IB Environmental Systems and Societies

Unit 2 The Ecosystem

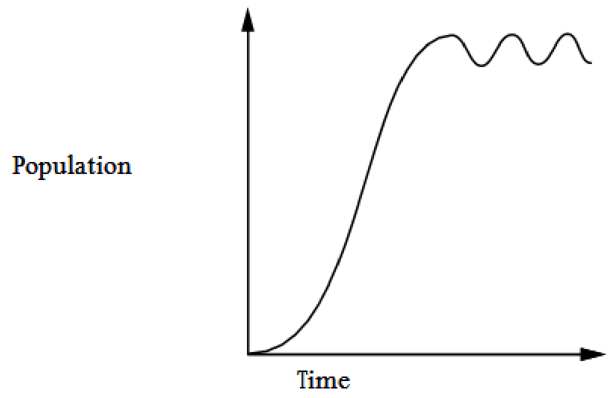
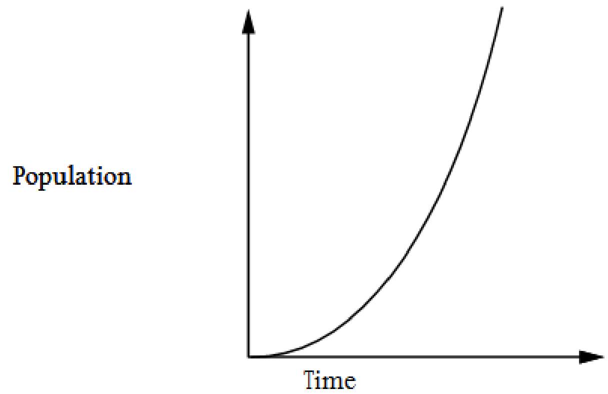
"Look deep into nature, and then you will understand everything better."
~ Albert Einstein

	Assessment Objective	Teacher Notes
2.1.1	Distinguish between biotic and abiotic components of an ecosystem.	
2.1.2	Define the term trophic level.	
2.1.3	Identify and explain the trophic levels in food chains and food webs selected from the local environment.	Relevant terms (for example producers, consumers, decomposers, herbivores, top carnivores) should be applied to local examples and other food chains and food webs.
2.1.4	Explain the principles of pyramids of numbers, pyramids of biomass, and pyramids of productivity, and construct such pyramids from given data.	Pyramids are graphical models of the quantitative differences that exist between the trophic levels of a single ecosystem. A pyramid of biomass represents the standing stock of each trophic level measured in units such as grams of biomass per square metre (g m–2). Biomass may also be measured in units of energy, such as J m–2. In accordance with the second law of thermodynamics, there is a tendency for numbers and quantities of biomass and energy to decrease along food chains; therefore the pyramids become narrower as one ascends. Pyramids of numbers can sometimes display different patterns, for example, when individuals at lower trophic levels are relatively large. Similarly, pyramids of biomass can show greater quantities at higher trophic levels because they represent the biomass present at a given time (there may be marked seasonal variations). Both pyramids of numbers and pyramids of biomass represent storages. Pyramids of productivity refer to the flow of energy through a trophic level and invariably show a decrease along the food chain. For example, the turnover of two retail outlets cannot be compared by simply comparing the goods displayed on the shelves; the rates at which the shelves are being stocked and the goods sold also need to be known. Similarly, a business may have substantial assets but cash flow may be very limited. In the same way, pyramids of biomass simply represent the momentary stock, whereas pyramids of productivity show the rate at which that stock is being generated. Biomass, measured in units of mass or energy (for example, g m–2 or J m–2), should be distinguished from productivity measured in units of flow (for example, g m–2 yr–1or J m–2 yr–1).

		A pyramid of energy may be represented either as the standing stock (biomass) measured in units of energy (J m–2) or as productivity measured in units of flow of energy (J m–2 yr–1), depending on the text consulted. As this is confusing, this syllabus avoids the term pyramid of energy.
2.1.5	Discuss how the pyramid structure affects the functioning of an ecosystem.	This should include concentration of non-biodegradable toxins in food chains, limited length of food chains, and vulnerability of top carnivores. Definitions of the terms biomagnification, bioaccumulation and bioconcentration are not required.
2.1.6	Define the terms species, population, habitat, niche, community and ecosystem with reference to local examples.	
2.1.7	Describe and explain population interactions using examples of named species.	Include competition, parasitism, mutualism, predation and herbivory. Mutualism is an interaction in which both species derive benefit. Interactions should be understood in terms of the influences each species has on the population dynamics of others, and upon the carrying capacity of the others' environment.
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 (physical) factors within an ecosystem.	Students should know methods for measuring any three significant abiotic factors and how these may vary in a given ecosystem with depth, time or distance. For example: **Marine** – Salinity, pH, temperature, dissolved oxygen, wave action. **Freshwater** – turbidity, flow velocity, pH, temperature, dissolved oxygen. **Terrestrial** – temperature, light intensity, wind speed, particle size, slope, soil moisture, drainage, mineral content.
2.3.1	Construct simple keys and use published keys for the identification	Students could practise with keys supplied and then construct their own keys for up to eight species.
2.3.2	Describe and evaluate methods for estimating abundance of organisms.	Methods should include capture–mark–release– recapture (Lincoln index) and quadrats for measuring population density, percentage frequency and percentage cover.
2.3.3	Describe and evaluate methods for estimating the biomass of trophic levels in a community.	Dry weight measurements of quantitative samples could be extrapolated to estimate total biomass.
2.3.4	Define the term diversity.	Diversity is often considered as a function of two components: the number of different species and the relative numbers of individuals of each species.

2.3.5	Apply Simpson's diversity index and outline its significance.	$$D = \frac{N(N-1)}{\sum n(n-1)}$$ Students are not required to memorise this formula but must know the meaning of the symbols: D = diversity index N = total number of organisms of all species found n = number of individuals of a particular species D is a measure of species richness. A high value of D suggests a stable and ancient site, and a low value of D could suggest pollution, recent colonisation or agricultural management. The index is normally used in studies of vegetation but can also be applied to comparisons of animal (or even all species) diversity.
2.4.1	Define the term biome.	
2.4.2	Explain the distribution, structure and relative productivity of tropical rainforests, deserts, tundra and any other biome.	Refer to prevailing climate and limiting factors. For example, tropical rainforests are found close to the equator where there is high insolation and rainfall and where light and temperature are not limiting. The other biome may be, for example, temperate grassland or a local example. Limit climate to temperature, precipitation and insolation.
2.5.1	Explain the role of producers, consumers and decomposers in the ecosystem.	
2.5.2	Describe photosynthesis and respiration in terms of inputs, outputs and energy transformations.	Biochemical details are not required. Details of chloroplasts, light-dependent and light- independent reactions, mitochondria, carrier systems, ATP and specific intermediate biochemicals are not expected. Photosynthesis should be understood as requiring carbon dioxide, water, chlorophyll and certain visible wavelengths of light to produce organic matter and oxygen. The transformation of light energy into the chemical energy of organic matter should be appreciated. Respiration should be recognised as requiring organic matter and oxygen to produce carbon dioxide and water. Without oxygen, carbon dioxide and other waste products are formed. Energy is released in a form available for use by living organisms, but is ultimately lost as heat.

