Summary

Topic 2 -Ecosystems and Ecology

Subject	Year	Start date	Duration
Environmental Systems & Societies	IB1, IB2	Week 1, October	6 weeks 25 hours

Course Part
Core

Description
This topic may be particularly appropriate for considering big questions A and E.

Curriculum

Aims

Acquire the knowledge and understandings of environmental systems at a variety of scales

Apply the knowledge, methodologies and skills to analyse environmental systems and issues at a variety of scales

Appreciate the dynamic interconnectedness between environmental systems and societies

Value the combination of personal, local and global perspectives in making informed decisions and taking responsible actions on environmental issues

Be critically aware that resources are finite, and that these could be inequitably distributed and exploited, and that management of these inequities is the key to sustainability

Develop awareness of the diversity of environmental value systems

Develop critical awareness that environmental problems are caused and solved by decisions made by individuals and societies that are based on different areas of knowledge

Engage with the controversies that surround a variety of environmental issues

Create innovative solutions to environmental issues by engaging actively in local and global contexts

Objectives

Demonstrate knowledge and understanding of relevant

facts and concepts

methodologies and techniques

values and attitudes

Apply this knowledge and understanding in the analysis of

explanations, concepts and theories

data and models

case studies in unfamiliar contexts

arguments and value systems

Evaluate, justify and synthesise, as appropriate

explanations, theories and models

arguments and proposed solutions

cultural viewpoints and value systems

Engage with investigations of environmental and societal issues at the local and global level through

evaluating the political, economic and social contexts of issues

Syllabus Content

Topic 2: Ecosystems and ecology

2.1 Species and populations

Significant ideas:

A species interacts with its abiotic and biotic environments, and its niche is described by these interactions.

Populations change and respond to interactions with the environment.

Any system has a carrying capacity for a given species.

Knowledge and understanding:

A species is a group of organisms that share common characteristics and that interbreed to produce fertile offspring.

A habitat is the environment in which a species normally lives.

A niche describes the particular set of abiotic and biotic conditions and resources to which an organism or population responds.

The fundamental niche describes the full range of conditions and resources in which a species could survive and reproduce. The realized niche describes the actual conditions and resources in which a species exists due to biotic interactions.

The non-living, physical factors that influence the organisms and ecosystem—such as temperature, sunlight, pH, salinity, and precipitation—are termed abiotic factors.

The interactions between the organisms—such as predation, herbivory, parasitism, mutualism, disease, and competition—are termed biotic factors.

Interactions should be understood in terms of the influences each species has on the population dynamics of others, and upon the carrying capacity of the others' environment.

A population is a group of organisms of the same species living in the same area at the same time, and which are capable of interbreeding.

S and J population curves describe a generalized response of populations to a particular set of conditions (abiotic and biotic factors).

Limiting factors will slow population growth as it approaches the carrying capacity of the system.

Applications and skills:

Interpret graphical representations or models of factors that affect an organism's niche. Examples include predator–prey relationships, competition, and organism abundance over time.

Explain population growth curves in terms of numbers and rates.

2.2 Communities and ecosystems

Significant ideas:

The interactions of species with their environment result in energy and nutrient flows.

Photosynthesis and respiration play a significant role in the flow of energy in communities.

The feeding relationships of species in a system can be modelled using food chains, food webs and ecological pyramids.

Knowledge and understanding:

A community is a group of populations living and interacting with each other in a common habitat.

An ecosystem is a community and the physical environment with which it interacts.

Respiration and photosynthesis can be described as processes with inputs, outputs and transformations of energy and matter.

Respiration is the conversion of organic matter into carbon dioxide and water in all living organisms, releasing energy. Aerobic respiration can be represented by the following word equation: glucose+oxygen -> carbon dioxide + water

During respiration, large amounts of energy are dissipated as heat, increasing the entropy in the ecosystem while enabling organisms to maintain relatively low entropy and so high organization.

