Biology

Year 1

SECTION

5

ECOLOGY

DIVERSITY OF LIVING THINGS AND THEIR ENVIRONMENT

Ecology

INTRODUCTION

In this section, you will cover fundamental aspects of ecology, including defining key terms such as ecology, ecosystem, habitat and factors like biotic and abiotic elements. You will then identify and study a variety of ecological habitats. Throughout the section, you will see a progression from understanding interdependency in habitats to studying ecological tools for population estimation and methods for determining energy flow within ecosystems. Discussions in the later part of the section will focus on the relevance of different energy flow determination methods, and energy flow. These lessons are meant to equip you to understand ecological concepts as they apply to different habitats. Such skills are vital for advising ecologists and contributing to environmental management, particularly in Ghana. Moreover, the acquired knowledge and skills will prepare you for further studies and eventually integrate you into the workforce, enhancing your capability to analyse and contribute to ecological research and environmental conservation efforts.

At the end of this section, you will be able to:

- Demonstrate knowledge of various ecological terms
- Demonstrate the importance of ecological concepts in named habitats.
- Analyse the interdependency of living organisms in their named habitats.
- Explain the outcome of the interdependency of living organisms in their environment.
- Explore ecological tools and sampling techniques for estimating population size and density.
- Distinguish between the direct counting, gut examination and radioactive/tracer methods of determining the flow of energy in an ecosystem
- Explore the methods of determining pyramids of numbers, biomass and energy, and compare the efficiency of energy flow in them.

Key ideas

- Ecology includes interactions among plants, and animals and between plants and animals. Also includes interactions between living things and their environment (abiotic factors).
- Abiotic factors are the non-living components of the environment. Abiotic factors can further be grouped into edaphic factors (e.g. soil pH), physiographic factors (e.g. hills) and climatic factors (e.g. rainfall).
- Biotic factors are the living components and their effects on other living things in the environment.
- Living things coexist and interact with each other and non-living things in their environment, resulting in a stable ecosystem/unit.
- Living things depend on each other for food, shelter/ habitat, transportation, protection, reproduction/multiplication.
- The impact of human activities in the habitat can disrupt the interdependency of living things leading to the destruction or loss of biodiversity.
- Flow of energy in an ecosystem may be determined using techniques such as direct counting, gut examination, and radioactive/tracer.
- Direct counting is often used for initial assessments or in simpler ecosystems, Gut examination works well for studying predator-prey interactions and Radioactive/tracer methods offer a more precise way to track energy flow through complex food webs.
- The pyramid of numbers, the pyramid of biomass and the pyramid of energy are the ecological pyramids used to determine the flow of energy across trophic levels.
- The pyramid of numbers is the least accurate method, and the pyramid of energy is the most accurate method.
- **Pyramid of numbers**: it is a diagrammatical representation of the total number of individual organisms at each trophic level in a food chain of an ecosystem where bars/blocks represent each trophic level
- **Pyramid of biomass**: it is a diagrammatical representation of the biomass of organisms in each trophic level in a food chain of an ecosystem.
- **Pyramid of energy**: it is a diagram that shows the flow of energy from one trophic level to the next in an ecosystem.

- The **amount of energy** at the base is higher/greater and reduces as you move up the pyramid.

ECOLOGY AND THE VARIOUS ECOLOGICAL TERMS

Living things, micro or macro do not exist independent of others. The interdependence on each other is seen in the various ways in which living things interact among themselves and with their environment. This interdependence brings a balance or harmony to nature. The branch of biology that studies these interactions among living things and their environment is ecology.

This is the branch of biology that deals with the scientific study of the interactions between organisms and their environment. It may also be defined as the study of plant and animal life in relation to the physical and biological environment. The physical environment refers to the non-living (abiotic) components that surround us, while the biological environment refers to the living components that surround us i.e. plants and animals as well as microbes. These make up the biotic factors / components.

Fundamental concepts in ecology (ecological terms)

Fig.5.1: An ecosystem

These are ideas or terms that give a better understanding to the study of ecology. They include:

1. **Ecosystem:** this is the interaction among living things and their environment at a particular place. Ecosystems exist in all habitats. Fo example aquatic ecosystem (ponds, rivers and coral reefs) and terrestrial ecosystem (rainforests and grasslands).
2. **Biosphere:** this is the part of the earth and its atmosphere where life exists. It includes the atmosphere (air), hydrosphere (water) and lithosphere (land).
3. **Biomes:** these are large natural areas of ecosystems with particular climates. The distinctive climate there influences the kind of flora and fauna found there. Examples of biomes are the tropical desert, rainforests, savanna grasslands and tundra.
4. **Abiotic factors:** these are thee non- living physical and chemical components of an ecosystem such as sunlight, temperature, water, soil, air and nutrients.

5. **Biotic factors:** these are all the living components and their products that affect other living organisms of an ecosystem. It includes all the plants, animals, fungi, micro - organisms and the activities of humans.
6. **Population:** is a group of individuals of the same species living in a specific area.
7. **Community:** a community is group of different populations of organisms living together and interacting in the same ecosystem. Members of a community depend on each other for food.
8. **Species:** this refers to a group of organisms that can interbreed and produce offspring capable of reproduction.
9. **Habitat:** a habitat is a specific place within an ecosystem where an organism can live successfully. In other words, it's the natural home of an organism.
10. **Niche:** a niche describes the location and function of an organism within its habitat or ecosystem. It includes how the organism uses resources, interacts with other species and responds to environmental conditions. E.g. pollinators, predators and decomposers.
11. **Food chain:** a food chain is a linear sequence of organisms existing in any ecosystem through which energy and nutrients are transferred. In other words, it's a linear feeding relationship between organisms in an ecosystem. A food chain shows how energy flows or is circulated within an ecosystem.
12. **Food web:** it's a complex feeding relationship between organisms in which some organisms may be part of more than one food chain. It can also be defined as a network of organisms in an ecosystem which directly and indirectly depend on each other for food.
13. **Autotrophs (producers)**: these are usually green plants or some bacteria which are capable of producing their food either through photosynthesis or chemosynthesis. Producers begin food chains /webs.
14. **Heterotrophs (consumers):** these are organisms that obtain energy by feeding on other living things. Consumers may be classified as:

    i. **Herbivores**: are primary consumers because they feed on plants: example goat and horse.

    ii. **Carnivores:** feed on other animals. They are secondary or tertiary consumers. E.g. lion and cheetah

    iii. **Omnivores:** feed on both plants and animals. E.g. human beings, birds and bears.

iv. **Decomposers:** feed on/break down dead organic matter, thus causing nutrient recycling in the ecosystem. E.g. bacteria and fungi.

15. **Predators:** are organisms that hunt, kill and feed on other organisms (prey) for food. The activities of Predators ensure population size of prey is regulated to maintain a balance in the ecosystem.
16. **Prey:** are organisms that are hunted and fed upon by other animals. Prey serves as a means for energy transfer to predators in food chains. e.g. deer.
17. **Competition:** this is interspecific (between species) or intraspecific (within species) struggle for resources such as food, shelter, mates and water, which ensure survival.
18. **Symbiosis:** this refers to a close and long-term interaction between two different organisms living in close physical association with each other. The three main types of symbiosis are parasitism (one species benefits at the expense of the other), commensalism (one species benefits while the other is unaffected) and mutualism (both species benefit from the relationship).
19. **Biodiversity:** refers to the variety and variability of life on earth. This also includes the variety of species in a particular place within the ecosystem.
20. **Ecological succession:** refers to the orderly series of species replacement. It can also be explained as the process of change in the species composition and community structure of an ecosystem over time.
21. **Primary succession:** this process takes place in areas where there have been no previous communities, such as on a bare rock, sand dunes or the wall of an abandoned building. On a bare rock, for instance, pioneer plants such as lichens may colonise the area, paving the way for other plant and animal species. Primary successions often proceed very slowly.
22. **Secondary succession:** secondary succession occurs in habitats that have been disturbed, as in abandoned croplands, unused railways, ploughed grasslands, or forests damaged by storms or timber harvesting. Secondary succession often proceeds faster than primary succession partly because secondary successions are often closer to sources of colonisers, and partly because the effects of the previous communities have not been wholly erased.
23. **Ecological footprint (EF):** this measures the total area of land and water needed to support an individual's or population's lifestyle. This includes resource consumption (food, energy, and materials), waste generation and carbon emissions.

24. **Carbon footprint (CF):** this specifically focuses on greenhouse gas emissions, mainly carbon dioxide resulting from human activities such as burning fossil fuels, transportation (cars) and industrial processes.
25. **Conservation:** refers to the effective utilisation and protection of natural resources to ensure a perpetual supply. This includes maintaining the health and function of ecosystems and biodiversity for present and future generations.

Activity 5.1

Visit an ecosystem (e.g. grassland, forest or wetland) in your school or community.

1. Observe and record data on the ecosystem's :
   - **a.** biodiversity (populations and habitats)
   - **b.** food chains and webs
   - **c.** abiotic factors e.g. soil type and climate
2. Compare your data with those gathered by your friends from other ecosystems.
3. If there are differences, what do you think accounts for those differences?

Ecological Concepts In Some Major Habitats

Ecological concepts help us understand the intricate relationships between living organisms and their surroundings. It encompasses various principles and ideas related to the interactions between organisms and their environment. Some of the major habitats and the ecological concepts at play there are:

1. **Grasslands:** grasslands, whether savannas, steppes or prairies support a diverse range of plant and animal species adapted to grassy environments. The grazing dynamics of animals also play a crucial role in controlling the grass population through herbivory. Again, grasslands are often maintained and revived by either natural or human-induced fires. This helps to maintain the ecosystem by preventing the invasion of tree species and triggering the growth of grasses adapted to resist fires.

