2.1 Species & Populations

Mark Schemes

Course	SL IB Environmental Systems & Societies (ESS)
Section	2. Ecosystems & Ecology
Topic	2.1 Species & Populations
Difficulty	Medium

To be used by all students preparing for
SL IB Environmental Systems & Societies (ESS)
Students of other boards may also find this useful

1a

Indicative Content
The role of abiotic factors can be outlined as follows: • Abiotic factors are the non-living components of an ecosystem; [1 mark] *Examples of abiotic factors and how they influence ecosystems include:* Any **three** from the following: • Temperature: different organisms have specific temperature ranges for optimal growth and survival. For example, coral reefs thrive in warm waters, while polar bears are adapted to cold environments; [1 mark] • Precipitation: the amount and distribution of rainfall affect the types of plants and animals that can survive in an area. For example, desert ecosystems have adapted to low precipitation levels, while rainforests thrive in areas with high rainfall; [1 mark] • Soil Composition: the nutrient content, pH levels, and texture of soil impact plant growth and determine the types of plants that can flourish. For example, acidic soils support heathland ecosystems, while alkaline soils are favourable for grassland vegetation; [1 mark] • Light intensity: different plants have specific light requirements for photosynthesis. For example, shade-tolerant plants, such as ferns, thrive in low-light environments, while sun-loving plants, like cacti, require high light intensity; [1 mark] • Wind: wind affects the distribution and growth of organisms. For example, many plant species have evolved wind-dispersed seeds that utilise wind as a means of dispersal; [1 mark] • Water pH levels: the acidity or alkalinity of water impacts the survival and growth of organisms. For example, fish species in rivers or lakes have specific pH requirements for proper physiological functioning; [1 mark]

Model Answer	Commentary
Abiotic factors play a crucial role in shaping ecosystems and influencing the life within them. These are non-living components of the environment that have a direct impact on the organisms living in an ecosystem [1 mark]. One important abiotic factor is temperature, which affects the metabolism and survival of various species. For example, certain animals like reptiles are more active in warmer climates, while other species, like the Arctic Fox, are adapted to colder temperatures [1 mark]. Another significant abiotic factor is water availability. Ecosystems with abundant water support diverse plant and animal life, while arid regions may have limited biodiversity. For instance, rainforests are known for their rich plant and animal diversity due to their high water availability, while deserts have minimal vegetation and fewer species [1 mark]. Light is another abiotic factor that influences ecosystems. Plants, as primary producers, require sunlight for photosynthesis. In deep ocean waters, where light penetration is limited, marine life is adapted to low light conditions, and unique ecosystems, like the deep-sea hydrothermal vents, thrive in complete darkness [1 mark].	You can only obtain full marks if you give specific examples of how abiotic factors influence ecosystems The examples given in the mark scheme and model answer are just some ideas to demonstrate what you should be aiming for when answering this question

1b

Indicative Content
The role of biotic factors can be outlined as follows: • Biotic factors are the living components of an ecosystem **OR** biotic factors are the living organisms within an ecosystem that interact with and influence each other; [1 mark] *Examples of biotic factors and how they influence ecosystems include:* Any **three** from the following:

- Competition: organisms compete for resources such as food, water, and shelter. For example, lions and hyenas compete for prey in the African savannah; [1 mark]
- Predation: predators hunt and consume other organisms, regulating population sizes and shaping community dynamics. An example is the relationship between wolves and deer in a forest ecosystem; [1 mark]
- Herbivory: herbivores consume plant material, influencing plant distribution and abundance. For example, grazing by herbivores, such as zebras, can shape the composition of grassland ecosystems; [1 mark]
- Mutualism: certain organisms engage in mutually beneficial relationships. An example is the partnership between pollinators, like bees, and flowering plants, where the plants provide nectar as a food reward, while the bees assist in pollination; [1 mark]
- Disease: diseases can have a significant impact on populations. For example, a fungal disease has caused declines in amphibian populations worldwide; [1 mark]
- Parasitism: parasites rely on a host organism for their survival and reproduction, negatively affecting the host. An example is the relationship between ticks and mammals, where ticks feed on the blood of the host, potentially transmitting diseases in the process; [1 mark]

Model Answer	Commentary
Biotic factors include that way in which living organisms interact with each other and the environment, affecting the overall balance of the ecosystem [1 mark]. One important biotic factor is predation. Predators, like lions hunting gazelles, control the population of prey species, which helps maintain a healthy balance in the ecosystem. Without predators, the population of prey species could explode and lead to overgrazing, causing environmental damage [1 mark]. Competition is another biotic factor.	You can only obtain full marks if you give specific examples of how biotic factors influence ecosystems

