Managing global ecosystems

Ecology is the study of how organisms interact with one another and with their non-living environment. It is the study of connections in nature. To survive and support the rapidly growing population of the world, we have greatly increased the number and area of the Earth's natural systems that we have modified, cultivated, built on or degraded. An appreciation of interacting ecosystems is critical in order to understand the impact of humans — particularly the indirect and potentially unpredictable effects. An understanding of the interrelationships between natural systems is essential for sustainable planning, so that feedbacks (both negative and positive) can be identified. The first part of this topic provides students with some of the basic concepts of ecosystems and allows them to test themselves on what they have read. This gives them a platform from which to discuss more general issues in the second half of the session.

Aims

- To introduce the basic language and concepts of ecology.
- To consider the principles that govern and the components that make up ecosystems.
- To assess the human impact and how the ecosystem concept can help human societies to operate more sustainably.

Introduction

1 Many geography students will not be familiar with the 'language' of ecology, so it may be necessary to spend some time discussing the basic concept of ecosystems. Ecological principles are essential to understanding many aspects of sustainability. The class should start with a simple 'warm-up' exercise to familiarise the students with key ideas.

Distribute IS2a, which contains some key terms in the study of ecosystems. Ask students to match each term with a definition. Review the correct answers (1d, 2c, 3e, 4b, 5g, 6a, 7f).

Main lesson

2 Ask students to read IS2b, which addresses the various principles of ecosystems (this should take around 10 minutes).

Students should then answer questions 1 to 5 on WS2. When all have finished, briefly review their answers.

The final question and answer on IS2b introduces the idea that species within ecosystems will interact. Among the most important influences, and easily the most destructive influence on many ecosystems, is humankind. The rest of the class time should now concentrate on two quite different, but nevertheless fundamentally related issues: first, how humans affect ecosystems and second (in an extended conclusion), how we can use our knowledge of ecosystems to develop more sustainable lifestyles.

3 Divide the class into pairs and give them the following headings on paper:

- Fragmenting and degrading habitat
- Simplifying natural ecosystems
- Eliminating some predators
- Accidental introduction of non-native species

- Over-harvesting of renewable resources
- Interfering with energy flows in ecosystems

Ask students to consider for 2 minutes what each heading might refer to. They will need to describe what the factor might mean and explain why it could be detrimental to other parts of the ecosystem. In a plenary, get each pair to report back briefly on their thoughts. Invite a contribution from a second pair if you feel the explanation is insufficient. Ask a third group to rate how seriously they regard the impact.

Give students IS2c and review the meaning of each of the headings.

Conclusion

4 In an extended conclusion, explore with the whole class how the general ideas derived from observing ecosystems can help us to formulate principles in a search for more sustainable lifestyles.

List the following *principles of sustainability* (in italics below) on the board or flipchart. Do not explain what they mean until the students have had some time to answer the follow-up questions (below).

- *Most ecosystems use renewable solar energy as their primary source of energy* — thus a sustainable society would be powered mostly by current sunlight, not energy from ancient sunlight stored as polluting fossil fuels.
- *Ecosystems replenish nutrients and dispose of wastes by recycling chemicals* — there is almost no waste in nature. The waste outputs and decomposed remains of one organism are resource inputs for other organisms.
- *Biodiversity helps maintain the sustainability and ecological functioning of ecosystems and serves as a source of adaptations to changing environmental conditions.*
- *In nature there are always limits to growth* — the population size and growth rate of all species are controlled by their interactions with other species and with their non-living environment. The evolutionary lesson to be learned from nature is that no species can dominate for too long.

Ask students to list *two ways* in which human activities violate each of these four principles of sustainability. Get them to identify whether their own lifestyle violates these principles. Ask them if they would be willing to change any of these practices.

Finally, ask them if there could be beneficial or harmful effects of changing their lifestyle. Students should be able to use some of the terms they have learned in this session when giving their answers.