Fig 5.2: Grassland

2. **Deserts:** the harsh and extreme conditions of temperature (heat and cold), scarcity of water and high light intensity make the concept of adaptation of great significance in desert habitats. There are deserts that are hot and dry, and those that are cold and dry. Organisms found in the desert have evolved various adaptations such as water conservation, heat resistance and nocturnal in order to make do with the almost non-existent resources. Also, desert plants (xerophytes) like cacti and succulents have thick fleshy stems with leaves reduced to spines to store water and reduce water loss by transpiration respectively. Indeed, the availability of water in desert habitats to a large extent determines the type of plants and animals that inhabit it. Again, desert ecosystems are fragile and vulnerable to disturbances due to low biodiversity.

Fig. 5.3: Desert land

3. **Forests:** the concept of species diversity is evident here, as the forest habitat hosts an incredible variety of plants, animals and microorganisms, fostering a closely knit mutualistic relationship between various species found there. For example, many plants depend on specific animals for pollination and seed dispersal, while those animals in turn depend on the plants for food and shelter. Decomposition is another vital ecological process that takes place in the forest. The remains of dead plants and animals are broken down by decomposers such as fungi and bacteria, thus bringing about nutrient recycling in the ecosystem. Also, the canopies of emergent plants serve as nesting places for arboreal organisms such as birds and other tree species. The concept of a food web is crucial here as forests host a complex network of organisms that rely on each other for food. Forest ecosystems undergo ecological succession. This is seen in changes in species composition over time. Again, forests play a role in carbon sequestration.

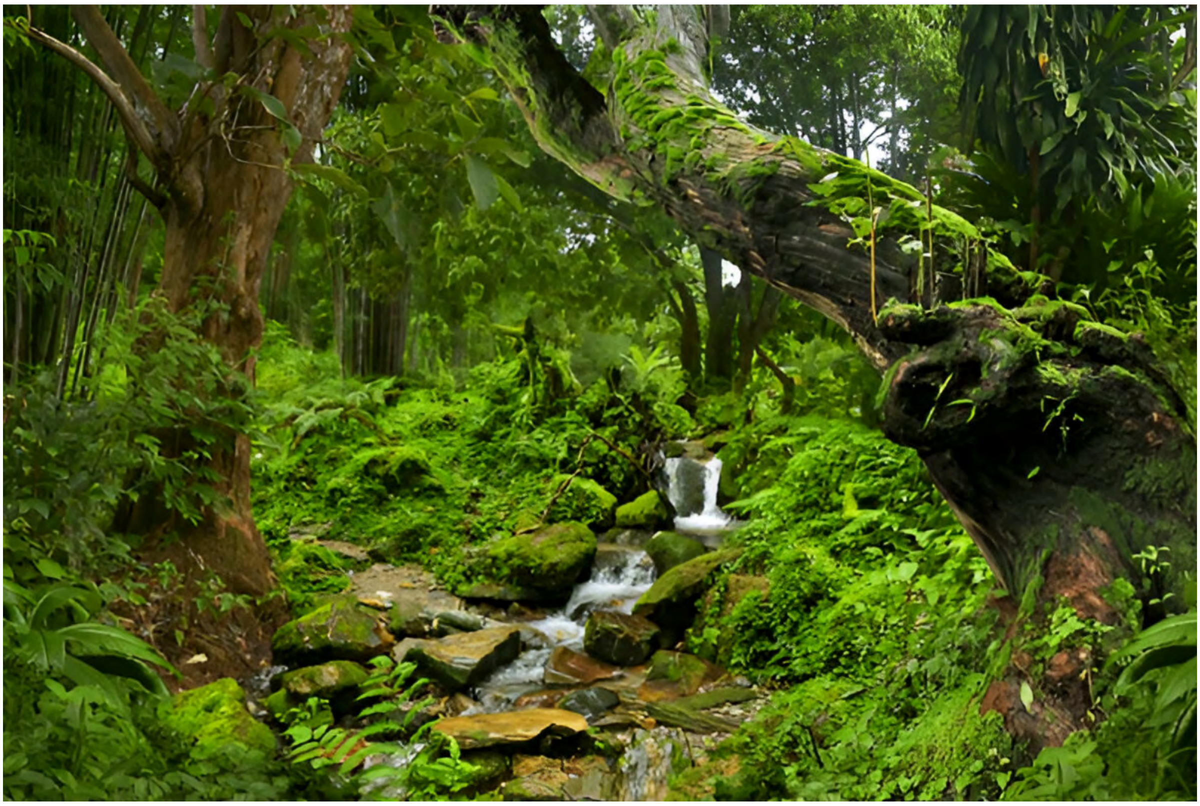

Fig 5.4: A Forest

4. **Freshwater bodies:** freshwater bodies such as rivers, lakes, ponds and streams are so named because of their low salt concentration. Riparian zones, which is the interface between aquatic and terrestrial environments in freshwater bodies support unique biodiversity and ecological functions. These are vital components of freshwater ecosystems because they provide

habitat, food and shelter for various species. The vegetation plays a crucial role in checking erosion at the banks. Interactions among aquatic organisms for instance, algae and aquatic plants result in the provision of oxygen and food for other aquatic organisms through photosynthesis. Herbivorous species like certain fish and invertebrates use these primary producers as food. Another outcome of the interaction is predation and decomposition.

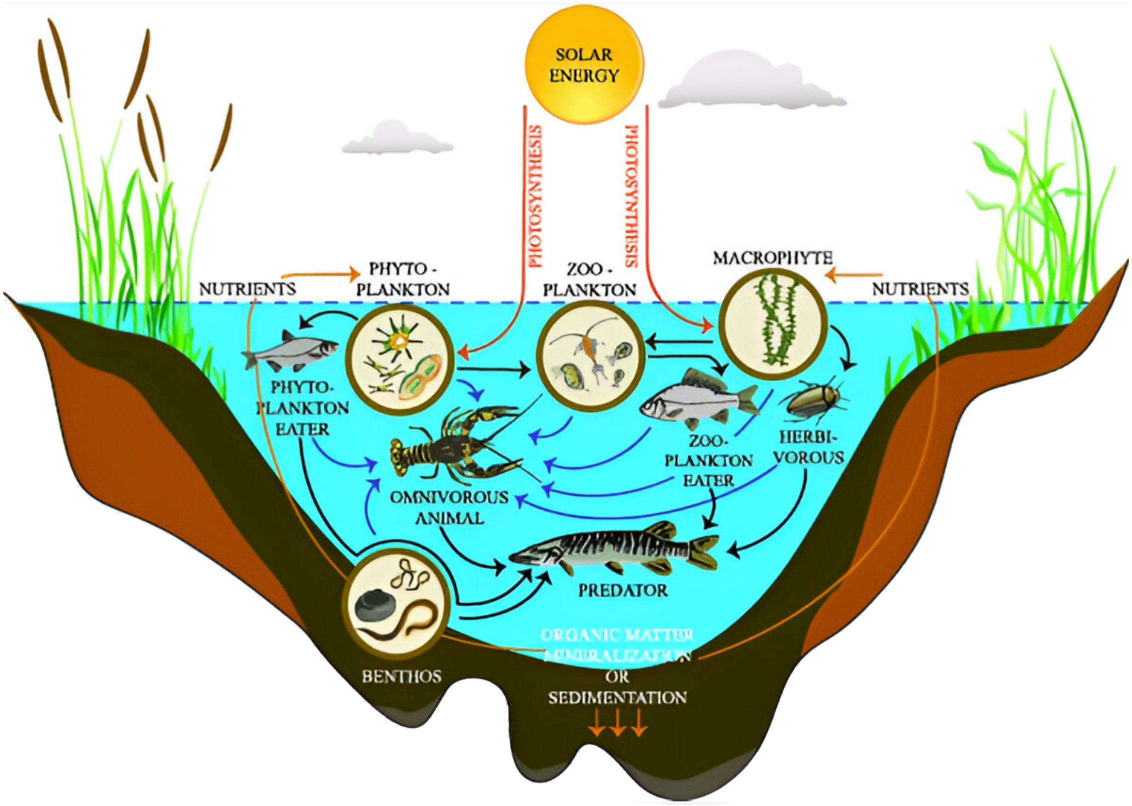

Fig 5.5: Freshwater body

5. **Arctic Tundra:** this habitat is a cold treeless biome found in the high-latitude regions of the world. Permafrost (permanently frozen subsoil) is a critical ecological concept in this type of habitat as it influences hydrology (availability of water) and the type of plants that can grow in that environment. Another critical concept is the impact of climate change on the fauna (animal) and flora (plant) communities, and the likelihood of releasing stored carbon which could make room for global warming. Warm temperatures can lead to melting of permafrost which can potentially influence the vegetation and wildlife shifts. The concept of climate change somewhat gives rise to the concept of seasonal migration of animals such as birds and caribou in the arctic tundra. These animals undertake long-distance migration in search of food and suitable breeding grounds. Another important concept worthy of note in the arctic tundra is the adaptations exhibited by the different species

for cold temperatures, having short growing seasons and also nutrient availability.

Fig. 5.6: Arctic Tundra

6. **Mangroves:** mangroves are unique coastal ecosystems found in tropical and subtropical regions. Mangroves serve to create conducive grounds or nursery habitats for various fish species as well as some marine organisms such as crustaceans. The complex root systems create a safe haven and also shelter, thus helping to conserve a host of aquatic life. Mangrove ecosystems also act as buffer zones against storms, tsunamis and tidal surges, thereby reducing the impact of coastal erosion and protecting communities and properties. Again, mangrove plants are adapted to high salinity tolerance and tidal changes to enable it to survive in that environment.

