THE ECOSYSTEM – Measuring Components of the Ecosystem'** booklet. <u>(Remember you have evaluated these techniques already and should be aware of their strengths and limitations)</u>

BIOTIC COMPONENT	**Equipment required**	**Formula required**	**Possible abiotic factors which may have had an influence**
SPECIES PRESENCE / ABSENCE		**NONE**	
POPULATION SIZE (SESSILE ORGANISMS)		**Running average of no. found in one quadrat x total area**	
POPULATION SIZE (MOTILE ORGANISMS) i.e.	VARIABLE i.e. ↓	**LINCOLN INDEX =**	
Soil organisms	Tullgren funnel		
Small insects			
Small crawling organisms			
Small mammals	Longworth mammal trap		
Flying / swimming organisms			
PRODUCTIVITY /BIOMASS / ORGANIC MATTER		Humus Content % $= \frac{\text{Initial mass(g)} - \text{final mass(g)}}{\text{Initial mass(g)}} \times 100$	
SPECIES DIVERSITY	Quadrat		

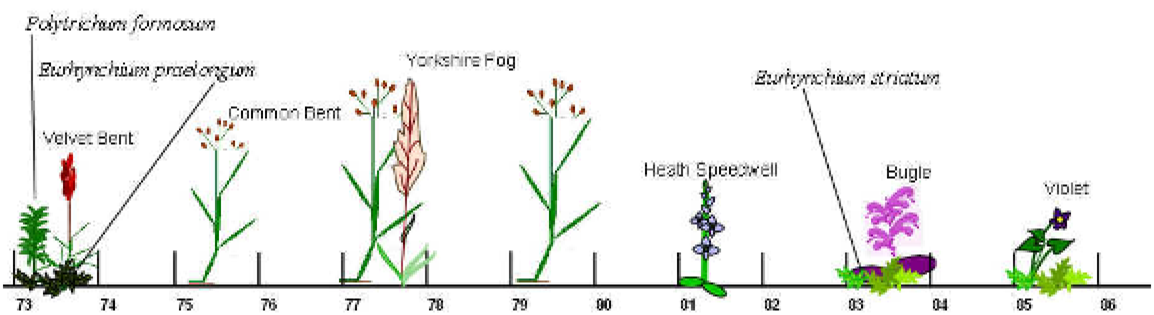
TRANSECTS

To measure any of these abiotic and/or biotic components of an ecosystem along an environmental gradient should be done using a **TRANSECT**. It is usually easier to study changes in immobile species such as plants, corals, barnacles etc.

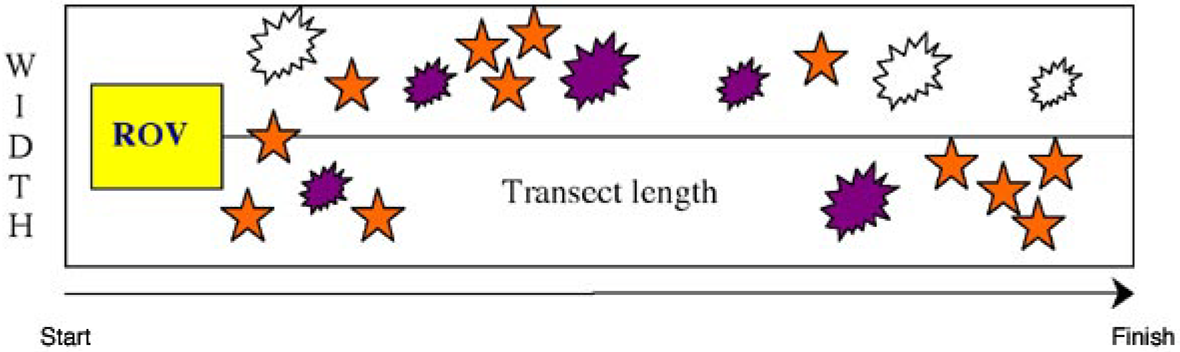
A TRANSECT -	**A line, strip or profile of vegetation which has been selected for study.**

In order to complete a transect, a piece of string or measuring tape is laid out along the selected gradient. There are a variety of possible methods for collecting data including:-

