Course No: S 971

Orange Unified School District

International Baccalaureate
Environmental Systems and Societies
Standard Level

Year Course

GRADE LEVEL: 11 - 12

PREREQUISITES: Completion of Earth Science and Biology or Honors Biology with a B- or better or teacher approval

INTRODUCTION TO THE SUBJECT:

The intent of the course is to provide a coherent perspective of the interrelationships between environmental systems and societies; one that enables them to adopt an informed personal response to the wide range of pressing environmental issues that they will face. Students' attention can be drawn to their own relationship with their environment and the significance of choices and decisions that they make in their own lives. It is intended that students develop a sound understanding of the interrelationships between environmental systems and societies, rather than a purely journalistic appreciation of environmental issues.

COURSE OBJECTIVES:
BY THE END OF THE COURSE THE STUDENT WILL BE ABLE TO:

The objectives of the **Environmental Systems and Societies** course are to:

1. Promote understanding of environmental processes from local to global levels.
2. Provide a body of knowledge, methodologies and skills that can be used in the analysis of environmental issues at local and global levels.
3. Enable students to apply the knowledge, methodologies and skills gained.
4. Promote critical awareness of a diversity of cultural perspectives.
5. Recognize the extent to which technology plays a role in both causing and solving environmental problems.
6. Appreciate the value of local and international collaboration in resolving environmental problems.
7. Appreciate that environmental issues may be controversial, and may provoke a variety of responses.
8. Appreciate that human society is both directly and indirectly linked to the environment at a number of levels and on a variety of scales.

COURSE OVERVIEW AND APPROXIMATE UNIT TIME ALLOTMENTS:

FIRST SEMESTER **WEEKS**

I. Topic 1: Systems and models **2**

It is essential that the systems approach is used throughout this course. This approach identifies the elements of the systems, and examines the relationships and processes that link these elements into a functioning entity. This topic may be best viewed therefore as a theme to be used in the delivery of the other topics, rather than as an isolated teaching topic.

The topic identifies some of the underlying principles that can be applied to living systems, from the level of the individual up to that of the whole biosphere. It would therefore be helpful to describe and analyze the systems addressed in the terms laid out in this topic (wherever possible). The systems approach also emphasizes the similarities between environmental systems, biological systems and artificial entities such as transport and communication systems. This approach stresses that there are concepts, techniques and terms that can be transferred from one discipline (such as ecology) to another (such as engineering).

	Assessment statement	Obj	Teacher's notes
1.1.1	Outline the concept and characteristics of systems.	2	The emphasis will be on ecosystems but some mention should be made of economic, social and value systems.
1.1.2	Apply the systems concept on a range of scales.	2	The range must include a small-scale local ecosystem, a large ecosystem such as a biome, and Gaia as an example of a global ecosystem.
1.1.3	Define the terms *open system*, *closed system* and *isolated system*.	1	These terms should be applied when characterizing real systems. • An open system exchanges matter and energy with its surroundings (for example, an ecosystem). • A closed system exchanges energy but not matter; the "Biosphere II" experiment was an attempt to model this. Strictly, closed systems do not occur naturally on Earth, but all the global cycles of matter, for example, the water and nitrogen cycles, approximate to closed systems. • An isolated system exchanges neither matter nor energy. No such systems exist (with the possible exception of the entire cosmos).
1.1.4	Describe how the first and second laws of thermodynamics are relevant to environmental systems.	2	The first law concerns the conservation of energy. The second law explains the dissipation of energy that is then not available to do work, bringing about disorder. The second law is most simply stated as: "In any isolated system entropy tends to increase spontaneously." This means that energy and materials go from a concentrated into a dispersed form (the availability of energy to do work diminishes) and the system becomes increasingly disordered.

			Both laws should be examined in relation to the energy transformations and maintenance of order in living systems.
1.1.5	Explain the nature of equilibria.	3	A steady-state equilibrium should be understood as the common property of most open systems in nature. A static equilibrium, in which there is no change, should be appreciated as a condition to which natural systems can be compared. (Since there is disagreement in the literature regarding the definition of dynamic equilibrium, this term should be avoided.) Students should appreciate, however, that some systems may undergo long-term changes to their equilibrium while retaining an integrity to the system (for example, succession). The relative stability of an equilibrium—the tendency of the system to return to that original equilibrium following disturbance, rather than adopting a new one—should also be understood.
1.1.6	Define and explain the principles of *positive feedback* and *negative feedback*.	3	The self-regulation of natural systems is achieved by the attainment of equilibrium through feedback systems. • Negative feedback is a self-regulating method of control leading to the maintenance of a steady-state equilibrium—it counteracts deviation, for example, predator–prey relationships. • Positive feedback leads to increasing change in a system—it accelerates deviation, for example, the exponential phase of population growth. Feedback links involve time lags.
1.1.7	Describe transfer and transformation processes.	2	Transfers normally flow through a system and involve a change in location. Transformations lead to an interaction within a system in the formation of a new end product, or involve a change of state. Using water as an example, run-off is a transfer process and evaporation is a transformation process. Dead organic matter entering a lake is an example of a transfer process; decomposition of this material is a transformation process.
1.1.8	Distinguish between flows (inputs and outputs) and storages (stock) in relation to systems.	2	Identify flows through systems and describe their direction and magnitude.
1.1.9	Construct and analyse quantitative models involving flows and storages in a system.	3	Storages, yields and outputs should be included in the form of clearly constructed diagrammatic and graphical models.
1.1.10	Evaluate the strengths and limitations of models.	3	A model is a simplified description designed to show the structure or workings of an object, system or concept. In practice, some models require approximation techniques to be used. For example, predictive models of climate change may give very different results. In contrast, an aquarium may be a relatively simple ecosystem but demonstrates many ecological concepts.

II. Topic 2: The ecosystem 8

The techniques required in this topic may be exemplified through practical work in marine, terrestrial, freshwater or urban ecosystems, or any combination of these. The selection of environments can be made according to the local systems available to the students, and the most convenient systems for demonstrating the techniques in question. However, there is an advantage in using the various practical measurements to quantify different aspects of the same ecosystem, where possible. In this way, the techniques are not simply rehearsed in isolation, but can be used to build up a holistic model of that system.

