WJEC Biology A-level

Topic 3.5: Population size and ecosystems

Notes

Populations

- The **population size** is influenced by immigration, emigration, birth and death rate.
- Population size can also be influenced by density dependent factors such as predation, parasitism, food source, space and competition. Density independent factors include climate, weather and natural disasters.
- The limiting factors which determine the carrying capacity, that is the **maximum population size that can be supported by the environment** include: **food, water, light, oxygen, nesting sites, shelter, parasites and predators**. **Competition** between organisms takes place in a case where a particular resource is **limited supply**.
- **Predator-prey relationships** give rise to a **fluctuating population** size of predators and prey. This is because, as the predator population grows, more prey is consumed thus meaning that prey population decreases to a point where there isn't a sufficient amount of prey to feed the predator population. As a result of that, there are fewer predators thus increasing the chance of survival of prey, thus causing the prey population to increase in size. This in turn means that the predator population can grow again, thus restarting the cycle.
- There are two types of **competition** between organisms; interspecific competition which is the **competition between individuals of different species** and **intraspecific competition between individuals of the same species**.
- **Conservation** serves to **maintain or increase the biodiversity within a particular habitat** by allowing a **sustainable use of the resources** whereas **preservation serves to maintain** the biodiversity **levels and the habitat intact** by **minimising the effects of human activities** on the particular habitat.
- There are many **economic, social and ethical reasons for conservation**. For instance, many species provide a source of food and medicine, and are important for processes such as **pollination of crops** as well as for maintaining a good **quality of water as well as tourism**. Social reasons include conservation for aesthetic reasons and recreation whereas ethical reasons include the right to survive.

Sampling

Abundance and distribution of organisms can be measured with the use of:

- **Line transect**- where a line is placed down across the habitat and species in contact with the line are recorde
- **Quadrat** – a square frame of a given size, randomly placed in the area being sampled, species inside the quadrat are identified and counted to determine the abundance
- **Belt transect** – combination of a line transects and quadrat

Ecosystems

- An **ecosystem** includes all the organisms living in a particular area known as the **community** as well as all the non-living elements of that particular environment.

- The **distribution** and **abundance** of organisms in a **habitat** is controlled by both **biotic** (living) factors e.g. predators, disease and **abiotic** (non-living factors) such as light levels and temperature. Each species has a particular role in its habitat called its **niche** which consists of its biotic and abiotic interactions with the environment.

Succession

Succession is the change of one community of organisms into the other. **Primary succession** occurs when area previously devoid of life is colonised by communities of organisms for instance after the **eruption of a volcano** which lead to formation of a rock surface. The area is first colonised by the **pioneer species** such as lichens which are adapted to survive in such harsh conditions. As organisms die, they add and are decomposed by microorganisms thus adding **humus**, this in turn leads to **formation of soil** which makes the environment more suitable for more complex organisms. Over time, the soil becomes richer in **minerals** thus enabling larger plants such as shrubs to survive. Eventually, a **climax community** is established which is the final stage of succession, a **self-sustaining and stable** community of organisms. **Secondary succession** occurs in a previously colonised area in which an existing community has been cleared. This type of succession can occur after events such **as forest fires**. As a soil layer is already present, succession begins at a later stage.

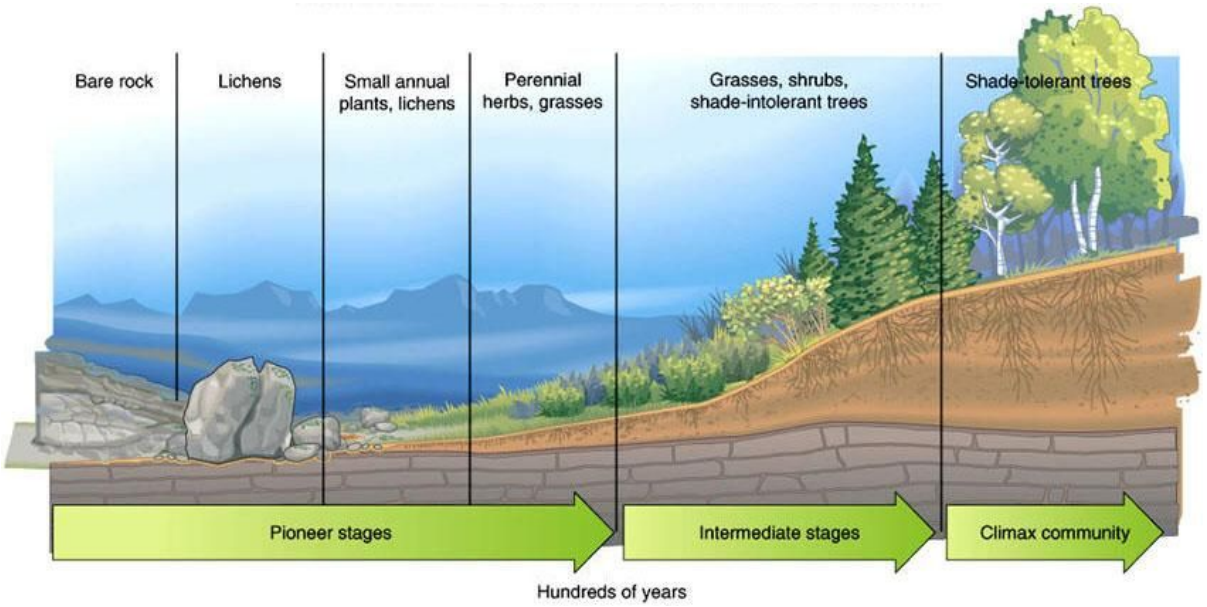

Figure 1 Yellowstone National Park

Biomass

In any ecosystem, plants synthesise organic compounds from either **atmospheric or aquatic carbon dioxide**. Most of the sugars synthesized by plants are used by the plant as respiratory substrates whereas the remaining sugars are used for synthesis of biological molecules which form the biomass of plants.

