Science / Mathematics Strand
Science

Unit E: Environmental Science

Module E1 Ecology

Student Support Material

Acknowledgements

Materials written and compiled by Rosina Paullon O.L.S.H. Teachers' College – Kabaleo, Osaku Openg, Balob Teachers' College and John Broadfoot Long Term Adviser, Science.

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O.L.S.H. Teachers' College - Kabaleo

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PASTEP

Primary and Secondary Teacher Education Project

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Unit outline

(Based on the National Curriculum Guidelines)

Unit	#	Modules
Unit E Environmental Science	E1	Ecology (Core)
	E2	Flora and Fauna (Core)
	E5	Earth Science (Core)
	E6	Earth in Space (Core)

Icons

 Read or research

 Write or summarise

 Activity or discussion

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Unit overview

There are four core modules in the Environmental Science Unit. These modules provide coverage of the prominent topics in the Draft Primary Syllabuses.

Module E1 Ecology

Distribution and adaptations of organisms

Community ecology (ecosystems, food chains and webs)

Ecosystem nutrient cycles

Sustainable biological development

Module E2 Flora and Fauna

Taxonomy of PNG fauna and flora

Endangered species

Field techniques and research skills

Project

Module E5 Earth Science

Plate tectonics

Earthquakes

Volcanoes

Natural disasters

Module E6 Earth in Space

Stars and constellations

Observing the Moon, stars and constellations

Observing the Sun and planets

Module Outline

Why study this module?

The Module Ecology covers topics in the lower and upper primary syllabuses and therefore is seen as one of the important foundation modules in **Environment Science.**

This module enables students to investigate issues affecting the environment from the broadest scale down to the ecological niche of organisms in terms of the factors that contribute to their distribution and adaptations. The impact of people on their environment is looked at in terms of suitable ways to solve problems.

Ecology is covered extensively and is not seen as new module. As a result, most of the work done will be mainly through library research, field research and class presentation so that student teachers grasp the concepts in a meaningful way.

It is also important that student teachers are exposed to some of these issues so that they can help children make better judgements on the types of development they want in their villages and PNG.

Objectives

By the end of the module student teachers should be able to:

Skills

- Observe the environment
- Measure temperature, humidity, pH, wind speed and wind direction,
- Identify types of biogeographical regions, biomes, zones and habitats
- Present research confidently to the class.
- Discuss PNG or global environmental issues
- Draw sketches
- Compare organisms in the same biomes by identifying common features
- Evaluate critically presentations

Knowledge

- State that the climatic, physiographic, edaphic and the biotic factors have a great impact on the distribution and adaptations of organisms.
- Explain and give examples of climatic, physiological, edaphic and biotic factors
- State that ecology is of the interaction that exists between living organisms themselves and the living organism with their environment.
- Discuss and present findings on people's impact or the environment and what precautions to take.
- Analysis or synthesis existing environmental issues and discuss how that would affect them.
- Understand the purpose of research.

Attitude

- Respect each other's views
- Work in perseverance
- Work in small groups

Content

Distribution and adaptations of organisms

Biosphere and biogeographical zones; biomes and zones; habitats and environment; ecological niche; abiotic (climatic factors, physiographic factors and edaphic factors) and biotic factors.

Community ecology

Food chains and food webs; ecosystem; energy flow and energetics; saprophytic nutrition; parasitic nutrition; nutrient cycles - carbon, oxygen, nitrogen.

Sustainable biological development

Ecological succession; destruction of natural environment and habitats; biological development in natural environments.

Main ideas developed

- Ecosystems are complex communities where many different species of plants and animals coexist and are interdependent.
- Food and energy flows in ecosystems are complex and easily disturbed by interference, especially by humans.
- Animals and plants show adaptations to the particular environment in which they live.
- Careful study and research are needed before and during any disturbance to an ecosystem to minimise disruption.
- There is a strong link between habitat preservation and species survival.
- A number of PNG's fauna and flora are under threat because of habitat removal. It is important that people in PNG are aware of the threats to endangered species.
- Conservation of habitats and species is important for the survival of humans.
- Factors contributing to the survival of species include competition, habitat, disease, food supply, adaptability, etc.
- Careful study and research are needed before any new plants or animals are introduced to the country.
- Because ecosystems are complex, destruction of even a part of the system can have many unintended consequences.
- Activities such as logging have short term and long term economic and social advantages and disadvantages.
- Careful study and research of ecosystems and habitats should be undertaken before any major project is commenced.
- All activities affect the environment. Sustainable activities are preferable to unsustainable development for the preservation of human lifestyles.
- Human population increases put great pressure on the environment.

Teaching and learning approaches

This module will be delivered through the use of support materials, a lecture program, laboratory and field based activities and a workshop/tutorial program. The practical component is strongly based on the application of ecological principles and problem-solving to Papua New Guinean examples. Excursions or field studies are an integral part of the teaching program. Activities provide a hands-on approach to the teaching of this module. Teaching and learning in this module is based on the constructivist model of learning to ensure students have a thorough grounding and understanding of the concepts.

Throughout the teaching of this module there should be a strong emphasis on the constructivist approach to learning which can be readily applied to science teaching in the classroom. Students will be encouraged to apply their new knowledge and skills to the context of teaching at different levels in primary schools.

Assessment strategies

This module will be assessed in a way which provides students with the opportunity to demonstrate their knowledge of the application of concepts and their ability to present an informed defensible opinion.

Practical activities occur throughout the learning process. Excursions form part of the College curriculum and field reports are part of the assessment program. Assignments or projects are based on individual and group research.

References

Science Advisory Group (2000). *Ecology*. Support materials developed for Program 2000. PASTEP: Port Moresby

Curriculum Development Unit (1998-1999). *Science Curriculum for Primary Schools in PNG*. National Department of Education: Port Moresby

ECOLOGY

The organism and its environment

Ecology is the study of how organisms interact with each other in their environment. Ecology consists of two components, the **living** and the **non-living**. For example, earthworms cannot survive in nature unless they are in moist soil and covered with leaf litter. Earthworms are living things but need soil, organic matter and water to survive. The organic matter is the remains of dead organisms while the water and soil are non-living things.

An ecologist may study one species of an organism in the natural surroundings or may study two or more species of organisms interacting with each other in their natural surroundings.

Ecology can be divided into **Aute-ecology** and **Synecology**. **Aute-ecology** refers to the study of single species of plants and animals and focuses on the population, distribution and seasons of abundance. **Synecology** is the study of the complete ecosystem and includes the study of many different species of plants and animals interacting with each other and their surroundings.

Distribution and adaptations of organisms

Biosphere and biogeographical regions

The **biosphere** is the region surrounding the earth that can support life. In its broadest sense an organism's home is that part of the earth and its atmosphere inhabitable by living things. The biosphere can be divided into a series of biogeographical regions. Each region is inhabited by distinctive species of animals and plants. These organisms are able to move freely from place to place within each region but not easily from one region to another because of different types of natural barriers. Biogeographical regions include Eurasia, South America, North America, Africa and Australia.