2.5.3	Describe and explain the transfer and transformation of energy as it flows through an ecosystem.	Explain pathways of incoming solar radiation incident on the ecosystem including: • loss of radiation through reflection and absorption. • Conversion of light to chemical energy. • Loss of chemical energy from one trophic level to another • Efficiencies of transfer. • Overall conversion of light to heat energy by an ecosystem. • Re-radiation of heat energy to the atmosphere. Construct and analyse simple energy-flow diagrams illustrating the movement of energy through ecosystems, including the productivity of the various trophic levels. The distinction between storages of energy illustrated by boxes in energy-flow diagrams (representing the various trophic levels), and the flows of energy or productivity often shown as arrows (sometimes of varying widths) needs to be emphasised. The former are measured as the amount of energy or biomass per unit area and the latter are given as rates, for example, J m–2 day–1.
2.5.4	Describe and explain the transfer and transformation of materials as they cycle within an ecosystem.	Processes involving the transfer and transformation of carbon, nitrogen and water as they cycle within an ecosystem should be described, and the conversion of organic and inorganic storage noted where appropriate. Construct and analyse flow diagrams of these cycles.
2.5.5	Define the terms gross productivity, net productivity, primary productivity and secondary productivity.	Productivity is production per unit time.
2.5.6	Define the terms and calculate the values of both gross primary productivity (GPP) and net primary productivity (NPP) from given data.	Use the equation NPP = GPP – R where R = respiratory loss
2.5.7	Define the terms and calculate the values of both gross secondary productivity (GSP) and net secondary productivity (NSP) from	Use the equations NSP = GSP – R GSP = food eaten – fecal loss where R = respiratory loss The term “assimilation” is sometimes used instead of “secondary productivity”.
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 curves.	Explain changes in both numbers and rates of growth in standard S and J population growth curves. S curve  
2.6.3	Describe the role of density-dependent and density-independent factors, and internal and external factors, in the regulation of populations.	According to theory, density-dependent factors operate as negative feedback mechanisms leading to stability or regulation of the population. Both types of factors may operate on a population. Many species, particularly r-strategists, are probably regulated by density- independent factors, of which weather is the most important. Internal factors might include density-dependent fertility or size of breeding territory, and external factors might include predation or disease.
2.6.4	Describe the principles associated with survivorship curves including, K- and r-strategists.	K- and r-strategists represent idealised categories and many organisms occupy a place on the continuum. Students should be familiar with interpreting features of survivorship curves including logarithmic scales.
2.6.5	Describe the concept and processes of succession in a named habitat.	Students should study named examples of organisms from a pioneer community, seral stages and climax community. The concept of succession, occurring over time, should be carefully distinguished from the concept of zonation, which refers to a spatial pattern.

2.6.6	Explain the changes in energy flow, gross and net productivity, diversity and mineral cycling in different stages of succession.	In early stages, 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, that is, 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 one.
2.6.7	Describe factors affecting the nature of climax communities.	Climatic and edaphic factors determine the nature of a climax community. Human factors frequently affect this process through, for example, fire, agriculture, grazing and/or habitat destruction.
2.7.1	Describe and evaluate methods for measuring changes in abiotic and biotic components of an ecosystem along an environmental gradient.	
2.7.2	Describe and evaluate methods for measuring changes in abiotic and biotic components of an ecosystem due to a specific human activity.	Methods and changes should be selected appropriately for the human activity chosen. Suitable human impacts for study might include toxins from mining activity, landfills, eutrophication, effluent, oil spills and overexploitation. This could include repeated measurements on the ground, satellite images and maps.
2.7.3	Describe and evaluate the use of environmental impact assessments (EIAs).	Students should have the opportunity to see an actual EIA study. They should realise that an EIA involves production of a baseline study before any environmental development, assessment of possible impacts, and monitoring of change during and after the development.

2.1.1 Distinguish between biotic and abiotic components of an ecosystem.

A biotic component "refers to the living components with an ecosystem (the community)"[1]. Biotic factors incorporate the physical characteristics of the environment such as "light, air, water, temperature, minerals, soil and climate aspects"[2].Whilst an abiotic component "refers to the non-living factors of the ecosystem"[3]. "Abiotic factors include the soil (edaphic factors) and topography (the landscape)."[4]

2.1.2 Define the term trophic level

"The **trophic level** of an organism is its position in a ***food chain***, the sequence of consumption and energy transfer through the environment."[5]

2.1.3 Identify and explain the trophic levels in food chains and food webs selected from the local environment.

Level 1	Level 2	Level 3	Level 4	Level 5
Autotroph	Herbivore	Omnivore/ Carnivore	Carnivore	Carnivore
Producer	Primary Consumer	Secondary Consumer	Tertiary Consumer	Quaternary Consumer

The trophic levels demonstrate the links between different species of plants and animals. They allow us to pull together food chains and construct food webs. This allows a clear representation of the interaction between species. At the base of all food webs and chains are the producers (autotrophs) these are plant species which convert energy through photosynthesis. They use the environment to produce a food source for other species, Level 1 in the Trophic Level system. All species in some shape or form are dependent on Trophic Level 1.

Species which consume other species whether plant or animal are known as consumers. This covers Levels 2 to 5 in the Trophic levels. We can split the consumers into Herbivore, Omnivore and Carnivore. As you can see, Herbivores only occupy level 2 and are only reliant upon the first trophic level for food. However, they are prey to the other trophic levels. As we ascend the

[1] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.14.
[2] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.14.
[3] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.14.
[4] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.14.
[5] 'Trophic Levels and Food Chains' in 'The Physical Environment: an Introduction to Physical Geography', Michael E. Ritter. 2009. ,Web. 17.07.2012 <http://www4.uwsp.edu/geo/faculty/ritter/geog101/textbook/biogeography/trophic_levels_and_food_chains.html>

trophic levels the prey-predator relationship changes. The higher the trophic level, the less predators there are to the species. Whilst species in low trophic levels are preyed upon the most having many predators.

2.1.4 Explain the principles of pyramids of numbers, pyramids of biomass, and pyramids of productivity, and construct such pyramids from given data.

"Pyramid of numbers – this records the number of individuals at each trophic level.
Pyramid of biomass- this represents the biological mass of the standing stock at each trophic level at a particular point in time.
Pyramid of productivity – this shows the flow of energy (i.e. the rate at which the stock is being generated) through each trophic level."[6]

See your notes for how to construct scaled Pyramids.

2.1.5 Discuss how the pyramid structure affects the functioning of an ecosystem.

Since the top consumers (top carnivores) are dependent on the rest of the ecosystem to provide food, they are most vulnerable to disturbance in their population due to lack of food. For example, "if there is a reducation in the numbers of producers or primary consumers, existence of the top carnivores can be put at risk if ther are not enough organisms (and therefore energy and biomass) to support them."[7]

Additionally, top carnivores are most susceptible to toxins and contaminants that are introduced into the natural environments. As toxins move through the trophic levels they build up to non-toxic levels in individual species, bioaccumulation, as they are preyed upon by species from a higher trophic level the toxics ascend the trophic levels, biomagnification. Since species higher in the food chain have a tendency to live longer the toxics have a much longer time to accumulate in their body fat. This leads to poisoning. There are some very good examples of fatalities through toxins spreading through food chains. The release of Mercury into the aquatic systems in and around Minamata Bay during the 1950s and 1960s is a perfect example how pyramid structures are changed through the functioning of an ecosystem.