The biomass can be measured in terms of mass of carbon or dry mass of tissue per given area per given time. The chemical energy stored in dry biomass can be estimated using calorimetry.

- **Net primary productivity (NPP) –** the rate at which energy is transferred into the organic molecules that make up new plant biomass, that is the chemical energy store in plant biomass after respiratory losses to the environment have been taken into account

- **Gross primary productivity (GPP) –** the rate at which energy is incorporated into organic molecule in the plants in photosynthesis, that is the chemical energy store in plant biomass, in a given area or volume, in a given time

- Therefore: **NPP = GPP – R**

- The net primary production is available for plant growth and reproduction as well as to other trophic levels in the ecosystem such as decomposers and herbivores

- The net production of consumers (N) such as animals can be calculated by: **N= I – (F+R)** where I represents the chemical energy store in ingested food, F

represents the chemical energy lost to the environment in faeces and urine and R represents the respiratory losses to the environment.

Nitrogen cycle

Nitrogen is an essential component of metabolism as it is required for the synthesis of **proteins and nucleic acids**. Nitrogen cannot be used in the form of gas, therefore to be of any use to plants, it first needs to be fixed either in the form of **ammonium ions or nitrates**.

The process occurs as following:

- Nitrogen is first **fixed by bacteria** such as Rhizobium which live in the **root nodules of leguminous plants** such as pea plants.
- The bacteria have a **mutualistic relationship** with the plant where they exchange the fixed nitrogen for glucose.

- In anaerobic conditions, which are maintained with the use of special oxygen absorbing proteins, enable **nitrogen reductase** to reduce nitrogen gas to ammonium ions.
- **Ammonium ions** are subsequently released by bacteria in the putrefaction of proteins from dead organic matter.
- **Chemotrophic bacteria** (Nitrosomonas) oxidise ammonium ions to nitrites
- **Nitrobacter** subsequently oxidise **nitrites to nitrates** in the presence of oxygen
- Plants absorb nitrates from soil for **nucleotide synthesis.**
- In anaerobic conditions, bacteria convert nitrates back to oxygen gas for respiration. **Nitrogen gas and nitrous oxide** are produced in the process.

Eutrophication is a process where **algal blooms** appear on the surface of a body of water such as a pond as a result of increase in **nitrate** levels, for instance when fertilisers reach the body of water. The algal blooms prevent the light from reaching the bottom of the pond, such as pond. As a result of that, light becomes a limiting factor and causes the death of organisms. **Saprobiotic organisms** then feed on the dead organisms, using up oxygen in the process which then becomes a limiting factor and causes the death of organisms such as fish. **Anaerobic organisms** thrive in such conditions with plenty of **dead organic matter** to be broken down, thus increasing the amount of toxic **waste.**

Climate change

Global warming is a term used to describe a **gradual increase in the average temperature of the Earth's atmosphere and surface**. It is believed that global warming will lead to a permanent change in the Earth's climate. The evidence for climate change includes:

- **Records of carbon dioxide levels** – increasing levels of carbon dioxide in the atmosphere are believed to contribute towards climate change as carbon dioxide is a greenhouse gas and is involved in the greenhouse effect
- **Temperature records** which enable analysis of changes in temperature
- **Pollen in peat bogs** – pollen grains are preserved in peat bogs and analysis of samples of pollen can give us an idea of what kind of plants were present at the time when the peat was being formed
- **Dendrochronology** is the study of tree rings as the size of tree rings is affected by temperature

The data can be **extrapolated to make predictions** which can then be used in **models of future climate change**. On the other hand, such models have limitations as they do not include factors such as reduction in emissions of greenhouse gases.
Greenhouse effect is the process in which infrared radiation from the Sun is trapped by gases such as carbon dioxide and methane thus leading to an increase in the temperature of the Earth's surface and atmosphere.
The **effects of climate change** include changing rainfall patterns and changes in seasonal cycles which in turn would lead to:

- **Changes in the distribution of species** – species would move to cooler areas i.e. northwards. This could potentially lead to extinction of some species due to competition.
- **Changes to development** – sex of many reptiles is determined by temperature therefore an increase in temperature would have an effect on the sex ratio of certain species thus potentially leading to extinction
- **Disrupted life cycles**

An increase in temperature will also affect **enzyme activity**, initially as temperature increases, the rate of reaction increases as the rate of formation of **enzyme-substrate complexes** increases as the **kinetic energy of molecules increases** thus leading to more frequent collisions. However, the rate of reaction decreases above the **optimum temperature** as enzymes become **denatured**.

One of the ways of **reducing global warming** is the reduction of carbon dioxide levels in the atmosphere. This can be done through:

- Growing plants to use as a fuel as **biofuels** which are **carbon neutral** – carbon dioxide released by burning the fuel is removed from the atmosphere by the plants it is made from.
- **Reforestation** to increase the rate at which carbon dioxide is removed from the atmosphere by plants which need it for photosynthesis.