- **A Line Transect** – record and count all species touching the string / tape



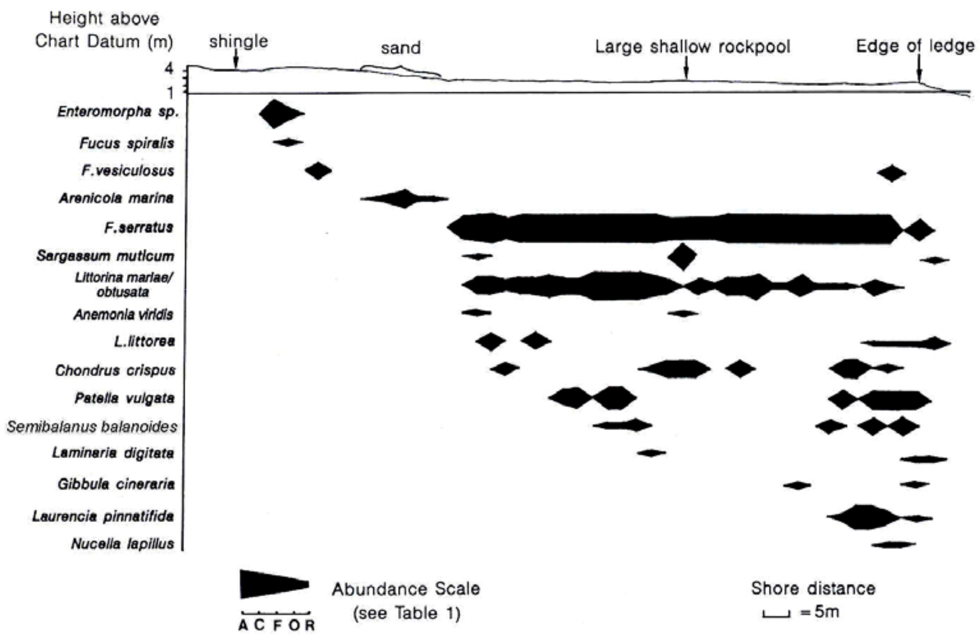
- **A Belt Transect** – record and count all species within a fixed width (usually between 0.5 and 1 metre)



These can either be sampled **continuously** or as an **interrupted** transect where samples are taken at regular, fixed distances along the line.

To measure changes in space i.e. zonation, this technique should be completed within a short space of time to avoid any daily cycles altering the organisms behaviour. For studies of long term change i.e. succession, the transect should be repeated at the same time of day and at regular intervals over a suitable time period depending on what is being studied or assessed.

KITE DIAGRAMS are often used to illustrate changes in species over space or time along an environmental gradient. The width of each 'kite' represents the percentage cover or abundance of that species.



N.B. ACFOR scale = A- Abundant, C – Common, F- Frequent, O – Occasional, R - Rare

MEASURING CHANGES CAUSED BY HUMAN ACTIVITY

Measuring changes over time is also important when assessing the impact of human activity on an ecosystem e.g. toxins from mining activities, landfills, eutrophication, effluent, oil spills and overexploitation. Depending on the scale of the activity, repeated measurements can be made from the **ground** (see below) or from **satellite images** and **maps**.

For each measurement technique, state how it could be used to monitor a specific environmental problem to detect whether any detrimental changes have occurred within the ecosystem in response to human interference.

INSTRUMENT	PHYSICAL FACTOR MEASURED	HOW COULD THE INFORMATION BE USED TO MONITOR POLLUTION? (What kind?)
Light Meter	Light Intensity	Density of algal blooms created by eutrophication from **fertilisers**.
Dissolved Oxygen Meter	Dissolved oxygen	
pH Meter	pH	
Total Dissolved Solids (TDS) Meter	Total Dissolved Solids	
Current Meter	Flow rate	
Secchi Disc	Turbidity	
Wind Meter	Wind speed and direction	

Satellite images and maps are particularly useful when studying human impact over a large area e.g. decline in productivity in an area due to the overexploitation of resources.

NASA's Earth Observatory is currently assessing current trends in deforestation, a major global issue:-

http://earthobservatory.nasa.gov/Features/Deforestation/deforestation_update4.php

Q1. Do you think there were other satellite images of the same area recorded during this time period? Explain your answer.

Q2. How could these maps help to determine the rate of destruction of the natural vegetation in this area?

Q3. Suggest reasons why this change may have occurred (try to include economic and social reasons as well as environmental ones).

Q4. Explain the impact that this change may have on the community of organisms living in the area (consider productivity, complexity, stability, diversity etc. in your answer).

Q5. Why is it important to have records in the form of data, maps, satellite images or photographs of areas which have yet to be influenced by any human activity? How could this information prove useful if human interference did start to occur?

ENVIRONMENTAL IMPACT ASSESSMENTS (EIAs)

ENVIRONMENTAL IMPACT ASSESSMENT – A method of detailed survey required in many countries, before a major development. Ideally it should be independent of, but paid for by, the developer.