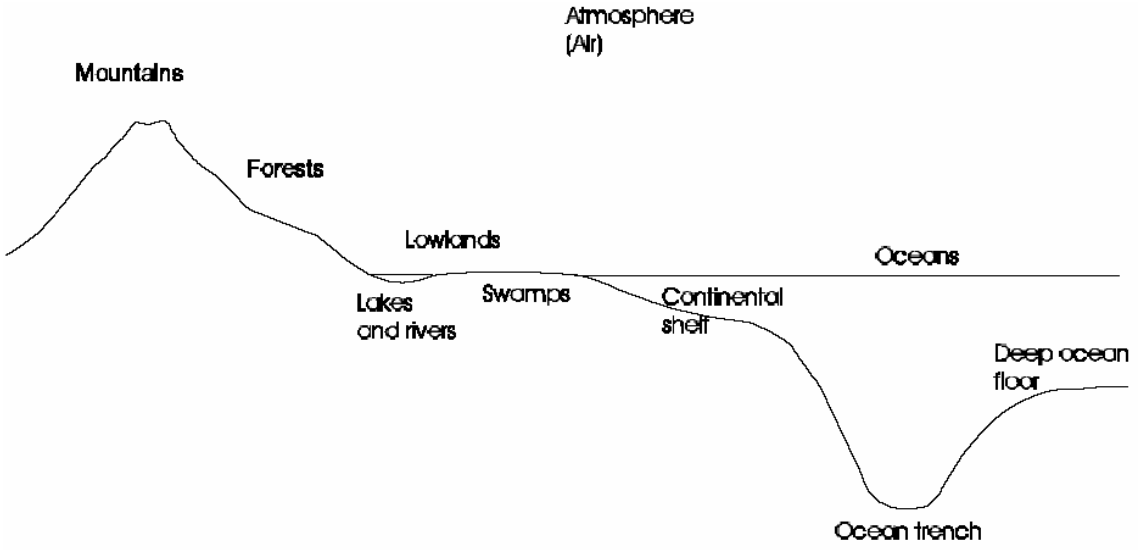


Figure 1. Biosphere is all regions of the Earth that support life

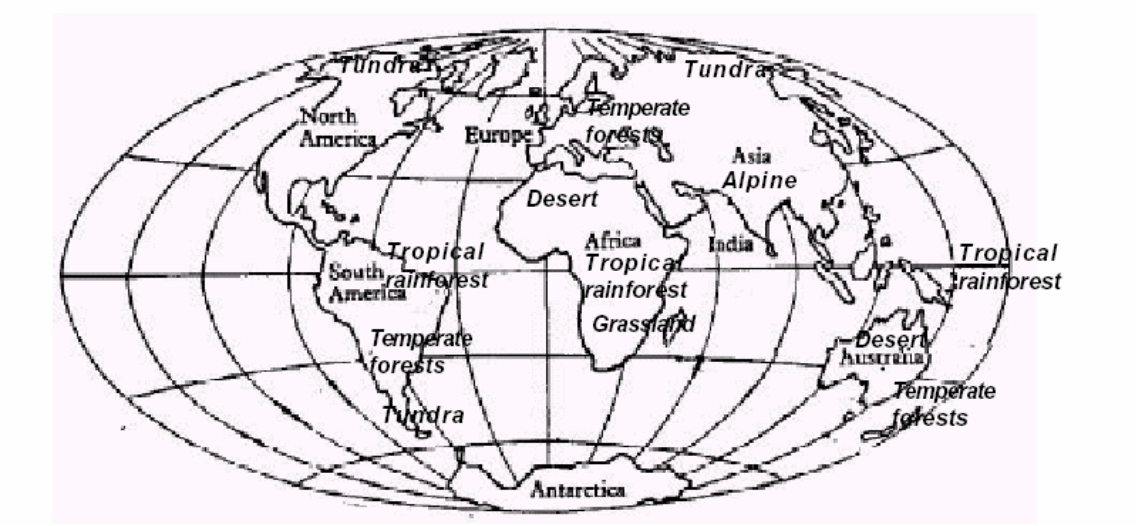


Figure 2. World map showing tundra, alpine, desert, tropical rainforest, temperate forest, grasslands and arctic biomes. (Adapted and modified from: Biology: A functional approach. 4th Edition.)

Emus are only found in Australia. They are well adapted to the climate and move around freely within Australia but cannot migrate easily to New Zealand because the sea serves as the natural barrier between Australia and New Zealand.

There are instances where organisms found in one region also have difficulty moving freely. For example some organisms are confined to the Southern part of Africa while others are confined to the northern part of Africa. This is because the desert serves as the natural barrier in the same continent.

Biomes and zones

Within each geographical region are **biomes**. A biome has its own unique sets of conditions that support only particular flora and fauna. There are different types of biomes. They include the tundra of the Arctic and Antarctica regions of the globe, alpine regions, grasslands, deserts, the different kinds of forests, rivers and oceans.

It should also be noted that regions that share the same line of latitude tend to have similar biomes because of the similar climatic conditions. For instance equatorial regions such as the top part of South America, middle Africa, Northern Australia, Indonesia, Malaysia and Papua New Guinea share the same line of latitude and all have tropical rainforests.

Biomes are divided into units called **zones**. A closer look at the tropical rainforest would show distinct habitat zones such as underground, understorey, canopy, emergent and so on, each inhabited by specific plants and animals. Each particular zone (**habitat**) has its own set of physical conditions.

Table 1. An illustration of the stratification of a rainforest in PNG

ZONES	SUNLIGHT	TEMPERATURE	WIND	HUMIDITY
Tree canopy	**Strong**	**Hot** *Big change from day to night*	**Strong**	**High to low** *Big change from day to night*
Upper Understorey	**Strong**	**Hot** *Big chance from day to night*	**Strong**	**High to low** *Big chance from day to night*
Lower Understorey	**Weak**	**Warm to hot** *Small chance from day to night*	**Weak**	**High** *Small change from day to night*
Herbs & shrubs Leaf litter	**Poor**	**Warm to hot** *Small change from day to night*	**Weak or none**	**High** *Small change from day to night*

Habitats and environment

Within each biome are numerous **habitats**. Habitats are places with a particular set of conditions and an adapted community of organisms. In other words a biome is a place where organisms adapt and live naturally. Adjectives commonly used to describe types of habitat include aquatic, for any water habitat, and terrestrial for those on land. Aquatic habitats may further be described as marine (sea) fresh water (lakes, rivers, ponds and streams) and estuarine (mouths of rivers where salt and fresh waters meet). Like wise, terrestrial habitats may be described as a boreal (on or in trees), ground or underground. **Environment** is the collective conditions and surroundings in which organisms live. Conditions may include both living and non-living things, e.g., *light, temperature, water, depth, acidity, soil and other organisms.*

Different organisms living under rocks prefer moisture and less light intensity. The environment mentioned consists of rocks, moisture, less light intensity and other organism.

Ecological niche

Another way of defining an organism's ecological situation is in terms of its **ecological niche.** An ecological niche is not only the place where organisms live but includes their behaviour, what they feed on and so on. A caterpillar and an aphid may both live in the same habitat; a cabbage leaf but they occupy different ecological niches. A caterpillar bites of pieces of leaf for food where as the aphid sucks sap from the veins.

A well camoflauged caterpillar feeding on pigweed leaves.

☞ Activity E1.1 – Biomes

1. *Define the following word(s): biosphere, biogeographic regions, biomes, zones, habitat, environment, ecological niche*
2. *What common features do biomes have?*
3. *Give some examples of biomes.*
4. *Find two countries that are in the same line of latitude and compare the types of vegetation or biomes. Make a list of the common types of biomes present in these two countries.*
5. *Complete the table on the next page by filling in the names of the countries that share the same line of latitude then identify the common types of biomes present and describe the similarities in flora and fauna types.*
6. *Are there similarities in the types of flora and fauna present in each biome? Explain.*
7. *Organisms have different physical characteristics however they may have some distinctive similarities. What does that tell us about their evolution?*
8. *Highlight and name on a map of the world the types of natural barriers that stop organisms migrating.*
9. *How do you think organisms have withstood changes in the conditions?*

Table2. Comparing different biomes of the world

Name the type of biome	Name of 2 countries that are in the same line of latitude and have the same type of biome		Name flora common to those two countries	Name common to those two countries
	County A	Country B		
A				
B				
C				
D				

Abiotic and biotic environments

An organism's environment can be divided into the **physical (abiotic)** and **living (biotic) environments**. The physical environment refers to factors that are not associated directly with the presence of other organisms. The biotic environment is made up of the other organisms living in the same environment.

All flora and fauna living in a habitat are under the influence of a variety of factors which vary from habitat to habitat. These factors may be classified as:

- Climatic
- Physiographic
- Edaphic
- Biotic

Climatic factors

The chief climatic factors of a habitat include temperature and water.

Temperature

Temperature refers to the degree of heat or cold and is measured as degrees Celsius. Heat affects the speed of chemical reactions in the cells of organisms.

Some organisms have adapted necessary behavioural skills and physical appearance to withstand extreme conditions. Plants growing in very cold regions have withstood the temperature by becoming stunted in their growth while animals grow very thick fur on their bodies to keep them warm. On the other hand plants growing in very hot regions may develop succulent stems and long spikes instead of leaves like the cacti.

Cacti stems only have spikes for leaves to reduce water loss in hot climates.

Others may grow long thin waxy leaves like some palms to reduce the surface area exposed to sunlight. In other cases plants develop less stomata on the lower leaves of plants or close their cells as much as possible.

Desert animals have adapted to move very quickly on the sand so that they are not burnt. They also take shelter and become less mobile as much as possible during daylight so that body temperature is properly regulated.

Water

Water is the colourless and odourless liquid that fills the oceans, lakes, rivers and ponds and falls from the sky. Water is abundant. It covers about 75% of the Earth's surface. Water is essential for life. It is believed that most living organisms evolved from water-based organisms. Water is essential to almost all organisms.

