G.1.1 Outline the factors that affect the distribution of plant species, including temperature, water, light, soil pH, salinity and mineral nutrients. (3m)

- plant distribution closely linked to levels of abiotic factors in the environment;
- given organism can survive only within a certain temperature range to which it is adapted;
- water is a limiting factor in most terrestrial ecosystems and plants are classified according to ability to tolerate water shortage;
- most plants can only tolerate narrow pH range;
- light intensity/quality/wavelength and duration/photoperiod are important for photosynthesis;
- most plants cannot tolerate large fluctuations in salinity/high salinity;
- mineral nutrients affect plant fertility/soil structure/water retention;
- reference to herbivore activity;

G.1.2 Explain the factors that affect the distribution of animal species, including temperature, water, breeding sites, food supply and territory. (3m)

- animal distribution is related to abiotic and biotic (niche) requirements;
- temperature must be within viable range based upon the adaptations of the animal; water must be available in species-specific quantities (Gila lizards require less water than elephants);
- breeding sites are required for maintenance of the species;
- food supply must be of the right kind for the species (e.g. nuts for squirrels and leaves for rabbits);
- territory is required for some species for breeding/feeding;
- dissolved oxygen affects aquatic species as some organisms can tolerate low levels of oxygen;
- salinity affects distribution as some species are more sensitive than others to salt;

G.1.3 Describe one method of random sampling, based on quadrat methods, that is used to compare the population size of two plant or two animal species. (6m)

G.1.4 Outline the use of a transect to correlate the distribution of plant or animal species with an abiotic variable. (2m)

- transect used when there is a transition in habitats and populations;
- description of use of a line or belt transect;
- height variation/light intensity/salinity/various abiotic factors can be recorded;
- along the transect, along with sampling of plant species present;
G.1.5 Explain what is meant by the niche concept, including an organism’s spatial habitat, its feeding activities and its interactions with other species. (2m)

- (ecological niche is) mode of existence/role of an organism within its ecosystem;
- (ecological niche includes) its habitat/abiotic factors of the environment;
  what the species eats / how the species obtains food;
  interactions with other species;
  the set of all ranges of limiting factors an organism tolerates

G.1.6 Outline the following interactions between species, giving two examples of each: competition, herbivory, predation, parasitism and mutualism.

G.1.7 Explain the principle of competitive exclusion.

G.1.8 Distinguish between fundamental and realized niches. (2m)

- **Fundamental niche**: the potential niche
- **Realized niche**: the actual niche
- the realized niche is often smaller than the fundamental niche (of a species);
- competition/predation is reason for the differences (between fundamental and realized niches);

G.1.9 Define **biomass**.

- the total dry organic matter of living organisms/ecosystems

G.1.10 Describe one method for the measurement of biomass of different trophic levels in an ecosystem. (3m)

- organism/sample is cleaned of any other material (e.g. plant is pulled free of soil and roots washed);
- measure wet mass of organism/sample;
- organism/sample is dried in an incubator/drying oven to constant mass;
- biomass calculated based on wet mass of sample;
- biomass is largest in lowest trophic level / lowest in highest trophic levels / decreases from lower to higher trophic levels;
- only 10–20% organic material/biomass passes up each trophic level;
- organic material used for respiration / activity / lost as heat;

G.2.1 Define **gross production**, **net production** and **biomass**.

- **gross production**: amount of organic matter/biomass produced by plants / plant respiration and net production;
- **net production**: amount of gross production of an ecosystem remaining after subtracting the amount used in respiration/gross production — respiration;
G.2.2 Calculate values for gross production and net production using the equation: gross production – respiration = net production.

- \( \text{GP} - \text{R} = \text{NP} \)

G.2.3 Discuss the difficulties of classifying organisms into trophic levels.

G.2.4 Explain the small biomass and low numbers of organisms in higher trophic levels. (2m)

- energy transfer along the food chain is less than 100% efficient;
- 10% energy transfer between trophic levels;
- nutrient transfer is less than 100% efficient;
- each carnivore needs to consume many prey organisms;
- tendency for size of organisms to increase as trophic level increases;

G.2.5 Construct a pyramid of energy, given appropriate information.

- The units are kJ m\(^{-2}\) yr\(^{-1}\).

G.2.6 Distinguish between primary and secondary succession, using an example of each.

Primary succession occurs on a surface lacking organic soil eg bare rock, whereas secondary succession occurs on a surface stripped of plants but already having an organic component.