Primary producers in most ecosystems convert light energy into chemical energy in the process of photosynthesis.

The photosynthesis reaction is can be represented by the following word equation: carbon dioxide + water —> glucose + oxygen

Photosynthesis produces the raw material for producing biomass.

The trophic level is the position that an organism occupies in a food chain, or the position of a group of organisms in a community that occupy the same position in food chains.

Producers (autotrophs) are typically plants or algae that produce their own food using photosynthesis and form the first trophic level in a food chain. Exceptions include chemosynthetic organisms that produce food without sunlight.

Feeding relationships involve producers, consumers and decomposers. These can be modelled using food chains, food webs and ecological pyramids.

Ecological pyramids include pyramids of numbers, biomass and productivity and are quantitative models that are usually measured for a given area and time.

In accordance with the second law of thermodynamics, there is a tendency for numbers and quantities of biomass and energy to decrease along food chains; therefore, the pyramids become narrower towards the apex.

Bioaccumulation is the build-up of persistent or non-biodegradable pollutants within an organism or trophic level because they cannot be broken down.

Biomagnification is the increase in concentration of persistent or nonbiodegradable pollutants along a food chain.

Toxins such as DDT and mercury accumulate along food chains due to the decrease of biomass and energy.

Pyramids of numbers can sometimes display different patterns; for example, when individuals at lower trophic levels are relatively large (inverted pyramids).

A pyramid of biomass represents the standing stock or storage of each trophic level, measured in units such as grams of biomass per square metre (g m–2) or Joules per square metre (J m-2) (units of biomass or energy).

Pyramids of biomass can show greater quantities at higher trophic levels because they represent the biomass present at a fixed point in time, although seasonal variations may be marked.

Pyramids of productivity refer to the flow of energy through a trophic level, indicating the rate at which that stock/storage is being generated.

Pyramids of productivity for entire ecosystems over a year always show a decrease along the food chain.

Applications and skills:

Construct models of feeding relationships—such as food chains, food webs and ecological pyramids—from given data.

Explain the transfer and transformation of energy as it flows through an ecosystem.

Analyse the efficiency of energy transfers through a system.

Construct system diagrams representing photosynthesis and respiration.

Explain the relevance of the laws of thermodynamics to the flow of energy through ecosystems.

Explain the impact of a persistent or non-biodegradable pollutant in an ecosystem.

2.3 Flows of energy and matter

Significant ideas:

Ecosystems are linked together by energy and matter flows.

The Sun's energy drives these flows, and humans are impacting the flows of energy and matter both locally and globally.

Knowledge and understanding:

As solar radiation (insolation) enters the Earth's atmosphere, some energy becomes unavailable for ecosystems as this energy is absorbed by inorganic matter or reflected back into the atmosphere.

Pathways of radiation through the atmosphere involve a loss of radiation through reflection and absorption.

Pathways of energy through an ecosystem include:

conversion of light energy to chemical energy transfer of chemical energy from one trophic level to another with varying efficiencies

overall conversion of ultraviolet and visible light to heat energy by an ecosystem

re-radiation of heat energy to the atmosphere.

The conversion of energy into biomass for a given period of time is measured as productivity.

Net primary productivity (NPP) is calculated by subtracting respiratory losses (R) from gross primary productivity (GPP). NPP = GPP - R

Gross secondary productivity (GSP) is the total energy or biomass assimilated by consumers and is calculated by subtracting the mass of fecal loss from the mass of food consumed. GSP = food eaten – fecal loss

Net secondary productivity (NSP) is calculated by subtracting respiratory losses (R) from GSP. NSP = GSP – R

Maximum sustainable yields are equivalent to the net primary or net secondary productivity of a system.

Matter also flows through ecosystems linking them together. This flow of matter involves transfers and transformations.

The carbon and nitrogen cycles are used to illustrate this flow of matter using flow diagrams. These cycles contain storages (sometimes referred to as sinks) and flows, which move matter between storages.

