Unit 4

Answers: Ecology

Quick checks

1 b They are all one species, living in the same area at the same time, so they are a population. The rhinos together with the park's grasses, trees, deer, tigers, birds and every other species would be a community; add the rivers, soil, air and climate, and it is an ecosystem.

2 c A fish pond is dug, stocked and fed by people, and needs their care to keep going. The lake, the forest and the river are natural ecosystems that keep going by themselves.

3 b More tigers eat more deer, so the deer decrease; fewer deer eat less grass, so the grass increases. The tiger never touches the grass, yet it helps it, two steps away. That the tigers don't eat grass is true, but the effect comes through the deer.

4 b The predators die too, and they come back more slowly than the fast-breeding planthoppers. With fewer enemies, the planthoppers that survive, or fly in, multiply unchecked: a decrease in the predators leads to an increase in their food.

5 b Leaching is the washing out of soluble substances by water. Fragmentation is the breaking into pieces by detritivores; humification is the forming of humus; mineralization is the release of inorganic minerals from humus.

6 b Wood is mostly cellulose and lignin, and lignin is broken down almost only by fungi, whose hyphae grow right inside the wood. Bacteria work fastest on soft, nitrogen-rich matter, and earthworms eat soft leaves and soil, not wood. Algae are producers, not decomposers.

7 b *Hydrilla* is a submerged plant. Lotus is rooted, its leaves on or just above the surface; water lettuce floats freely, its roots hanging in the water; reeds are rooted in shallow water and stand up out of it (emergent).

1 a. **b** Ernst Haeckel made the word in 1866, from the Greek *oikos* (home) and *logos* (study). Arthur Tansley gave us the word "ecosystem" in 1935.

1 b. **c** One species in one place at one time is a population. All the populations of a place together are a community.

1 c. **b** With fewer foxes, fewer rabbits are eaten, so the rabbits increase. More rabbits eat more grass, so the grass then decreases. The effect on the grass comes through the rabbits, a step later.

1 d. **c** Bacteria and fungi break dead matter right down, outside their bodies, to simple substances. Earthworms and termites are detritivores, vultures and jackals scavengers; algae and mosses are producers.

1 e. **b** Humus is formed by humification. Detritus and litter are the dead matter before it is broken down; peat is plant matter only partly decomposed in waterlogged, airless ground.

1 f. **c** Lignin is broken down almost only by certain fungi (white-rot fungi), whose hyphae grow into wood and release the enzymes that break it.

1 g. **b** In waterlogged mud there is no oxygen, and microbes break down dead matter anaerobically, giving out methane (the main gas in biogas) and carbon dioxide.

1 h. **c** Koshi Tappu was listed on 17 December 1987. Rara and Gosaikunda were listed in 2007, and Phewa, as part of the Lake Cluster of Pokhara Valley, in 2016.

1 i. **c** *Pistia* floats freely. The lotus is rooted in the mud, its leaves on or just above the surface; a reed is rooted and stands out of the water; *Hydrilla* is rooted and wholly submerged.

2 a. In a food web, most animals have several kinds of food and several enemies. If one food becomes scarce, an animal can eat another, so it doesn't starve, and a loss at one place is shared among many links instead of passing straight up a single line. In a food chain, each animal depends on just one food: if that one disappears, the animal above it starves, and so does everything above that. So an ecosystem with a complex web can take a change in one population with less damage.

2 b. Bacteria and fungi release enzymes onto dead matter and digest it outside their bodies, breaking it right down to simple inorganic substances (carbon dioxide, water, ammonia and mineral salts) that plants can use again. Earthworms swallow dead leaves and soil and digest part of them inside their bodies; they break dead matter into pieces and mix it into the soil, but they don't break it down to minerals. So earthworms are detritivores, which help the decomposers, while bacteria and fungi are the true decomposers.

2 c. Decomposers need warmth and water. In the Terai in the monsoon it is hot (often over 30 °C) and wet, so bacteria and fungi grow and multiply fast and their enzymes work fast. On a high Himalayan slope it is cold for most of the year, and the ground is often frozen or dry, so the decomposers work very slowly and dead leaves can lie for years.

2 d. Kidneys clean the blood by removing wastes. In the same way, as water flows slowly through a wetland, mud and silt settle out, plants and microbes take up the extra nutrients (from fertilizers and sewage), and many pollutants are broken down by the bacteria in the mud. The water that leaves a wetland is cleaner than the water that entered it.

2 e. Waterlogged ground has very little oxygen, because oxygen dissolves poorly in water and spreads through it slowly, and what there is is used up near the surface. Most fungi and many bacteria need oxygen; only anaerobic microbes can work, and they are slow and leave the breakdown incomplete. Peat bogs are often cold and acid too, which slows decomposers further. So dead plants pile up as peat instead of rotting away.

3 i.