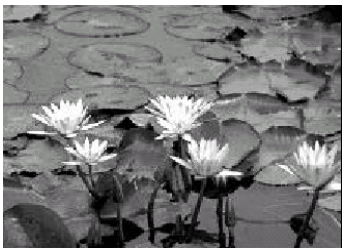
Living cells in plants and animals are made of protoplasm which is largely water. The human body is approximately 70 % water while the jellyfish are 98 % water. Water keeps living cells "blown up" while cells without water would collapse like empty balloons.

Water has special properties:

- Water can dissolve many substances therefore is sometimes referred to as the universal solvent.
- Water has a high ability to store heat energy. This prevents large bodies of water from heating or cooling too rapidly. Therefore animals composed largely of water have a relatively stable temperature. As well aquatic organisms are protected from the shock of abrupt temperature changes in a watery environment.
- Water expands when it freezes. Frozen water floats allowing plants and animals to live in lakes and rivers under the ice in cold climates.
- Organisms need water to live, for reproduction purposes and for the normal functions of the body cells.

The extent to which an organism needs water may vary from species to species depending on the amount of water they need. Organisms living in dry habitats generally have good water conservation. Other organisms without the presence of water can go into hibernation or form capsules around them and become inactive for an indefinite period of time.

Some organisms need more water than others. For instance, hydrophytes such as water lilies, elodea, and animals such as fish and shrimps. If they are taken out of the water they will eventually die. Hydrophytes are plants, which live in fresh water. Elodea, water lettuce and water lilies are some examples. Some float on the surface, while others anchor themselves to the bottom of the stream or pond.



Water lillies - flowering plants with floating leaves that depends on water for survival.

Habitat

Hydrophytes show a number of adaptations:

- The cuticles of many hydrophytes are thin and permeable. This allows the plant to absorb water, mineral salts, carbon dioxide and oxygen over its whole surface. Because hydrophytes do not depend on their roots for water supply, many have roots that are poorly developed.
- Xylems are not properly developed in hydrophytes because they are supported by water around them.
- Well-developed air spaces are present making the plants buoyant.
- The floating leaves have well developed cuticle, and Stomata only on the upper surface. The lower epidermis, which is usually submerged, has this cuticle and no stomata. The upper cuticle is either waxy (e.g. water lily) or covered in hairs (e.g. water lettuce and salvinia) so that water collects in drops on the surface and does not block the stomata.

- The typical characteristics of aquatic animals is that they have developed gills instead of lungs to breath in water. Oxygen diffuses through microscopic blood vessels on the gills.
- Most are stream lined, have fins and have scales or shiny skins they enable them to move freely in water. Microscopic animals use cilia and Gills flagellates for movement purpose.
- Some animals have swim bladder that they could regulate for buoyancy. Buoyancy is determined by the amount of air present in the swim bladder.

Organisms that survive dry arid land have adapted special features that help them minimize the amount of water intake. Plants that can survive in places where the water supply is limited are called xerophytes. Adaptations shown by xerophytes include the following.

An extensive root system

Xerophytes have roots that are much more developed than the shoot. These roots may go down to considerable depths and/or spread widely to cover a large area for absorption and increasing the chances of trapping deep water supplies.

Reduction of leaf area

Many xerophytes have small leaves with a much-reduced surface area. For instance the try scales which occur in whorls around branches of Casuarina and the cacti spines.

The Spinifex plant is well adapted to desert environments having needle shaped leaves and an extensive shallow root system to take advantage of what little rain falls.

Sunken stomata, leaf rolling, long slender leaf and waxy leaf

In some xerophytes the stomata are sunk into pits or grooves so that there is a space containing moisture air between the stomata and the atmosphere. Xerophytic grass transpiration is further reduced by leaf rolling on dry days, the edges of the leaf curl inwards to form a space containing still air around the stomata. On most days the leaves flatten out. Pandanus species have waxy upper leaves that reflect heat and light energy from the sun, keeping the plant cool as much as possible so that less water is transpired into the atmosphere. Kunai grasses have thin slender leaves that have very little stomata present so less amount of water is transpired into the atmosphere.

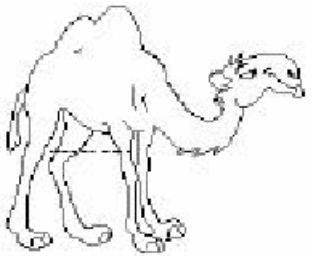
Casurina leaves are long and slender to reduce water loss.

Loose leaves

Many plants loose their leaves to conserve water.

Animals

- Camels developed humps. These humps help them store water to use in the dessert whenever they thirst.
- Rodents and other nocturnal animals roam the desert in the night when the temperature of their surroundings is low. This enables these animals to loose less water.



Reproduction

Some organisms need water for reproduction to occur. For instance frogs and snails need water for mating and fertilization while water lilies need water to transport pollen grains onto the stigma for pollination to occur before fertilization.

Function of the body cells

Water is essential for the normal functions of the body cells. Water aids in the transportation of blood cells, hormones, gas exchange for respiration, digestion and absorption of food matter, and the cooling of the body temperature.

Dehydration occurs when organisms have low levels of water in their body cells. The main sign seen in plants is the withering of the leaves, whilst in animals it is the feeling of thirst. If organisms go without water for along time they will die.

Some organisms have developed ways to overcome the problem of using less amount of water to survive.

In plants

The cacti stores water in its fleshy leaves. Many plants loose their leaves during dry times to conserve water.

In animals

One frog species in the desert goes into hibernation during drought times. Most desert animals sleep during the daytime and become active at night so they don't loose a lot of water. Bacteria, not classified under animals, form protective capsules around them and become inactive while there is no water.

Light

The source of light is the sun. Light travels as electromagnetic waves and has energy. This energy is necessary for photosynthesis. **Photosynthesis** is the process where green plants and other microscopic organisms make food (carbohydrates) using sunlight, water and carbon dioxide.

Some plants thrive in conditions with less intensity of light but many need a lot of sunlight to grow well. Plants that need less sunlight are found to grow in places where there is shade. Plants have adapted to life in tropical forests in various ways.

Ground living plants like ginger usually grow so that maximum area of every leaf is exposed to what light is available. Epiphytes such as lichens, mosses, ferns and orchids grow on tall trees in a position to capture as much light as possible for photosynthesis. Climbers including the rope-like woody climbers such as liana vine may climb to the tops of the tallest trees to reach the light. Their stems often grow very long.

The thickness of the liana stem is usually small compared with its length because there is little need for strengthening tissue. The trees on which it climbs support the liana. The stems of smaller climbing plants like yams are also weak and collapse if removed from their supports.

Plants climb in various ways:

Scramblers

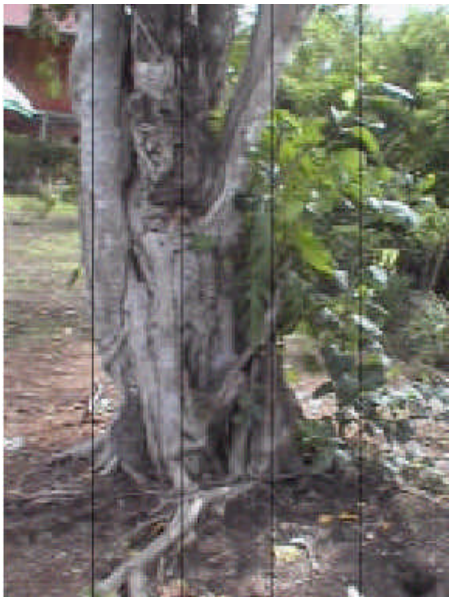
Some plants scramble over other vegetation, often helped by hooks or prickles. Bougainvillea is a good example. It can sometimes get tangled up with other shrubs while scrambling over them.

Twiners

Many lianas, yams and beans twine their stems around a support. The twining is haptotropic and the plants of a particular species always twine the same direction; either clockwise or anticlockwise.

Tendril climbers

Part of the plant may become modified to form a special twining organ. In Bignonia a leaflet, in Glorioso the leaf tip, and in the passion fruit, pumpkins and gourds some of the lateral branches become modified into tendrils. Tendrils respond haptotrepically to contact with support. The basal part coils before actually touching the support. This acts as a spring which prevents the tendril being broken.



The strangling fig is able to establish itself by sending aerial roots to the ground. Eventually the host plant is "strangled" and dies.

Root climbers

Climbing figs, orchids develop aerial clasping roots. These grow tightly again the supporting plant.

Low light environments

Corals and marine plants thrive well in environments where there is lower levels of sunlight. These organisms have adapted to frequencies (colours) of light that penetrate water to depth. Red and orange light is quickly absorbed in the first metre of clear water.