2.1.6 Define the terms species, population, habitat, niche, community and ecosystem with reference to local examples.

Species – " a group of organisms that interbreed and produce fertile offspring."[8]
Population – " a group of organisms of the same species living in the same area at the same time, which are capable of interbreeding."[9]

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[6] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.16.
[7] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.17.
[8] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.19.

Habitat – "...the environment in which a species normally lives."[10]
Niche – "...where, when and how an organism lives."[11]
Community - "...a group of populations living and interacting with each other in a common habitat."[12]
Ecosystem – "...a community of interdependent organisms (the biotic component) and the physical environment (the abiotic component) they inhabit."[13]

2.1.7 Describe and explain population interactions using examples of named species.

Populations interact with each other in many ways. In some cases this is to benefit each of the populations involved. On other occasions it is a competition for resources or survival. The five main interactions you need to know about are **competition, parasitism, mutualism, predation and herbivory**.

Competition is one of the most obvious interactions there is between populations. But what are the populations competing for? It could one of many factors; territory, food and mating partners are the most common. Competition is split into **interspecific** and **intraspecific** competition. **Interspecific** competition is between different types of species so for example Bees and Wasps. This normally occurs where two different species environmental niche overlap. Therefore they are in competition with one another for food or territory. Whereas **intraspecific** competition is competition within a species (probably for a mating partner) for example the Bird of Paradise.

Parasitism is when one organism (parasite) is detrimental to the health of the host. Ticks, Flees and tapeworms are all perfect examples of parasites.
Symbiosis "is a relationship in which two organisms live together (parasitism is a form of symbiosis where one of the organisms is harmed)."[14]

In contrast, "**Mutualism** is a symbiotic relationship in which both species benefit."[15]

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[9] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.19.
[10] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.20.
[11] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.20.
[12] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.20.
[13] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.20.
[14] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.22.
[15] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.22.

Predation is another common interaction between populations. This is where one species survives by hunting and eating another species. This helps to stabilise populations so that they do not exceed their capacity in the environment. A negative feedback.

The final type of interaction between populations is **herbivory**. Simply put, this is the consumption of producers.

2.2.1 List the significant abiotic (physical) factors of an ecosystem.

Ecosystems can be categorised into three main categories; Marine, Freshwater and Terrestrial. Marine ecosystems encompass the seas and oceans, estuaries, salt marshes and mangroves. Essentially, areas which have a high salt content in the water. Freshwater includes rivers, wetlands and lakes, whiles terrestrial ecosystems are land based.

Each of the different types of ecosystems is subject to different abiotic factors. However, **temperature** and **pH** are common throughout all three types of ecosystem.

Abiotic factors unique to Marine ecosystems are **salinity** and **wave action**. Whilst **turbidity** and **flow velocity** are unique to Freshwater ecosystems. **Dissolved oxygen** is an abiotic factor that is shared by marine and freshwater ecosystems.

Terrestrial ecosystems have many abiotic factors. These include **light intensity**, **wind speed**, **particle size**, **gradient**, **aspect**, **soil moisture**, **drainage** and **mineral content**.

2.2.2 Describe and evaluate methods for measuring at least three abiotic (physical) factors within an ecosystem.

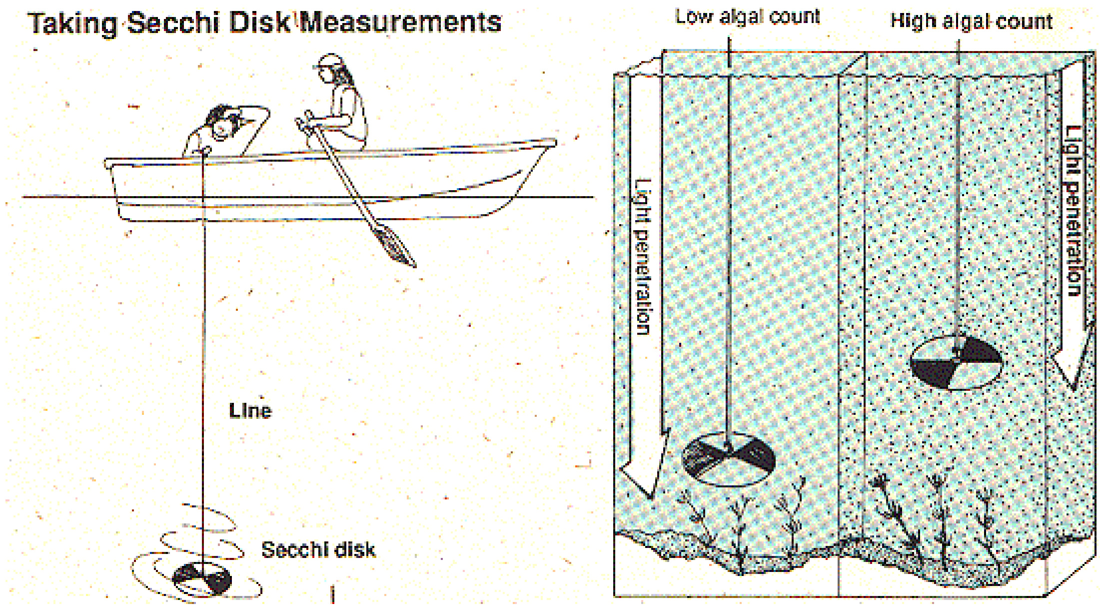
Temperature can easily be measured with a simple digital thermometer. However some precautions need to be taken depending on the type of temperature measurement needed. The thermometer needs to be in a sheltered place to record the air temperature itself, though sometimes another measurement can be taken in the open to examine the effect of wind chill on the temperature. Whilst, a traditional mercury or alcohol thermometer is too fragile for fieldwork use and also harder to read in comparison to a digital thermometer.

Wind speed can be measured easily with a hand held anemometer. Again precautions need to be taken with regards where to take the wind speed reading.

pH of soils, rain, rivers or lake waters can be measured in a number of different ways. Traditionally pH would have been measured with universal indicator liquid or paper for quick evaluation. For more accurate evaluation of pH, back titration against known standards is used. However the development of reliable and accurate electronic pH meters means that field ecologists can now make quick but accurate assessments of the conditions without the need to carry universal indicator, ionised water for sterilisation of containers etc.

Light intensity is measured using photoelectric meter similar to a photographic light meter (exposure meter) found in a camera. Light values can be measured as wavelength, energy of as relative values such as Lux and luminance. Measuring light intensity is very useful tool when undertaking vegetation ecology especially within forest ecosystems.

"Cloudy water is said to have high turbidity and clear water low turbidity. Turbidity affects the penetration of sunlight into water and therefore rates of photosynthesis. Turbidity can be measured using a secci disk."[16]



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"Salinity can be measured using electrical conductivity or by the density of the water (water with a high salt content is much denser than low-salt water). Salinity is most often expressed as parts of salt per thousand parts of water (ppt). Sea water has an average salinity of 35 ppt..."[18]

2.3.1 Construct simple keys and use published keys for the identification of organisms.

In order to identify organisms or objects correctly, we categorise their distinguishing features. We, as humans, do this naturally without thinking about it. However, identifying different types of grass or beetles is somewhat harder to the untrained eye. Therefore we use dichotomous keys to identify the different characteristics. See below for an example of a key for the following objects; shark, dog, cow, cloud, dolphin, spider, car and human.