2.1 Structure (4 hours)

	Assessment statement	Obj	Teacher's notes
2.1.1	Distinguish between biotic and abiotic (physical) components of an ecosystem.	2	
2.1.2	Define the term *trophic level*.	1	
2.1.3	Identify and explain trophic levels in food chains and food webs selected from the local environment.	3	Relevant terms (for example, producers, consumers, decomposers, herbivores, carnivores, top carnivores) should be applied to local, named examples and other food chains and food webs.
2.1.4	Explain the principles of pyramids of numbers, pyramids of biomass, and pyramids of productivity, and construct such pyramids from given data.	3	Pyramids are graphical models of the quantitative differences that exist between the trophic levels of a single ecosystem. A pyramid of biomass represents the standing stock of each trophic level measured in units such as grams of biomass per square metre (g m^{-2}). Biomass may also be measured in units of energy, such as J m^{-2}. 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 as one ascends. Pyramids of numbers can sometimes display different patterns, for example, when individuals at lower trophic levels are relatively large. Similarly, pyramids of biomass can show greater quantities at higher trophic levels because they represent the biomass present at a given time (there may be marked seasonal variations). Both pyramids of numbers and pyramids of biomass represent storages. Pyramids of productivity refer to the flow of energy through a trophic level and invariably show a decrease along the food chain. For example, the turnover of two retail outlets cannot be compared by simply comparing the goods displayed on the shelves; the rates at which the shelves are being stocked and the goods sold also need to be known. Similarly, a business may have substantial assets but cash flow may be very limited. In the same way, pyramids of biomass simply represent the momentary stock, whereas pyramids of productivity show the rate at which that stock is being

			generated. Biomass, measured in units of mass or energy (for example, g m^{-2} or J m^{-2}), should be distinguished from productivity measured in units of flow (for example, g m^{-2} yr^{-1} or J m^{-2} yr^{-1}). A pyramid of energy may be represented either as the standing stock (biomass) measured in units of energy (J m^{-2}) or as productivity measured in units of flow of energy (J m^{-2} yr^{-1}), depending on the text consulted. As this is confusing, this syllabus avoids the term pyramid of energy.
2.1.5	Discuss how the pyramid structure affects the functioning of an ecosystem.	3	This should include concentration of non-biodegradable toxins in food chains, limited length of food chains, and vulnerability of top carnivores. Definitions of the terms biomagnification, bioaccumulation and bioconcentration are not required.
2.1.6	Define the terms *species*, *population*, *habitat*, *niche*, *community* and *ecosystem* with reference to local examples.	1	
2.1.7	Describe and explain population interactions using examples of named species.	3	Include competition, parasitism, mutualism, predation and herbivory. Mutualism is an interaction in which both species derive benefit. 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. Graphical representations of these influences should be interpreted.

2.2 Measuring abiotic components of the system (1 hour)

	Assessment statement	Obj	Teacher's notes
2.2.1	List the significant abiotic (physical) factors of an ecosystem.	1	
2.2.2	Describe and evaluate methods for measuring at least three abiotic (physical) factors within an ecosystem.	3	Students should know methods for measuring any three significant abiotic factors and how these may vary in a given ecosystem with depth, time or distance. For example: • marine—salinity, pH, temperature, dissolved oxygen, wave action • freshwater—turbidity, flow velocity, pH, temperature, dissolved oxygen • terrestrial—temperature, light intensity, wind speed, particle size, slope, soil moisture, drainage, mineral content. This activity may be carried out effectively in conjunction with an examination of related biotic components.

2.3 Measuring biotic components of the system (4 hours)

	Assessment statement	Obj	Teacher's notes
2.3.1	Construct simple keys and use published keys for the identification of organisms.	3	Students could practise with keys supplied and then construct their own keys for up to eight species.
2.3.2	Describe and evaluate methods for estimating abundance of organisms.	3	Methods should include capture–mark–release–recapture (Lincoln index) and quadrats for measuring population density, percentage frequency and percentage cover.
2.3.3	Describe and evaluate methods for estimating the biomass of trophic levels in a community.	3	Dry weight measurements of quantitative samples could be extrapolated to estimate total biomass.
2.3.4	Define the term *diversity*.	1	Diversity is often considered as a function of two components: the number of different species and the relative numbers of individuals of each species.
2.3.5	Apply Simpson's diversity index and outline its significance.	2	$D = \frac{N(N-1)}{\sum n(n-1)}$ Students are not required to memorize this formula but must know the meaning of the symbols: *D* = diversity index *N* = total number of organisms of all species found *n* = number of individuals of a particular species *D* is a measure of species richness. A high value of *D* suggests a stable and ancient site, and a low value of *D* could suggest pollution, recent colonization or agricultural management. The index is normally used in studies of vegetation but can also be applied to comparisons of animal (or even all species) diversity.

2.4 Biomes (3 hours)

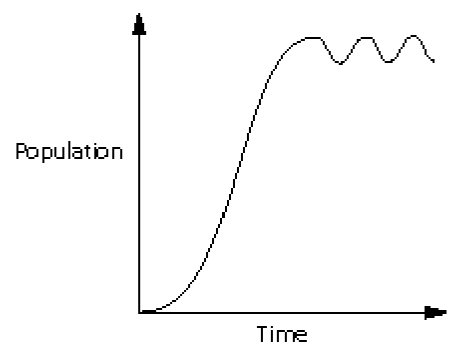
	Assessment statement	Obj	Teacher's notes
2.4.1	Define the term *biome*.	1	**Int:** Biomes usually cross national boundaries (biomes do not stop at a border; for example, the Sahara, tundra, tropical rainforests).
2.4.2	Explain the distribution, structure and relative productivity of tropical rainforests, deserts, tundra and any other biome.	3	Refer to prevailing climate and limiting factors. For example, tropical rainforests are found close to the equator where there is high insolation and rainfall and where light and temperature are not limiting. The other biome may be, for example, temperate grassland or a local example. Limit climate to temperature, precipitation and insolation.

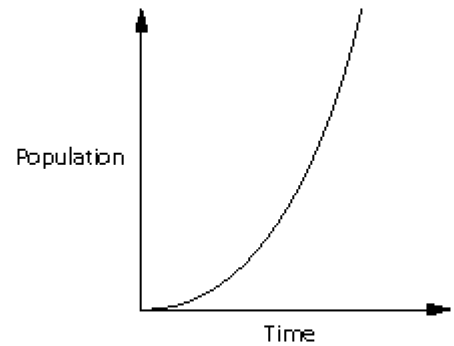
2.5 Function (7 hours)