Other animals such as earthworms, snails, leeches, millipedes and centipedes prefer less light and so are found under leaf litter of canopy of trees.

Animals have developed eyesight to adapt to their feeding and behaviour patterns. They need light to see, to hide from their predators, reproduce and feed. Animals such as bats and flying foxes have poor eyesight and do not need much light. They are generally more active at night. Some animals such as the owl have adapted for darkness and have excellent night vision for hunting. These animals are called **nocturnal animals.**

Humidity

Humidity is the state of being humid, moist or damp. The relative humidity is the ratio expressed as a percentage between the amount of water vapour present in the air and the greatest amount the air could contain at the same temperature. A relative humidity of 100% would mean that the air is saturated and cannot hold any more water vapour. This condition is experienced in fog and clouds. A 20 % humidity would indicate very dry conditions. Humidity is important for organisms because it affects the rate at which water evaporates from the skin or respiratory organs of organisms. High humidity also decreases the cooling effect of sweating.

Oxygen and carbon dioxide

All organisms need oxygen for respiration. Respiration is a chemical reaction that takes place in cells of organisms. It is a process where food such as carbohydrate, fat and oils taken in by organisms are burnt with oxygen to give energy for movement.

Without oxygen many organisms would die, yet there are some organisms that can thrive in conditions where there is less or no oxygen at all. How is that possible?

Carbon dioxide is found on land and in water. In water it is in a solution form. Carbon dioxide gas is one of the waste products of respiration yet is necessary for photosynthesis. Green plants use carbon dioxide to photosynthesis Humidity

Humidity is important because it affects the rate at which water evaporates from the surface of an organism.

Wind and air currents

Wind is air in motion. The wind varies in force from a slight breeze to a strong gale. The wind bends branches. Air current is the flow of air can be also referred to as wind.

Wind and air currents do affect organisms. This particularly applies to plants. Only plants with strong root systems and tough stems can live in exposed places where the wind is fierce. Wind

also affects the evaporation rate and is also important for the dispersal of seeds and pollination in some plants.

Physiographic factors

Physiographic factors relate to the physical features of the earth surface. This include the:

The crinoid or sea lilly is a marine animal that has adapted to take advantage of water currents to feed.

1. Water currents

Water current is the flow of water. Running water makes current. Water currents vary is speed. The width and the depth of the river and stream determine the speed of the water current.

Not many organisms survive strong water currents. Only organisms capable of avoiding strong currents can survive in open water. Animals incapable of actively swimming generally live under stones, in burrows and crevices or attach themselves to the substrata.

Pigweed, a natural ground cover, protects the beach from wave erosion.

2. Salinity

Refers to how salty the water is. Organisms that prefer saline environment are found in the sea, while organisms that prefer the non-saline environment live in fresh water. Estuary organisms have special adaptation that enables them to withstand the daily fluctuation in salinity that accompanies the tidal rhythm. Mangroves are an example.

3. Wave action

Wave is the swell of water caused by disturbance in wave action.

Wave actions affect organisms living in intertidal zone. To survive the bombardment of the waves, organisms have adapted by resorting to burrowing into the sand, attaching themselves firmly onto rocks or anchoring themselves firmly into crevices. Small shrimps burrow into sand, oysters attach themselves to rocks, and water lilies anchor themselves firmly onto reef however jellyfishes move with the direction of the current.

During periods of abnormal high tides a creeping ground cover such as pigweed helps prevent the beach from eroding due to wave action. Removing this weed exposes the shoreline to erosion.

4. Topography

Topography refers to the surface feature of a place or region. The topography of a region includes mountains, hills, valleys, streams, lakes, swamps and beach.

Topography also influences how organisms distribute themselves and occupy a part of the environment. This will depend on the differences in illumination, temperature, moisture and soil. For example organisms living in the tree canopy are different from the animals found in the leaf litter. Those that are found in the tree canopy

prefer illumination while those in the leaf litter prefer shade. The topography with beach plants is easy to distinguish. Close to the sea shore are creeping plants, after the creeping plants come the callophyllum species. Further inland are the herbaceous plants.

Aphids being tended by ants on a bean plant. Aphids and scale insects often look like the thorns on a plant and are hard to see.

5. Background

Background is the part of the picture or scenes toward the back of the focused organisms. Organisms can adapt themselves to the background by camouflaging themselves. They could do that by relating to the general texture and pattern of the environment. A stick insect, brown in colour, is well camouflaged against the dry stick it sits on.

Sometimes the background consists of the biotic environment. Aphids may look like thorns.

Edaphic factors

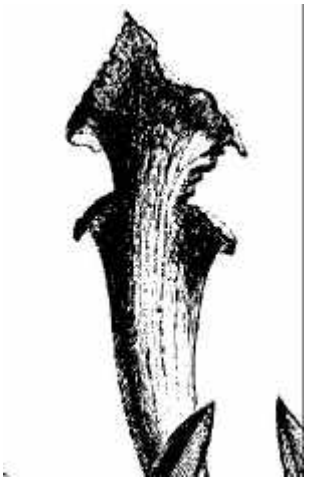
Edaphic factors refer to the influences of soils on plants and animal distribution. This include the:

1. pH

pH is a symbol used (with a number) to indicate how acidic basic or neutral the soil or water is. pH represents the relative concentration of hydrogen (in atoms per litre) in a given solution.

The distribution of plants in soils and fresh water is influenced by the pH. Some plants thrive in acidic conditions; others in neutral or alkaline conditions but most are highly sensitive to changes in the pH.

Pineapples grow well in acidic soils but most vegetables grow in alkaline soil.



Pitcher plants trap insects for food and live in swampy areas with an acid pH.

2. Soil

Soil is the ground or earth. Not all soils are the same. They differ in particle size, mineral composition, and nutrient content, water holding ability, acidity, amount of humus and air

spaces. Loamy soils produce better crops than clayey or sandy soil because it holds water that is readily available, has good aeration, does not crack when it dries out and holds fertilizers longer.

There are also large numbers of microorganisms present in the soil that decompose leaf litter.

3. Mineral salts and trace elements

Minerals have definite properties that can be accurately determined. Quartz, contained in sand, is an example of a mineral. Some soluble salts such as sodium chloride (common salt) are also minerals.

Plants prefer to grow in environments were there are sufficient mineral salts. Plants living in soils with mineral deficiencies have adapted special methods of obtaining nutrients. For example the **pitcher plant,** which grows in waterlogged areas, traps insects for food.

Biotic factors

Biotic factors refer to the influences of the living organisms within a community on each other. Special relationships may influence the distribution and abundance of organisms. These special relationship are described.

1. Feeding

All living organisms need food to survive. Organisms feed in many different ways. The type of food needed by organisms depends on the structure of mouth parts or feeding mechanisms.

- Suckers have mouth parts used for sucking liquid forms
- Rodents have gnawing mouth parts to enable them to shave off food
- Herbivores have chewing mouth parts to break up vegetable matter such as grass
- Omnivores having cutting, tearing and crushing mouth parts to enable them to eat both plants and animals
- Carnivores having tearing mouth parts for ripping apart their prey

2. Predation

A predator is an animal that preys upon other animals. A succession of predations occurs after the first plant eaters.

Herbivores feed on kaukau for food. A good example is the grasshopper. Rodents may also feed on grains and kaukau. Rodents will also eat grasshoppers therefore they can be predators. Cats are predators as they prey on rodents.

The distribution is restricted to what is available in the environment. Herbivores are only found where there is suitable plant food. Grasshopper plagues occur when there is an abundance of grass and grains. A lot of grasshoppers will mean a lot of rodents to eat grasshoppers. Cats prefer rodents for food therefore cats will thrive if there are a lot of rodents such as mice and rats. If the environment has plenty of kaukau more rodents would be seen and consequently more high order consumers.

Grasshoppers are herbivores and are food for rodents.

3. Competition

Competition occurs when organisms have to win or gain something wanted by others for instance food, shelter, water, light, nesting materials, mating partners and even space.

Two types of competition can occur amongst organisms, inter-specific or intra-specific. **Inter-specific competition** refers to organisms of different species competing for the same thing while **intra-specific competition** refers to organisms of the same species competing for the same thing. **Coexistence** is impossible between two different species. The fiercer organisms usually oust the other and have the territory to themselves. This is known as **territorial** behaviour.