- An Environmental Impact Assessment should include a **BASELINE STUDY** to measure **environmental conditions before development commences**, and to **identify areas and species of conservation importance.**
- **An assessment of the possible impacts which may be caused by the development should also be carried out.**
- The report produced is known as an **ENVIRONMENTAL IMPACT STATEMENT (EIS)** or **ENVIRONMENTAL MANAGEMENT REVIEW** in some countries.
- **The monitoring of change should occur during and continue for some time after the development.**

An Environmental Impact Assessment is a management tool which attempts to put environmental factors on an equal footing with economic ones. An EIA is a means of estimating change to the environment that might occur as a result of a project, and weighing up the problems and benefits. It is usually carried out in the following way:

1. **An assessment of the existing environment is made.**
2. **The proposed development is described.**
3. **The probable environmental impacts of the development are estimated and assessed in relation to the impact upon the natural environment, its ecology, habitats, and the impact that any change or pollution might have. It is also assessed in relation to the impact upon the human environment, such as recreation, health, aesthetics, well-being of people, and local employment opportunity or reduction.**
4. **These environmental impacts are scored on a grid like the 'Leopold Matrix' shown on the following page).**
5. **Any modifications that could be undertaken to minimize adverse impacts are considered and their impact reassessed.**
6. **A decision is made.**

One technique which is sometimes used in EIAs is the **Leopold Matrix** – this is traditionally the most common method in which the **magnitude and importance** are given for each action of a proposal. The data are presented in a **matrix grid** with **environmental characteristics on the left and actions across the top.**

A section of the Leopold Matrix

	Environmental Effects / Development	Treatment - Comminution - Sedimentation - Millscreening - Oxidation ponds - Activated sludge - Trickling filter - Nutrient removal - Chlorination - Further treatment offsite	Disposal - Land - Rapid infiltration - Surface flooding - Spray irrigation Disposal - Inland Water - River - Lake Disposal - Marine Water - Estuary - Inshore marine - Offshore marine Deep well injection
BIOLOGICAL ENVIRONMENT	Forest Shrubland Grassland Herbfield (alpine) Sand/shingle/rock Cropland Urban land Lakes Rivers Estuaries Inter-tidal Marine Wetlands		
PHYSICAL ENVIRONMENT	River regime Erosion/land stability Sedimentation Surface water Ground water Agricultural soil Foundation materials Climate/atmosphere Nuisance (noise, dust, smell) Landform		
SOCIAL ENVIRONMENT	Public participation Employment Settlement Land value Existing land uses Risks and anxieties Personal and social values Historical/cultural Landscape/visual Recreation		

Example of a completed section of an EIA matrix

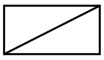
Table 6 Leopold Matrix Explaining the Impact of Mining on Environmental Parameters Presented in Terms of Weightings

Project Actions / Environmental Characteristics	Blasting Drilling	Surface Excavations	Mineral Processing	River Transport	Surface Transport	Ocean Transport	River Dumping/ Loading	Pumping of Mine Pit Water	Ocean Dumping	Solid Waste Disposal	Total
Soils	2 / 3.5	8.5 / 9	2 / 2.5		3 / 2			1.5 / 2		7.5 / 8	24.5 / 23
Land Forms	3 / 4	8 / 10			1 / 1.5					7.5 / 10	19.5 / 25.5
Surface Water			6.5 / 6	4.5 / 6			3.5 / 4	3 / 4		4.5 / 4	18 / 24
Ground Water		7.5 / 7						4.5 / 6		1.5 / 2	13.5 / 15
Ocean Water						1.5 / 3			1 / 1		2.5 / 4
Air	3 / 4	3 / 4	1.5 / 2		4.5 / 6						12 / 16
Erosion	1.5 / 2	5.5 / 7	1 / 2					1 / 1.5			9 / 12.5
Deposition/ Sedimentation			3 / 3	3.5 / 4			3 / 4	2 / 2		4.5 / 5.5	16 / 18.5
Flora	2 / 3	7 / 8.5	1.5 / 3	2 / 3	2.5 / 3	1.5 / 1.5	1.5 / 2		2 / 1	5 / 6	25 / 31
Fauna	2.5 / 2.5	5 / 6	1 / 1	1.5 / 2		1.5 / 1	1.5 / 2		1 / 1	1 / 1.5	15 / 17
Agriculture			4 / 6		1.5 / 2.5			3 / 4		4.5 / 6.5	13 / 19
Noise	3.5 / 4	2.5 / 4	2 / 2	1.5 / 2.5	3 / 4		1.5 / 1.5	1.5 / 1.5			15.5 / 20.5
Asthetics		7.5 / 9.5			4 / 5.5		1 / 1	1.5 / 1.5		9.5 / 9	23.5 / 26.5
Social Health & Safety	4.5 / 4.5	3 / 3			5 / 6						12.5 / 13.5
Total	18.5 / 27	57 / 64	22.5 / 27.5	13 / 17.5	21.5 / 40.5	4.5 / 5.5	12 / 14.5	17 / 22.5	4 / 3	45.5 / 52.5	