Fig.5.7: Mangrove

7. **Coral reefs:** Coral reefs are known to be among the most biodiverse ecosystems, playing host to a wide array of marine species and symbiotic relationships hence making it a biodiversity hotspot on earth. The symbiotic relationships between corals and algae (*Zooxanthellae*) are critical to the survival of these habitats. The coral provides a safe home for the algae which in turn supply nutrients to the coral through photosynthesis. Competition also plays a major role in coral reef ecosystems. Competition for limited resources including space, light and food can be observed among various species, corals and other marine organisms.

Fig. 5.8: Coral reefs

8. **Mountains:** mountain ecosystems are composed of a wide range of habitats and altitudes zonation. The concept of altitudinal zonation is prominent as mountain ecosystems exhibit distinct vegetation zones based on altitude (height), temperature, precipitation, soil differences and oxygen levels. Different vegetation and wildlife are adapted differently owing to the variations in climatic factors at different altitudes. Mountains also play a crucial role in maintaining water supply as they capture and store water which is gradually released downstream, contributing to river flow and also supporting downstream ecosystems and human communities. Erosion processes is another concept affecting mountain habitats. Mountain landscapes are shaped by erosion processes such as glaciation, landslides

and changes in river dynamics. Mountains also show endemism in that they harbour endemic species which are adapted to specific altitudes and microclimates. E.g. Togo slippery frog (*Conraua derooi*).

Fig. 5.9: Mountains

9. **Glacial habitats:** glacial environments are characterised by wide areas/ expanses of ice and snow with extreme cold temperatures and little vegetation cover. An important concept in this type of habitat is glacier retreat and its impact. Glacier retreats due to climate change affects downstream water availability, biodiversity and ecosystem changes as well as human activities. The meltwater of glacial habitats supports specialized flora and fauna including microorganisms, algae, invertebrates and sometimes larger organisms like birds and mammals such as the polar bear. Glacial lakes, ice caves and ice balls are also features which contribute to the overall biodiversity of these ecosystems.
10. **Wetlands:** wetlands can be viewed as a bridge between terrestrial and aquatic habitats. The key ecological concepts that can be observed in this type of habitat are water filtration, hydrological functions and biodiversity hotspots. Wetlands act as natural filters, removing pollutants and excess nutrients through processes like sedimentation thus helping to maintain water quality. Also, wetlands play a key role in regulating water flow, which

directly influences the types of plants and animals that can survive in these areas. Again, the hydrological functions of wetlands help in flood prevention as they act as reservoirs for run-off water. Wetlands also support diverse plant and animal species including migratory birds and amphibians owing to the rich supply of nutrients and nesting areas during long-distance flights thus making these habitats biodiversity hotspots. Furthermore, wetlands also demonstrate the concept of biogeochemical cycling which involves the cycling of various elements such as carbon, nitrogen and phosphorus in the ecosystem.

Activity 5.2

1. Embark on a field trip to a grassland, forest, freshwater, mangrove, wetlands and mountain wetland habitat.
2. What are some ecological concepts you can identify in these habitats?

Activity 5.3

1. Watch videos of Coral reefs, Arctic Tundra, Deserts and Glacial ecosystems.
2. Write down key ecological concepts you identified in these ecosystems.
3. Discuss with your colleagues the concepts you identified in (2) above

Interdependency Of Living Organisms In Various Ecological Habitats

The interdependency of living organisms refers to the reliance of different species on each other for survival and well-being within an ecosystem. This interdependence is a fundamental aspect of ecological relationships and plays a crucial role in shaping the structure and functioning of ecosystems. It is a central feature of ecosystems and shapes the life patterns and population dynamics within them.

Below are some examples observed in different habitats.

Forests

The forests exhibit a high degree of interdependency due to their extraordinary biodiversity. Plants, animals and decomposers in these ecosystems are intricately linked through various ecological relationships such as:

a. ***Primary productivity and shelter:*** In forest ecosystems, trees play a foundational role. They provide habitats, oxygen and food for a wide variety of organisms. Many bird and insect species rely on specific tree species for nesting sites or food sources.

a. ***Provision of carbon dioxide and pollination***: The animals, in turn, provide the trees with the carbon dioxide necessary for photosynthesis. Many flowering plant species in forests rely on specific pollinators for successful reproduction. For example, certain orchid species depend on specific insect species for pollination.

b. ***Dispersal:*** Some animals, like frugivorous (fruit-eating) birds and mammals, are important seed dispersers for many plant species. They eat fruits and then disperse the seeds through their droppings, aiding in the dispersal and regeneration of plants across the rainforest.

c. ***Competition for light***: Forest trees and climbers engage in fierce competition for light. Trees dominate the upper canopy, shading out competitors below. Climbers, equipped with strategies like rapid growth and flexible stems, exploit gaps to reach sunlight in the crowded forest's middle store. Undergrowth species, adapted to low light conditions, thrive beneath the canopy. This competition drives vertical stratification, shaping the forest's diverse structure and species composition.

d. ***Decomposition:*** Decomposers, such as fungi and bacteria, play a vital role in breaking down dead organic material, converting it back into nutrients that plants can use, which shows the dependency of plants on these organisms. The cycle of life and death in rainforests is highly dependent on these decomposers.

e. ***Predation:*** Predators and their prey are interdependent, as predators control the population of prey species, preventing overgrazing or overpopulation, which could negatively impact the ecosystem.

f. ***Symbiosis***: The forest harbours diverse symbiotic relationships crucial for ecosystem balance. Mycorrhizal fungi form mutualistic associations with tree roots, aiding in nutrient uptake and water absorption. Nitrogen-fixing bacteria in the root nodules of certain plants provide essential nutrients, benefiting both parties. Additionally, epiphytes, such as mosses, ferns, and orchids, establish symbiotic relationships with trees, using them as support structures while obtaining moisture and nutrients from the air and debris. Parasitic interactions also occur; for instance, mistletoe extracts nutrients from host trees.

Wetlands

Wetlands are home to specialised plant species like cattails and reeds, which can tolerate water-saturated soils, for example Keta lagoon complex, Songhor, Sakumonor, Densu Delta and Muni-Pomadze lagoon.

a. ***Nutrition and shelter:*** These plants provide food and habitat for various animal species, such as insects, birds and mammals. Many bird species are dependent on wetlands for breeding and as stopover sites during migration. Some fish and amphibians also rely on the temporary pools created in wetlands for spawning.

a. ***Decomposition*:** Wetlands also host numerous decomposer organisms, which break down dead plant material and recycle nutrients through the ecosystem. These nutrients support the growth of algae and other primary producers, which form the base of the food web in these systems. In each of these habitats, the various species depend on each other and the specific conditions of their environment. Changes or disruptions to any part of these ecosystems, whether due to human activity or natural events, can have significant impacts due to this interdependency.

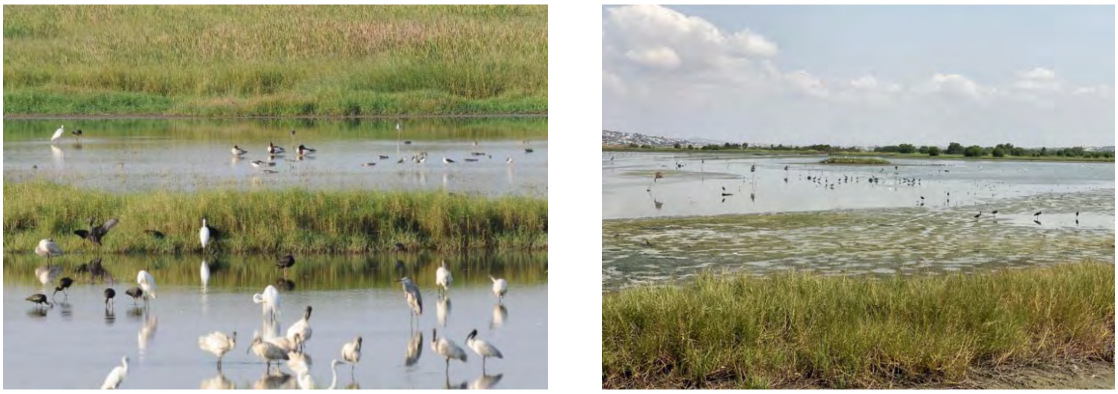

Fig 5.10: Interdependency in a Wetland

Grasslands

a. ***Grazing***: In grassland ecosystems, the relationship between herbivores and grasses is a classic example of interdependency. Herbivores, such as zebras and bison, depend on grasses as their primary food source. The grazing activities of these herbivores help maintain the health and biodiversity of grassland habitats by preventing any single plant species from dominating the landscape.

b. ***Predation***: Grasslands are also home to many predators, such as lions and wolves, which are dependent on herbivores for their survival. The presence of predators helps regulate herbivore populations, ensuring that their grazing activities do not over-consume the vegetation.

c. ***Symbiosis:*** Additionally, grassland ecosystems are also interconnected with soil microorganisms, such as mycorrhizal fungi, which form symbiotic relationships with plant roots. These fungi help plants absorb nutrients, particularly phosphorus, from the soil, making them crucial for the growth and health of grasses.