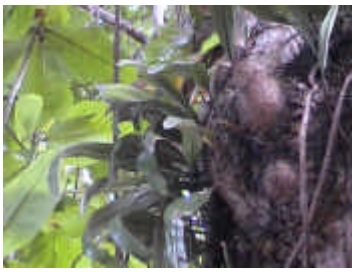
4. Symbiosis/association

Symbiosis is the term often used to mean the association between two species whatever the relationship is between the two.

Some plants and animals develop special relationships with other organisms in order to survive. Relationship between organisms may be **beneficial, harmful** or **neutral** for each organism involved. Relationships could be mutual, commensal, amensal or parasitic.

- **Mutualism** is an interaction between two organisms that is mutually beneficial to both. For instance, the anemone and the anemone fish in the sea benefit from each other as a result live harmoniously together.
- **Commensalism** is an interaction between two organisms of which one benefits while the other is neither benefited nor harmed. For instance, orchids sit on tall trees to reach out for sunlight to photosynthesis. The trees orchids sit on are not affected nor do the trees benefit from the orchids.
- **Amensalism** is an interaction in which one population inhibits the other while remaining unaffected itself. By modifying the environment, the one organism improves its chances of survival. Amensalism usually involves some type of chemical interaction with other organisms. For instance, mushrooms growing on grass kill grass as they multiply in number.

An anemone fish is able to live with a stinging anemone



This fern lives attached to the tree without harming the tree.

- **Parasitism** is when one organism benefits by feeding on a host organism. For instance, white spots on human skin. White spots benefit from humans causing skin itchiness.
- **Predation** is an interaction in which one organism kills and feeds upon another organism. For instance cats kill rodents for food.

6. Mimicry

Mimicry. *Moths (left) are resting on a rotten log. They mimic the bracket fungus (right).*

Mimicry is the act of copying to look almost like the other. Most defenceless organisms' use these mechanisms to closely resemble another species that happens to be the predator by posing distinctive colours or markings that will scare away their enemies.

This small marine crab protects itself with the thorny protrusions in its shell. These make it look menacing to other would-be predators!

A stick insect which appears to be part of the branch or twig.

7. Diseases

Diseases are conditions in which organ systems, or part does not function properly. Diseases spread quickly if there is overcrowding or where organisms are weak. In most cases the strongest and the fittest survive. Pollination and seeds dispersals

8. Pollination and seed dispersal

Pollination is the process of carrying pollen from the anther to the stigmas of flowers for fertilization. Pollination and seed dispersal is usually carried out by animals or wind. Pollination is of two types. One is called **cross-pollination** and the other **self-pollination**. Self-pollination occurs when the ripe pollen from the anther is transferred to the ripe stigma of the flower of the same species. Nature is such that it allows for cross-pollination to occur most of the time. The duration between pollination and fertilization often takes a long time but commonly only a few days.

Some seeds germinate quickly if the conditions are favourable however others can remain dormant for as long as a year if the conditions are poor then germinate if nature cross-pollination to occur most of the time. The duration between pollination and fertilization often takes a long time but commonly only a few days.

Some seeds germinate quickly if the conditions are favourable however others can remain dormant for as long as a year if the conditions are poor then germinate if nature is favourable to them.

☞ Activity E1.2 – Abiotic and biotic factors

1. *Form a group of four (4) made up of males and females. Select one person to be the recorder and another to be the facilitator.*
2. *Each group is to go outside of the classroom to observe and make a list of the **abiotic (climatic, physiographic and edaphic)** and **biotic factors** that have an impact on the environment and how these factors have an influence on the organisms that are present.*
3. *Take readings of the temperature, amount of rainfall, humidity, pH, wind speed and direction by using the measuring instruments provided.*
4. *This exercise is to be done in your own time but it should be ready for class display on request.*
5. *Choose one of the biomes (forest, coral reefs, pond, river, grassland, classroom or etc) and do a research on it.*
6. *Find out what the climatic, physiographic, edaphic and the biotic factors of that biome and then change your text into graphics that could capture the audiences attention.*

Community ecology

Plants and animals do not live singly but are dependent on each other and their surroundings for food, water, shelter and so on. The branch of biology that studies plants and animals relationships with their surroundings is called **ecology.** The abiotic and the biotic factors as mentioned previously make up the **environment** of organisms**.** A **community** refers to the association of plants and animals living together and affecting each other's lives in an obvious feature of the habitat. For example the plants and animals of the sea could be regarded as forming one community, while those under the leaf litter form another.

So **community ecology** is the study of laws governing communities and ecosystems. An **ecosystem** refers to a system of interacting organisms in a particular habitat. For instance how different species of organisms interact in terms of energy flow, food chains, food webs, nutrient cycles, and also the structure of communities, including ecological succession.

Energy flow

All ecosystem whatever they maybe, are affected by the both the biotic and abiotic factors. These all work together to form a balanced, constantly changing unit of nature. To keep this system in place and working, energy is needed. The means through which this is passed on from one organism to another is via food.

All energy from plants and animals whether living or dead originates from the sun. This energy usually captured through the process of photosynthesis by plant eaters, the ecosystem from there hence, forth this energy passes from organism to organism.

Hence the feeding relationship is a good point to start in the study of the ecosystem.

Photosynthesis is important as mentioned earlier, in the process where green plants use sunlight to make their own food. In, the process of making their own food, oxygen is also produced. The essential ingredients for photosynthesis are carbon dioxide and water.

The process can be summered as a chemical equation:

$$\text{Carbon dioxide} + \text{water} \xrightarrow{\text{sunlight}} \text{glucose} + \text{oxygen.}$$

$$6\,CO_2 + 6\,H_2O \xrightarrow{\text{Chlorophyll}} C_6H_{12}O_6 + 6O_2$$

No animals or plants can be said to be truly independent. For a start animals need plants for food and oxygen and through photosynthesis plants produce carbon dioxide for animals.

The food plants make is passed from one organism to another. This transfer of energy is done through the food chain.

Food chains

Food chains always start with primary producers or autotrophs, which in most cases are plants. Plants convert a very small fraction of the Sun's energy to stored chemical energy which is in the form of glucose. This energy is then passed onto herbivores then to higher order

carnivores and then onto even higher order carnivores. The resulting nutrition sequence can be illustrated as below.

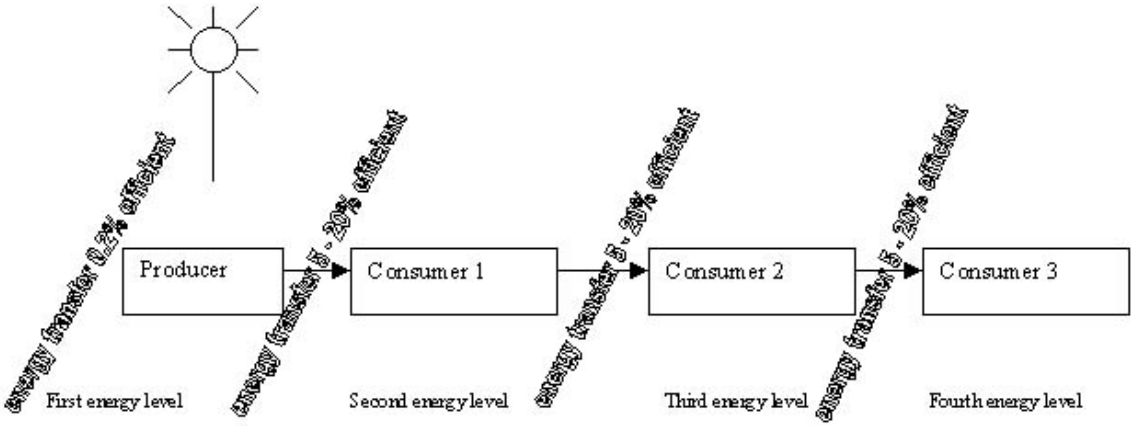


Figure 3. A simplified food and energy chain showing the flow of energy from producer to high order consumers. (Adapted from Biology A Functional Approach)

In general, in any community there will always be green plants, herbivores feeding on green plants, carnivorous animals preying on the herbivores and fungi and bacteria living on organic remains.

The green plants of a community are referred to as the **primary producers** or autotrophs, the animals as the **consumers** and the fungi and bacteria as the **decomposers** and/or parasites: The herbivores are the **primary consumers** and the carnivores can be **secondary consumers or tertiary consumers depending on where the carnivore is on the food chain.** There may be several carnivores in the series, the first being preyed upon by a second and so on. The resulting nutritional sequence is known as a **food chain**.

In general a food chain can be defined as the transfer of carbon compounds, initially produced by plants or other photosynthetic organisms, to other organisms down the line of the food chain. Not all food chains are as long as the one illustrated above. Some are short such as grass to cow to human or from algae to fish to human. There are rarely more than six links in the chain. Each link represents a **trophic level**, trophic meaning feeding.