	Assessment statement	Obj	Teacher's notes
2.5.1	Explain the role of producers, consumers and decomposers in the ecosystem.	3	
2.5.2	Describe photosynthesis and respiration in terms of inputs, outputs and energy transformations.	2	Biochemical details are not required. Details of chloroplasts, light-dependent and light-independent reactions, mitochondria, carrier systems, ATP and specific intermediate biochemicals are not expected. Photosynthesis should be understood as requiring carbon dioxide, water, chlorophyll and certain visible wavelengths of light to produce organic matter and oxygen. The transformation of light energy into the chemical energy of organic matter should be appreciated. Respiration should be recognized as requiring organic matter and oxygen to produce carbon dioxide and water. Without oxygen, carbon dioxide and other waste products are formed. Energy is released in a form available for use by living organisms, but is ultimately lost as heat.
2.5.3	Describe and explain the transfer and transformation of energy as it flows through an ecosystem.	3	Explain pathways of incoming solar radiation incident on the ecosystem including: • loss of radiation through reflection and absorption • conversion of light to chemical energy • loss of chemical energy from one trophic level to another • efficiencies of transfer • overall conversion of light to heat energy by an ecosystem • re-radiation of heat energy to the atmosphere. Construct and analyse simple energy-flow diagrams illustrating the movement of energy through ecosystems, including the productivity of the various trophic levels. The distinction between storages of energy illustrated by boxes in energy-flow diagrams (representing the various trophic levels), and the flows of energy or productivity often shown as arrows (sometimes of varying widths) needs to be emphasized. The former are measured as the amount of energy or biomass per unit area and the latter are given as rates, for example, J m^{-2} day^{-1}.
2.5.4	Describe and explain the transfer and transformation of materials as they cycle within an ecosystem.	3	Processes involving the transfer and transformation of carbon, nitrogen and water as they cycle within an ecosystem should be described, and the conversion of organic and inorganic storage noted where appropriate. Construct and analyse flow diagrams of these cycles.
2.5.5	Define the terms *gross productivity*, *net productivity*, *primary productivity* and	1	Productivity is production per unit time.

	secondary productivity.		
2.5.6	Define the terms and calculate the values of both *gross primary productivity* (GPP) and *net primary productivity* (NPP) from given data.	2	Use the equation NPP = GPP – R where R = respiratory loss
2.5.7	Define the terms and calculate the values of both *gross secondary productivity* (GSP) and *net secondary productivity* (NSP) from given data.	2	Use the equations NSP = GSP – R GSP = food eaten – fecal loss where R = respiratory loss The term “assimilation” is sometimes used instead of “secondary productivity”.

2.6 Changes (7 hours)

	Assessment statement	Obj	Teacher's notes
2.6.1	Explain the concepts of limiting factors and carrying capacity in the context of population growth.	3	
2.6.2	Describe and explain S and J population curves.	3	Explain changes in both numbers and rates of growth in standard S and J population growth curves. Population curves should be sketched, described, interpreted and constructed from given data. **S curve**  **J curve**

			
2.6.3	Describe the role of density-dependent and density-independent factors, and internal and external factors, in the regulation of populations.	2	According to theory, density-dependent factors operate as negative feedback mechanisms leading to stability or regulation of the population. Both types of factors may operate on a population. Many species, particularly *r*-strategists, are probably regulated by density-independent factors, of which weather is the most important. Internal factors might include density-dependent fertility or size of breeding territory, and external factors might include predation or disease.
2.6.4	Describe the principles associated with survivorship curves including, *K*- and *r*-strategists.	2	*K*- and *r*-strategists represent idealized categories and many organisms occupy a place on the continuum. Students should be familiar with interpreting features of survivorship curves including logarithmic scales.
2.6.5	Describe the concept and processes of succession in a named habitat.	2	Students should study named examples of organisms from a pioneer community, seral stages and climax community. The concept of succession, occurring over time, should be carefully distinguished from the concept of zonation, which refers to a spatial pattern.
2.6.6	Explain the changes in energy flow, gross and net productivity, diversity and mineral cycling in different stages of succession.	3	In early stages, gross productivity is low due to the 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, with an increased consumer community, gross productivity may be high in a climax community. However, this is balanced by respiration, so net productivity approaches zero and the production: respiration (P:R) ratio approaches one.
2.6.7	Describe factors affecting the nature of climax communities.	2	Climatic and edaphic factors determine the nature of a climax community. Human factors frequently affect this process through, for example, fire, agriculture, grazing and/or habitat destruction.

2.7 Measuring changes in the system (5 hours)

	Assessment statement	Obj	Teacher's notes
2.7.1	Describe and evaluate methods for measuring changes in abiotic and biotic components of an ecosystem along an environmental gradient.	3	
2.7.2	Describe and evaluate methods for measuring changes in abiotic and biotic components of an ecosystem due to a specific human activity.	3	Methods and changes should be selected appropriately for the human activity chosen. Suitable human impacts for study might include toxins from mining activity, landfills, eutrophication, effluent, oil spills and overexploitation. This could include repeated measurements on the ground, satellite images and maps.
2.7.3	Describe and evaluate the use of environmental impact assessments (EIAs).	3	Students should have the opportunity to see an actual EIA study. They should realize that an EIA involves production of a baseline study before any environmental development, assessment of possible impacts, and monitoring of change during and after the development.

III. Topic 3: Human population, carrying capacity and resource use 10

3.1 Population dynamics (5 hours)

	Assessment statement	Obj	Teacher's notes
3.1.1	Describe the nature and explain the implications of exponential growth in human populations.	3	
3.1.2	Calculate and explain, from given data, the values of crude birth rate, crude death rate, fertility, doubling time and natural increase rate.	3	
3.1.3	Analyse age/sex pyramids and diagrams showing demographic transition models.	3	**Int:** While many of the more economically developed countries (MEDCs) have a declining population size, that of many of the less economically developed countries (LEDCs) is rising rapidly. The position of various countries on the demographic transition model reflects their development stages.
3.1.4	Discuss the use of models in predicting the growth of human populations.	3	This might include computer simulations, statistical and/or demographic tables for LEDCs and MEDCs, age/sex pyramids and graphical extrapolation of population curves.