Fig. 5.11: Interdependency of organisms on Grassland

Arctic Tundra

In the harsh environment of the Arctic tundra, interdependency is evident in the relationships between species and their adaptation to extreme conditions.

a. ***Symbiosis:*** Arctic plants, like Arctic willow and mosses, grow low to the ground, forming a dense carpet to protect against cold temperatures and harsh winds. These plants provide food for herbivores like lemmings and caribou.

b. ***Predation:*** The Arctic fox is a predator in this ecosystem, relying on small mammals like lemmings for sustenance.

c. ***Migration***: The tundra also hosts numerous migratory bird species that rely on the region's abundant insect population for food during their breeding seasons.


Fig. 5.12: Interdependency in Artic Tundra

Coral Reefs

Coral reefs are one of the most biodiverse habitats on the planet. Here, the interdependency of organisms is highly complex.

Symbiosis: Corals and algae (zooxanthellae) have a symbiotic relationship. The corals provide the algae with a protected environment and the algae provide energy-rich foods in return.


Fig. 5.13: Organisms in symbiosis in a coral reef.

River

Aquatic organisms rely on one another for various resources and services, shaping complex webs of interactions.

a. ***Provision of oxygen and food***: For instance, algae and aquatic plants provide oxygen and food for other organisms through photosynthesis. In turn, herbivorous species like certain fish and invertebrates graze on these primary producers.

a. ***Predation and decomposition:*** Predators such as larger fish and birds feed on herbivores, regulating their populations. Decomposers like bacteria and fungi break down organic matter, recycling nutrients essential for plant growth.

c. ***Symbiosis:*** Additionally, symbiotic relationships occur such as between certain fish species and cleaning organisms that remove parasites. This interdependency ensures the flow of energy and nutrients maintains biodiversity and supports the overall health of river ecosystems.

d. ***Anthropogenic activities***: Human activities like pollution, habitat destruction and overfishing can disrupt these delicate balances, threatening the stability of river ecosystems and the services they provide.

Fig. 5.14: Interdependency in aquatic ecosystem

Outcome Of The Interdependency Of Living Things In Their Environment

The outcome of the interdependency of living organisms in their environment is the complex web of life that sustains Earth's ecosystems, providing habitats for diverse species and essential services for both nature and humanity. It is a delicate balance that sustains the functioning of ecosystems and ultimately supports life on Earth. Recognising and respecting these interdependencies is fundamental for the conservation and sustainable management of ecosystems.

Some key outcomes include the following:

1. ***Ecological Balance***: Interdependency helps maintain ecological balance by regulating population sizes and preventing any one species from dominating an ecosystem. For example, predators keep prey populations in check,

preventing them from overgrazing or over-reproducing, which could disrupt the balance of the ecosystem.

2. ***Biodiversity***: Interdependency promotes biodiversity, as different species rely on each other for survival. This diversity enhances ecosystem resilience and stability, making it more adaptable to environmental changes.
3. ***Nutrient Cycling:*** Living organisms are interconnected through food webs and nutrient cycles. Decomposers break down dead organic matter, releasing nutrients back into the environment for other organisms to use. This cycling of nutrients is essential for the productivity of ecosystems.
4. ***Ecosystem Services***: Interdependency supports the provision of ecosystem services essential for human well-being, such as pollination, water purification and soil formation. These services are often the result of complex interactions between multiple species within an ecosystem.
5. ***Adaptation and Evolution***: The interdependency of organisms drives natural selection and adaptation over time. Species evolve traits and behaviours that allow them to better exploit resources or avoid predation, leading to a continuous coevolutionary process.
6. ***Resilience:*** Ecosystems with higher levels of interdependency tend to be more resilient to disturbances. When one species is affected by a disturbance, the effects can ripple through the ecosystem, but the interconnectedness often allows for recovery and stability over time.
7. ***Human Impact***: Understanding the interdependency of living organisms is crucial for managing human impacts on ecosystems. Human activities such as habitat destruction, pollution, and climate change can disrupt these interdependencies, leading to ecosystem degradation and loss of biodiversity.

Activity 5.4

1. In groups with your teacher or as an individual, take a walk through your school compound/farm
2. Identify all the living things within the area (such as bees, butterflies, plants, ants, lizards, earthworms.
3. Complete the table by writing down the living things that play the roles below within the ecosystem

Role/function	Living things
Pollination/pollinators	
Predation/predators	
Preys (provide food for other animals	
Provide food and oxygen (photosynthesis)	
Nutrient recycling/decomposers	
Parasite/parasitic	

a. How are the living things written above interdepended in the habitat

b. Compare your answers with your friends or show your answer to your teacher

Activity 5.5

1. Consider the following ecosystems below

a. savanna ecosystem,

b. forest ecosystem,

c. river ecosystem and

d. grassland ecosystem

2. Write down the living organisms that are producers, herbivores, carnivores and decomposers/recycle nutrients

3. Write down how living things in ecosystems interdepend on each other

a. How do you think human activities such as pollution, and illegal mining (galamsey) building on waterways disrupt the stability (the normal functioning) of the ecosystem?

b. Compare your answers with your friends or show your answer to your teacher

EXTENDED READING

Taylor, D.J. Green, N.P.O & Stout, G.W. (2010) pgs. 298-348. *Biological Science* Cambridge University Press

VARIOUS ECOLOGICAL TOOLS AND HOW THEY ARE USED TO ESTIMATE POPULATION SIZE AND DENSITY

Ecological tools are methods and techniques used to study and understand ecosystems, populations, and communities. These tools help ecologists and researchers collect data, measure variables, and analyse patterns to better comprehend the complex relationships within ecosystems.

Some examples of ecological tools include Quadrats and transects for sampling vegetation and animal populations, Pitfall traps and sweep nets for capturing insects and small animals, camera traps and acoustic monitoring for wildlife observation, water quality testing kits for measuring chemical and physical parameters, GPS and remote sensing for tracking movements and habitat analysis and genetic analysis for understanding population structure and diversity

Identifying the Various Ecological Tools and How They are Used to Estimate Population Size and Density

Ecological tools are instruments or methods used by ecologists and environmental scientists to study, monitor, manage, and conserve ecosystems and biodiversity. These tools help researchers gather data, analyse patterns, and make informed decisions regarding ecological management and conservation efforts. Some common ecological tools and their uses include the following:

1. **Quadrat:** A quadrat is a square or rectangular frame used to outline a sample area, often used for vegetation or study plant and sessile animal populations. It helps to estimate abundance, density, and species composition in a specific area.

Fig 5.15: A quadrant

2. **Transect:** A transect is a straight line or path place through a habitat to measure vegetation frequency. It is used to study changes in ecological parameters across a piece of land. Transects are used to gather data on vegetation, animal populations, or environmental factors like temperature and moisture.
3. **A pitfall trap**: It is a simple trap used to capture small ground-dwelling animals, such as insects, spiders, and other invertebrates. It consists of a container buried in the ground with its rim at ground level, and a cover is often placed over the top to prevent rainwater filling it up.

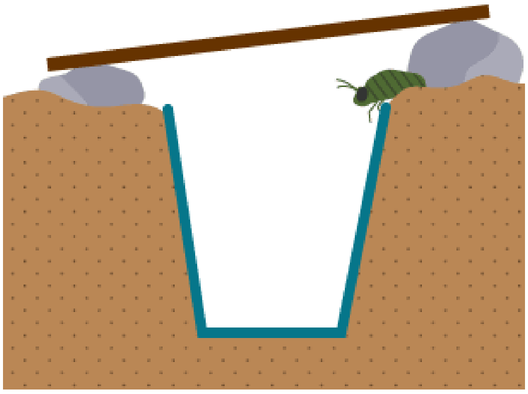

Fig 5.16: A pitfall trap

4. **Pooter:** A pooter, also known as a suction sampler, is a small device used to collect or suck very small invertebrates without harming them. It consists of two tubes—one is used to gently suck air, and the other tube collects the insect into a container.

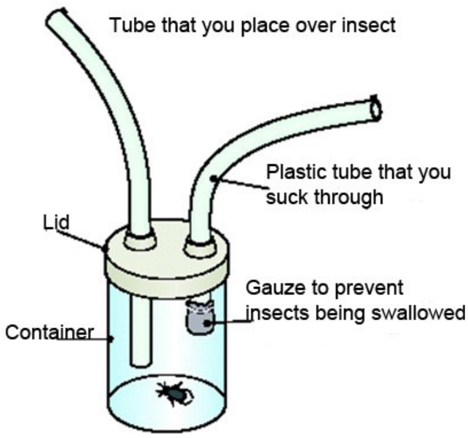

Fig 5.17: A pooter

5. **Secchi disk**: This is a simple device used to measure water transparency or turbidity in bodies of water, particularly rivers, lakes or oceans. It

consists of a circular disk, typically with four white and black alternating quadrants, attached to a rope or pole. The disk is lowered into the water until it disappears from view, and the depth at which it vanishes is recorded. This measurement indicates water clarity and can be used to monitor changes in water quality or assess the effects of pollution.

Fig 5.18: A Secchi disk

6. **Sweep net:** A sweep net is a tool used to collect small organisms from vegetation or water in ecological surveys. It consists of a mesh net attached to a handle, which is swept through vegetation or water to capture insects and other arthropods. Sweep nets are commonly used in studies of insect biodiversity, population dynamics, and pest management.

Fig 5.19: A sweep net

7. **Butterfly net**: A butterfly net, as the name suggests, is a specialized net used to catch butterflies and other flying insects. It typically consists of a long handle attached to a large, conical-shaped net with a fine mesh. Butterfly nets are used by researchers, collectors, and enthusiasts to capture

butterflies for scientific study, identification, and conservation purposes. They are often used in field surveys to assess butterfly populations, monitor species diversity, and study butterfly behaviour and ecology.