Food webs

In reality food chains do not exist. Instead more complex feeding relationships occur called a food webs. A food web is formed when two or more food chains are interconnected.

Observations have shown that an animal species cannot feed entirely on one species. For instance grasshoppers feed on taro leaves and aibika, Willie wagtails and lizards prey on grasshoppers, crows feed on lizards while snakes might feed on birds. An example of a food web is illustrated below.

Decomposers and parasites are also have important roles in food webs in absorbing and recycling living or decomposing organisms.

There are basically three types of food webs. They are the grazing food web, detritus food web and the parasitic food web.

Grazing food web

The most familiar food web is the grazing food web.

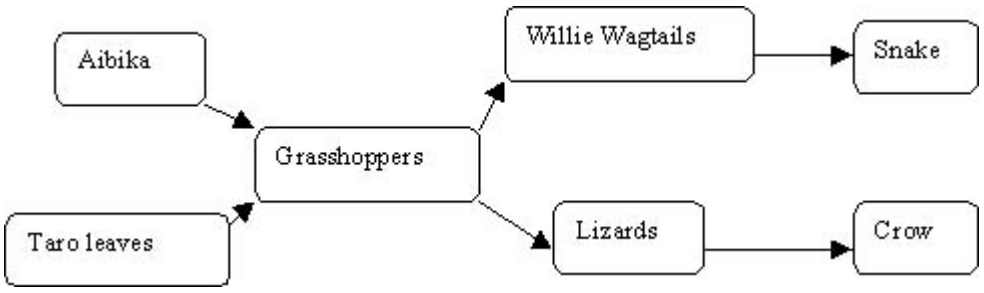


Figure 4. An illustration of a grazing food web

Detritus food web

Foodwebs consisting of decomposes are referred to as the detritus food web. Decomposers can be saprophytes or bacteria.

Saprophytes are fungi. Examples are moulds, mushrooms and mildew.

Decomposers do not have any special mouth parts. They secrete enzymes onto dead organic matter and absorb the nutrients into their bodies. The enzymes they pass out of their bodies help break down organic matter.

Bracket fungus breaks down the organic matter in this dead tree.

Parasitic food web

Parasites are organisms that depends on their host for food. Lice, leaches are some saprophytes while grille, white spot and rust are examples of parasites.

A complete ecosystem of any kind takes into account the three food webs and should appear as illustrated in figure 5.

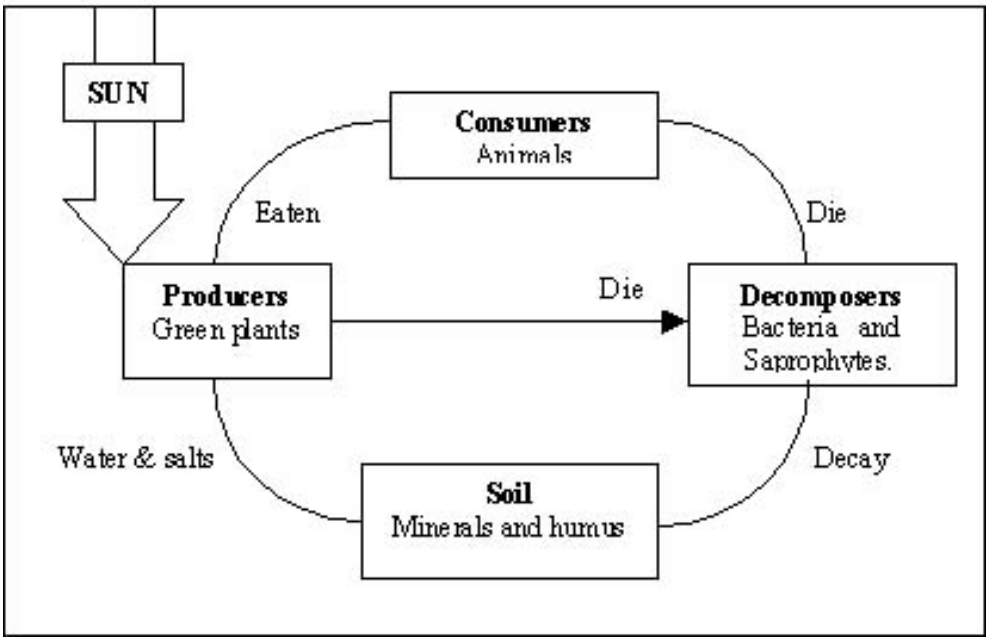


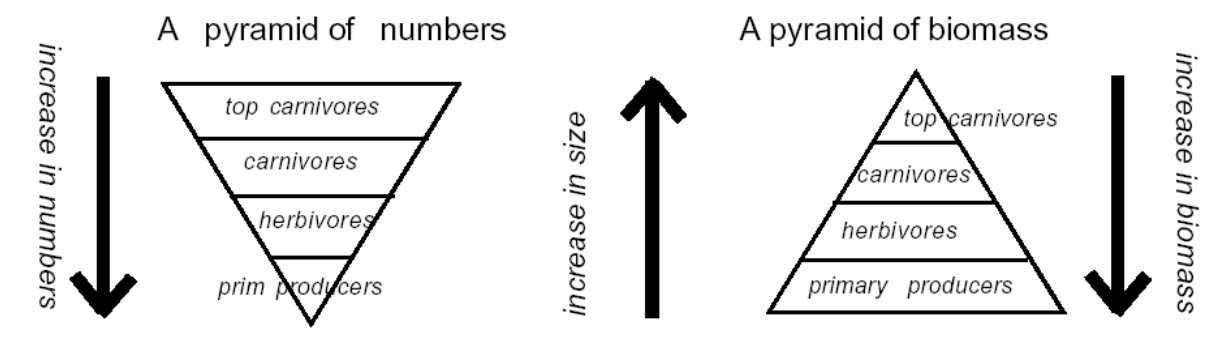
Figure 5. An illustration of the relationships between different food webs in an ecosystem.

Ecological pyramids

The diagram below shows what happens to the food chain as the biomass increases. Two things are obvious:

1. The trophic level decreases.
2. The number of organisms decrease while the size increases.

The latter even though true can be contradictory if the dry masses or biomass of organisms is taken into account.



A pyramid of numbers shows that there are less numbers of primary producers few herbivores and more consumers.

A pyramid of biomass on the other hand shows that primary producers weigh the most followed by herbivores and lastly carnivores.

Scientists prefer to use pyramids of biomass more then the pyramids of numbers because the dry masses of organisms in each trophic level when combined and weighed gave the correct amount of matter (g/m). This idea also amounts for the availability of energy.

Ecological energetics

A closer look at different trophic levels up the food chain would give the shape of the pyramid of biomass.

The transferral of materials up an ecological pyramid is a continuous process rather than static; energy flowing through the different trophic levels is replaced by the energy provided by the sun. Thus the energy flowing through an ecosystem theoretically should be in a state of equilibrium. The study of energy flow through an ecosystem and the factors involved is called Ecological energetic.

Since the energy flow is continuous through an ecosystem, energy which leaves an ecosystem is termed **export** and energy which enters is known simply as **import.**

The type of diet of animals depends on the type of mouth part. Animals that have chewing mouth parts feed on green plants therefore are called **herbivores**. Animals that feed on other animals have tearing mouth parts therefore are called **carnivores** and those that feed on both plants and animals for are called **omnivores**.

Nutrient cycles

Nutrients important for organisms include saprophytic nutrition, parasitic nutrition, carbon dioxide, oxygen and nitrogen cycle.

The carbon cycle

Green plants use up carbon dioxide in the air to photosynthesis, yet the amount of air in the atmosphere remains at about 0.04%. This is because carbon dioxide is being returned to the air by most organisms as a result of respiration.

Oceans also play an important part in regulating the amount of carbon dioxide in the air. Carbon dioxide is slightly soluble in water and huge amounts of the gas are dissolved in the oceans. When there is little carbon dioxide in the atmosphere, more is released from solution in the sea, and where there is much in the atmosphere, more dissolves in the sea.

The oxygen cycle

Closely connected to the carbon cycle is the **oxygen cycle**. Oxygen used up in respiration and combustion is returned to the environment by photosynthesis. The atmosphere contains a " pool" of oxygen as it contains a "pool" of carbon dioxide. A natural balance exists between the oxygen that is drawn from the atmosphere, and that which is added to, as a result the pool maintains the oxygen in the atmosphere at a steady level.