When different species compete for resources like food, water, and shelter, it can limit the growth and survival of some organisms. For example, various bird species competing for insects in the same habitat may lead to the dominance of one species over the others [1 mark]. Symbiotic relationships are essential biotic factors too. Mutualism, where two species benefit from each other, is an example of such a relationship. An example of mutualism is the relationship between ants and aphids. Ants protect aphids from predators and parasites, while aphids secrete a sweet substance called honeydew that ants consume as food. This mutualistic interaction benefits both species: ants get a nutritious food source, and aphids gain protection from potential threats [1 mark].	The examples given in the mark scheme and model answer are just some ideas to demonstrate what you should be aiming for when answering this question

2a

Indicative Content	Commentary
The terms habitat and niche can be distinguished as follows: • Habitat is the physical (biotic and abiotic) environment in which a species normally lives, whereas a species' niche refers to all its interactions/adaptations within its (biotic and abiotic) environment / the role of the species within its habitat; [1 mark] • For example, the habitat of a polar bear is the Arctic region, including the icy landscapes and freezing waters, whereas	The command word 'distinguish' requires you to make clear the differences between two or more concepts or items Whenever you are asked to contrast or distinguish between two approaches, a good technique is to use the word '**whereas**' in the middles of each of your contrasting points, to demonstrate to the examiner that you are directly contrasting one approach with the other A niche can only be occupied by **one species**, meaning that every individual species has its own unique niche

the niche of a polar bear includes predating on seals, possessing adaptations like a thick layer of blubber and fur to withstand cold temperatures, and utilising sea ice as a platform for hunting; [1 mark] **OR** • A habitat may be shared by many species, whereas a niche is limited to a single species; [1 mark] • For example, several different big cat species inhabit tropical grasslands but only lions hunt in groups, allowing them to take larger prey on average / have a higher hunt success rate; [1 mark]	If two species try to occupy the same niche, they will compete with each other for the same resources One of the species will be **more successful** and **out-compete** the other species until only one species is left and the other is either forced to occupy a new, slightly different niche or to go extinct from the habitat or ecosystem altogether North American warbler species feeding at different heights within trees is an example of how each species has a specialised niche within the same habitat

2b

Indicative Content	Commentary
The terms fundamental niche and realised niche can be distinguished as follows: Any **two** from the following: • The fundamental niche describes the full range of conditions/resources in which a species could exist/survive/reproduce, whereas the realised niche describes the	The command word 'distinguish' requires you to make clear the differences between two or more concepts or items Whenever you are asked to contrast or distinguish between two approaches, a good technique is to use the word '**whereas**' in the middles of each of your contrasting

actual conditions/resources in which a species exists/survives/reproduces due to biotic interactions **OR** the fundamental niche represents the theoretical/conceptual niche of a species, whereas the realised niche represents the actual/real world interactions/adaptations/role (of a species) within its (biotic and abiotic) environment/habitat; [1 mark] • The fundamental niche represents the niche a species would occupy if there were no limiting factors on the environment/resources the species could use, whereas the realised niche represents the niche that a species actually occupies, in the presence of limiting factors/resources; [1 mark] • The fundamental niche has no competition for resources/no predation/no disease, whereas the realised niche takes into account competition/predation/disease; [1 mark] • The fundamental niche is (theoretically large(r) in size, whereas the realised niche is small(er) in size; [1 mark]	points, to demonstrate to the examiner that you are directly contrasting one approach with the other An example of a fundamental niche compared to a realised niche can be seen in the case of the barnacle species *Chthamalus dalli* Its fundamental niche includes a wide range of rocky intertidal areas, where it can attach to a variety of substrates and tolerate a wide range of temperature and salinity conditions However, in reality, the realised niche of this species is much smaller or 'narrower' due to **competition** with other barnacle species, such as *Balanus glandula*, for space and resources

3a

Indicative Content	Commentary
Predation and competition can be compared in the following ways: Any **two** from the following: • Both predation and competition can involve interactions between populations/within the same species (intraspecific) / between different species (interspecific); [1 mark] • Both predation and competition involve at least two individuals; [1 mark] • Both can lead to a stable equilibrium in populations; [1 mark] • Both have the potential to lead to the extinction of a species; [1 mark] • Both interactions act as limiting factors on population size; [1 mark] • In both cases, at least one species is negatively affected; [1 mark] • Both predation and competition are density-dependent processes / both interactions become more significant as population density increases; [1 mark] *Predation and competition can be contrasted in the following ways:* Any **two** from the following: • Predation results in one species / the prey species being negatively affected, whereas competition results in both/all species/competitors/individuals being negatively affected; [1 mark] • Predation involves animal species only, whereas competition may involve animal or plant species; [1 mark]	The command 'compare and contrast' requires you to give an account of similarities and differences between two items or situations, referring to both of them throughout Whenever you are asked to compare two factors, a good technique is to use the word '**both**' at the start of each point you make, to demonstrate to the examiner that you are directly **comparing** one factor