8. **GPS (Global Positioning System)**: GPS is used to precisely locate sampling sites, track animal movements, map habitat types and monitor changes in land cover and land use patterns.
9. **Water Quality Testing Kits**: Water quality testing kits are used to measure parameters such as pH, dissolved oxygen, turbidity, nutrient levels, and pollutants in aquatic ecosystems to assess water quality and identify sources of pollution.
10. **Camera Traps**: Camera traps are motion-activated cameras used to monitor wildlife populations, study animal behaviour, estimate population densities, and assess the effectiveness of conservation measures.

Lincoln Index

The Lincoln Index is a method used in ecology to estimate the population size of a species, particularly when individuals are difficult to observe directly. It's named after Frederick Charles Lincoln, an American biologist who developed the method in the early 1930s. It is based on the capture-mark-recapture technique. The process involves capturing and marking or tagging a sample of the population (e.g., with a unique identifier), releasing them back into the environment, and allowing enough time for complete mixing of individuals. After, the complete mixing of individuals in the population, another sample of individuals is captured from the same population. This second sample includes both marked (previously captured) and unmarked individuals.

Calculation: The Lincoln Index uses the proportion of marked individuals recaptured in the second sample to estimate the total population size.

The formula is given as: $N = (M \times C)/R$

N =the estimated population size.

M = the number of individuals initially marked and released.

C =the total number of individuals captured in the second sample.

R =the number of marked individuals recaptured in the second sample.

Assumptions: The Lincoln Index assumes that the marking does not significantly affect the behaviour or survival of the marked individuals, that the population is closed (no births, deaths, or migration during the study period), and that individuals have an equal probability of being captured on each occasion.

Activity 5.6

1. Search from textbooks and available sources (e.g. audio and video documentaries) to identify and discuss the importance of at least five ecological tools used in the estimation of the population size of organisms in a habitat.
2. Describe how a named ecological tool can be used to estimate the population size of different plants.

Hint: A guide to estimating the population of grass on a school field using a quadrat

- **a.** *Define the study area*
- **b.** *Determine the quadrat size*
- **c.** *Randomly select sampling points*
- **d.** *Place the quadrat*
- **e.** *Count the grass*
- **f.** *Record data*
- **g.** *Repeat the process (10 - 20 times)*
- **h.** *Express the results as an estimated number of grass per hectare*

Activity 5.7

Embark on a project using a named ecological tool to estimate the population size of organisms (e.g. grasshopper) in a named habitat (e.g. School field)

Hint: A guide to estimate the population of grasshoppers on a school field using a sweep net

- **a.** *Choose a sweep net*
- **b.** *Define the study area*
- **c.** *Determine the sampling area*
- **d.** *Randomly select sampling points*
- **e.** *Sweep the net*

f. *Count the grasshoppers caught in the net*

g. *Record data*

h. *Repeat the process (10 - 20)*

i. *Calculate the mean*

j. *Scale up (multiply the mean by the total area of the field to estimate the total grasshopper population)*

k. *Express the results*

Activity 5.8

Embark on a project using a named ecological tool to estimate the population size and density of organisms (e.g. grasshopper) in a named habitat (e.g. School field) using the Lincoln index.

Hint: Using the Lincoln Index:

a. *Mark -Release-Recapture: Capture a random sample of organisms, mark them (e.g., with a tag or dye), and release them into the habitat.*

b. *Recapture: Recapture a second random sample of organisms.*

c. *Calculate the Lincoln Index: use the number of marked individuals in the second sample to estimate population size (N) using the formula:* $N = (M \times C)/R$, *where M = Number of individuals marked and released, C = total number of individuals in the second sample, and R = number of marked individuals in the second sample*

DIRECT COUNTING, GUT EXAMINATION AND RADIOACTIVE METHODS OF DETERMINING THE FLOW OF ENERGY IN AN ECOSYSTEM

The flow of energy in an ecosystem may be determined using techniques such as direct counting, gut examination, and radioactive/tracer. Direct counting is often used for initial assessments or in simpler ecosystems, Gut examination works well for studying predator-prey interactions and Radioactive/tracer methods offer a more precise way to track energy flow through complex food webs. Ecological pyramids are used to determine the flow of energy across trophic levels. We will be exploring which of the pyramids provide more accurate information on energy flow across trophic levels.

Flow of Energy in an Ecosystem

Flow of energy in an ecosystem may be determined using techniques such as direct counting, gut examination, and radioactive/tracer.

Direct Counting, Gut Examination and Radioactive/Tracer Methods

Direct counting, gut examination, and radioactive/tracer methods are different techniques used to study and determine the flow of energy in an ecosystem. Each method has its relevance and provides valuable insights into the interactions between different organisms and the energy transfer within the ecosystem.

1. **Direct counting**: Direct counting involves the direct observation and counting of organisms within an ecosystem. This method is particularly useful for studying simple ecosystems or specific populations within a larger ecosystem. For example, researchers may count the number of individuals of different species in a specific area, such as counting the number of herbivores, carnivores, and producers in a grassland. By knowing the population sizes, scientists can estimate the flow of energy from one trophic level to another.

   Limitations: It's time-consuming, may not capture seasonal variations and might not be feasible for very small or elusive organisms.

2. **Gut examination**: Gut examination involves analysing the stomach contents of organisms to determine their diet and feeding habits. It is especially relevant for understanding the flow of energy in food chains and food webs. By examining the gut contents of predators or consumers, researchers can identify the prey or food items that contribute to their energy intake. This information helps in understanding the pathways of energy transfer between different trophic levels in the ecosystem.

   Limitations: It only reveals recent feeding activity and may not provide an accurate picture of the entire predator's diet. Additionally, some prey might be difficult to identify from partially digested remains.

3. **Radioactive/tracer methods**: Radioactive or tracer methods involve using isotopes or tagged substances to track the movement of energy through an ecosystem. In this technique, a specific isotope or tracer is introduced into the ecosystem, and its movement is monitored as it passes through different organisms or trophic levels. This method is highly precise and provides

detailed information on energy transfer rates and pathways. It allows researchers to study complex interactions and the fate of energy within the ecosystem.

Limitations: Requires specialised equipment and expertise to handle radioactive materials. Additionally, not all organisms readily take up the tracers.

The best method depends on the specific ecosystem, research question, and resources available.

a. Direct counting is often used for initial assessments or in simpler ecosystems.
b. Gut examination works well for studying predator-prey interactions.
c. Radioactive/tracer methods offer a more precise way to track energy flow through complex food webs.

Ecologists often combine these methods for a more comprehensive understanding of energy flow in an ecosystem.

Activity 5.9

1. Identify at least two different techniques used to study and determine the flow of energy in an ecosystem.
2. Describe with some friends at least two different techniques used to study and determine the flow of energy in an ecosystem.
3. Describe the three techniques used in the study to determine the flow of energy in an ecosystem and provide justification for your selection of one of the methods as the best technique.

Ecological Pyramids

An ecological pyramid is a graphical representation illustrating the distribution of organisms across different trophic levels in a food chain. When food passes from primary producers to secondary consumers and then to tertiary consumers (carnivores), it is estimated that about 10% of energy is lost during the process. Ecologists use the pyramid to graphically represent this and call it 'Ecological Pyramids'.

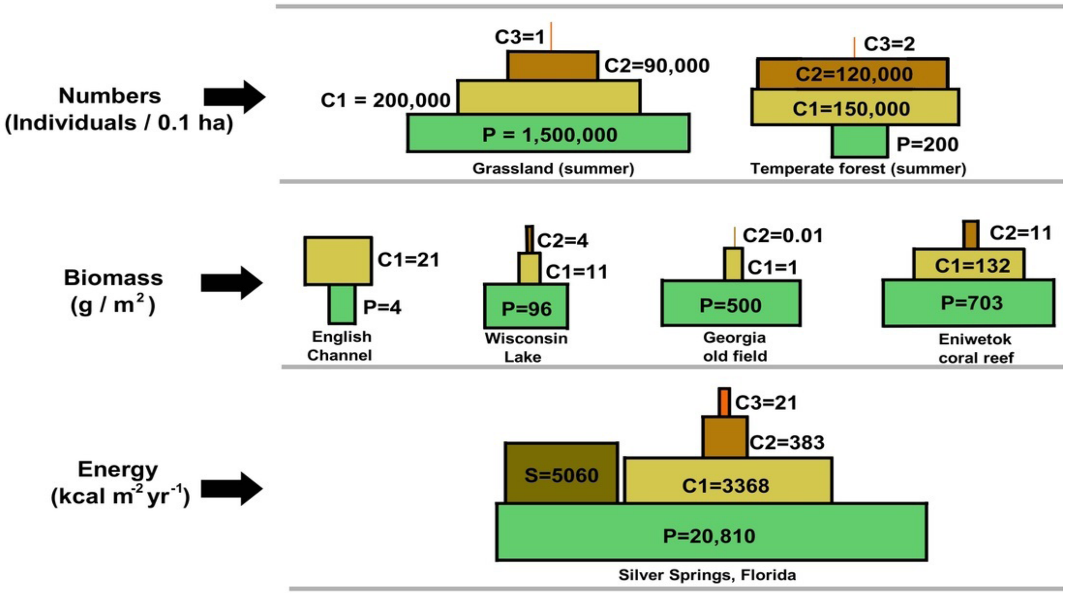

Fig. 5.20

Comparing the Efficiency of Energy Flow in Pyramids of Numbers, Biomass and Energy.