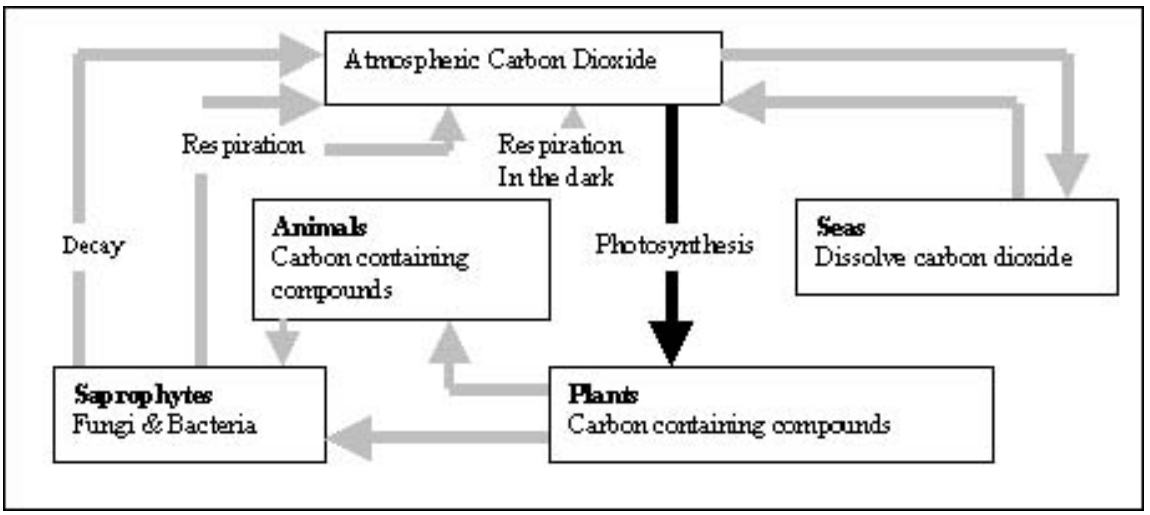


Figure 6. An illustration of the carbon cycle. Adapted from New Biology for Tropical Schools

The nitrogen cycle

1. Nitrogen is constant circulation between **autotrophs, heterotrophs,** the s**oi**l and the **atmosphere**. Plants absorb nitrogen in the form of **nitrates** and **ammonium salts**, and use it to manufacture the **proteins** they need. Animals obtain the nitrogen they need by eating either plants, or other animals that have eaten plants. At death plants and animals fall egestion and excretion, the nitrogen of plants and animals is returned to the soil. This takes place in a number of stages.

1. The proteins and the other organic nitrogenous compounds are broken down into inorganic ammonium salts, carbon dioxide and water. Many types of **saprophytic soil bacteria** and **fung**i take part in this process of decay, which is their method of feeding and containing energy.

2. One group of soil bacteria obtains energy by **oxidising ammonium salts** to **nitrites** while a second group **oxidises nitrites** to **nitrates**. The activities of these nitrifying bacteria are important because nitrogen is mostly taken up by plants as nitrates. Plants also use ammonium salts but not nitrites that are toxic to them. This conversion of ammonium salts to nitrates is called **nitrification**. In very acid soils or in waterlogged soils, that are short of oxygen, nitrification does not take place easily.

3. The nitrogen cycle is more complicated because it also involves atmospheric nitrogen. However in a process called **denitrification** also occurs where certain bacteria and fungi reduce nitrates in the soil to gaseous nitrogen thus lessening the amount available to plants. The denitrifying bacteria are especially active in soils such as badly drained soils which are short of oxygen. Also as a general rule the higher the temperature of the soil the more active the denitrifying bacteria become compared with the nitrifying bacteria. This is also one reason why tropical soils tend to contain little humus and are poor in nitrogen levels.

4. Nitrogen dioxide released from volcanic action eventually ends up in the atmosphere.

5. Nitrates are also lost from the topsoil by **leaching**.

6. **Nitrogen fixation** is the process by which combined nitrogen is added to the soil from the free gaseous nitrogen in the air. It is carried out by **nitrogen fixing bacteria** that can make proteins using carbohydrates and gaseous nitrogen. Some of these bacteria live on their own in soils and obtain their carbohydrates from the humus. Others live in swellings or **nodules** on the roots of **leguminous plants** like beans and peanuts. These plants obtain nitrogenous compounds from the bacteria. Soils generally become richer in nitrogen as a result of having grown leguminous plants in them.
7. During **thunderstorms** nitrates are also added to the soil. The energy of the lightning discharge causes tiny amounts of oxygen and nitrogen in the air to combine to form **nitrogen dioxide** gas. This gas dissolves in raindrops to form **nitrous** and **nitric acid**. Thus the rain that falls during a thunderstorm is really a very dilute solution of acid that enters the soil and combines with the metallic parts of salts to form nitrites and nitrates.

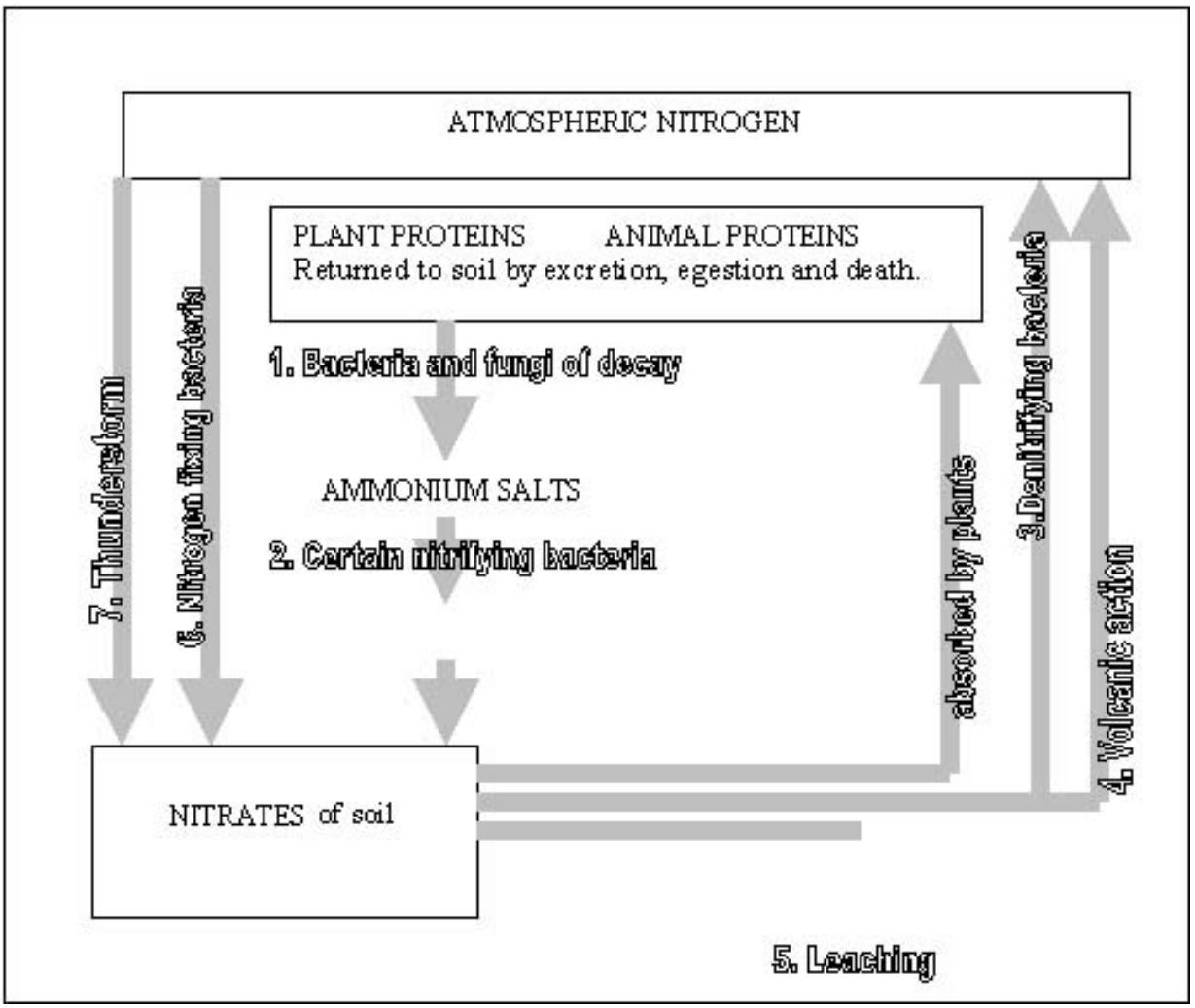


Figure 7. An illustration of the nitrogen cycle Adapted from New Biology for Tropical Schools: A Functional Approach to Biology

☞ Activity E1.3 – Nutrient cycles

1. *Redraw the carbon cycle using actual examples of PNG plants and animals.*
2. *Explain why there is constant percentage of oxygen and carbon dioxide in the earth's atmosphere.*
3. *Describe the importance of nitrogen gas in the atmosphere, to plants and the other benefits to modern agriculture.*
4. *Define the following words:*
    - Nitrification
    - Leaching
    - itrogen fixation
    - Denitrification

Ecological succession and the structure of communities

Ecological succession refers to a series of developments whereby specific groups of living organisms colonise an ecosystem over a period of time until the ecosystem becomes **stable.** At each stage in this gradual evolution a dominant species can be recognised. This then influences the environment in such a way as to make it suitable for another species which then replaces previous ones as the dominant species and so on. As new plants move in and develop so too do the animal species. A stable ecosystem is one that has diverse plant and animal species because it has reached a **climax** and succession has stopped. A climax community is stable and will not change unless there is a major change in the abiotic and biotic factors of the environment.