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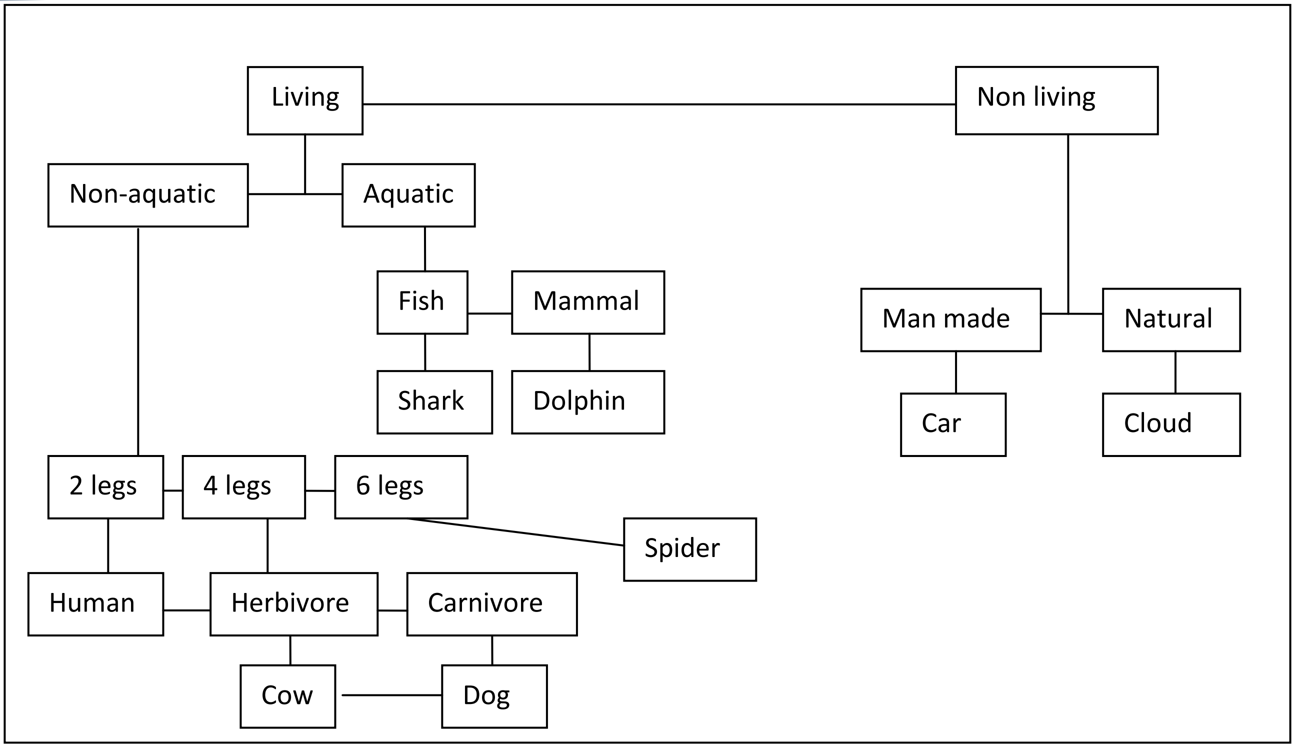
[16] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.28.

[17] 'Secci Disk Depth', Department of Ecology, State of Washington. 1994. ,Web. 18.07.2012 <lhttp://www.ecy.wa.gov/programs/wq/plants/management/joysmanual/secchi.html>

[18] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.27.



2.3.2 Describe and evaluate methods for estimating abundance of organisms.

It is impossible to get accurate and precise data for every organism within an ecosystem. Therefore this must be taken into consideration when attempting to estimate the abundance of organisms. However, the following methods can be carried out to be able to sample small mobile organisms.

- Small mammal traps.
- Canopy flooding.
- Light traps.
- Pitfall traps.

Other methods include "counting the percentage cover of organisms in a selected area (for organisms that do not move or are limited in movement), or by indirectly calculating abundance using a formula (for animals that are mobile – see the Lincoln index)."[19]

The Lincoln index is a mathematical way to determine the total population size within the study area. It "involves collecting a sample from the population, marking them in some way (paint can be used on insects, or fur clipping on mammals), releasing them back into the wild, then

[19] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.30.

resampling some time later and counting how many marked individuals you find in the second capture." [20]

You then use the formula:

$$N = \frac{n1 \times n2}{m}$$

N = the total population size of animals in the study area.
n1 = number of animals captured and marks on the first day.
n2 = total number of animals captured on the second day.
m = total of animals captured on the second day which were marked on the first day.

Quadrats are used to limit the sampling area when you want to measure the population size of non-mobile organisms.

2.3.3 Describe and evaluate methods for estimating the biomass of trophic levels in a community.

"Rather than weighing the total number of organisms at each level and extrapolation method is used: the mass of one organism, or the average mass of a few organisms, is multiplied by the total number of organisms present to estimate total biomass...To obtain quantitative samples of biomass, biological material is dried to constant weight. The sample is weighed in a previously weighed container. The specimens are put in a hot oven (not hot enough to burn the tissue) – around 80oC – and left for a specific length of time. The specimen is reweighed and replaced in the oven. This is repeated until a similar mass is obtained on two subsequent readings."

2.3.4 Define the term diversity.

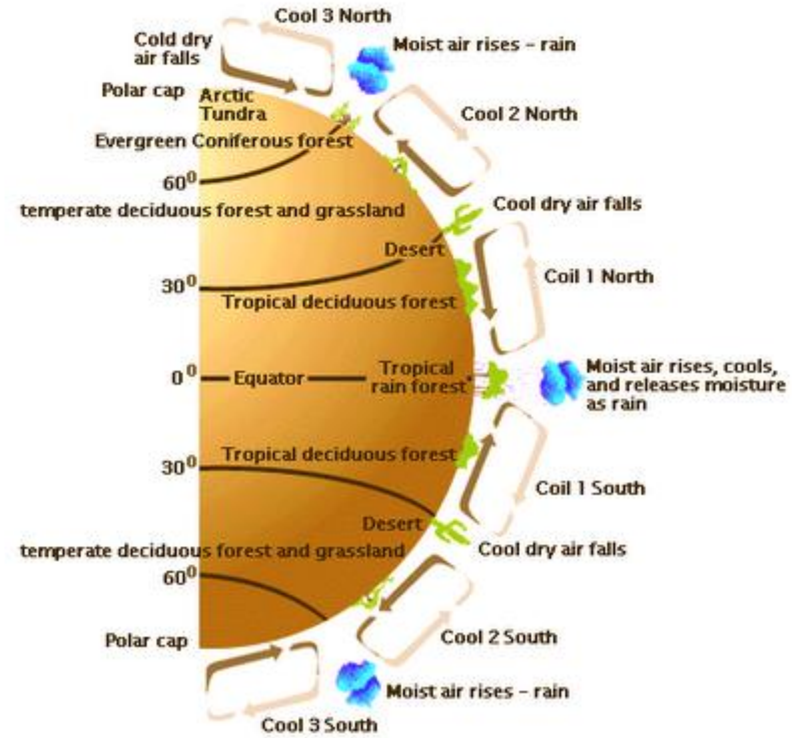
"Diversity is the function of two components: the number of different species and the relative numbers of individuals of each species. This is different to species richness, which refers to the number of species in a sample or area."[21]

2.4.1 Define the term biome.

"A biome is a collection of ecosystems sharing similar climatic conditions."[22]

2.4.2 Explain the distribution, structure and relative productivity of tropical rainforests, deserts, tundra and any other biome.