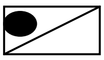
Environmental impact of Iron ore mining in Goa through Remote Sensing.
(Sponsored by the Ministry of Environment & Forests, Govt. India, Principal Investigator)(1988-92)

Where:-

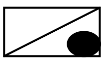
TOP HEADINGS = the actions that are part of the proposed project



= the presence of this indicates thatan impact is possible



= the MAGNITUDE of the possible impact (1-10) [+ means beneficial]



= the IMPORTANCE of the possible impact i.e. 10 is of the greatest importance.

Q1. Which actions appear to have caused the most damage?

Q2. Which environmental parameters have been most affected?

Q3. Suggest some example projects for which an EIA would be useful / important.

Q4. Research your own example of an EIA which has been performed stating where, why, the advantages, disadvantages, potential effects, final outcome etc.
(To be produced on a separate piece of paper with reference to your research sources).

SUMMARY

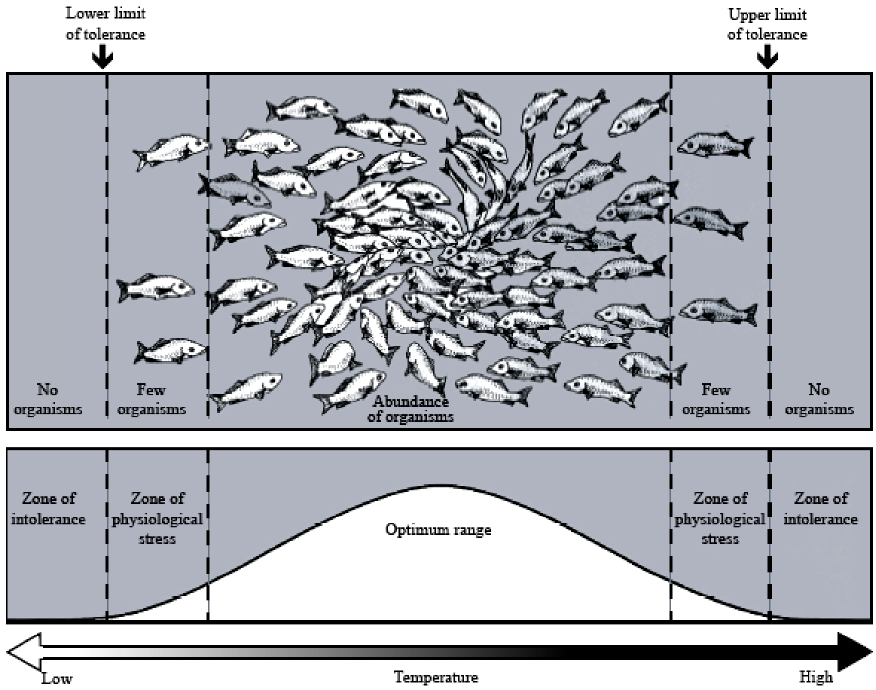
1. **Identify impacts**
2. **Predict the scale of the potential impacts**
3. **Limit the effect of impacts to acceptable limits (mitigation)**

Example questions

1.

Figure 6 shows the range of tolerance to temperature for a fish population.

Figure 6



[Source: Tyler Miller, G (1990) *Living in the Environment,* Wadsworth, p. 85]

(a) (i) Outline what the graph in figure 6 shows about fish density and temperature. *[2]*

. . . .

. . . .

. . . .

. . . .

(ii) Explain what is meant by a limiting factor in the context of the fish population in this lake. *[1]*

. . . .

. . . .

(iii) State, giving a reason, whether temperature is a density–dependent or density–independent factor in the regulation of fish populations. *[1]*

. . . .

. . . .

(This question continues on the following page)

(b) Temperature is an abiotic feature of an ecosystem. List **four** other abiotic factors of an ecosystem. *[2]*

. . . .

. . . .

. . . .

. . . .

(c) With reference to **one** abiotic factor you have named in (b), outline and evaluate a method for measuring this factor. *[3]*

. . . .

. . . .