1. **Pyramid of Numbers:** This method represents the number of organisms at each trophic level in an ecosystem. It is the simplest method and involves counting the number of individuals at each trophic level and arranging them in a pyramid shape. In a typical pyramid of numbers, the number of individuals usually decreases with increasing trophic levels. This reflects the decreasing energy available as one moves up the food chain, due to energy losses through heat, waste materials and the fact that not all parts are consumed by organisms at higher trophic levels.

   Example: In a grassland ecosystem, there are more grasshoppers (primary consumers) than hawks (tertiary consumers), forming an upright pyramid of numbers

Pyramids of numbers are not always true pyramids, because of the variation in size of the organisms involved. Compare an oak tree with aphids and the insects that eat aphids.

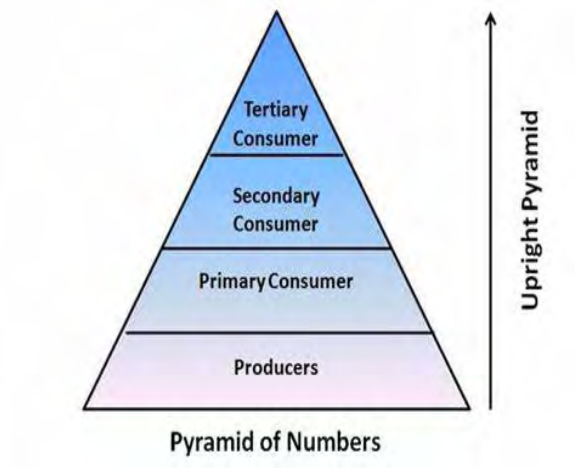

Fig 5.21: Pyramid of Numbers

2. **Pyramid of Biomass:** The pyramid of biomass represents the total dry weight (usually) of the organisms at each trophic level. Biomass is a more accurate representation of energy available since it takes into account the actual total mass of living organisms, rather than the number of organisms. In a pyramid of biomass, the biomass always decreases at each trophic level.

   Example: In a forest, the total biomass of trees (producers) exceeds that of herbivores (primary consumers), forming an upright pyramid of biomass.

   This biomass pyramid provides a better indication of energy flow efficiency than the pyramid of numbers. Energy loss can be typically 90% or more from one level to the next.

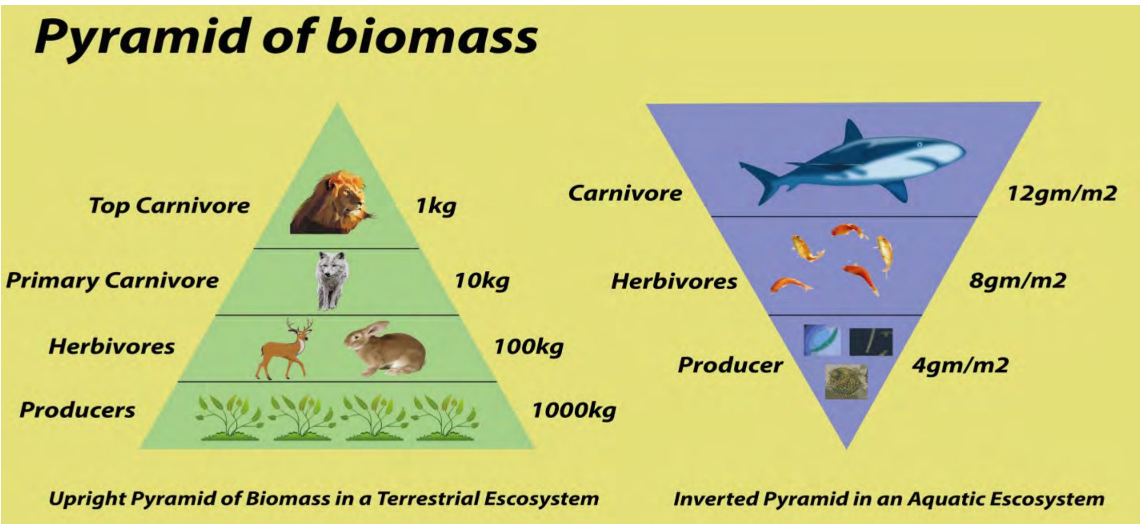

Fig 5.22: A pyramid of biomass

3. **Pyramid of Energy:** The pyramid of energy represents the actual flow of energy through each trophic level in an ecosystem. It quantifies the amount of energy transferred from one trophic level to the next. The energy value is usually determined using the calorimetry method. This involves measuring the heat released or absorbed during chemical reactions, including the combustion of organic matter. By burning samples of biomass collected from different trophic levels and measuring the heat produced. By this, one can estimate the energy content of the biomass.

   Example: In a marine ecosystem, energy flows from phytoplankton (producers) to fish (secondary consumers) and then to sharks (tertiary consumers)

   This type of pyramid is always a proper upright pyramid. The pyramid of energy offers the most accurate representation of energy flow through an ecosystem but is the most difficult to measure.

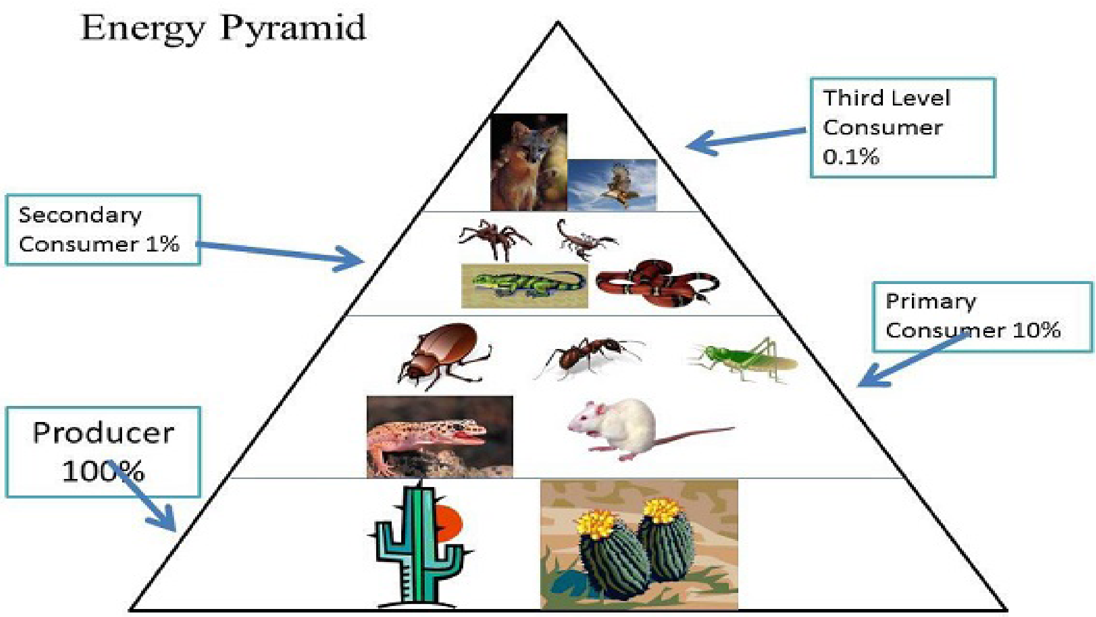

Fig 5.23: An energy pyramid

Activity 5.10

1. What does the pyramid of numbers represent in an ecosystem? With your friends,

   a. Visit a maize farm that is infested with army worms or watch a video of an army worm-infested maize farm

   b. Count the number of producers (P)
   c. Count the number of primary consumers (C1)
   d. Count the number of secondary consumers (C2)
   e. Count the number of tertiary consumers (C3)
   f. With the data obtained, construct a pyramid of numbers to represent this ecosystem.

2. Observe and count different organisms at different locations of your school compound with your friends.
3. Use the data obtained to construct your pyramid of numbers, biomass, and energy.
4. Define biomass and explain its significance in ecological studies.
5. Describe the direction of energy flow in a pyramid of energy.

EXTENDED READING

Click on the links below for more information on ecological pyramids.

- Ecological Pyramid - Types, Limitations And Importance (byjus.com)
- Ecological Pyramid | Definition, Number, BioMass, Energy Pyramids (bioexplorer.net)

RELEVANCE OF METHODS USED IN DETERMINING ENERGY FLOW IN AN ECOSYSTEM

The relevance of these methods lies in their ability to offer complementary insights into the flow of energy in an ecosystem:

1. **Comprehensive understanding**: By combining direct counting, gut examination, and radioactive/tracer methods, researchers can obtain a more comprehensive understanding of energy flow. Direct counting provides population-level data, gut examination offers insights into feeding relationships, and radioactive/tracer methods provide precise information on energy transfer rates and paths.
2. **Ecosystem structure and function:** Studying energy flow helps in understanding the structure and functioning of ecosystems. It reveals the relationships between different species and their roles, in understanding trophic cascades and predicting the consequences of disturbances. In conclusion, direct counting, gut examination, and radioactive/tracer methods are valuable tools for ecologists to study and determine the flow of energy in ecosystems. By combining these techniques, scientists gain a more holistic understanding of energy transfer and ecosystem dynamics, which is essential for ecological research, conservation efforts and sustainable management of natural resources.
3. **Impact of environmental changes**: Monitoring energy flow in an ecosystem allows researchers to assess the impact of environmental changes, such as climate change or the introduction of invasive species. Changes in energy flow can indicate disruptions in ecological balance and potential threats to the stability of the ecosystem.
4. **Management and conservation**: Understanding the flow of energy helps in making informed decisions for the management and conservation of ecosystems. It aids in identifying keystone species

Activity 5.11

1. Revise the previous lesson in week 12 on the direct /observation/counting, gut examination and radioactive/ tracer methods of determining the flow of energy in an ecosystem and the methods of determining pyramids of numbers, biomass and energy

2. Watch videos from the internet on the direct observation/counting method, gut examination method and radioactive/ tracer method of determining the flow of energy in an ecosystem.
3. Use the information provided below to complete the table below:

   a. Good for larger population size,
   b. Good for small population size,
   c. Too much time-consuming
   d. May not capture seasonal variations
   e. Enable energy transfer between different trophic levels in the ecosystem.
   f. Reveals recent feeding activity not providing an accurate picture of the entire predator's diet.
   g. Difficult to identify the prey
   h. Killing of the consumers/organisms or destructive
   i. Use of isotopes
   j. Study complex interactions the fate of energy within the ecosystem
   k. Requires specialised equipment and expertise to handle radioactive materials.

