Teaching Guide

Topic 2 Ecosystems and ecology

Topic map

Sub-topic number and name	**Learning outcome**	**Number of lessons (suggested)** **1 hour per lesson**	**Relevant material**
2.01 Species and populations	Species interact with their environment.	3	Pages 51–61 Figures 2.02, 2.04 Self-assessment questions 2.01.01, 2.01.02 Case studies 2.01.01, 2.01.02 End-of-topic question 1
2.02 Communities and ecosystems	Energy and nutrients flow in an environment. Feeding relationships can be modelled.	5	Pages 62–73 Figures 2.06, 2.08, 2.11, 2.13 Self-assessment questions 2.02.01, 2.02.02 Case study 2.02.02 End-of-topic question 3
2.03 Flows of energy and matter	Ecosystems are linked by energy flows. Humans are affecting the flow of energy and matter.	5	Pages 74–85 Figures 2.08, 2.20, 2.22 Self-assessment questions 2.03.01–2.03.03 Case study 2.03.02 End-of-topic question 2
2.04 Biomass, zonation and succession	Climate determines biomes. Ecosystem stability, succession and biodiversity are linked.	6	Pages 86–102 Figures 2.24, 2.25 Self-assessment questions 2.04.01, 2.04.02 Case study 2.04.01 End-of-topic question 5

2.05 Investigating ecosystems	Ecosystems can be investigated using practical quantitative techniques that enable evaluation, monitoring and modelling.	6	Pages 103–116 Figures 2.31, 2.33; Images 2.25, 2.26 Self-assessment questions 2.05.01, 2.05.02, 2.05.03 Case study 2.05.01 End-of-topic question 4

Sub-topic 2.01: Species and populations

Overview

Students should have a general idea of the concepts here, but the emphasis should be on precision in definition of terms. These are key concepts for the whole course.

Suggested activities

Possible starters

Introduce the concept of a species with some anomalous examples such as a mule or zorse to clarify the definition.
http://a-z-animals.com/animals/zorse has images and information.

Main lesson content

- Students should select their own chosen species and outline to others the details of its habitat and its fundamental and realised niche. Stress the need for accuracy in naming the chosen species.
- Discussion of species interactions, such as predation, herbivory and mutualism, should naturally follow. Useful visual material is available at: http://education.nationalgeographic.co.uk/education/activity/ecological-relationships/?ar_a=1
- Examples of abiotic factors can be included here.
- Students can present their work as presentations, posters or reports, which can be viewed by everyone.
- Teachers should clearly define a population, as this is a vital concept for subsequent topics.
- Simulations can be used to show how population size is affected by birth, death, immigration and emigration and to draw a sigmoid growth curve; explain the reasons for the shape of the curve and list three factors that limit population growth: www.abpischools.org.uk and http://sepuplhs.org/high/sgi/teachers/fishery_sim.html
  Predator–prey relationships are also useful:
  www.biologycorner.com/worksheets/pred_prey.html

Common misunderstandings and misconceptions

Recall of S- and J-curves may need reinforcement.

Supporting struggling students

Few students find these descriptive concepts difficult, but students could be asked to select examples of each category that is defined and record the definitions with a visual backup.

Challenging high achievers

High achievers could be asked to consider how the definition of a species has had to change as new evidence from molecular biology has added genetic and biochemical information to our understanding of what a species is. Students could look at species relationships and how cladistics is used in defining them.

Homework suggestion

Outline reasons for the exponential growth of the human population.

Cross-references with other sub-topics

8.04 Human population carrying capacity.

Sub-topic 2.02: Communities and ecosystems

Overview

Students may be familiar with the idea of feeding relationships in ecosystems. These can be extended to include photosynthesis, respiration and interactions that result in energy flow.

Suggested activities

Possible starters

Ask students to choose an organism and produce a spider diagram to identify all the links that the organism has with the environment. A video clip of a selected species could be used for all students to consider the same organism.