Population	Community
All the organisms of **one species** in an area at one time.	All the populations of **different species** in an area at one time.
Its members can breed with each other.	Its members belong to many species, which can't all interbreed.
Example: all the rohu fish in Phewa Lake.	Example: all the plants, fish, birds, insects and microbes of Phewa Lake.
Smaller unit; part of a community.	Larger unit; made of many populations, and part of an ecosystem.

3 ii.

Food chain	Food web
A single line of organisms, each eaten by the next.	A network of many food chains joined together.
Each organism has one food and one enemy in it.	Each organism may have several foods and enemies.
Losing one link breaks the chain: those above it starve.	Losing one link is softened: animals turn to other foods.
Less stable.	More stable.
Example: rice → grasshopper → frog → snake.	Example: the paddy-field web, where frogs, spiders and egrets all eat insects, and snakes eat both frogs and rats.

3 iii.

Bacterial decomposition	Fungal decomposition
Done by single-celled bacteria, about 1–2 µm long.	Done by fungi, through branching threads (hyphae) many cells long.
Works best on soft, rich matter: proteins, sugars, fats; dead animals, dung, soft leaves.	Works best on tough plant matter: cellulose and lignin; wood, straw, dry leaves.
Can work with or without oxygen (aerobic or anaerobic).	Mostly needs oxygen (aerobic).
Works mostly at the surface of the matter.	Hyphae grow deep inside the matter.
Prefers moist, warm, near-neutral conditions.	Can work in drier, cooler and more acid conditions.
Examples: *Bacillus*, *Pseudomonas*, *Clostridium*.	Examples: *Rhizopus*, *Penicillium*, *Agaricus*, bracket fungi.

3 iv.

Natural ecosystem	Artificial ecosystem
Develops and keeps itself going without people.	Made and kept going by people.
Many species; a complex food web.	Few species; a simple food web.
Stable, controls itself.	Less stable; needs weeding, watering, fertilizer and pest control.
Example: a sal forest, Rara Lake.	Example: a paddy field, a fish pond, an aquarium.

4 a. **Ecology** is the branch of biology that studies how living things interact with each other and with their environment. Taking a village pond:

- **Population:** all the organisms of one species in an area at the same time, e.g. all the snails of one kind in the pond.
- **Community:** all the populations of different species living and interacting in that area, e.g. the algae, water plants, snails, tadpoles, fish, frogs, insects and bacteria of the pond.
- **Ecosystem:** the community together with its non-living environment, working as one system, e.g. the pond's living things with its water, mud, dissolved gases, sunlight and temperature.

4 b. Take the chain **rice → grasshopper → frog → snake → hawk**, and suppose the frogs decrease (because they are caught or poisoned).

- **The frogs' eaters:** the snakes have less food, so fewer survive and breed, and the snakes decrease. With fewer snakes, the hawks have less food and decrease too.
- **The frogs' food:** fewer grasshoppers are eaten, so the grasshoppers increase. More grasshoppers eat more rice, so the rice crop decreases.

So a decrease in one population makes its eaters decrease and its food increase, and each change passes on to the next link. The ecosystem's balance is upset, and the farmer may lose his crop, though nobody touched the rice.

4 c. When a predator increases, it eats more of its prey, so its prey decrease; the prey's own food is then eaten less, so it increases. Example: in a paddy-field web, spiders eat planthoppers and grasshoppers, and frogs eat spiders, planthoppers and grasshoppers. If the spiders increase (say, a farmer stops spraying), the planthoppers and grasshoppers decrease, so less rice is eaten and the rice does better. The frogs, which eat spiders, have more of one food but fewer insects, so they may change little. In a web, the effects spread along every link, and some of them pull against each other; but the animals with several foods are affected less than those with one.

4 d. **Decomposition** is the breaking down of complex organic matter in dead plants, animals and their wastes into simpler substances, and finally into inorganic ones (carbon dioxide, water and minerals), mainly by bacteria and fungi. Its steps:

1. **Fragmentation:** detritivores such as earthworms, termites and millipedes break the dead matter into small pieces, giving more surface for microbes.
2. **Leaching:** water dissolves the soluble substances of the dead matter and carries them down into the soil.
3. **Catabolism:** bacteria and fungi release enzymes that break the large molecules (cellulose, starch, proteins, fats) into simple ones (sugars, amino acids, fatty acids), which they absorb.
4. **Humification:** the resistant remains form **humus**, a dark, crumbly, organic substance that holds water and minerals.
5. **Mineralization:** humus is slowly broken down by microbes, releasing inorganic nutrients (ammonium, nitrates, phosphates, potassium) that plants take up again.

4 e. Bacteria and fungi are **saprotrophs**: they release enzymes onto dead matter, digest it outside their cells, and absorb the simple products.