Direct observation method	Gut examination method	Radioactive/tracer method

4. Create a chart on the advantages and disadvantages of the various methods of determination of energy flow in an ecosystem. Share your findings with your colleagues

Activity 5.12

1. Visit the internet to watch videos on the feeding relationship in any ecosystem. Or research or read from relevant textbooks on the feeding relationship in any ecosystem.
2. write down the effects of environmental changes on the flow of energy in an ecosystem.
3. Write down the importance of environmental conservation/management on the flow of energy in the ecosystem. Share your findings with your colleagues and teacher.

EXTENDED READING

- Taylor C.J., Green N.P.O, stout GW (2010) Biological science (pages 300-309) Cambridge University Press (India by Repro. India Ltd.
- Sarojini, T. R. (2009). Modern biology for senior secondary schools. (5th ed).Onitsha-. Nigeria: Africana First Publishers Ltd.
- Nyavor, C. B. & Seddoh, S. (2006). *Biology for senior secondary schools*. (3rd ed.). Accra-North: Unimax MacMillan Education Ltd.

REVIEW QUESTIONS

Review Question 5.1

1. Describe briefly the term ecology.
2. Briefly explain the following ecological terms as used in the study of ecology:
    a. environment
    b. ecosystem
    c. biosphere
    d. biome
3. Distinguish between a niche and a habitat

Review Questions 5.2

1. a. Classify the following organisms into *producers, primary consumers, secondary consumers* and *decomposers.* Bacterium, Frog, Grass, Grasshopper, Groundnut plant, Hawk and Rhizopus.
    b. Use any **four** organisms listed in (a) above to construct a food chain.
2. a. Complete the table by placing **each** of the following organisms under the appropriate heading. **Algae, Bacteria, Dog, Water lettuce, Tadpole, Human, Lemna, Waterleaf, Rhizopus, Mushroom.**

Decomposers	Producer	Consumer

i. Name **four** products of decomposition.
ii. Mention **three** roles of decomposers on a refuse dump.

   c. List **three** materials found in your school's refuse dump which would **not** be affected by the action of decomposers.
   d. How can some of the names of the materials in (c) be controlled in the environment
3. Explain briefly the following:
   a. Ecological balance
   b. Nutrient cycling
   c. Ecosystem service
4. Predict at least three possible consequences of each of the following human activities on ecological systems.
   a. Illegal mining
   b. Bush fires
   c. Disposal of sewage into water bodies.

Review Question 5.3

After random sampling, 200 catfish are captured tagged and released. A week later,180 untagged and 20 tagged catfish were captured. Use the Lincoln index to estimate the total catfish population.

Accept oral/written responses for the procedure in using the Lincoln index to estimate the population size of catfish.

Review Questions 5.4

1. What does the pyramid of numbers represent in an ecosystem?
2. Define biomass and explain its significance in ecological studies.
3. Discuss the potential reasons for an inverted pyramid of numbers in an aquatic ecosystem.
4. Explain why the pyramid of energy is always upright and what factors contribute to the inefficiency of energy transfer between trophic levels.
5. How will human activities, such as deforestation or overfishing, affect the shape and stability of a named ecological pyramid in an ecosystem?

Review Questions 5.5

1. Match these three techniques Direct observation/counting, Gut examination and Radioactive/ tracer methods used to study and determine the flow of energy in an ecosystem with their corresponding advantages and disadvantages listed below:
   - **a.** Good for larger population size,
   - **b.** Good for small population size,
   - **c.** Too much time-consuming
   - **d.** May not capture seasonal variations
   - **e.** Enable energy transfer between different trophic levels in the ecosystem.
   - **f.** Reveals recent feeding activity not providing an accurate picture of the entire predator's diet.
   - **g.** Difficult to identify the prey
   - **h.** Killing of the consumers/organisms or destructive
   - **i.** Use of isotopes
   - **j.** Study complex interactions and the fate of energy within the ecosystem
   - **k.** Requires specialised equipment and expertise to handle radioactive materials.
2. Study/consider the energy flow in this illustration within a given ecosystem. Solar energy Grass Grasshopper Lizard Hawk Man Suggest **two** possible impacts/effects that could occur in the ecosystem if:
   - **a.** More grasshoppers are introduced.
   - **b.** Most grasshoppers are killed.

ANSWERS TO REVIEW QUESTIONS

Review Question 5.1

1. Ecology is the branch of biology that deals with the scientific study of the interrelationships between living things and their environment. In other words, the interaction between the biotic (living) and abiotic (non-living) factors.
    a. environment refers to the total surroundings of an organism. It includes the biotic and abiotic factors.
    b. ecosystem refers to the interaction between living things and their environment at a particular place or location. E.g. forest ecosystem.
    c. biosphere refers to the part of the earth and its atmosphere where living things can live or be found. This also includes the hydrosphere (water) and lithosphere (land).
    d. biome refers to a large natural area of an ecosystem with a particular climate. Biomes are often defined by the dominant vegetation type. E.g. desert
2. A habitat is the physical environment where an organism lives while the niche is the specific role or position of a species within its habitat which includes its food, shelter, breeding grounds and other resources. In other words, habitat refers to the physical space while niche refers to its functional role within that space.

Review Question 5.2

1. a.

Producers	**Primary consumer**	**Secondary consumers**	**Decomposers**
Grass, Groundnut plant	Grasshopper	Frog, Hawk	Rhizopus, Bacterium

Example of food chain Grass Grasshopper Frog Hawk

2. a.

Decomposer	Producer	Consumer
Rhizopus	Algae	Dog
Bacteria	Waterleaf	Human
Mushroom	Water lettuce	Tadpole
	Lemna	

b. i. ***Products of decomposition***

- Hydrogen Sulphide
- Carbon (IV) oxide
- Heat
- Mineral salt
- Ammonia
- Water vapour
- Humus
- Methane

ii. ***Roles of decomposers on a refuse dump***

- They feed on dead or decaying organisms.
- They form a link in a food chain.
- They form a link between biotic and abiotic factors in an ecosystem.
- They release inorganic components from organic material.
- They facilitate the recycling of nutrients in the ecosystem.
- They reduce the bulky nature of debris.

c. ***Materials in a refuse dump which would not be affected by the action of decomposers.***

- Plastics
- Metals (e.g. iron, zinc, tin, aluminium)
- Glass
- Nylon / Polythene
- Rubber
- Stones
- Ceramics

d. Recycle, reuse them, reduce usage, and proper disposal such as incineration.

3. a. **Ecological Balance:** Is the equilibrium between and harmonious coexistence of organisms and their environment. A favourable ecosystem ensures that each organism thrives and multiplies as expected and gets enough food to keep it alive. Ecological balance leads to the continued existence of organisms and also ensures that no peculiar species is exploited or overused.

b. **Nutrient Cycling:** This is the movement and exchange of inorganic and organic matter back into the production of matter. This occurs as animals and plants consume nutrients found in the soil, and these nutrients are released back into the environment through death and decomposition.

c. **Ecosystem Service:** The direct and indirect contributions that the ecosystem provides for human well-being and quality of life (food, clean water and air, climate regulation, stress reduction, pollination of crops, decomposition of wastes and flood control.

4. a. Illegal mining leads to deforestation, pollution of water bodies that kills aquatic organisms, and destruction of soil nature hence reducing soil fertility and crop yield, pits left after mining may serve as death traps for some animals.

b. Bush fire pollutes the air, kills microorganisms in the soil, destruct habitat of some animals, destruct plant species, reduces soil fertility, leaves the land exposed to the sun and increases leaching, increases global warming, soil erosion, loss of biodiversity and destruction of the ozone layer.

c. Disposal of sewage into water bodies leads to water pollution, eutrophication, death of fishes, contamination of soil, degradation of habitat, and damage to the marine ecosystem.

Review Question 5.3

The Lincoln Index is a method for estimating population size based on mark-recapture data. Here's how to apply it:

Number of individuals marked (tagged) and released: $M = 200$

Total number of individuals captured in the second sample:
$C = 180 + 20 = 200$

Number of marked individuals recaptured: R = 20

The Lincoln Index formula:

Population estimate(N) = (M × C) / R

Plug in the values:

Population estimate(N) = (200 × 200) / 20

Population estimate(N) = 40,000 / 20

Population estimate(N) = 2,000

So, the estimated total catfish population is approximately 2,000 individuals.

Note: This method assumes that the marking process doesn't affect the animals' behaviour and that the samples are representative of the population. It also assumes that the population is closed (no births, deaths, immigration, emigration or migration during the study period), and that individuals have an equal probability of being captured on each occasion.