A good example of succession may be seen where there has been recent volcanic eruptions such as on Mt Vulcan.

Gardens also represent a dramatic change to an environment particularly where the natural forest has been slashed and burned. It is natural for succession to occur.

Some of the abiotic factors that may suddenly cause a destabilisation of a stable ecosystem include:

- Volcanoes
- Erosion
- Sedimentation
- Landslides
- Flooding
- Earthquakes
- Forest fire

- Cyclones and
- Prolong drought.

Likewise, the abiotic factors include:

- The introduction of new species by humans into the environment.
- Human activities (farming and forestry)

The size of animal population is largely controlled by its food supply and by the organisms that prey on it. These are called **limiting factors**. The population of each species in a settled community remains fairly constant because of the ways the different species react upon one another.

For example in the large kaukau garden the following scene amy be observed:

> Rodents begin to increase suddenly followed by an increase of hawks. The hawks help to minimise the rodent population. The kaukau plants increase and the hawks would then look elsewhere for another food source until the rodents become plentiful again. The cycle may continue like this until a major disruption occurs. Stable communities like this are sometimes called **balanced communities**.

There are two types of successions. One is called the **primary succession** while the other is called the **secondary succession.** Primary succession occurs when the first organism colonises a barren area. Examples of barren areas include large rocks exposed in the sun, volcanic ash after an eruption and a new volcanic island. Usually the first colonisers that invade and inhabit these places are microscopic organisms followed by plants such as lichens and algae and eventually other complex plants and animals.

Secondary succession is the secondary growth of organisms from once fully established ecosystems. The secondary growth may occur in an area previously occupied by a community that been partially or completely destroyed. Examples of secondary successions can be seen along road sides, abandoned gardens and old airstrips.

☞ Activity E1.4 – Succession excursion

1. *Visit an area where a natural or human event has drastically changed the natural environment.*
2. *For that event, describe the change and the effects on the living environment.*
3. *Through reading and/or field studies investigate the order of succession for that area.*
4. *Illustrate the changes using field sketches and collected data and observations.*

GLOSSARY

Abiotic Factors	These are the non living things that have an impact of organisms
Autotrophs	Primary producers
Biogeographical regions	These are the main continents of the earth where life is found
Biomes	Specified areas, e.g., Tundra, pine forests, woodlands, deciduous forests, temperate rainforests, tropical rainforests, savannah, grassland and deserts. The same biomes have similar climate and similar vegetation types although the major species which constitute these communities vary within biomes depending upon altitude, species diversity and the distance from their major source of colonists.
Biosphere	The part of the earth sphere where life exists
Carnivores	Animals that eat other animals for food
Clear felling	Cutting down of virtually all trees
Climatic Factors	Physical factors such as temperature, light, wind, water and air currents and humidity
Coexistence	Organisms living together and sharing a habitat
Crop rotation	Method of cultivation when a piece of land is divided into a number of plots and the same piece of land is used over and over again by moving the crops around
Decomposers	Organisms that feed on decaying matter for nutrition
Denitrification	Reduction of soil nitrates into gaseous nitrogen. This lessons the amount available to plants
Ecological niche	Sometimes referred to as the ecological situation in which organisms are able to exist
Ecological succession	Refers to a series of development whereby specific groups of living organisms colonises an ecosystem at any one time over a period of time until the ecosystem becomes stable
Ecology	Study of living organisms interacting with each other and their surroundings
Edaphic Factors	The influence of soil on organism distribution
Egestion	Process by which the soluble parts of the food are discharged from the body as faeces
Emergent trees	Trees that tower above the forest canopy
Environment	All the conditions necessary for an organism to live

Food chain	Refers to the feeding sequence of organisms. The sequence starts with producers followed by herbivores, that feed on producers, and they in turn are eaten by the carnivores.
Food web	Refers to the interconnection of feeding relationships between organisms
Global warming	Warming of the earth's atmosphere to higher temperatures than considered normal. This is considered to be due to excess gases such as carbon dioxide and methane.
Green house effect	The natural heating of the earth's atmosphere and trapping of heat due to the conversion of ultraviolet light to infra red within the earth's atmosphere
Habitats	A place where organisms live
Herbivores	Animals that feed on plants for food
Heterotrophs	Consumers that feed on either plants or other animals for food
Humidity	The amount of water vapour in the atmosphere expressed as a percentage of the total capacity at a particular temperature
Inter cropping	Smaller trees are planted between larger trees. For example Luciana trees are planted between cocoa trees.
Inter specific competition	Competition that exists between two different species of organisms for food, shelter and etc …
Intra specific competition	Competition that exists between organisms of the same species for food, water, shelter and etc …
Leaching	Is the dissolving and washing away of essential nutrients vital to plants
Leguminous plants	Plants that usually have swellings on their roots. Examples are the peanuts and beans which are good sources of organic nitrogen
Limiting factors	Factors that control the population size of organisms. The factors could be food, resistance to diseases, competition, etc.
Mesosphere	A region of the atmosphere, based on temperature, that lies between 66 and 970 km in altitude. The temperature then decreases rather uniformly to a temperature of about -95^{o}C.
Mimicry	Copy another organism's markings, structure or behaviour to avoid detection or take advantage of the habitat
Mix cropping	A garden where more than one type of crop species is planted in the same piece of land during a season
Nitrification	The conversion of ammonium salts to nitrates

Nitrogen fixation	Process by which nitrogen is added to the soil from the free gaseous nitrogen in the air
Nitrogen-fixing bacteria	Bacteria that can make proteins, using carbohydrates and gaseous nitrogen in the air
Nodules	Swellings containing nitrogen-fixing bacteria in the roots of leguminous plants
Omnivores	Animals that feed on both plants and animals for food
Open cut mining	Mining the earth's surface with an open pit
Ozone	Layer of gas (O_3) found in the stratosphere that absorbs and converts most of the harmful ultraviolet rays from the sun
Parasites	Either plants or animals that live off other organisms for nutrients harming them as a result
pH	Refers to alkalinity or acidity of soil or water
Physiographic factors	Physical features of the earth's surface. This includes water current, salinity, topography, and background of organisms such as forest.
Primary succession	Occurs when the first organisms invade and colonise a barren area
Producers	Usually plants, e.g., algae, grass
Salinity	Refers to the amount of salt (sodium chloride) dissolved in water or contained in a soil sample
Saprophytes	Mainly fungi which feed on decaying matter
Secondary succession	Areas that are fully established and when cleared can have secondary growth of organisms
Selective Logging	Selected species or sizes of trees that are logged
Stratosphere	Is the second layer of the atmosphere above the earth's surface. The temperature is constant at around -57^0c. This zone contains high speed horizontal winds called the jet streams which can assist airplanes.
Thermosphere	The third layer of atmosphere above the earth's surface. Because this layer of the atmosphere is closest to the sun the temperature is the greatest.
Topography	Refers to how organisms distribute themselves in an environment and occupy the environment depending of what kind of abiotic factor they prefer the most what kind of organisms are found
Trophic Level	The level of energy at which organisms feed
Troposphere	The first layer of atmosphere closet to the earth. This layer contains most water vapour, dust and clouds in the atmosphere and is the main influence of weather on earth.
Under ground mining	Mining done under the earth's surface by means of tunnels and shafts

Understorey	Plants growing beneath the main trees
Zones	Subdivisions within biomes.

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