[20] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.31.
[21] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.33.
[22] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.35.



23 Tri- Cellular Atmospheric Model with Biomes.

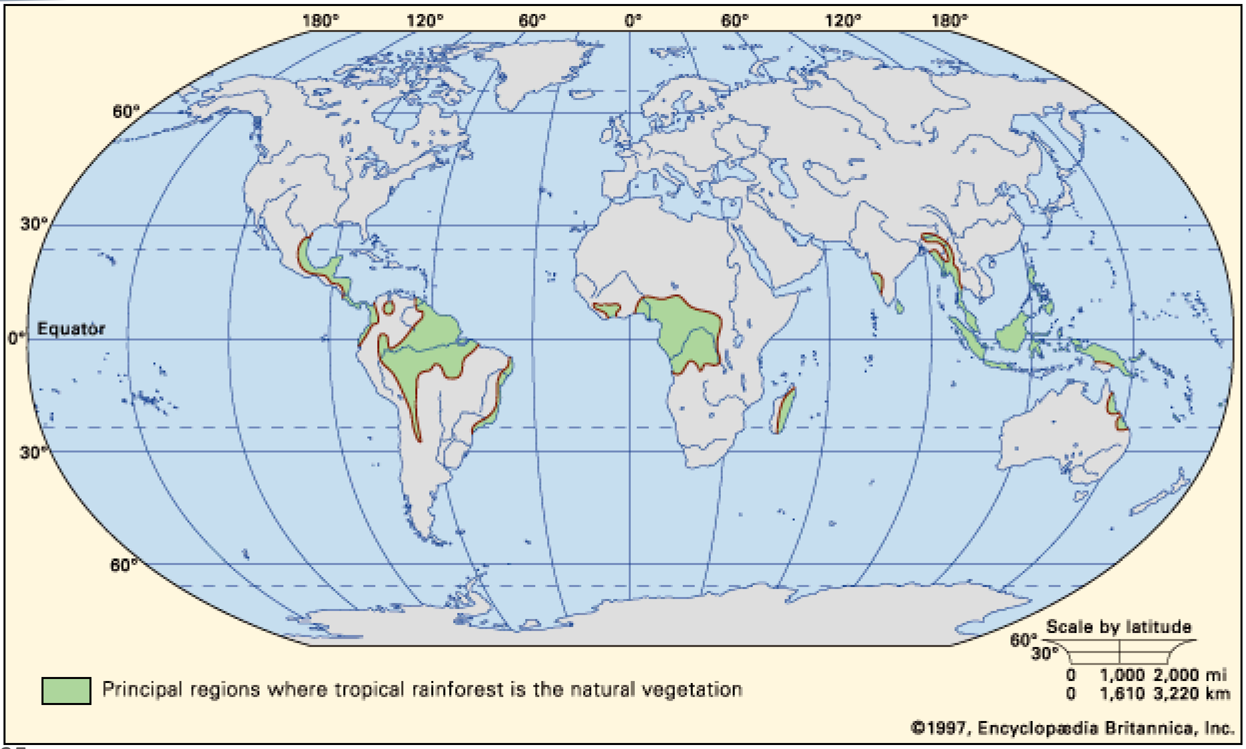
Tropical Rainforests

These are generally found between 0^o – 23.5^o North and South of the Equator (see distribution map next page). As a result of their location they receive over 2500 mm of precipitation per year. This is due to the atmospheric pressure see the Tri-Cellular model. At the equator there is a band of low pressure where the two Hadley cells meet together. As a result of the sun's energy water evaporates quickly causing air to rise and cool rapidly. These are characteristics of low pressure. Subsequently, the rapid cooling causes the formation of cumulonimbus clouds and therefore thunder and rain storms.

The geographical position of the Tropical rainforests allows the areas receive a high amount of precipitation, high temperatures and high amount of the sun's energy. This combination gives to an all –year growing season and rich biodiversity. High levels of photosynthesis occur giving way to high productivity which explain the rich biodiversity. "Rainforests are estimated to produce 40 per cent of NPP of terrestrial ecosystems."[24]

[23] 'The Global distribution of Ecosystems', WorldlyWise Blog. 2007. Web. 23.07.2012 <http://worldlywise.blogspot.co.uk/2007/08/global-distribtuion-of-ecosystems.html>

[24] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.37.



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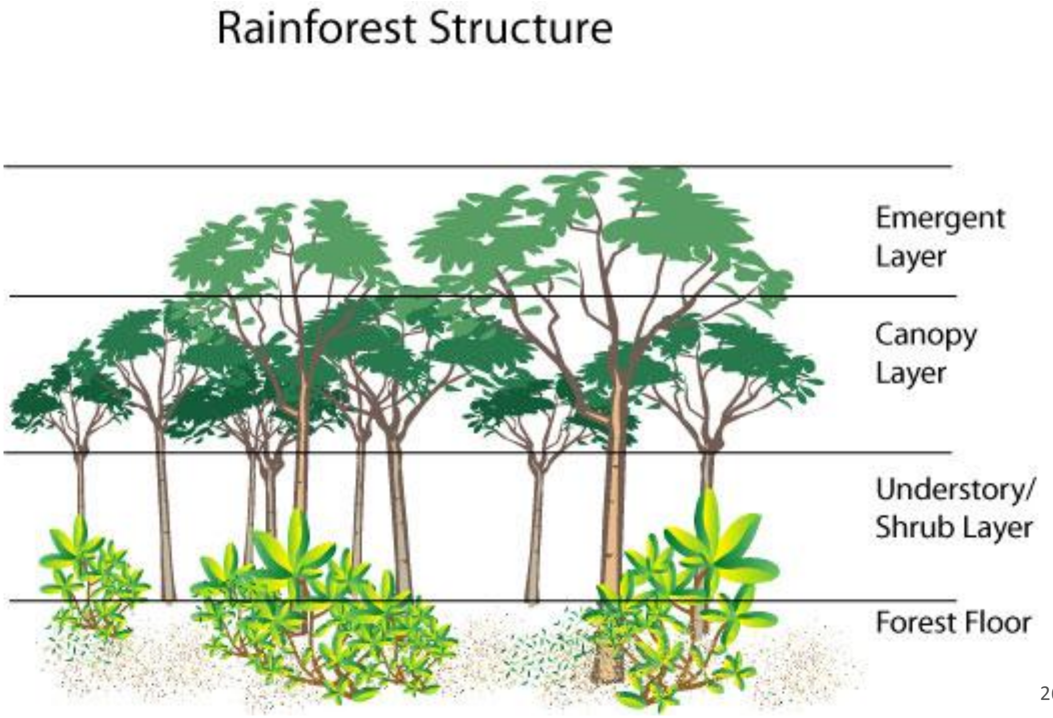
As a result of the structure of the tropical rainforest biome, many different types of species occupy many environmental niches. The structure and climate however, does result in poor soil due to the amount of rain and lack of sunlight on the forest floor. When areas are deforested, soil erosion occurs rapidly due to the intensity of the water and lack of roots binding the soil. This has resulted in plant and animal adaptations. Some plants have had to become carnivores in order to receive nutrients form animals as the soil lacks the nutrients. Trees tend to have shallow root systems as the soils are thin, but to support their height they have 'buttresses'. Vegetation has waxy leaves, shaped with a 'drip tip' so that water runs off the leaves down the stems to the roots.