3.2 Resources—natural capital (8 hours)

	Assessment statement	Obj	Teacher's notes
3.2.1	Explain the concept of resources in terms of natural income.	3	Ecologically minded economists describe resources as “natural capital”. If properly managed, renewable and replenishable resources are forms of wealth that can produce “natural income” indefinitely in the form of valuable goods and services. This income may consist of marketable commodities such as timber and grain (goods) or may be in the form of ecological services such as the flood and erosion protection provided by forests (services). Similarly, non-renewable resources can be considered in parallel to those forms of economic capital that cannot generate wealth without liquidation of the estate.
3.2.2	Define the terms *renewable*, *replenishable* and *non-renewable natural capital*.	1	There are three broad classes of natural capital. • Renewable natural capital, such as living species and ecosystems, is self-producing and self-maintaining and uses solar energy and photosynthesis. This natural capital can yield marketable goods such as wood fibre, but may also provide unaccounted essential services when left in place, for example, climate regulation. • Replenishable natural capital, such as groundwater and the ozone layer, is non-living but is also often dependent on the solar “engine” for renewal. • Non-renewable (except on a geological timescale) forms of natural capital, such as fossil fuel and minerals, are analogous to inventories: any use implies liquidating part of the stock.
3.2.3	Explain the dynamic nature of the concept of a resource.	3	Consider how cultural, economic, technological and other factors influence the status of a resource over time and space. For example, uranium, due to the development of nuclear technology, has only recently become a valuable resource.
3.2.4	Discuss the view that the environment can have its own intrinsic value.	3	Organisms or ecosystems that are valued on aesthetic or intrinsic grounds may not provide commodities identifiable as either goods or services, and so remain unpriced or undervalued from an economic viewpoint. Organisms or ecosystems regarded as having intrinsic value, for instance from an ethical, spiritual or philosophical perspective, are valued regardless of their potential use to humans. Therefore, diverse perspectives may underlie the evaluation of natural capital. Attempts are being made to acknowledge diverse valuations of nature (for example, biodiversity, rate of depletion of natural resources) so that they may be weighed more rigorously against more common economic values (for example, gross national product (GNP)). However, some argue that these valuations are impossible to quantify and price realistically. Not surprisingly, much of the sustainability debate centres on the problem of how to weigh conflicting values in our treatment of natural capital.

			TOK: How can we quantify values such as aesthetic value, which are inherently qualitative?
3.2.5	Explain the concept of sustainability in terms of natural capital and natural income.	3	The term "sustainability" has been given a precise meaning in this syllabus. Students should understand that any society that supports itself in part by depleting essential forms of natural capital is unsustainable. If human well-being is dependent on the goods and services provided by certain forms of natural capital, then long-term harvest (or pollution) rates should not exceed rates of capital renewal. Sustainability means living, within the means of nature, on the "interest" or sustainable income generated by natural capital.
3.2.6	Discuss the concept of sustainable development.	3	The term "sustainable development" was first used in 1987 in *Our Common Future* (The Brundtland Report) and was defined as "development that meets current needs without compromising the ability of future generations to meet their own needs." The value of this approach is a matter of considerable debate and there is now no single definition for sustainable development. For example, some economists may view sustainable development as a stable annual return on investment regardless of the environmental impact, whereas some environmentalists may view it as a stable return without environmental degradation. Consider the development of changing attitudes to sustainability and economic growth, since the Rio Earth Summit (1992) leading to Agenda 21. **Int:** International summits on sustainable development have highlighted the issues involved in economic development across the globe, yet the viewpoints of environmentalists and economists may be very different.
3.2.7	Calculate and explain sustainable yield from given data.	3	Sustainable yield (SY) may be calculated as the rate of increase in natural capital, that is, that which can be exploited without depleting the original stock or its potential for replenishment. For example, the annual sustainable yield for a given crop may be estimated simply as the annual gain in biomass or energy through growth and recruitment. See figures 1 and 2.

Figure 1

$$SY = \left(\frac{\text{total biomass}}{\text{energy}} \text{ at time } t+1 \right) - \left(\frac{\text{total biomass}}{\text{energy}} \text{ at time } t \right)$$

Figure 2

SY = (annual growth and recruitment) – (annual death and emigration)

3.3 Energy resources (4 hours)

	Assessment statement	Obj	Teacher's notes
3.3.1	Outline the range of energy resources available to society.	2	
3.3.2	Evaluate the advantages and disadvantages of two contrasting energy sources.	3	Consider one non-renewable (fossil fuels or nuclear) and one renewable energy source.
3.3.3	Discuss the factors that affect the choice of energy sources adopted by different societies.	3	This may include availability, economic, cultural, environmental and technological factors.

3.4 The soil system (4 hours)

	Assessment statement	Obj	Teacher's notes
3.4.1	Outline how soil systems integrate aspects of living systems.	2	Emphasize a systems approach. Students should draw diagrams that show links between the soil, lithosphere, atmosphere and living organisms. The soil as a living system should be considered with reference to a generalized soil profile. Studies of specific soil profiles, for example, podsol, are not required. Transfers of material (including deposition) result in reorganization of the soil. There are inputs of organic and parent material, precipitation, infiltration and energy. Outputs include leaching, uptake by plants and mass movement. Transformations include decomposition, weathering and nutrient cycling.
3.4.2	Compare and contrast the structure and properties of sand, clay and loam soils, including their effect on primary productivity.	3	Consider mineral content, drainage, water-holding capacity, air spaces, biota and potential to hold organic matter, and link these to primary productivity.
3.4.3	Outline the processes and consequences of soil degradation.	2	Human activities such as overgrazing, deforestation, unsustainable agriculture and irrigation cause processes of degradation. These include soil erosion, toxification and salinization. Desertification (enlargement of deserts through human activities) can be associated with this degradation.
3.4.4	Outline soil conservation measures.	2	Consider: • soil conditioners (for example, use of lime and organic materials) • wind reduction techniques (wind breaks, shelter belts, strip cultivation)

			• cultivation techniques (terracing, contour plowing) • efforts to stop plowing of marginal lands.
3.4.5	Evaluate soil management strategies in a named commercial farming system and in a named subsistence farming system.	3	

3.5 Food resources (6 hours)

	Assessment statement	Obj	Teacher's notes
3.5.1	Outline the issues involved in the imbalance in global food supply.	2	Students should appreciate the differences in food production and distribution around the world, including the socio-political, economic and ecological influences on these.
3.5.2	Compare and contrast the efficiency of terrestrial and aquatic food production systems.	3	Compare and contrast these in terms of their trophic levels and efficiency of energy conversion. There is no need to consider individual production systems in detail. In terrestrial systems, most food is harvested from relatively low trophic levels (producers and herbivores). However, in aquatic systems, perhaps largely due to human tastes, most food is harvested from higher trophic levels where the total storages are much smaller. Although energy conversions along the food chain may be more efficient in aquatic systems, the initial fixing of available solar energy by primary producers tends to be less efficient due to the absorption and reflection of light by water.
3.5.3	Compare and contrast the inputs and outputs of materials and energy (energy efficiency), the system characteristics, and evaluate the relative environmental impacts for two named food production systems.	3	The systems selected should be both terrestrial or both aquatic. In addition, the inputs and outputs of the two systems should differ qualitatively and quantitatively (not all systems will be different in all aspects). The pair of examples could be North American cereal farming and subsistence farming in some parts of South-East Asia, intensive beef production in the developed world and the Maasai tribal use of livestock, or commercial salmon farming in Norway/Scotland and rice-fish farming in Thailand. Other local or global examples are equally valid. Factors to be considered should include: • inputs—for example, fertilizers (artificial and natural), irrigation water, pesticides, fossil fuels, food distribution, human labour, seed, breeding stock • system characteristics—for example, selective breeding, genetically engineered organisms, monoculture versus polyculture, sustainability • socio-cultural—for example, for the Maasai, cattle equals wealth and quantity is more important than quality • environmental impact—for example, pollution, habitat loss, reduction in biodiversity, soil erosion • outputs—for example, food quality and quantity, pollutants, soil erosion.