G.2.7 Outline the changes in species diversity and production during primary succession. (2m)

- one/few species/lichens/moss at the start;
- pioneer community slowly increases in species diversity;
- production gradually increases as more soil develops/better conditions/more diversity;

G.2.8 Explain the effects of living organisms on the abiotic environment, with reference to the changes occurring during primary succession. Include soil development, accumulation of minerals and reduced erosion. (3m)

- named type of habitat; \((e.g. \text{land left after lava flow/glacier retreat/sand dune})\)
- primary succession occurs on bare/lifeless substrate;
- organisms move into an area and change its nature/pioneers colonize;
- pioneers are simple autotrophs; \((e.g. \text{lichens grow first})\)
- break down substrate; \((e.g. \text{to form organic soil})\)
- leads to an eventual climax ecosystem; \((e.g. \text{forest})\)
- stages in the succession follow a set sequence;

G.2.9 Distinguish between biome and biosphere.
• a biome is a geographical region where similar climate conditions give rise to similar vegetation (whereas) the biosphere refers to all areas of the Earth (atmosphere, hydrosphere, lithosphere) where living things can be found

G.2.10 Explain how rainfall and temperature affect the distribution of biomes. A climograph showing the biomes can be used to illustrate the interaction between these two factors.

G.2.11 Outline the characteristics of six major biomes.
• correctly named biome;
• temperature range;
• dominant plant/ecosystem characteristics;

<table>
<thead>
<tr>
<th>Biome</th>
<th>Temperature</th>
<th>Moisture</th>
<th>Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>tropical rain forest</td>
<td>hot; little fluctuation</td>
<td>wet</td>
<td>evergreen / stratified / epiphytes</td>
</tr>
<tr>
<td>desert</td>
<td>variable daily and seasonally / extreme daily variations / some deserts cold and some deserts hot</td>
<td>very dry, very low rainfall/long periods without rain</td>
<td>few/scattered (with bare ground) / xerophytes</td>
</tr>
<tr>
<td>savanna</td>
<td>high/little seasonal fluctuations</td>
<td>dry/low rainfall/long dry season</td>
<td>grasses with scattered trees</td>
</tr>
<tr>
<td>grassland</td>
<td>cold to warm / seasonal fluctuations</td>
<td>medium dry / moderate rainfall / rainfall seasonal</td>
<td>mainly grasses</td>
</tr>
<tr>
<td>broadleaf / deciduous forest</td>
<td>moderate, seasonal variations / cool winters, warm summers</td>
<td>moist/moderate rainfall / rain throughout year</td>
<td>trees with broad leaves/deciduous / trees shed leaves (in winter)</td>
</tr>
<tr>
<td>coniferous forest / taiga</td>
<td>low temperatures, seasonal variation / very cold winters, short cool summers</td>
<td>moist / moderate rainfall / irregular rainfall</td>
<td>conifers</td>
</tr>
<tr>
<td>tundra</td>
<td>low temperatures / very long cold winters</td>
<td>little precipitation, mainly snow / higher for alpine</td>
<td>herbaceous with lichens and mosses / shrubs / dwarf trees</td>
</tr>
</tbody>
</table>

G.3.1 Calculate the Simpson diversity index for two local communities.

\[ D = \frac{N(N-1)}{\sum n(n-1)} \]

• \( N \) = total number of organisms of all species found;
• \( n \) = number of individuals of a particular species/per species;
G.3.2 Analyse the biodiversity of the two local communities using the Simpson index.

G.3.3 Discuss reasons for the conservation of biodiversity using rainforests as an example. (5m)

- **name of ecosystem:**
  - e.g. (tropical) rainforest;

- **ethical reason:**
  - every species has a right to life, regardless of whether it is useful/non
  - useful to humans;
  - potential of undiscovered medicines;

- **ecological reasons:**
  - better use of the rainforest may occur by respecting the existing balance
  - in concert with the indigenous people;
  - native species are adapted to local conditions whereas invasive species are less likely to be in balance;
  - species in the rainforest are interdependent so loss of species threatens the rest of the community;
  - deforestation of rainforests increases soil erosion/silting of rivers/flooding/ CO$_2$ atmospheric levels;

- **economic reasons:**
  - ecotourism is a potential source of income;

- **aesthetic reasons:**
  - loss of beauty of the system;
  - artists are inspired by the images/flowers/animals of rainforests;

- **heritage/cultural reasons:**
  - maintenance of the rainforest preserves human cultural diversity;

G.3.4 List three examples of the introduction of alien species that have had significant impacts on ecosystems.

- Accidental: rats accidentally introduced to mainland of New Zealand from visiting ships
G.3.5 Discuss the impacts of alien species on ecosystems. (3m)

- alien species have characteristics that may enable them to out-compete native species;
- lack of predators may allow alien species to reproduce more rapidly;
- alien species may utilize areas or resources that native species cannot;
- predation by invasive species can cause loss of biodiversity;
- can lead to species extinction, especially of endangered species;
- alien species may introduce new diseases;
- use of alien species for biological control can be ineffective or negative;

G.3.6 Outline one example of biological control of invasive species.

G.3.7 Define biomagnification.