- **Bacteria** multiply fast and break down soft, protein-rich matter: dead animals, dung, soft leaves. Some work without oxygen, in mud and water. They also release the nitrogen of proteins as ammonia, which other bacteria turn into nitrates.
- **Fungi** grow their hyphae into tough matter, even wood, and break down cellulose and lignin, which bacteria can hardly touch.

Importance: they return the carbon, nitrogen, phosphorus and other nutrients locked in dead bodies to the soil and air, so that plants can use them again; without them, the nutrients would run out. They form humus, which keeps soil fertile; and they clean the environment of dead bodies and wastes. They are also used to make compost and biogas and to treat sewage.

4 f. Any four of:

- **Temperature:** decomposition is faster in warm conditions and slow in the cold.
- **Moisture:** decomposers need water; dry matter hardly decays.
- **Oxygen:** decomposition is fast and complete with air, slow and incomplete without it.
- **Nature of the dead matter:** soft matter rich in nitrogen and sugar decays fast; tough matter rich in lignin, wax or resin decays slowly.
- **pH of the soil:** most bacteria need near-neutral soil; in acid soil decay is slower.
- **The number of decomposers and detritivores** present.

4 g. A **wetland** is an area of land covered by shallow water or soaked with water for all or much of the year, so that its soil is waterlogged and its plants and animals are adapted to water. Lakes, ponds, marshes, swamps, river floodplains, reservoirs and paddy fields are wetlands.

Abiotic components: water (shallow, still or slow-flowing), sunlight, dissolved oxygen and carbon dioxide, temperature, and soft, nutrient-rich mud that is low in oxygen.

Biotic components:

- **Producers:** phytoplankton in the open water; submerged plants such as *Hydrilla*; floating plants such as lotus, water lilies and *Pistia*; emergent plants such as reeds and cattails at the edge; grasses and sedges in the marsh.
- **Consumers:** zooplankton, snails, insect larvae, fish, frogs, turtles, snakes, crocodiles, birds such as egrets, herons, kingfishers, storks and ducks, and mammals such as otters and the wild water buffalo.
- **Decomposers:** bacteria and fungi in the water and mud.

A wetland has zones from open water to the bank (open water, floating plants, reed swamp, marsh, swamp forest), and both grazing food chains (phytoplankton → zooplankton → fish → heron) and detritus food chains (dead reeds → bacteria and fungi → snails → fish → kingfisher).

4 h. **Importance:** they are homes for many plants, fish and birds (including winter migrants); they soak up floods and release water slowly in the dry season; they recharge groundwater; they filter and clean water; they store carbon in their mud; they give fish, reeds, lotus and irrigation water, and tourism, to local people; and many are sacred.

Threats: encroachment and draining for farms and buildings; siltation from bare hillsides; pollution by sewage and fertilizers, which causes too much algae and weeds (eutrophication); invasive species such as water hyacinth; overfishing, poisoning and hunting; dams; and climate change.

Conservation: listing important wetlands as **Ramsar sites** (Nepal has ten, the first Koshi Tappu in 1987) and protecting them; planting forests in their catchments to stop silt; treating sewage; removing invasive weeds; controlling fishing and hunting; involving local communities in managing them; and raising awareness, for example on World Wetlands Day (2 February).

5 a.

- Moist soil: lost $25.0 - 17.5 = 7.5$ g; $7.5 \div 25.0 \times 100 = \mathbf{30\%}$.
- Dry ground: lost $25.0 - 23.0 = 2.0$ g; $2.0 \div 25.0 \times 100 = \mathbf{8\%}$.
- Compost heap: lost $25.0 - 11.5 = 13.5$ g; $13.5 \div 25.0 \times 100 = \mathbf{54\%}$.

The compost heap is warm (its microbes give out heat as they respire), moist and full of decomposers and detritivores, so the leaves decayed fastest. Moist soil has water and decomposers but is cooler. Dry, sunny ground has too little water for bacteria and fungi to work, so the leaves hardly changed. Most of the lost mass went into the air as carbon dioxide breathed out by the decomposers.

5 b. With fewer leopards, fewer deer, monkeys and wild boar are eaten, so all three increase. More deer and wild boar eat more grass and shrubs, and more monkeys eat more fruit and leaves, so those plants decrease. Young trees (saplings) are grazed by deer and their seeds and seedlings eaten and dug up by wild boar, so fewer young trees grow, and in time the forest could thin out. Losing the top predator affects the plants at the bottom, two steps away: a trophic cascade. (The prey animals may later decrease again as their food runs short.)

5 c. No. Vultures are **scavengers**: animals that eat dead bodies and digest them inside their bodies. The true decomposers are bacteria and fungi, which break dead matter right down to simple inorganic substances. But vultures do an important job: they clear carcasses fast. When diclofenac killed most of South Asia's vultures, carcasses lay rotting for longer, spreading germs, and stray dogs ate them instead and multiplied, bringing more dog bites and rabies. One study estimated about half a million extra human deaths in India from 2000 to 2005. A decrease in one population affected many others, people among them.