3.5.4	Discuss the links that exist between social systems and food production systems.	3	This could be illustrated through the use of examples, such as: • the way in which the low population densities and belief systems of shifting cultivators links with the ecosystem of “slash and burn” agriculture • the relationship between high population densities, culture, soil fertility and the wet-rice ecosystem of South-East Asia • the link between the political economy of modern urban society, corporate capitalism and agro-ecosystems.

3.6 Water resources (3 hours)

	Assessment statement	Obj	Teacher's notes
3.6.1	Describe the Earth’s water budget.	2	Only a small fraction (2.6% by volume) of the Earth’s water supply is fresh water. Of this, over 80% is in the form of ice caps and glaciers, 0.6% is groundwater and the rest is made up of lakes, soil water, atmospheric water vapour, rivers and biota in decreasing order of storage size. Precise figures are not required.
3.6.2	Describe and evaluate the sustainability of freshwater resource usage with reference to a case study.	3	Irrigation, industrialization and population increase all make demands on the supplies of fresh water. Global warming may disrupt rainfall patterns and water supplies. The hydrological cycle supplies humans with fresh water but we are withdrawing water from underground aquifers and degrading it with wastes at a greater rate than it can be replenished. Consider the increased demand for fresh water, inequity of usage and political consequences, methods of reducing use and increasing supplies. A case study must be explored that covers some of these issues and demonstrates either sustainable or unsustainable water use.

3.7 Limits to growth (2.5 hours)

	Assessment statement	Obj	Teacher's notes
3.7.1	Explain the difficulties in applying the concept of carrying capacity to local human populations.	3	By examining carefully the requirements of a given species and the resources available, it might be possible to estimate the carrying capacity of that environment for the species. This is problematic in the case of human populations for a number of reasons. The range of resources used by humans is usually much greater than for any other species. Furthermore, when one resource becomes limiting, humans show great ingenuity in substituting one resource for another. Resource requirements vary according to lifestyles, which differ from time to time and from population to population. Technological developments give rise to continual changes in the resources required and available for consumption. Human populations also regularly import resources from outside their immediate environment, which enables them to grow beyond the boundaries set by

			their local resources and increases their carrying capacity. While importing resources in this way increases the carrying capacity for the local population, it has no influence on global carrying capacity. All these variables make it practically impossible to make reliable estimates of carrying capacities for human populations.
3.7.2	Explain how absolute reductions in energy and material use, reuse and recycling can affect human carrying capacity.	3	Human carrying capacity is determined by the rate of energy and material consumption, the level of pollution and the extent of human interference in global life-support systems. While reuse and recycling reduce these impacts, they can also increase human carrying capacity.

3.8 Environmental demands of human populations (6.5 hours)

	Assessment statement	Obj	Teacher's notes
3.8.1	Explain the concept of an ecological footprint as a model for assessing the demands that human populations make on their environment.	3	The ecological footprint of a population is the area of land, in the same vicinity as the population, that would be required to provide all the population's resources and assimilate all its wastes. As a model, it is able to provide a quantitative estimate of human carrying capacity. It is, in fact, the inverse of carrying capacity. It refers to the area required to sustainably support a given population rather than the population that a given area can sustainably support.
3.8.2	Calculate from appropriate data the ecological footprint of a given population, stating the approximations and assumptions involved.	2	Although the accurate calculation of an ecological footprint might be very complex, an approximation can be achieved through the steps outlined in figures 3 and 4. The total land requirement (ecological footprint) can then be calculated as the sum of these two *per capita* requirements, multiplied by the total population. This calculation clearly ignores the land or water required to provide any aquatic and atmospheric resources, assimilate wastes other than carbon dioxide (CO_2), produce the energy and material subsidies imported to the arable land for increasing yields, replace loss of productive land through urbanization, and so on.

Figure 3

$$\text{\textit{per capita} land requirement for food production (ha)} = \frac{\text{\textit{per capita} food consumption (kg yr}^{-1}\text{)}}{\text{mean food production per hectare of local arable land (kg ha}^{-1}\text{yr}^{-1}\text{)}}$$

Figure 4

$$\text{\textit{per capita} land requirement for absorbing waste } CO_2 \text{ from fossil fuels (ha)} = \frac{\text{\textit{per capita} } CO_2 \text{ emission (kg C yr}^{-1}\text{)}}{\text{net carbon fixation per hectare of local natural vegetation (kg C ha}^{-1}\text{yr}^{-1}\text{)}}$$

	Assessment statement	Obj	Teacher's notes
3.8.3	Describe and explain the differences between the ecological footprints of two human populations, one from an LEDC and one from an MEDC.	3	Data for food consumption are often given in grain equivalents, so that a population with a meat-rich diet would tend to consume a higher grain equivalent than a population that feeds directly on grain. Students should be aware that in MEDCs, about twice as much energy in the diet is provided by animal products than in LEDCs. Grain production will be higher with intensive farming strategies. Populations more dependent on fossil fuels will have higher CO_2 emissions. Fixation of CO_2 is clearly dependent on climatic region and vegetation type. These and other factors will often explain the differences in the ecological footprints of populations in LEDCs and MEDCs.
3.8.4	Discuss how national and international development policies and cultural influences can affect human population dynamics and growth.	3	Many policy factors influence human population growth. Domestic and international development policies (which target the death rate through agricultural development, improved public health and sanitation, and better service infrastructure) may stimulate rapid population growth by lowering mortality without significantly affecting fertility. Some analysts believe that birth rates will come down by themselves as economic welfare improves and that the population problem is therefore better solved through policies to stimulate economic growth. Education about birth control encourages family planning. Parents may be dependent on their children for support in their later years and this may create an incentive to have many children. Urbanization may also be a factor in reducing crude birth rates. Policies directed towards the education of women, enabling women to have greater personal and economic independence, may be the most effective method for reducing population pressure.
3.8.5	Describe and explain the relationship between population, resource consumption and technological development, and their influence on carrying capacity and material economic growth.	3	Because technology plays such a large role in human life, many economists argue that human carrying capacity can be expanded continuously through technological innovation. For example, if we learn to use energy and material twice as efficiently, we can double the population or the use of energy without necessarily increasing the impact (load) imposed on the environment. However, to compensate for foreseeable population growth and the economic growth that is deemed necessary, especially in developing countries, it is suggested that efficiency would have to be raised by a factor of 4 to 10 to remain within global carrying capacity.