Storages in the carbon cycle include organisms and forests (both organic), or the atmosphere, soil, fossil fuels and oceans (all inorganic).

Flows in the carbon cycle include consumption (feeding), death and decomposition, photosynthesis, respiration, dissolving and fossilization.

Storages in the nitrogen cycle include organisms (organic), soil, fossil fuels, atmosphere and water bodies (all inorganic).

Flows in the nitrogen cycle include nitrogen fixation by bacteria and lightning, absorption, assimilation, consumption (feeding), excretion, death and decomposition, and denitrification by bacteria in water-logged soils.

Human activities such as burning fossil fuels, deforestation, urbanization and agriculture impact energy flows as well as the carbon and nitrogen cycles.

Applications and skills:

Analyse quantitative models of flows of energy and matter.

Construct a quantitative model of the flows of energy or matter for given data.

Analyse the efficiency of energy transfers through a system.

Calculate the values of both GPP and NPP from given data.

Calculate the values of both GSP and NSP from given data.

Discuss human impacts on energy flows, and on the carbon and nitrogen cycles.

2.4 Biomes, zonation and succession

Significant ideas:

Climate determines the type of biome in a given area, although individual ecosystems may vary due to many local abiotic and biotic factors.

Succession leads to climax communities that may vary due to random events and interactions over time. This leads to a pattern of alternative stable states for a given ecosystem.

Ecosystem stability, succession and biodiversity are intrinsically linked.

Knowledge and understanding:

Biomes are collections of ecosystems sharing similar climatic conditions that can be grouped into five major classes: aquatic, forest, grassland, desert and tundra. Each of these classes has characteristic limiting factors, productivity and biodiversity.

Insolation, precipitation and temperature are the main factors governing the distribution of biomes.

The tricellular model of atmospheric circulation explains the distribution of precipitation and temperature and how they influence structure and relative productivity of different terrestrial biomes.

Climate change is altering the distribution of biomes and causing biome shifts.

Zonation refers to changes in community along an environmental gradient due to factors such as changes in altitude, latitude, tidal level or distance from shore (coverage by water).

Succession is the process of change over time in an ecosystem involving pioneer, intermediate and climax communities.

During succession, the patterns of energy flow, gross and net productivity, diversity, and mineral cycling change over time.

Greater habitat diversity leads to greater species and genetic diversity.

r- and K-strategist species have reproductive strategies that are better adapted to pioneer and climax communities, respectively.

In early stages of succession, gross productivity is low due to the unfavourable initial conditions and low density of producers. The proportion of energy lost through community respiration is relatively low too, so net productivity is high - that is, the system is growing and biomass is accumulating.

In later stages of succession, with an increased consumer community, gross productivity may be high in a climax community. However, this is balanced by respiration, so net productivity approaches 0 and the productivity–respiration (P:R) ratio approaches 1.

In a complex ecosystem, the variety of nutrient and energy pathways contributes to its stability.

There is no one climax community, but rather a set of alternative stable states for a given ecosystem. These depend on the climatic factors, the properties of the local soil and a range of random events that can occur over time.

Human activity is one factor that can divert the progression of succession to an alternative stable state by modifying the ecosystem; for example, the use of fire in an ecosystem, the use of agriculture, grazing pressure, or resource use (such as deforestation). This diversion may be more or less permanent depending upon the resilience of the ecosystem.

An ecosystem's capacity to survive change may depend on its diversity and resilience.

Applications and skills:

Explain the distributions, structure, biodiversity and relative productivity of contrasting biomes.

Analyse data for a range of biomes.

Discuss the impact of climate change on biomes.

Describe the process of succession in a given example.

Explain the general patterns of change in communities undergoing succession.

Discuss the factors which could lead to alternative stable states in an ecosystem.

Discuss the link between ecosystem stability, succession, diversity and human activity.

Distinguish the roles of r and K selected species in succession.

Interpret models or graphs related to succession and zonation.