- Biomagnification is a process in which chemical substances become more concentrated at each trophic level.

G.3.8 Explain the cause and consequences of biomagnification, using a named example.

- biomagnification is a process in which chemical substances become more concentrated at each trophic level;
- certain toxins will accumulate in the body;
- fat soluble toxins have a longer half life/will accumulate in body tissues;
- examples are: DDT/TBT/organophosphates/mercury/other;
- effects of toxins can be magnified up the food chain;
- top predators/consumers/carnivores have highest concentrations stored in their body;

For named example include:

- source of toxin e.g. TBT anti-fouling paint used on ships;
- how it enters food chain e.g. taken up by filter feeders;
- links in food chain;
- effect on top consumer;
- ecosystem/community affected;
G.3.9 Outline the effects of ultraviolet (UV) radiation on living tissues and biological productivity.

- ultraviolet/UV light penetrates tissues;
- damages DNA / causes gene mutation;
- can lead to uncontrolled cell division/mitosis;
- stimulates the production of vitamin D;
- stimulates the synthesis of pigments/melanin;
- can cause skin cancer / cataracts;
- affects photosynthesis;
- small amount beneficial
  - used to kill microbes/water purification;
  - used to treat jaundice in newborn infants;

G.3.10 Outline the effect of chlorofluorocarbons (CFCs) on the ozone layer (4–6m).

- UV light causes CFCs to release chlorine;
- CFCs cause ozone to form oxygen (by chlorine atoms reacting);
- causes a reduction in ozone concentration (allowing more UV to enter);
- increases the ozone hole;
- particularly effective in the Antarctic spring;
- effective in very low concentrations / a small amount of CFC can destroy a large amount of ozone;

G.3.11 State that ozone in the stratosphere absorbs UV radiation.

G.4.1 Explain the use of biotic indices and indicator species in monitoring environmental change. (6m)

- indicator species sensitive to specific environmental conditions needed to survive;
- monitor population size of indicator species over time;
- biotic index can be calculated;
- low overall score when abundance of tolerant species / lack of indicator species / vice versa;
- represent summation of factors/overall assessment of environmental conditions;
- time consuming / species not easy to identify (need keys) / species may not be present for other reasons such as season / another disadvantage
- methodology is simple / minimum equipment needed;
- needs a reference study/guide to compare;
• example of variable e.g. oxygen level / temperature / heavy metals / sulphur dioxide in air / other;
• example of appropriate indicator species e.g. *Tubifex* to heavy metals / *Chironomis* to low oxygen levels / lichens to sulphur dioxide / other;

**G.4.2 Outline the factors that contributed to the extinction of one named animal species.**

- passenger pigeon (became extinct when) hunted as a source of food

**G.4.3 Outline the biogeographical features of nature reserves that promote the conservation of diversity.** (3m)

- size;
  - edge effect;
  - example of edge effect;
  - habitat corridor;
  - example of habitat corridor;
  - habitat/niche diversity;
  - human management;

  e.g. size:
large reserves usually promote diversity more effectively than small ones;

  habitat corridor:
permit organisms to move between different parts of a fragmented habitat;

  example of habitat corridor:
tunnels under roads;

  habitat/niche diversity:
functioning reserve requires a diversity of niches to support the ecosystem structure;

  human management:
banning hunting/lumbering/petroleum exploitation;

  example of edge effect:
cowbird lays eggs in nests of other birds near edges of forests / fragmentation of forests increased cowbirds as more edges;

  edge effect:
cause different ecology of central areas compared to edges;

due effect is the contrast between different environments/from central area of reserve;
small reserves have more edge effect;
as fragmentation increases so does edge (effect);
e.g. cowbirds that lay eggs in edge will increase;

**G.4.4 Discuss the role of active management techniques in conservation.**

**G.4.5 Discuss the advantages of *in situ* conservation of endangered species (terrestrial and aquatic nature reserves).**

a. *in situ* conservation is carried out in nature reserves/natural habitats;
b. named example of a species that is being conserved *in situ*;
c. *in situ* conservation reduces possibility that habitat disappears and the whole
community is lost / may prevent the total number of species that become endangered from increasing;

d. allows species to live in an environment for which they are adapted / they are able to fit into their normal food chains;

e. threatened species in a reserve may be monitored for further deterioration in numbers / remedial steps can be taken;

f. offspring acquire skills from parents/peers around them / offspring acquire natural behaviour;

g. reserves and protected areas in various parts of the world can share experience on how to manage them successfully;

h. nature reserves are popular sites for the public to visit maintaining awareness/education/scientific study;

i. reserves are places to return endangered individuals from breeding programmes as they provide realistic conditions for re-adaptation / OWTTE; [6 max]

G.4.6 Outline the use of ex situ conservation measures, including captive breeding of animals,