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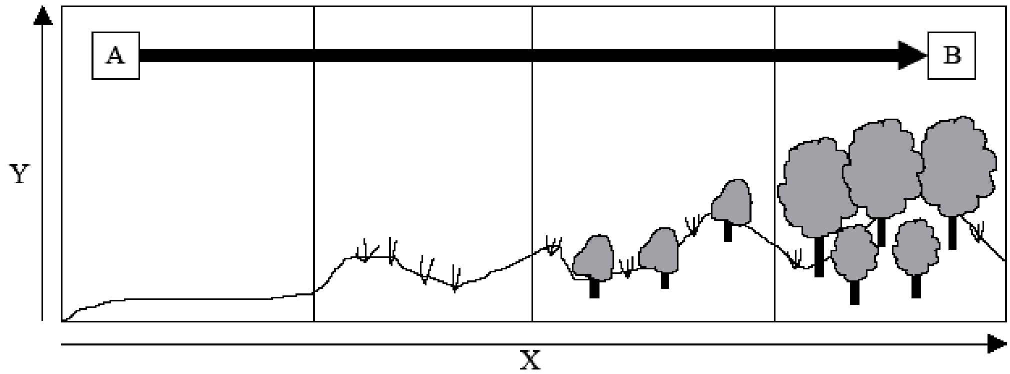
. . . .

2.

Figure 1 shows succession in a sand dune ecosystem.

Figure 1



(a) (i) Define the term *succession*. *[2]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(ii) State what variable may be appropriate for the x-axis in **Figure 1**. *[1]*

. . . .

(iii) Outline what will happen to soils as the ecosystem in **Figure 1** changes from A to B. *[2]*

. . . .

. . . .

. . . .

. . . .

(b) State what is happening within a system when a decrease in variable "P" leads to a decrease in variable "Q" which in turn leads to a further decrease in variable "P". *[1]*

. . . .

3. Outline the components of an Environmental Impact Assessment (EIA) and justify your personal viewpoint on the value of EIAs in the environmental decision making process. Refer to a specific EIA in your answer. [7]

M08/4/ECOSO/SP2/ENG/TZ0/XX/T

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.
CARRYING CAPACITY	The maximum number of a species or "load" that can be sustainably supported by a given environment.
CLIMAX COMMUNITY	A community of organisms that is more or less stable, and that is in equilibrium with natural environmental conditions such as climate; the end-point of ecological succession.
COMMUNITY	A Group of populations living and interacting with each other in a common habitat.
COMPETITION	A common demand by two or more organisms upon a limited supply of a resource (e.g. food, water, light, space, mates, nesting sites). It may be intraspecific or interspecific.
DECOMPOSITION	The degradation of organic material into smaller molecules by fungi and bacteria.

DENSITY-DEPENDENT FACTOR	Factors which lower the birth rate or increase the death rate as a population grows in size e.g. quantity of food.
DENSITY-INDEPENDENT FACTOR	Factors which affect population size irrespective of population density e.g. climate, fire etc.
K-STRATEGISTS	Species using K-strategies will usually concentrate their reproductive investment in a small number of offspring thus increasing their survival rate and adapting them for living in long-term climax communities.
J-CURVE	A growth curve which illustrates exponential growth.
LIMITING FACTORS	Various factors which limit the distribution or numbers of an organism.
NICHE	A species' shape of a habitat and the resources in it. An organism's ecological niche depends not only on where it lives but on what it does.
PHOTOSYNTHESIS	The process by which autotrophs (plants) make their own food by converting light energy into chemical energy.
PIONEER SPECIES	The first plant colonisers of a newly created habitat as part of the first stage of succession e.g. lichens on bare rock.
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	Production over time (see previous glossary for definitions of GPP and NPP)
RESPIRATION	The breakdown of food to release energy.

r-STRATEGISTS	Species using r-strategies will tend to spread their reproductive investment among a large number of offspring so that they are well adapted to colonise new habitats rapidly and make opportunistic use of short-lived resources.
SERE	The set of communities that succeed one another over the course of succession at a given location.
SUCCESSION	The orderly process of change over time in a community. Changes in the community of organisms frequently cause changes in the physical environment that allow another community to become established and replace the former through competition. Often, but not inevitably, the later communities in such a sequence or sere are more complex than those that appear earlier.
TRANSECT	A line, strip or profile of vegetation which has been selected for study.
ZONATION	The arrangement or patterning of plant communities or ecosystems into parallel or sub-parallel bands in response to change, over a distance, in some environmental factor. The main biomes display zonation in relation to latitude and climate. Plant communities may also display zonation with altitude on a mountain, or around the edge of a pond in relation to soil moisture.