2.5 Investigating ecosystems

Significant ideas:

The description and investigation of ecosystems allows for comparisons to be made between different ecosystems and for them to be monitored, modelled and evaluated over time, measuring both natural change and human impacts.

Ecosystems can be better understood through the investigation and quantification of their components.

Knowledge and understanding:

The study of an ecosystem requires that it be named and located; for example, Deinikerwald in Baar, Switzerland—a mixed deciduous–coniferous managed woodland.

Organisms in an ecosystem can be identified using a variety of tools including keys, comparison to herbarium or specimen collections, technologies and scientific expertise.

Sampling strategies may be used to measure biotic and abiotic factors and their change in space, along an environmental gradient, over time, through succession, or before and after a human impact (for example, as part of an EIA).

Measurements should be repeated to increase reliability of data. The number of repetitions required depends on the factor being measured.

Methods for estimating the biomass and energy of trophic levels in a community include measurement of dry mass, controlled combustion and extrapolation from samples. Data from these methods can be used to construct ecological pyramids.

Methods for estimating the abundance of non-motile organisms include the use of quadrats for making actual counts, measuring population density, percentage cover and percentage frequency.

Direct and indirect methods for estimating the abundance of motile organisms can be described and evaluated. Direct methods include actual counts and sampling. Indirect methods include the use of capture–mark–recapture with the application of the Lincoln index.

Species richness is the number of species in a community and is a useful comparative measure.

Species diversity is a function of the number of species and their relative abundance and can be compared using an index.

Applications and skills:

Design and carry out ecological investigations.

Construct simple identification keys for up to eight species.

Evaluate sampling strategies.

Evaluate methods to measure at least three abiotic factors in an ecosystem.

Evaluate methods to investigate the change along an environmental gradient and the effect of a human impact in an ecosystem.

Evaluate methods for estimating biomass at different trophic levels in an ecosystem.

Evaluate methods for measuring or estimating populations of motile and nonmotile organisms.

Calculate and interpret data for species richness and diversity.

Draw graphs to illustrate species diversity in a community over time, or between communities.

ATL Skills

Approaches to Learning

Thinking

- In this unit, we will

ask students to formulate a reasoned argument to support their opinion or conclusion

give students time to think through their answers before asking them for a response

reward a new personal understanding, solution or approach to an issue

ask open questions

set students a task which required higher-order thinking skills (such as analysis or evaluation)

build on a specific prior task

help students to make their thinking more visible (for example, by using a strategy such as a thinking routine)

require students to take an unfamiliar viewpoint into account when formulating arguments

ask questions that required the use of knowledge from a different subject from the one you are teaching

include a reflection activity

make a link to TOK

Social

- In this unit, we will

    have students work in small groups

    allocate, or ask students to allocate among themselves, different roles in a classroom discussion or activity

    have students peer assess their group performance or process

    support students in resolving a conflict in a team

    give a group assessment task

    give students feedback on how they worked as a group

    have students discuss their understanding of a text or idea among themselves and come up with a shared understanding

    provide an opportunity for students to analyse the impact of their behaviour on the class or on a group performance

    encourage students to consider alternative points of view or to take the perspective of others

    provide opportunities for students to make decisions

Communication

- In this unit, we will

    ask students to explain their understanding of a text or idea to each other

    construct a task around the use of different vocabulary and examples when speaking to different audiences

    have students give an oral presentation without reading from their notes

    ask students to monitor and check the quality of their writing

    construct a task so that students practise their listening skills

    assess or give feedback on speaking or writing concisely

    provide opportunities for students to read and understand different types of texts

    encourage or require students to plan a response before they begin

    ask students to formulate arguments clearly and coherently

    encourage all students to contribute to discussions

Developing IB Learners

Learner Profile

Inquirers

Knowledgeable

Thinkers

Communicators

Principled

Open-minded

Caring

Risk-takers (Courageous)

Balanced

Reflective