[25] 'Tropical Rainforest: Worldwide distribution', Encyclopaedia Britannica, Inc. 2012. Web. 18.07.2012 <http://www.britannica.com/EBchecked/media/42/Worldwide-distribution-of-tropical-rainforests>



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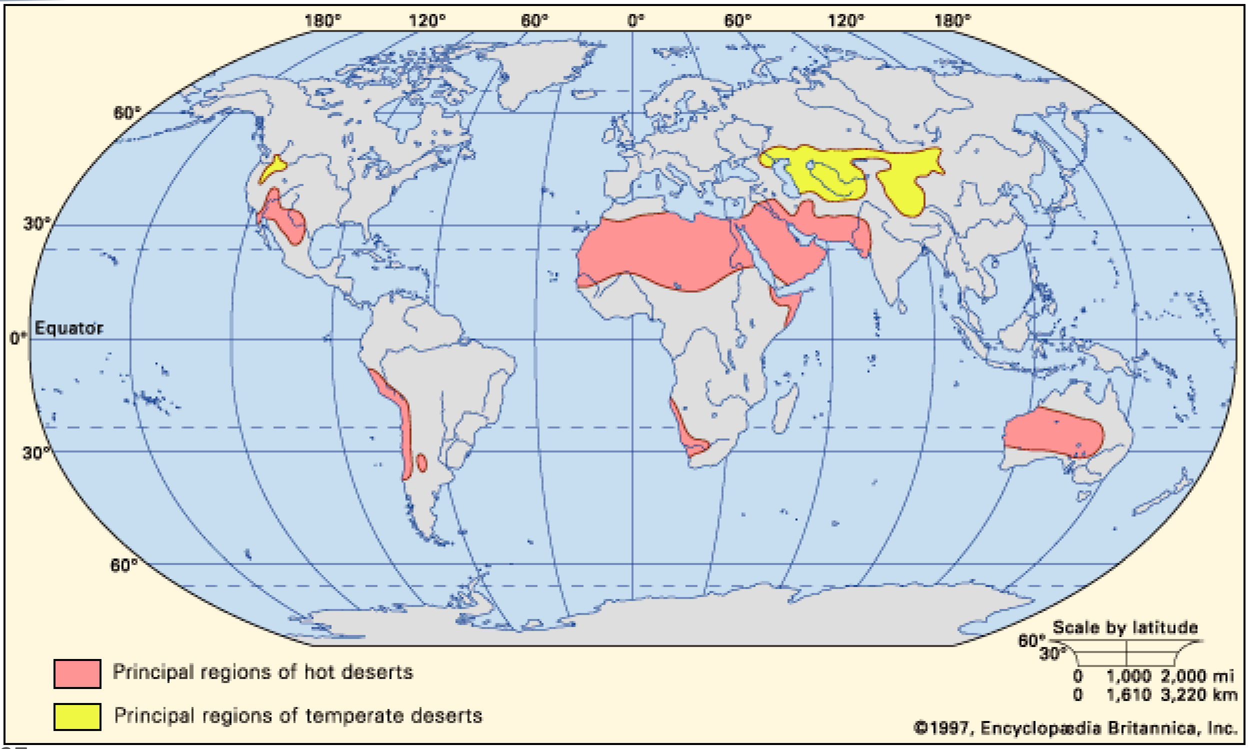
Tropical Deserts

These are generally found between 20° – 30° North and South of the Equator (see distribution map below). As a result of their location they receive less than 250 mm of precipitation per year. This, once again, is due to the atmospheric pressure. At approximately, the tropics of Cancer and Capricorn (23.5° North and South of the Equator respectively), the Hadley Cell meets the Ferrell cell as the cold dry air, having ascended from equatorial regions, descends through the atmosphere towards the tropics. This causes high pressure. As a result of the sun's energy water evaporates quickly causing a lack of moisture.

The geographical position of the Tropical Deserts allows the areas receive a low amount of precipitation, high temperatures and high amount of the sun's energy. The fact that Deserts do not receive much water annually makes it hard for vegetation to grow. Therefore this limiting factor reduces the amount of producers (autotrophs) in an ecosystem. This has a knock on effect to the food webs. Whereby a lack of producers impacts on how many other species can survive with water and food shortages. Subsequent lack of producers means a lack of photosynthesis and directly links to a very low NPP.

[26] 'Weekend Science Fun: Birds of the Rainforest' Roberta Gibson, 2011. Web. 18.07.2012 <http://blog.growingwithscience.com/2011/11/weekend-science-fun-birds-of-the-rain-forest/>



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As a result of the lack of vegetation cover in the Desert biome, many different types of species occupy many environmental niches, however, populations are low. The harsh climatic conditions and lack of water has resulted in plant and animal adaptations. Many adaptations are xerophytic adaptations (to reduce water loss). Thick skin or bark, reduction in leaf surface areas and the ability to expand. The vegetation that can survive in the desert is obviously prone to herbivory. Therefore they have adapted spiney leaves or spikes to deter predators as well as to capture moisture from the air without having the same surface area as leaves.

Arctic Tundra

The highest latitudes are occupied by the Arctic Tundra Biome. This is found from around 60^{o} North of the Equator (as seen on the distribution map on the next page). There is some Tundra biomes found in very high altitudes (Alpine Tundra) and in Antarctica. Although Tundra Biomes are adjacent to ice margins therefore the most amount of Tundra is found in the Northern Hemisphere to the South of the Arctic Ice Sheet. The geographical position of the Tundra means that it receives less of the suns energy per square kilometre than at the Equator. Additionally, due to the Earth's axis the length of day tends to be much shorter in the Arctic than further south, especially in the Winter where the sun does not even rise above the horizon. This obviously impacts upon plant growth, productivity and photosynthesis. So NPP is very low in the winter although in the summer NPP increases due to an increase in temperature and sunlight, subsequently providing water and energy for growth.

[27] 'Deserts: global distribution of deserts', Map, Encyclopaedia Britannica for Kids. 2012. Web. 18.07.2012 <http://kids.britannica.com/comptons/art-72219/Most-of-the-worlds-hot-deserts-lie-between-20-and>

Due to the tri-cellular atmospheric model, the Arctic is in an area of high pressure (just like the Tropical Deserts) and receives a very small amount of precipitation. Also because of the lack of energy from the sun, temperatures are very low. Low temperatures reduce decomposition rates, rates of photosynthesis and rates growth. So the soil is very rich in carbon due to the slow rate of decomposition. This leads to the formation of peat bogs.