Some important ecosystem terminology

Terms

1 Organisms
2 Species
3 Population
4 Habitat
5 Community
6 Ecosystem
7 Biosphere

Definitions

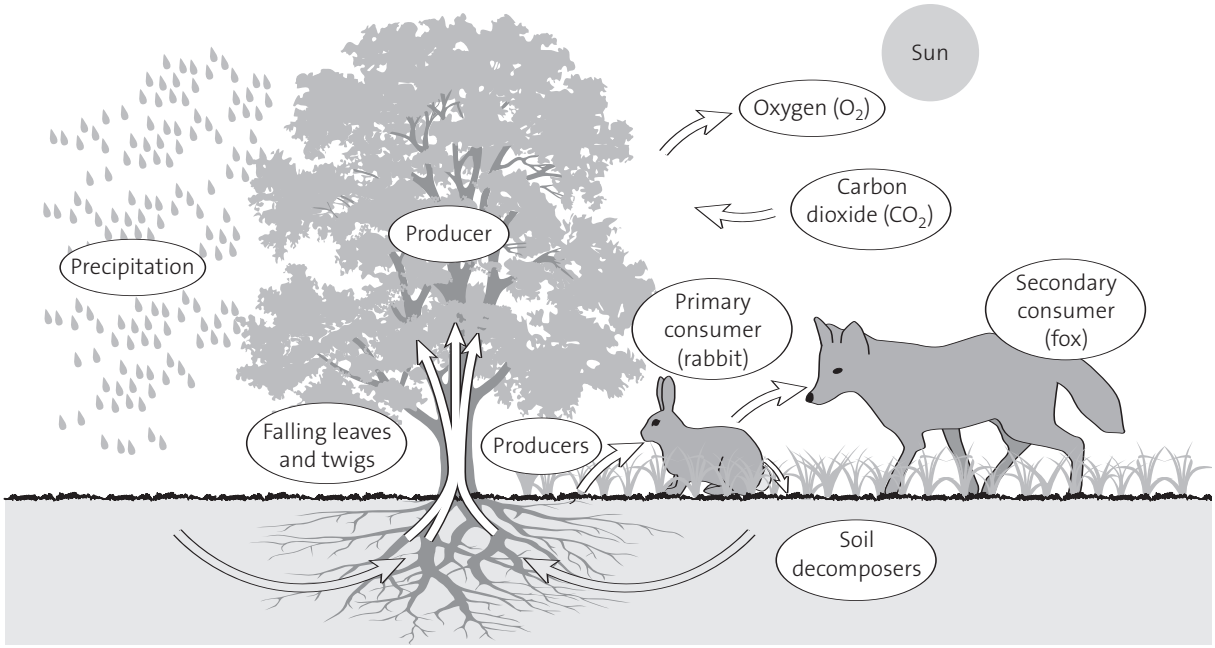
a A community of different species interacting with one another and their non-living environment of matter and energy.
b The place where a population (or organism) normally lives.
c Groups of organisms that resemble one another in appearance, behaviour, chemistry and genetic make-up.
d Any form of life, from basic single-celled entities (bacteria) to human beings.
e A group of interacting individuals of the same species that occupy a specific area at the same time.
f All the Earth's ecosystems together.
g Populations of all the different species occupying a place; a complex interacting network of plants, animals and microorganisms.

Ecosystems: some frequently asked questions

Q What are the major components of ecosystems?

A The biosphere and its ecosystems can be divided into two parts:

- abiotic or non-living components (water, air, nutrients and solar energy)
- biotic or living components (plants, animals and microorganisms, sometimes called biota) (see Figure 2.1)



Source: Miller (2002).

Figure 2.1 Major components of an ecosystem

Q What are abiotic components?

A The abiotic components of an ecosystem are the physical and chemical factors that influence living organisms. Different species thrive under different physical conditions. Some species require hot temperatures, whereas others prefer cooler environments. Some prefer bright sunlight, others prefer shade. Each population in an ecosystem has a range of tolerance to variation in its physical and chemical environment. Individuals within a population may also have slightly different tolerance ranges for temperature or other factors because of small differences in genetic make-up, health and age. The optimal level or range describes the narrow band of environmental conditions that is best suited to a specific population.

Q What is the law of tolerance?

A The law of tolerance states:

The existence, abundance and distribution of a species in an ecosystem are determined by whether the levels of one or more physical or chemical factors fall within the range tolerated by that species.

A species may have a wide range of tolerance to some factors (see Table 2.1) and a narrow range of tolerance to others. Most organisms are least tolerant during juvenile or reproductive stages of their lifecycles. Highly tolerant species can live in a variety of habitats with widely different conditions.

Table 2.1 Main physical and chemical abiotic factors affecting ecosystems

Terrestrial ecosystems	Aquatic ecosystems
Sunlight Temperature Precipitation Wind Latitude Altitude Fire frequency Soil	Light penetration Water currents Dissolved nutrient concentrations (especially nitrogen and phosphorus) Suspended solids

Q What is the limiting factor principle?

A This states:

Too much or too little of any abiotic factor can limit or prevent growth of a population, even if all other factors are at or near the optimum range of tolerance.