- e.g. zoo/botanic garden/seed bank/aquarium/laboratory
  Ex situ conservation describes the preservation of an endangered species away from its natural habitat

- example 1:
  name: zoos;
  captive breeding of animals / permits assisted reproductive methods / use of modern technology;

- example 2:
  name: botanic gardens;
  allows for protected growth of plants / protected from extreme climatic conditions / provision of all necessary conditions;

advantages:
- prevent extinction / help in conservation of species;
- possible breeding;
- reintroduction into the wild;
- correct nutrition constantly;
- veterinary care;
- educational use / research use;
- prevent poaching/picking rare flowers/damage to habitat by man;

disadvantages:
- difficulty in the reintroduction of the species to the wild;
- increases inbreeding / restricted gene pool;
- selection of organisms to be kept ex situ;
- not their natural habitat / reduces evolution;
• does not solve the cause/problem e.g. habitat loss;

G.5.1 **Distinguish between r-strategies and K-strategies.** (6m)

<table>
<thead>
<tr>
<th>r-strategy</th>
<th>K-strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many offspring at a time</td>
<td>Few offspring at a time</td>
</tr>
<tr>
<td>Little care of offspring</td>
<td>Much care of offspring</td>
</tr>
<tr>
<td>High mortality rate</td>
<td>Low mortality rate</td>
</tr>
<tr>
<td>Small body size</td>
<td>Large body size</td>
</tr>
<tr>
<td>Short lifespan</td>
<td>Long lifespan</td>
</tr>
<tr>
<td>Reproduce only once</td>
<td>Reproduce repeatedly</td>
</tr>
<tr>
<td>Favoured by unstable/changing environments</td>
<td>Favoured by stable/consistent environments</td>
</tr>
<tr>
<td>Pioneer species</td>
<td>Climax species</td>
</tr>
<tr>
<td>Variable population size</td>
<td>Stable population size</td>
</tr>
</tbody>
</table>

G.5.2 **Discuss the environmental conditions that favour either r-strategies or K-strategies** (6m)

- **r-strategy** occurs in unstable environment/where there are ecological disruptions;
- resources used to maximize reproducing (once);
- for example in coastal rock pools / other example;
- pathogens/pest species have r-strategies / other example of r-strategy organism;
- **in stable/predictable environments K-strategy predominates**;
- more resources are invested for long-term survival
- are large so require large habitats;
- slow maturation requiring longer protection from predators
- perform better in an environment with high levels of competition
- for example in forests / other example;
- trees / humans / whales / other example of K-strategy organism;
- difficult to determine strategy / r- and K-strategies represent two extremes in a range of strategies;

G.5.3 **Describe one technique used to estimate the population size of an animal species based on a capture–mark-release-recapture method.** (4m)

- capture–mark–release–recapture method;
- marked unit area;
- apply a paint spot/ear tag/leg ring/radio transmitter to the captured rabbits;
- sufficient time must elapse to allow mixing of population to occur;
- second capture must be from same marked area;
- calculate the Lincoln index / population size = \( \frac{n_1 \times n_2}{n_3} \);
- $n_1 =$ first capture, $n_2 =$ second capture, $n_3 =$ number marked in second capture;

G.5.4 Describe the methods used to estimate the size of commercial fish stocks.

- monitor fish catches;
- calculate the mass of fish that can be removed annually / maximum sustainable yield;
- required knowledge of birth rate, growth rate of fish and mortality rates;
- can be estimated by looking at age structure of landed fish;
- can be estimated by catch per fishing effort;

G.5.5 Outline the concept of maximum sustainable yield in the conservation of fish stocks.

- is the maximum number of fishes of a species that can be caught/harvested without causing a population decline / still allowing a population to regenerate;
- corresponds to the turning point of a population growth curve;
- below that point yield is lower and population grows / above that point yield and population will decline;
- used to determine fishing quotas;
- difficulty in estimating populations; [2 max]

G.5.6 Discuss international measures that would promote the conservation of fish. (6m)

- require international agreement/cooperation;
- difficulties of enforcing agreements / to determine maximum sustainable yield / to obtain and interpret data / monitor populations/stocks;
- economic consequences for livelihood of fishermen/associated trades;
- total ban on fishing in threatened areas/endangered species/exclusion zones/limit where fishing can take place;
- limiting size of fish caught / limits on total net size / ban on drift nets / indiscriminate in species of fish caught;
- limiting size to total allowable catch/quotas;
- limiting fishing to non-productive periods of fish / closed seasons banning fishing during breeding season;
- reducing fishing days at sea / fixing number and type of vessels authorized to fish;
- reduce fishing effort/ total allowable catch to below MSY;
- regulation on pollution of bodies of water;
- use of fish farms;
- Increase mesh size to let immature fish swim through
- Reduce subsidies for increasing fleet size