SECOND SEMESTER

IV:Topic 4: Conservation and biodiversity 6

4.1 Biodiversity in ecosystems (3 hours)

	Assessment statement	Obj	Teacher's notes
4.1.1	Define the terms *biodiversity*, *genetic diversity*, *species diversity* and *habitat diversity*.	1	
4.1.2	Outline the mechanism of natural selection as a possible driving force for speciation.	2	Speciation occurs as a result of the isolation (geographical or reproductive) of populations. The concept of fitness should be understood. The history of the development of the modern theory of evolution is not expected, nor is a detailed knowledge of genetics (including allele frequency).
4.1.3	State that isolation can lead to different species being produced that are unable to interbreed to yield fertile offspring.	1	Isolation of populations, behavioural differences that preclude reproduction and the inability to produce fertile offspring (leading to speciation) should all be examined, with examples.
4.1.4	Explain how plate activity has influenced evolution and biodiversity.	3	The consequences of plate tectonics on speciation should be understood (that is, the separation of gene pools, formation of physical barriers and land bridges) together with the implications these consequences have for evolution. The role of plate activity in generating new and diverse habitats, thus promoting biodiversity, should also be considered. Detailed understanding of the mechanism of plate tectonics is not required.
4.1.5	Explain the relationships among ecosystem stability, diversity, succession and habitat.	3	Consider how: • diversity changes through succession • greater habitat diversity leads to greater species and genetic diversity • a complex ecosystem, with its variety of nutrient and energy pathways, provides stability • human activities modify succession, for example, logging, grazing, burning • human activities often simplify ecosystems, rendering them unstable, for example, North America wheat farming versus tall grass prairie • an ecosystem's capacity to survive change may depend on diversity, resilience and inertia.

4.2 Evaluating biodiversity and vulnerability (6 hours)

	Assessment statement	Obj	Teacher's notes
4.2.1	Identify factors that lead to loss of	2	These include: • natural hazard events (for example, volcanoes,

	diversity.		drought, ice age, meteor impact) • habitat degradation, fragmentation and loss • agricultural practices (for example, monoculture, use of pesticides, use of genetically modified species) • introduction and/or escape of non-native species • pollution • hunting, collecting and harvesting. **Int:** Rate of loss of biodiversity may vary from country to country depending on the ecosystems present, protection policies and monitoring, environmental viewpoints and stage of economic development.
4.2.2	Discuss the perceived vulnerability of tropical rainforests and their relative value in contributing to global biodiversity.	3	Consider: • the vulnerability of other systems • the regeneration rate of tropical rainforests • total area and species diversity • rainforest and "green politics".
4.2.3	Discuss current estimates of numbers of species and past and present rates of species extinction.	3	Examine the fossil record for evidence of mass extinctions in the past, and compare and contrast the possible causes of these to present-day extinctions. The time frame of these periods of extinction should be considered.
4.2.4	Describe and explain the factors that may make species more or less prone to extinction.	3	The following factors (among others) will affect the risk of extinction: numbers, degree of specialization, distribution, reproductive potential and behaviour, and trophic level.
4.2.5	Outline the factors used to determine a species' Red List conservation status.	2	Students should be aware of the factors used to determine a species' conservation status, and that a sliding scale operates. Students should appreciate that a range of factors are used to determine conservation status, such as: • population size • reduction in population size • numbers of mature individuals • geographic range and degree of fragmentation • quality of habitat • area of occupancy • probability of extinction. Definitions of the conservation status categories are not required and the term "criteria" has been avoided due to the complexity of the Red List classification system.
4.2.6	Describe the case histories of three different species: one that has become extinct, another that is critically endangered, and a third species whose conservation status has been improved by intervention.	2	Students should know the ecological, socio-political and economic pressures that caused or are causing the chosen species' extinction. The species' ecological roles and the possible consequences of their disappearance should be understood.

4.2.7	Describe the case history of a natural area of biological significance that is threatened by human activities.	2	Students should know the ecological, socio-political and economic pressures that caused or are causing the degradation of the chosen area, and the consequent threat to biodiversity.

4.3 Conservation of biodiversity (6 hours)

	Assessment statement	Obj	Teacher's notes
4.3.1	State the arguments for preserving species and habitats.	1	Students should appreciate arguments based on ethical, aesthetic, genetic resource and commercial (including opportunity cost) considerations. They should also appreciate life-support and ecosystem-support functions.
4.3.2	Compare and contrast the role and activities of intergovernmental and non-governmental organizations in preserving and restoring ecosystems and biodiversity.	3	Consider the United Nations Environment Programme (UNEP) as an intergovernmental organization and the World Wide Fund for Nature (WWF) and Greenpeace as non-governmental organizations. Compare and contrast UNEP and WWF in terms of use of the media, speed of response, diplomatic constraints and political influence. Consider also recent international conventions on biodiversity (for example, conventions signed at the Rio Earth Summit (1992) and subsequent updates).
4.3.3	State and explain the criteria used to design protected areas.	3	In effect, protected areas may become “islands” within a country and will normally lose some of their diversity. The principles of island biogeography might be applied to the design of reserves. Appropriate criteria should include size, shape, edge effects, corridors and proximity.
4.3.4	Evaluate the success of a named protected area.	3	The granting of protected status to a species or ecosystem is no guarantee of protection without community support, adequate funding and proper research. Consider a specific local example.
4.3.5	Discuss and evaluate the strengths and weaknesses of the species-based approach to conservation.	3	Students should consider the relative strengths and weaknesses of: • the Convention on International Trade in Endangered Species (CITES) • captive breeding and reintroduction programmes, and zoos • aesthetic versus ecological value.

V. Topic 5: Pollution management 6

The purpose of this topic is to give a broad overview of pollution and its management with reference to examples from aquatic, terrestrial and atmospheric systems.

5.1 Nature of pollution (1 hour)

	Assessment statement	Obj	Teacher's notes

5.1.1	Define the term *pollution*.	1	
5.1.2	Distinguish between the terms point source pollution and non-point source pollution, and outline the challenges they present for management.	2	Point source pollution is generally more easily managed because its impact is more localized, making it easier to control emission, attribute responsibility and take legal action.
5.1.3	State the major sources of pollutants.	1	Sources of pollutants are combustion of fossil fuels, domestic and industrial waste, manufacturing and agricultural systems.