For instance, too little water or nutrients can be a single limiting factor. Similarly, too much of an abiotic factor, such as water or fertiliser, can be detrimental to the successful functioning of an organism.

Q What are the major living components of ecosystems?

A Living organisms in ecosystems are usually classified as either **producers** or **consumers**, based on how they get food.

Q What is a producer?

A Producers, sometimes also called **autotrophs**, make their own food from compounds obtained from their environment. On land most producers are green plants. Algae and plants are the dominant producers in freshwater and coastal areas, whereas in the open sea the major producers are phytoplankton. Most producers use sunlight to make complex carbohydrate compounds (such as glucose) by photosynthesis.

$$\text{carbon dioxide} + \text{water} + \text{solar energy} \rightarrow \text{glucose} + \text{oxygen}$$

Q What is a consumer?

A All other organisms in an ecosystem are consumers or **heterotrophs**. They get their energy and nutrients by feeding on other organisms or their remains. Based on their primary source of food, consumers are classified as follows:

- **herbivores** (plant eaters) — feeding directly on producers
- **carnivores** (meat eaters) — feeding on herbivores or other carnivores
- **omnivores** — feeding on both plants and animals
- **scavengers** — feeding on dead organisms
- **detrivores** — feeding on detritus (which are parts of dead organisms or their waste)
- **decomposers** — organisms that are able to break down detritus to get nutrients. This process releases simpler inorganic compounds that are then available to producers

Q What role does any species play in an ecosystem?

A A species' functional role in an ecosystem is called its **ecological niche**. This represents its ranges of tolerance, the types and amounts of resources and space it uses, how it interacts with abiotic and biotic components of its ecosystem and the role it plays in the energy flow of an ecosystem.

Q How do species interact?

A When different species in an ecosystem have activities or resource needs in common, they may interact with one another. Members of these species may be harmed by, benefit from or be unaffected by the interaction. There are five basic types of interaction between species:

- **Interspecific competition**. Each species has a fundamental ecological niche — the full potential range of physical, chemical and biological conditions and resources that it could theoretically use if there were no competition from other species. However, most species face competition from other species for one or more of the same limited resources (such as food, sunlight or water). This occurs where fundamental niches overlap.
- **Predation**. Members of one species (the predator) feed directly on all or part of a living organism of another species (the prey), but they do not live on or in the prey.
- **Parasitism**. One species (the parasite) obtains its nourishment by living on, in or near a member of another species (its host) over an extended time. Parasitism is similar to predation but the parasite is often smaller than its host (the prey) and, although it may weaken its host it does not kill it.
- **Mutualism**. Two species interact in ways that benefit both. The benefits could include having pollen and seeds dispersed or being supplied with food.
- **Commensalism**. This is an interaction in which one species benefits but another is neither harmed nor helped in any way.

Forms of ecological degradation

Fragmenting and degrading habitat

The undisturbed landscape of continuous forest, grassland or other natural ecosystems has been divided into a patchwork of (often degraded) fragments surrounded by urban areas, recreational areas and farmland.

Simplifying natural ecosystems

Many grasslands and forests have been cleared and replaced with a single crop or tree species (monocultures) or with buildings or roads. Herbicides and pesticides are then applied to prevent the invasion of other organisms.

Eliminating some predators

Livestock farmers have tried to eradicate animals that might prey on their livestock, or even compete with them for food.

Accidental introduction of non-native species

Although they are sometimes beneficial, there are instances when severe disruption to ecosystems has occurred following the introduction of non-native species, such as rabbits in Australia and grey squirrels in the UK.

Over-harvesting of renewable resources

Overgrazing of grassland can degrade the quality of the land and enhance erosion rates. Excessive crop growing can deplete the soil of nutrients. Wildlife species (e.g. fish) can be over-harvested and may become endangered.

Interfering with energy flows in ecosystems

Emissions of carbon dioxide, for instance from industrialisation and forest clearance, can interfere with the radiation balance of the entire globe and potentially have far-reaching impacts.

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Read IS2b and then work through the following questions. Once you have read the information sheet, try not to refer back to it.

1 Distinguish between abiotic and biotic components of ecosystems and give three examples of each component.

2 Define the range of tolerance for a population in an ecosystem. Name two of the key environmental factors and suggest an example for each.

3 Distinguish between producers and consumers in ecosystems and give three examples of each.

4 Define 'ecological niche'.

5 Distinguish between predation, parasitism and mutualism and give an example of each.