• In predation, one species / the predators species is dependent upon the other for survival, whereas in competition the individuals/species are not dependent on the other; [1 mark] • Predation involves killing/consuming, whereas competition does not; [1 mark] • Competition reduces the availability of shared resources for both/all species/competitors/individuals, whereas predation does not; [1 mark] • Competition can involve competition for habitat/water, as well as food resources, whereas predation is for food resources only; [1 mark] • Predation usually involves species/individuals from different trophic levels, whereas competition usually involves species/competitors/individuals from the same trophic level; [1 mark]	with the other Similarly, whenever you are asked to contrast two factors, a good technique is to use the word '**whereas**' in each of your **contrasting** points, to demonstrate to the examiner that you are directly contrasting one factor with the other

3b

Indicative Content
i) The term carrying capacity can be defined as: • The maximum number of individuals/load/population size of a (single) species that can be sustainably supported by a given area/habitat/environment; [1 mark] *ii) Carrying capacity can be difficult to estimate because:* Any **four** from the following (at least **two** should focus on human populations):

- Natural populations can be affected by a wide range of potential limiting factors e.g. availability of food/water/shelter/suitable breeding sites, as well as factors like disease/predation; [1 mark]
- The needs/characteristics of populations change over time e.g. genetic changes / evolutionary processes within a species can influence their requirements/adaptations; [1 mark]
- Environmental conditions are not constant / factors like climate change / introduction of new species can alter resource availability / affect the capacity of an ecosystem to support a particular population; [1 mark]
- It can require extensive / long-term studies to identify a precise relationship between some (e.g. long-lived) species and a given environmental factor; [1 mark]
- Human populations display a much broader range of resource requirements/exploitation compared to most other species; [1 mark]
- Human populations are able to substitute one resource for another when required, making it challenging to pinpoint specific resource needs accurately; [1 mark]
- Human populations have varying lifestyles/cultures/economic statuses, resulting in differences in resource usage/needs; [1 mark]
- Human populations are able to import resources from other ecosystems/regions, which can offset resource limitations in a particular area; [1 mark]
- Advancements in technology can cause shifts in the types/amounts of resources required by / available to (human populations) over time, influencing resource consumption patterns / affecting carrying capacity calculations; [1 mark]

4a

Indicative Content	Commentary
Limiting factors at high altitudes include: Any **three** from the following: • Lack of (available/liquid) water / water locked up/frozen in (soil) permafrost; [1 mark]	You would not gain a mark for giving altitude, oxygen, sunlight or low rainfall as limiting

• Cold temperatures; [1 mark] • Lack of (sufficient) soil nutrients / poor soil (quality); [1 mark] • Steep slopes / gradient is too steep; [1 mark] • Thin soils / soil of insufficient depth (to support large/deep roots required by larger vegetation/bushes/trees); [1 mark] • Exposure to (severe/strong/fast) wind; [1 mark]	factors You would also not gain a mark for stating only '*temperature*' or '*nutrients*' - you would need to be more specific than this

4b

Indicative Content	Commentary
Limiting factors are involved in shaping S and J population curves in the following ways: Any **four** from the following: • Both S and J population curves start with low initial gradients due to limiting factors e.g. limited reproduction (rates) / sub-optimal gender ratios / sub-optimal/unmodified habitat; [1 mark] • As populations overcome the initial limiting factors/constraints, population growth occurs as positive feedback occurs in both S and J population curves (due to decrease/lack of limiting factors); [1 mark] • (New) limiting factors then slow down S population curves/growth, leading to an	You may also come across a question in your exam that asks you to compare and contrast S and J population curves Similarities: • Both curves show how populations grow and reach a carrying capacity • Both curves start with low initial gradients, which then increase as these populations grow • Both curves can be influenced by density-independent factors Differences: • The S-curve occurs in a limited environment, whereas the J-curve occurs in an unlimited environment

equilibrium/plateau at carrying capacity; [1 mark] • These limiting factors may include limited food / predation / disease / competition / waste accumulation; [1 mark] • J population curves experience rapid decline/crashes due to limiting factors; [1 mark] • These limiting factors may include seasonal climate changes / disease / overexploited food resources (e.g. for r-selected species); [1 mark] • Both curves can be influenced by density-independent factors / density-dependent factors maintain equilibrium in S population curves; [1 mark]	• The S-curve represents logistic growth, whereas the J-curve represents exponential growth • The S-curve eventually levels off at the carrying capacity, whereas the J-curve continues to increase past the carrying capacity until a catastrophic limiting factor is encountered • The S-curve is more common in nature, whereas the J-curve is less common and is often observed in laboratory conditions