Main lesson content

- Experiments with photosynthesis and respiration highlight the inputs and outputs of the processes. There are many ideas at: www.biotopics.co.uk/plants/psfac2.html and www.saps.org.uk
- Review the definitions of 'community' and 'ecosystem', then draw and describe food chains and food webs using ten organisms (using common names).
- Define 'trophic level' and identify the trophic level of organisms in food chains and webs.
- Explain how energy flows through a food web and that energy transformation is not 100 per cent efficient; explain the shape of an energy pyramid, a pyramid of biomass and numbers.
- Contrast the flow of energy with the cycling of nutrients, and outline the importance of saprotrophic bacteria and fungi in nutrient cycles.

Common misunderstandings and misconceptions

For the International Baccalaureate (IB) Environmental Systems and Societies (ESS) course, 'biomass' refers to standing crop, and pyramids of productivity indicate the rate of flow of biomass or energy. These concepts are not consistently used in other courses or literature.

Supporting struggling students

Construction of pyramids from food chains can support weaker students who need help to understand numerical concepts.

Challenging high achievers

Calculations involving units of biomass or energy can stretch the best students.

Homework suggestion

Work on biomagnification using data from the textbook or elsewhere can emphasise concepts of persistent pollutants and bioaccumulation.

Cross-references with other sub-topics

1.03 Energy and equilibria, 4.04 Water pollution, Topic 3 Biodiversity.

Sub-topic 2.03: Flows of energy and matter

Overview

That the Sun drives ecosystems will be a familiar concept, but the interaction and interdependence of ecosystems may be unfamiliar.

Suggested activities

<u>Possible starters</u>

The Sun as the driver for life on Earth provides a good starting point. There is a lot of information on sites such as NASA's to promote discussion:
www.nasa.gov/vision/universe/solarsystem/sun_for_kids_main.html

<u>Main lesson content</u>

- Build on the starter activity to trace the fate of insolation that reaches the Earth. (Use the syllabus as guidance.)
- Define productivity (net primary productivity (NPP) and gross primary productivity (GPP)) and measure primary productivity by the harvest method or oxygen production method.
- Values for GPP and NPP from different biomes can be compared with data from websites such as www.world-builders.org/lessons/less/biomes/primaryP.html
- The idea of sustainable yield can be introduced and linked to productivity.
- Construct diagrams of the carbon and nitrogen cycles and identify the flows and storages they contain.

- Evaluate and discuss the impact of human activities on the carbon cycle, the nitrogen cycle and on the flow of energy.

Common misunderstandings and misconceptions

GPP and NPP are often confused, and terminology can differ in different texts. 'Assimilation' may be used instead of 'secondary productivity'.

Supporting struggling students

Students with weaker maths skills may require support with calculations.

Challenging high achievers

High achievers can evaluate the links between ecosystem structure and NPP and examine agricultural systems as a comparison. This will require evaluation of human impacts.

Homework suggestion

Construct diagrams showing storages of energy and flows through selected systems, which will reinforce the concepts here.

Cross-references with other sub-topics

4.01 Introduction to water systems, 5.01 Introduction to soil systems, 8.04 Human population carrying capacity.

Sub-topic 2.04: Biomass, zonation and succession

Overview

The concept of a biome determined by climate may be new. Succession and the development of different ecosystems is an interesting idea to explore.

Suggested activities

Possible starters

Identification of biomes from maps, video material and climate data is always interesting. Useful references are:
www.blueplanetbiomes.org/world_biomes.htm and www.worldbiomes.com

Main lesson content

- Having identified different biomes, students should choose two that interest them and draw up a comparative table.
- Introduce the tricellular model of climate here to supplement information about biome climate.
  www.s-cool.co.uk/alevel/geography/introduction-to-weather-and-climate/atmospheric-circulation-and-motion.html and www.physicalgeography.net/fundamentals/7p.html may be helpful.

- Succession and zonation are two concepts that are easily confused. Succession is an important concept that can be studied both practically using a cleared patch of land to observe colonisation, and theoretically by examining long-term succession using reference sources.
  www.sandsoftime.hope.ac.uk/succession/studying.htm describes succession on a sand dune and how measurements are made.
- K- and r-strategists can be identified from the local species that colonise the cleared area.
- Comparisons of GPP and NPP and their links to biomass accumulation lead nicely to discussion of ecosystem stability.
- The concept of a climax community can be reviewed here and factors influencing the climax noted.
- Students should review the human impact on climax communities and interruption of succession, particularly in relation to farming.
- Zonation can also be studied in a practical session if time permits, and this is a good opportunity to introduce the use of transects on a seashore, or in a meadow or other local ecosystem and relate the zones to abiotic factors.