5.2 Detection and monitoring of pollution (3 hours)

	Assessment statement	Obj	Teacher's notes
5.2.1	Describe two direct methods of monitoring pollution.	2	Students should describe one method for air and one for soil or water.
5.2.2	Define the term *biochemical oxygen demand* (BOD) and explain how this indirect method is used to assess pollution levels in water.	3	
5.2.3	Describe and explain an indirect method of measuring pollution levels using a biotic index.	3	This will involve levels of tolerance, diversity and abundance of organisms. The concept of indicator species should be understood. A polluted and an unpolluted site (for example, upstream and downstream of a point source) should be compared.

5.3 Approaches to pollution management (2 hours)

	Assessment statement	Obj	Teacher's notes
5.3.1	Outline approaches to pollution management with respect to figure 5.	2	Pollutants are produced through human activities and create long-term effects when released into ecosystems. Strategies for reducing these impacts can be directed at three different levels in the process: altering the human activity, regulating and reducing quantities of pollutant released at the point of emission, and cleaning up the pollutant and restoring ecosystems after pollution has occurred. Using figure 5, students should be able to show the value and limitations of each of the three different levels of intervention. In addition, students should appreciate the advantages of employing the earlier strategies over the later ones and the importance of collaboration in the effective management of pollution.
5.3.2	Discuss the human factors that affect the	3	Cultural values, political systems and economic systems will influence the choice of pollution

	approaches to pollution management.		management strategies and their effective implementation. Real examples should be considered.
5.3.3	Evaluate the costs and benefits to society of the World Health Organization's ban on the use of the pesticide DDT.	3	

5.4 Eutrophication (3 hours)

	Assessment statement	Obj	Teacher's notes
5.4.1	Outline the processes of eutrophication.	2	Include increase in nitrates and phosphates leading to rapid growth of algae, accumulation of dead organic matter, high rate of decomposition and lack of oxygen. The role of positive feedback should be noted in these processes.
5.4.2	Evaluate the impacts of eutrophication.	3	Include death of aerobic organisms, increased turbidity, loss of macrophytes, reduction in length of food chains and loss of species diversity.
5.4.3	Describe and evaluate pollution management strategies with respect to eutrophication.	3	Students should apply the model in 5.3.1 in the evaluation of the strategies. For example: • Altering the human activity producing pollution can be exemplified by alternative methods of enhancing crop growth, alternative detergents, and so on. • Regulating and reducing pollutants at the point of emission can be illustrated by sewage treatment processes that remove nitrates and phosphates from the waste. • Clean-up and restoration can be exemplified by pumping mud from eutrophic lakes and reintroducing plant and fish species.

5.5 Solid domestic waste (2 hours)

	Assessment statement	Obj	Teacher's notes
5.5.1	Outline the types of solid domestic waste.	2	Students should consider their own and their community's generation of waste. Consider the different types of material, for example, paper, glass, metal, plastics, organic waste (kitchen or garden), packaging, as well as their total volume.
5.5.2	Describe and evaluate pollution management strategies for solid domestic (municipal) waste.	3	Consider recycling, incineration, composting and landfill.

5.6 Depletion of stratospheric ozone (3 hours)

	Assessment statement	Obj	Teacher's notes
5.6.1	Outline the overall structure and composition of the atmosphere.	2	
5.6.2	Describe the role of ozone in the absorption of ultraviolet radiation.	2	Ultraviolet radiation is absorbed during the formation and destruction of ozone from oxygen. Memorization of chemical equations is not required.
5.6.3	Explain the interaction between ozone and halogenated organic gases.	3	Halogenated organic gases are very stable under normal conditions but can liberate halogen atoms when exposed to ultraviolet radiation in the stratosphere. These atoms react with monatomic oxygen and slow the rate of ozone re-formation. Pollutants enhance the destruction of ozone, thereby disturbing the equilibrium of the ozone production system (see 1.1.5).
5.6.4	State the effects of ultraviolet radiation on living tissues and biological productivity.	1	The effects include mutation and subsequent effects on health and damage to photosynthetic organisms, especially phytoplankton and their consumers such as zooplankton.
5.6.5	Describe three methods of reducing the manufacture and release of ozone-depleting substances.	2	For example, recycling refrigerants, alternatives to gas-blown plastics, alternative propellants and alternatives to methyl bromide (bromomethane).
5.6.6	Describe and evaluate the role of national and international organizations in reducing the emissions of ozone-depleting substances.	3	Examine the role of the United Nations Environment Programme (UNEP) in forging international agreements (for example, the Montreal Protocol and subsequent updates) on the use of ozone-depleting substances, and study the relative effectiveness of these agreements and the difficulties in implementing and enforcing them. In addition, students should be familiar with what steps national governments are taking to comply with these agreements.

5.7 Urban air pollution (2 hours)

	Assessment statement	Obj	Teacher's notes
5.7.1	State the source and outline the effect of tropospheric ozone.	2	When fossil fuels are burned, two of the pollutants emitted are hydrocarbons (from unburned fuel) and nitrogen monoxide (nitric oxide, NO). Nitrogen monoxide reacts with oxygen to form nitrogen dioxide (NO_2), a brown gas that contributes to urban haze. Nitrogen dioxide can also absorb sunlight and break up to release oxygen atoms that combine with oxygen in the air to form ozone. Ozone is a toxic gas and an oxidizing agent. It damages crops and forests, irritates eyes, can cause breathing difficulties in humans and may increase susceptibility to infection. It is highly reactive and can

			attack fabrics and rubber materials.
5.7.2	Outline the formation of photochemical smog.	2	Photochemical smog is a mixture of about one hundred primary and secondary pollutants formed under the influence of sunlight. Ozone is the main pollutant. The frequency and severity of photochemical smogs in an area depend on local topography, climate, population density and fossil fuel use. Precipitation cleans the air and winds disperse the smog. Thermal inversions trap the smogs in valleys (for example, Los Angeles, Santiago, Mexico City, Rio de Janeiro, São Paulo, Beijing) and concentrations of air pollutants can build to harmful and even lethal levels.
5.7.3	Describe and evaluate pollution management strategies for urban air pollution.	3	Measures to reduce fossil fuel combustion should be considered, for example, reducing demand for electricity and private cars and switching to renewable energy. Refer to clean-up measures, for example, catalytic converters.