Review Questions 5.4

1. The pyramid of numbers is a graphical representation that illustrates the count of individual organisms occupying each trophic (feeding) level within an ecosystem. It provides an idea about the distribution of organisms across the different feeding levels from producers to tertiary consumers. The number of organisms decreases as you move up the trophic levels in the pyramid of numbers. For example, grasses (producers) form the base of the pyramid, then herbivores (like grasshoppers), followed by fewer carnivores (like lizards). secondary carnivores (like snakes) occupy the next level and at the top apex predators (like hawks) are the least in number.

2. Biomass refers to the total weight or amount of living organisms within a given ecosystem. In ecology, it is an essential concept for understanding the overall health and productivity of an ecosystem. The biomass of an ecosystem includes all living organisms, such as plants, animals, microorganisms, and their byproducts.

   In ecological studies, biomass serves several key purposes:

   - Indicator of Ecosystem Health: Biomass provides insight into the abundance and distribution of living organisms. High biomass often indicates a healthy and productive ecosystem while low biomass may signal environmental stress or disturbances.

- Energy flow and Trophic levels: Biomass is directly related to energy flow within an ecosystem. It represents the stored energy available for consumption by higher trophic levels (that is herbivores and carnivores). Understanding biomass helps ecologists study food webs and energy transfer.
- Carbon Sequestration: Biomass plays a crucial role in carbon cycling. Plants capture carbon dioxide in photosynthesis and convert it into organic matter. This stored carbon contributes to climate regulation by reducing atmospheric carbon dioxide levels.
- Biodiversity Assessment: By measuring the biomass, researchers can assess the diversity and composition of species within an ecosystem. Different species contribute varying amounts to the total biomass.
- Ecosystem Management: Biomass data can inform decisions about biodiversity conservation.

3. In an aquatic ecosystem, the pyramid of numbers can take an inverted shape. This is why:

- Phytoplankton Dominance: tiny phytoplankton (such as algae and bacteria) serve as primary producers. These organisms grow and reproduce very fast due to the abundance of water and sunlight which result in very high numbers at the base of the pyramid.
- Consumer Biomass: Despite their small individual size, phytoplankton collectively contribute considerable biomass. However, consumers (such as zooplankton, fish and other aquatic organisms) have larger individual sizes and accumulate more biomass. This leads to an inverted pyramid, where the base (phytoplankton) supports the relatively heavier consumer biomass at the top

NB: Remember that the pyramid of numbers does not consider energy flow or utilisation; it simply reflects the numerical abundance of organisms at each trophic level.

4. The pyramid of energy represents the total amount of energy consumed by each trophic level in a given food chain. It is always upright due to energy loss as heat during transfer between trophic levels. As energy flows from one trophic level to another, some of it is lost as heat. This heat escapes to the atmosphere and is never returned.

5. Human activities like deforestation and overfishing can significantly impact the shape and stability of ecological pyramids in ecosystems.

Deforestation:

- Primary Producers (Autotrophs): Deforestation reduces the number of trees and plants, which are primary producers. This decreases the base of the ecological pyramid.
- Herbivores (Primary Consumers): With few plants, herbivores have less food available. Their population may decline affecting the next trophic level.
- Carnivores (Secondary Consumers): Carnivores that rely on herbivores will also be affected due to the reduced prey availability.
- Apex Predators (Tertiary Consumers): Apex predators at the top of the pyramid may suffer from reduced prey population.

Overfishing: Overfishing reduces fish populations, affecting the trophic levels.

- Fish (Primary Consumers) Reduced fish populations impact their predators (secondary consumers).
- Top Predators (Tertiary Consumers): Overfishing can lead to the collapse of apex predator populations.

Review Questions 5.5

Techniques	Advantages	Disadvantages
Direct observation/ counting	Easy to identify the prey Good for a larger population size Studying simple ecosystems or specific populations within a larger ecosystem	Too much time-consuming May not capture seasonal variations Might not be feasible for very small or elusive organisms

Techniques	Advantages	Disadvantages
Gut examination	Enable energy transfer between different trophic levels in the ecosystem	Reveals recent feeding activity not providing an accurate picture of the entire predator's diet. Difficult to identify the prey Killing of the consumers/ organisms or destructive
Radioactive/ tracer	Highly precise and provides detailed information on energy transfer rates and pathways. Allows researchers to study complex interactions and the fate of energy within the ecosystem.	Requires specialised equipment and expertise to handle radioactive materials. Not all organisms readily take up the tracers

a. If more grasshoppers are introduced; the population of grasses will reduce, there will be competition among grasshoppers, number of lizards/hawks/men will increase.

b. If most grasshoppers are killed: the grass population will increase, competition among lizards for food, lizard/hawk/man population will reduce

REFERENCES

1. McFadden, C.H. & Keeton, W.T. (1995).*Biology: An exploration of life*. (5th edition). W.W. Norton & Company ,Inc., New York.
2. Nyavor, C.B. & Seddoh, S. (2000).*GAST: Biology for senior high schools*. (2nd edition). Unimax Macmillan Ltd, Accra.
3. Roberts, M.B.V. (1982). *Biology: A Functional Approach*. (3rd edition). Butler &Tanner Ltd.
4. Stone, R.H., Cozens, A.B. & Ndu, F.O.C. (1985). *New biology for west African schools*.(2nd edition). Longman Group ltd, England.
5. Abbey, T. K., & Essiah, J.W. (1995). *Ghana association of science teachers' physics for senior high schools*. Accra: Unimax Macmillan.
6. Abbey, T. K., Alhassan, M. B., Ameyibor, K., Essiah, J. W., Fometu, E., & Wiredu, M.B. (2008). *Ghana association of science teachers integrated science for senior high schools*. Accra: Unimax MacMillan.
7. American Association for the Advancement of Science (1903). Science. Moses King. pp. 502–. Retrieved 8 October 2010.
8. Nyavor, C. B. & Seddoh, S. (2006). Biology for senior secondary schools. (3rd ed.). Accra North: Unimax Mac
9. Raven, P. H. & Johnson, G. B. (1999). Biology. (5th ed). New York. Wm. C. Brown Publishers. 20. Sarojini, T. R. (2009). Modern biology for senior secondary schools. (5th ed.). Onitsha-. Nigeria: Africana First Publishers Ltd.
10. Ameyibor, K., & Wiredu, M. B. (2006). *Ghana association of science teachers' chemistry for senior high schools*. Accra: Unimax MacMillan.
11. Asabere-Ameyaw, A., & Oppong, E. K. (2013). *Integrated science for the basic schoolteacher I*. Winneba: IEDE.*1*
12. DeWoody, J., Rowe, C.A., Hipkins, V.D., & Mock, K.E. (2008). Pando Lives: Molecular Genetic Evidence of a Giant Aspen Clone in Central Utah "Western North American Naturalist. 68 (4): 493–497. doi:10.3398/1527-0904-68.4.493
13. Griffiths, A.J.F, et al. (1999). An Introduction to Genetic Analysis. (7th ed.). San Francisco: W.H. Freeman. ISBN 0-7167-3520-2

14. Holmes, R.K, & Jobling, M.G. (1996). Genetics: Conjugation. In Baron S, et al., eds Baron's Medical Microbiology. (4th ed. Pp 20-55). Univ. of Texas Medical Branch. ISBN 0-9631172-1-1
15. Lederberg, J. & Tatum, E.L. (1946). "Gene recombination in E. coli". Nature 158 (4016): 558.
16. Mader, S. S. (1996). *Biology*. (5th ed). New York. Wm. C. Brown Publishers.
17. McFarland, D. (2000). "Preparation of pure cell cultures by cloning". Methods in Cell Science. 22 (1): 63–66. doi:10.1023/A:1009838416621
18. Mock, K.E., Rowe, C.A., Hooten, M.B., Dewoody, J., & Hipkins, V.D. (2008). "Blackwell Publishing Ltd Clonal dynamics in western North American aspen (Populus tremuloides)". U.S. Department of Agriculture, Oxford, UK: Blackwell Publishing Ltd. p. 17. Retrieved 2013-12-05
19. Nyavor, C. B. & Seddoh, S. (2006). *Biology for senior secondary schools*. (3rd ed.). Accra-North: Unimax MacMillan Education Ltd.
20. Oddoye, E. O. K., Taale, K. D., Ngman-Wara, E., Samlafo, V., & Obeng-Ofori, D. (2011). *SWL integrated science for senior high schools: Students book*. Accra, Ghana; Sam-Woode Ltd.
21. Peter J. R. (2005). Genetics: A Molecular Approach. San Francisco, California, United States of America: Pearson Education. ISBN 978-0-8053-4665-7
22. Raven, P. H. & Johnson, G. B. (1999). *Biology*. (5th ed). New York. Wm. C. Brown Publishers.
23. Sarojini, T. R. (2009). *Modern biology for senior secondary schools*. (5th ed.). Onitsha-. Nigeria: Africana First Publishers Ltd.

GLOSSARY

- **Ecology** is the branch of biology concerned with the scientific study of the interactions between living things and their environment.
- **Ecological tools** are instruments used by ecologists to study, monitor, manage and conserve ecosystems and biodiversity.
- **The Lincoln Index** is a method for estimating population size based on Mark-Release-Recapture data.
- **Biomass** is organisms' mass/dry weight per unit area of ground or water.

ACKNOWLEDGEMENTS

Ghana Education Service (GES)

List of Contributors

NAME	INSTITUTION
Vincent Ahorsu	OLA SHS, Ho
Peter Blankson Daanu	Nkyeraa SHS
Very Rev. Lewis Asare	Prempeh College, Kumasi
Gloria N.D. Nartey	Nsutaman Catholic SHS