Common misunderstandings and misconceptions

The main areas of confusion are likely to be succession and zonation. Succession occurs over time, but zonation is a spatial phenomenon. Both occur over a geographical area, so the distinction must be clearly made.

Supporting struggling students

Students who find the concepts of K- and r-strategies difficult could be encouraged to seek out local examples of wind-dispersed plants and slowly reproducing animals. They may also require several examples of the differences between zonation and succession to reinforce the concepts.

Challenging high achievers

High-achieving students could lead a discussion, drawing together time, climate, reproductive strategy and ecosystem stability in the development of climax communities and ecosystems.

Homework suggestion

Students can identify and categorise pioneer, intermediate and climax communities. They can research examples of K- and r-strategists and discuss why these categories are helpful but imperfect.

Cross-references with other sub-topics

2.05 Investigating ecosystems (zonation can be studied in this sub-topic if preferred), 5.02 Terrestrial food production systems and food choices.

Sub-topic 2.05: Investigating ecosystems

Overview

This sub-topic is essentially a practical one and may be covered on a field trip or during a series of outdoor activities. Highlight the importance of ecosystem studies for comparison monitoring and modelling.

Suggested activities

Possible starters

- Review the abiotic factors that affect the distribution of organisms in ecosystems. Ask students to rank these in order of importance for the habitat they will be studying.

Main lesson content

Details of the practical work described here can be found on the 'Fieldwork and practical work guidance' page.

- Identification of common or local species can be carried out using keys, reference books or other suitable materials. If it is not possible for students to collect their own material, drawings can be used for classification, for example http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/Media/Html/TheCrop/AboutTheCrop/Botany/Bot%20leaves.htm. Many others are available. Students should use eight organisms to construct a key.
- Fieldwork should involve sampling a marine (seashore), terrestrial or freshwater system. Abiotic factors such as pH, temperature, light intensity, slope and mineral content can be easily measured. This can also provide an opportunity for students to use data loggers if these are available.
- Transects and quadrats are sampling methods that students should be familiar with, and random number tables can be used here too.
- In theoretical work, students should understand how factors can be measured over time and along environmental gradients using the techniques they have learned.
- The Lincoln index can be used to estimate populations and emphasis should be put on the importance of not harming organisms using capture–mark–recapture techniques. (If practical work is impossible, students can sample a theoretical population of pasta shells in a large container to demonstrate the method used. This will produce interesting data that represents a real-life situation with various inaccuracies between groups who carry out the procedure.) Reliability and accuracy of data can be discussed in the context of this work.
- The Simpson diversity index can be calculated using students' own data if two habitats have been compared, or using published data for different habitats. Some examples are included in the textbook, and data is available on websites such as: http://geographyfieldwork.com/Simpson%27sDiversityIndex.htm
  Note that many texts use the reciprocal index, so ensure that students use the formula used for the IB ESS course.

- It may be useful to introduce indicator species here and form a link with the detection and management of pollution (in Topic 6 Atmospheric systems and societies). www.arkive.org/education/teaching-resources-14-16 has good resources.

Common misunderstandings and misconceptions

Students should be reminded that not all features of an organism are suitable for constructing a key. For example, size will vary with age or maturity of an individual, and colour may be continuously variable, so features like these must be used with care.

Supporting struggling students

It is unlikely that students will struggle with this practical sub-topic. Weaker students usually enjoy the practical work, which involves visual and kinetic learning.

Challenging high achievers

More numerate students might enjoy using biomass data to construct ecological pyramids.

Homework suggestion

Historic or aerial photographs provide interesting resources for comparisons of ecosystems or habitats over time. Students could calculate and analyse diversity indexes in relation to species richness and relative abundance.

Cross-references with other sub-topics

Topic 3 Biodiversity and conservation.