5.8 Acid deposition (2 hours)

	Assessment statement	Obj	Teacher's notes
5.8.1	Outline the chemistry leading to the formation of acidified precipitations.	2	Refer to the conversion of sulfur dioxide and oxides of nitrogen (NO_x) into the sulfates and nitrates of dry deposition and the sulfuric and nitric acids of wet deposition. Knowledge of chemical equations is not required.
5.8.2	Describe three possible effects of acid deposition on soil, water and living organisms.	2	Include: • one direct effect, for example, acid on aquatic organisms and coniferous forests • one toxic effect, for example, aluminium ions on fish • one nutrient effect, for example, leaching of calcium.
5.8.3	Explain why the effect of acid deposition is regional rather than global.	3	Refer to areas downwind of major industrial regions that are adversely affected by acid rain and link them to sources of sulfur dioxide and nitrogen dioxide emissions. Consider the effect of geology (rocks and soils) on water acidity through buffering.
5.8.4	Describe and evaluate pollution management strategies for acid deposition.	3	Measures to reduce fossil fuel combustion should be considered, for example, reducing demand for electricity and private cars and switching to renewable energy. Refer to clean-up measures at “end of pipe” locations (points of emission). Consider the role of international agreements in effecting change. The cost-effectiveness of spreading ground limestone in Swedish lakes in the early 1980s provides a good case study.

VI. Topic 6: The issue of global warming 4

This topic allows the study of a controversial global issue in more depth. Opinion within scientific and political communities is divided on this issue, and students should be encouraged to develop a personal viewpoint having considered the arguments.

	Assessment statement	Obj	Teacher's notes
6.1.1	Describe the role of greenhouse gases in maintaining mean global temperature.	2	The greenhouse effect is a normal and necessary condition for life on Earth. Consider carbon dioxide (CO_2) levels in geological times.
6.1.2	Describe how human activities add to greenhouse gases.	2	Water, CO_2, methane and chlorofluorocarbons (CFCs) are the main greenhouse gases. Human activities are increasing levels of CO_2, methane and CFCs in the atmosphere, which may lead to global warming.
6.1.3	Discuss qualitatively the potential effects of increased mean global temperature.	3	Consider the potential effects on the distribution of biomes, global agriculture and human societies. Students should appreciate that effects might be adverse or beneficial, for example: • biomes shifting • change in location of crop growing areas • changed weather patterns • coastal inundation (due to thermal expansion of the oceans and melting of the polar ice caps) • human health (spread of tropical diseases).
6.1.4	Discuss the feedback mechanisms that would be associated with an increase in mean global temperature.	3	For example: • negative feedback—increased evaporation in tropical latitudes leading to increased snowfall on the polar ice caps, which reduces the mean global temperature • positive feedback—increased thawing of permafrost, leading to an increase in methane levels, which increases the mean global temperature. Any feedback mechanisms associated with global warming may involve very long time lags.
6.1.5	Describe and evaluate pollution management strategies to address the issue of global warming.	3	Students should consider the following strategies: • global—intergovernmental and international agreements (for example, Kyoto Agreement and subsequent updates), carbon tax and carbon trading, alternative energy sources • local—allow students to explore their own lifestyle in the context of local greenhouse gas emissions • preventive and reactive. Students should evaluate these strategies with regard to their effectiveness and the implications for MEDCs and LEDCs of reducing CO_2 emissions in terms of economic growth and national development.
6.1.6	Outline the arguments surrounding global	2	Students should appreciate the variety of sometimes conflicting arguments surrounding this issue. Note the

	warming.		complexity of the problem and the uncertainty of global climate models. Students should be aware of the concept of global dimming due to increased levels of atmospheric pollution.
6.1.7	Evaluate contrasting human perceptions of the issue of global warming.	3	Students should explore different viewpoints in relation to their own.

VII. Topic 7: Environmental value systems 4

Understanding environmental value systems is a central theme in this course. Therefore, this topic should be used in the analysis of environmental issues throughout the course, as well as being taught as a discrete unit.

	Assessment statement	Obj	Teacher's notes
7.1.1	State what is meant by an environmental value system.	1	This is a particular world view or set of paradigms that shapes the way an individual or group of people perceive and evaluate environmental issues. This will be influenced by cultural (including religious), economic and socio-political context. An environmental value system is a system in the sense that it has inputs (for example, education, cultural influences, religious doctrine, media) and outputs (for example, decisions, perspectives, courses of action) determined by processing these inputs. **Int:** Ecosystems may often cross national boundaries and this may lead to conflict arising from the clash of different value systems about exploitation of resources (for example, ocean fishing and whaling).
7.1.2	Outline the range of environmental philosophies with reference to figure 6.	2	

Figure 6

ENVIRONMENTAL

ECOCENTRISM (nature centred) ← ANTHROPOCENTRISM (people centred) → TECHNOCENTRISM (technology centred)

ECOCENTRISM (nature centred)	ANTHROPOCENTRISM (people centred)	TECHNOCENTRISM (technology centred)
Holistic world view. Minimum disturbance of natural processes. Integration of spiritual, social and environmental dimensions. Sustainability for the whole Earth. Self-reliant communities within a framework of global citizenship. Self-imposed restraint on resource use.	People as environmental managers of sustainable global systems. Population control given equal weight to resource use. Strong regulation by independent authorities required.	Technology can keep pace with and provide solutions to environmental problems. Resource replacement solves resource depletion. Need to understand natural processes in order to control them. Strong emphasis on scientific analysis and prediction prior to policy-making. Importance of market, and economic growth.

	Assessment statement	Obj	Teacher's notes
7.1.3	Discuss how these philosophies influence the decision-making process with respect to environmental issues covered in this course.	3	
7.1.4	Outline key historical influences on the development of the modern environmental movement.	2	Consider major landmarks, for example, Minamata, Rachel Carson's *Silent Spring*, Bhopal, whaling (Save the Whale), Chernobyl, leading to environmental pressure groups, both local and global, the concept of stewardship and increased media coverage raising public awareness.
7.1.5	Compare and contrast the environmental value systems of two named societies.	3	The societies chosen should demonstrate significant differences, for example: • First Nation Americans and European pioneers operating frontier economics, which involved exploitation of seemingly unlimited resources • Buddhist and Judaeo-Christian societies • Communist and capitalist societies.
7.1.6	Justify your personal viewpoint on environmental issues.	3	Students should be encouraged to reflect upon where they stand on the continuum of environmental philosophies with regard to specific issues arising throughout the syllabus, for example, population control, resource exploitation, sustainable development, and so on. **Int:** The environmental philosophy of an individual, as with that of a community (see 7.1.1), will inevitably be shaped by cultural, economic and socio-political context. Students should recognize this and appreciate that others may have equally valid viewpoints (aims 4 and 7).

DATE OF LAST CONTENT REVISION: **February 2009**

DATE OF BOARD APPROVAL: **February 12, 2009**

Addendum
CALIFORNIA CONTENT STANDARDS

BIOLOGY/LIFE SCIENCES

Ecology

6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:
   a. *Students know* biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
   b. *Students know* how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

c. *Students know* how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.
d. *Students know* how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.
e. *Students know* a vital part of an ecosystem is the stability of its producers and decomposers.
f. *Students know* at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment as heat. This dissipation may be represented in an energy pyramid.