[28]

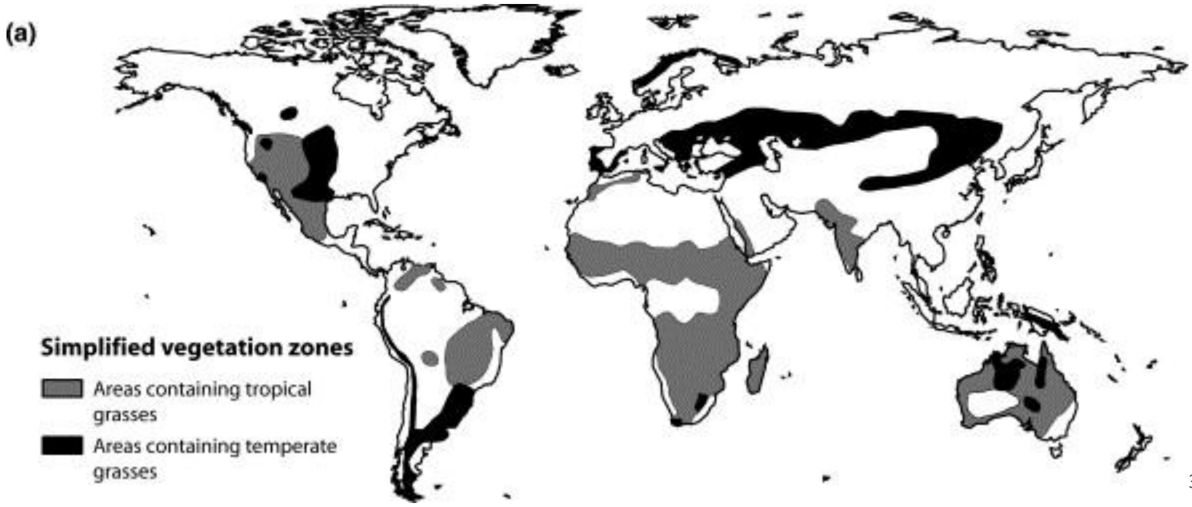
Once again, the harsh conditions have forced plants and animals to adapt to their environment. Most mammals have thick fur for insulation whilst plants have leathery leaves. Vegetation is low lying, mostly shrubs and small bushes. This is because the poor soil and low levels of photosynthesis cannot support taller vegetation.

Grasslands

"Grasslands are found on every continent except Antarctica, and cover about 16 per cent of the Earth's surface. They develop where ther is not enough precipitation to support forests, but enough to prevent deserts forming. There are several types of grassland: The Great Plains and

[28] 'Polar Ecosystem, Map, Encyclopaedia Britannica. 2012. Web. 23.07.2012 < http://www.britannica.com/EBchecked/media/58/Southern-limit-of-Arctic-tundra-and-approximate-line-of-demarcation>

the Russian Steppes are temperate grasslands; the Savannah of East Africa are tropical grassland."[29]



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The large geographical distribution of Grassland makes it difficult to describe where Grasslands can be found. However, we find temperate grasslands is where the cold air from polar cells meets the warmer air from Ferrell cells. The cooler air in the temperate grasslands slows down the rate of decomposition. This causes nutrients to build up slowly forming a thick layer of nutrients. This explains why there is so much diversity.

The absence of extreme climates is a distinguishing factor. In Grasslands the rates of precipitation and evaporation are equal. As the conditions are not suited to trees, there is a high diversity of grass types. The grasses however have low levels of productivity.

2.5.1 Explain the role of producers, consumers and decomposers in the ecosystem.

Producers

"Plants, algae and some bacteria are autotrophs. Organisms that use sunlight to create food are called photoautotrophs...Producers are the basis of ecosystems, supporting them through constant input of energy and new biomass."[31]

Consumers

"Consumers do not contain photosynthetic pigment such as chlorophyll so they cannot make their own food. They must obtain their energy, minerals and nutrients by eating other organisms."[32]

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[29] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.42.

[30] 'Chemotaxonomic significance of distribution and stable carbon isotopic composition of long-chain alkanes and alkan-1-ols in C4 grass waxes', Organic Geochemistry, Volume 37, Issue 10. 2006. Web. 23.07.2012 <http://www.sciencedirect.com/science/article/pii/S0146638006000234>

[31] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.43.

[32] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.44.

Decomposers
"Decomposers obtain their food and nutrients from the breakdown of dead organic matter."[33]

2.5.2 Describe photosynthesis and respiration in terms of inputs, outputs and energy transformations.

	Inputs	Processes	Outputs	Transformation
Photosynthesis	Sunlight Carbon dioxide Water	Chlorophyll traps sunlight. Energy splits H2O molecules	Glucose Oxygen	Light → Chemical Energy
Respiration	Glucose Oxygen	Oxidation	Heat Release of energy	Chemical → Kinetic Energy

2.5.3 Describe and explain the transfer and transformation of energy as it flows through an ecosystem.

Here the laws of thermodynamics come into play, not as a theory but in practice. Using your own notes on the Energy Budget you can see that the amount of energy which an ecosystem receives is very small in comparison to the total solar energy at the outer atmosphere. The solar radiation (energy) can be absorbed or reflected by the atmosphere, it's gases or clouds. Equally, the surface also reflects some of the energy. Of the energy which reaches the surface, some is lost through the;

- "reflection from leaves
- light not hitting chloroplasts
- light of the wrong wavelengths (not absorbed by chloroplast pigments)
- transmission of light through the leaf
- inefficiency of photosynthesis."[34]

2.5.4 Describe and explain the transfer and transformation of materials as they cycle within an ecosystem.

There are many transfers and transformations of materials within ecosystems. Again, your class notes should provided examples of Carbon and Nitrogen Cycles.

2.5.5 Define the terms gross productivity, net productivity, primary productivity and secondary productivity.

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[33] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.44.
[34] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.46.

"Primary productivity – The gain by producers (autotrophs) in energy or biomass per unit area per unit time.
Secondary productivity - The biomass gained by heterotrophic organisms, through feeding and absorption, measured in units of mass or energy per unit area per unit time."[35]

"...gross productivity (GP) is the total gain in energy or biomass per unit area per unit time. Net productivity (NP) is the gain in energy or iomass per unit area per unit time remaining after allowing for respiratory losses (R)."[36]

2.5.6 Define the terms and calculate the values of both gross primary productivity (GPP) and net primary productivity (NPP) from given data.

To calculate the Gross Primary Productivity (the total amount of energy gained by producers) is very difficult. Therefore we normally calculate the net primary productivity as it is more useful. It tells us "...the actual store of energy contained in potential food for consumers rather than the amount of energy fixed into sugar initially by the plant."[37]

NPP = GPP - R

2.5.7 Define the terms and calculate the values of both gross secondary productivity (GSP) and net secondary productivity (NSP) from given data.

"Gross Secondary Productivity (GSP) is gained through absorption in consumers"[38]. Therefore:

GSP = food eaten - faecal loss

Whilst the Net Secondary Productivity (NSP) "the gain by consumers in energy or biomass per unit area per unit time remaining after allowing for respiratory losses" is calculated using the following formula:

NSP = GSP - respiratory loss

2.6.1 Explain the concepts of limiting factors and carrying capacity in the context of population growth.

Each population, regardless of species, have limits. Such constraints could be water, food, nutrients or other abiotic factors such as temperature. Every species has a different tolerance to the lack or shortage of some abiotic factors. Water salinity is a good examples to use. Certain species of fish only survive in salt water whilst others in fresh water. Such tolerance levels

[35] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.52.
[36] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.53.
[37] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.54.
[38]

determine which environments are optimum for growth.

The carrying capacity concept also varies. This is the amount of organisms that an ecosystem can sustainably support.

2.6.2 Describe and explain S and J population curves.

S curves show initial rapid growth in a population although when the carrying capacity of an ecosystem is reached then the population levels out. As the ecosystem cannot support any more individuals. This encourages intra-specific competition where food and habitat are in short supply.

J curves show exponential growth. So the population increases rapidly and does not slow down.

2.6.3 Describe the role of density-dependent and density-independent factors, and internal and external factors, in the regulation of populations.

Density-dependent factors - these are negative feedback mechanisms. They are directly linked to the density of a population in an ecosystems. As previously mentioned this increases competition for habitat or food, therefore decreasing populations. Predator -prey relationships are density dependent. As seen on the next page. Therefore the larger the population size and area occupied then the larger the chances of survival. Take mosquitoes as an example.

"Density-independent factors can operate alongside density-dependent factors. Density-independent factors are generally abiotic. The most important ones are extremes of weather (drought, fire, hurricanes) and long-term climate change."[39]

As the two terms internal and external factors would suggest many factors influence the size and density of populations. Internal factors occur within a species population whilst external factors cannot be changed by the species affected. When we take Salmon as an example, their population is limited by the fact they return to specific spawning grounds annually, normally where they were born themselves. This means they are restricted, geographically to breeding sites. If those spawning grounds are destroyed or damaged then that population will reduce, something which the salmon cannot control.

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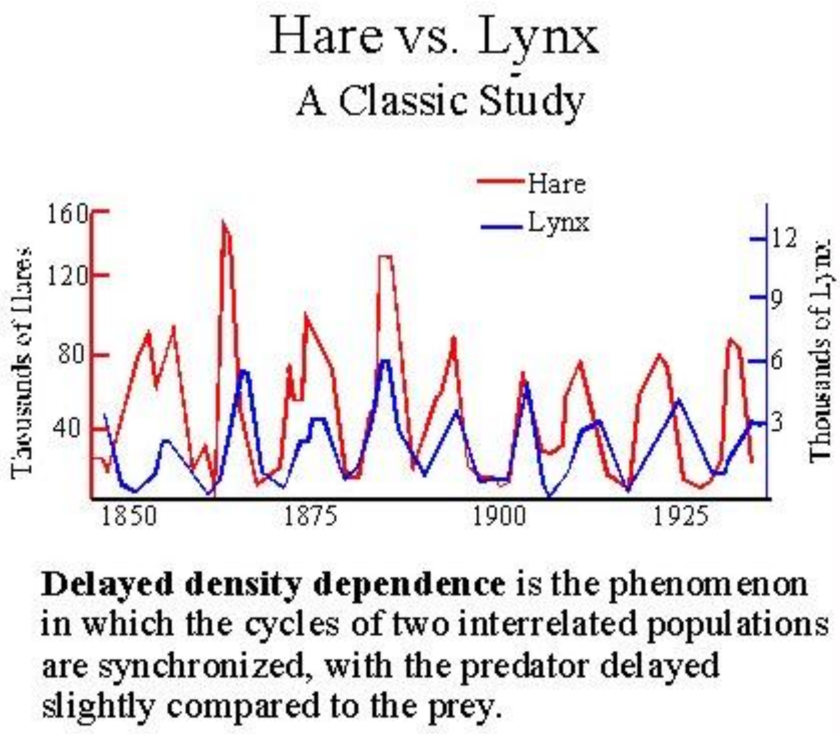
[39] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.60.



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2.6.4 Describe the principles associated with survivorship curves including, K- and r-strategists.

The terms r and K strategists are used to describe the characteristics of certain species. r Strategists have rapid population growth, development and reproduction rates. They tend to be small and have a short life span. Whilst K strategists are the opposite, slow population growth, development and reproduction rates.

2.6.5 Describe the concept and processes of succession in a named habitat.

In class we have studied with species names the processes of succession on a Sand Dune. Use your own notes for details.

2.6.6 Explain the changes in energy flow, gross and net productivity, diversity and mineral cycling in different stages of succession.

Using the example of Psammosere (Plant succession on Sand Dunes) at the shoreline the abiotic factors are at their most extreme. High salinity, submersion in water and poor nutrients all contribute to a very low density of producers as the conditions are significantly restricted by these limiting factors. Subsequently, gross productivity, respiration and energy lost are all relatively low. This leads onto but accumulation of decomposed material (an increase in the net productivity), which is moved further way from the shoreline ensuring an increase in soil fertility the further from the shoreline you travel. As a consequence, the fertile soil can support a higher

[40] 'Predation', Jim Swan. 2008.,Web. 25.08.2012 <http://envirosci.net/111/predation/predation.htm>

biodiversity and therefore more producers. Here we have a very classic example of a positive feedback system where the ecosystem is actively counteracting the limiting factors to encourage species population growth.

2.6.7 Describe factors affecting the nature of climax communities.

Firstly, a climax community is a community of species that could be considered to have a stable population and therefore developed and mature.

Climax communities tend to have the following features:

- "greater biomass
- higher levels of species diversity
- more favourable soil conditions (e.g. greater organic content)
- better soil structure (therefore greater water retention)
- lower pH
- taller and longer-living plant species
- more K-strategists or fewer r-strategists
- greater community complexity and stability
- greater habitat diversity
- steady-state equilibrium."[41]

As a result of the above characteristics, climax communities can be lucrative to humans due to the fertility of the soil or value of the species. Therefore, they are susceptible to exploitation through intensive farming and deforestation.

2.7.1 Describe and evaluate methods for measuring changes in abiotic and biotic components of an ecosystem along an environmental gradient.

Environmental or ecological gradients occur when there is a sudden change in the abiotic conditions of an ecosystem. Therefore usually where 2 ecosystems meet we can clearly identify change along a gradient. This could be where an area of marsh meets grassland. The species found in marshes would obviously be different to those found in grasslands due to the different factors which limit the growth of particular species.

In order to record this change, transects and belt transects are used. This is in contrast to determining biomass, where the quadrat may be randomly selected. Since the variation is the environmental factors, using a transect allows there to be a steady change in the abiotic factors. Again, we will take the example of a sand dune. The conditions change very rapidly with the introduction of a higher fresh water table. Random quadrat work would not determine that the change in species is necessarily to do with the distance from the sea. Normally, the gradient is measured with a measuring tape and species touching the tape are recorded. Line transects

[41] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.69.

however, are not representative of an entire ecosystem as they focus on a very small part. Therefore many line transects need to be carried out. Whilst fewer belt transects need to be taken out. Belt transects are very similar to quadrats, however the length is variable whilst the width stays the same. Species are then recorded within the belt transect.

2.7.2 Describe and evaluate methods for measuring changes in abiotic and biotic components of an ecosystem due to a specific human activity.

Use your notes for specific case study. Human changes to ecosystems can be measured by either looking at the overall impact on the environment via satellite images with pictures before and after the human activity or by recording the characteristics of the ecosystem. This may included soil and water pH, the level of nitrogen, dissolved oxygen and so on. Each of these have advantages and disadvantages which have already been outlined.

2.7.3 Describe and evaluate the use of environmental impact assessments (EIAs).

"The purpose of an EIA is to establish the impact of the project on the environment. It predicts possible impacts on habitats, species, and ecosystems, and helps decision makers decide if the development should go ahead."[42]

Once again use your own notes on the EIA carried out in class to evaluate its strengths and weaknesses.

[42] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.78.

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