**1.** standard deviation (s.d.) is a measure of the spread about the mean value;
68 % of values fall within 1 s.d. of the mean;
small s.d. means data is clustered around the mean;
the larger the s.d. the greater the spread of the data;
the larger the s.d. the less useful the mean is for comparing data;
quoting the formula for s.d.;
as the means and s.d. become closer, the less likely the data from the two sites are different;
the s.d. can be used to help decide whether the difference between the two means is likely to be significant;

**[4]**

**2.** a shape (rectangular or circular frame) of known area / definition of quadrat;
placed / thrown randomly in each area;
random number tables can be used to avoid human bias;
count the number of individuals of the species in that quadrat;
small quadrats placed many times / large quadrats fewer times;
enough samples must be taken to make it representative;
size of quadrats determined by size of species / area used / the number / size of quadrats can be determined by tables;
population density is number of plants divided by area;
measurement of total area requires a proportion calculation;

**[6]**

**3.** name of relevant activity;
*(To obtain full marks, a candidate must include at least one idea from each of the following categories.)*

**cause** of the problem;
another detail of the cause of the problem;

**effect** caused by the problem / activity;
another detail of the effect caused by the problem / activity;
other discussion concerning another feature (cost, geographical features);

**contained / reduced**; detail how cause / problem can be contained / reduced;
another detail how cause / problem can be contained / reduced;
effectiveness of one solution;

**conclusion**;

*example*:

air pollution;
burning fossil fuels / industrial smoke;
internal combustion engine / diesel engines / petrol engines;
smoke / soot particles damage / aggravate lungs / breathing disorders;
sulfur dioxide may irritate respiratory tract / kill plants;
sulfur dioxide contributes to acid rain;
nitrogen oxide leads to photochemical smog;
pollution more pronounced in industrial / urban areas;
aggravated by closed valleys / geographical location (temperature inversion);
a solution is low-sulfur fuels;
also desulfurisation units on chimneys / power stations;
can also use hydrogen / methane / ethanol / electricity powered vehicles;
but these are currently (generally) expensive / short range / lower power;
clean air acts effectively reduce pollution;
further research on cleaner fuels / solar power will help;
cheaper and more widely available public transport will also help;
alternative means of generating energy will be effective;
poorer countries are still unable to buy the technology / solutions;

**[8]**

**4.** no two species can coexist in same niche;
one is displaced / one survives;
one species has an advantage over competitor /
species compete with each other;
description of (Gause' s) experiments with Paramecium;

**[3]**

**5.** define parasitism / one benefits one suffers;
define mutualism / both benefit (neither suffer);
example of parasite and host (*e.g.* tapeworm and human);
what the parasite gains from host specific to example given
(*e.g.* obtains digested food);
what the host suffers specific to example given
(*e.g.* cysticercosis / weight loss);
example of two organisms in mutualistic interaction
(*e.g.* sea anemone and hermit crab);
what one gains (*e.g.* protection and camouflage);
what the other gains (*e.g.* mobility);

**[6]**

**6.** name of one organisation (*e.g.* WWF);
gathering information / global view of the biosphere;
protect genetic / species / ecosystem diversity;
recognises damage to environment /
recognises waste of non-renewable resources;
co-ordinates action (internationally and locally);
raise money (in rich nations);
stimulate / finance research;
publicise / educate;
lobby (governments/companies);

**[4]**

**7.** increase in N or P / eutrophication / algal bloom;
increase in bacteria / microbes;
increased BOD / reduced dissolved oxygen;
oxygen sensitive organisms in river die/emigrate /
pollution sensitive organisms increase /
diversity decreases;
increased levels of toxins / hormones / heavy metals;

**[3]**

**8.** (a) 08.00 and 23.00 1

(b) Eskdalemuir showed greater variations over the 24 hour period;
Strath Vaich always had greater ozone content;
both had least during early morning hours (or numerical);
both had most in early afternoon (or numerical); 3 max

(c) sunlight / higher temperature 1

(d) Strath Vaich;
as less ozone was absorbed (due to windy conditions); 2

**[7]**

**9.** ***[1]*** *for a correct s-shaped curve.*
*Must have correct labelled diagram for full marks.*
***[3 max]*** *for any of the following.*
(exponential) – rapid increase in population;
(transitional) – slowing of growth;
(plateau) – levelling off, birth rate = death rate;

carrying capacity labelled;

**[4]**

**10.** *Maximum **[3]** for causes or maximum **[3]** for effects, if not linked.*
*To get full credit, must link causes and effects,*
*causes*:
fossil fuel burning;
deforestation;
cattle ranching / methane production;
use of CFCs;
production of nitrogen oxides;

*effects:*
increasing $CO_2$ concentration;
increasing temperature;
increase in photosynthesis;
changing climate;
extinction of species;
glaciers melt / increase in sea level / flooding;

**[6]**

**11.** (a) thicker branches have more cover /
branches near the tree have more cover;
thinner branches have less cover /
no change until the branch is 17.9–1 cm; 1 max

(b) with higher angles there is usually less coverage;
there is less change between 0 – 30° and 31 – 60°
than between 31 – 60° and 61 – 90°;
the coverage for horizontal and inclined
branches is almost the same;
the ends of branches show least coverage; 2 max

(c) the overall patterns are the same;
for branch diameters of 40–9 cm there is 100 % coverage
in the mountains compared to 40 % in the lowland forest;
for thinner branches (8.9–1 cm) the percentage
cover in lowland forests is almost zero
whereas mountain branches have 40 % cover; 2 max

(d) mountain forests are often covered in mist or clouds
so there is more moisture available;
more precipitation in mountain forests;
lowland forests are warmer and plants dry out more easily;
more animal activity / grazers in lowland forest; 1 max

**[6]**

**12.** (a) *Award **[1]** for any **three** of the following.*
temperature, water, breeding sites, food supply,
territory, predation, competition 1 max

(b) an index of diversity is a measure of species diversity;
can be applied to plant or animal species;
index diversity of species is a measure of health /
stability / degree of stress of an environment;
comparison of two values is a measure of
change for better or worse;
data can be used for policy decisions regarding the environment;
measure of species richness;
low diversity indicates environmental stress; 3 max

(c) *A named organization and at least one role is required*

*examples:*
CITES – identifies endangered organisms / restricts trade / encourages sustainable exploitation of species / ecotourism;
WWF – fund raising / education / public awareness research / coordination / lobbying;
IUCN – coordination; 1 max

**[5]**

**13.** new medicines /
materials could be found from organisms growing in the wild;
ecotourism could provide income;
crop plants and farm animals could be improved with alleles from wild populations;
loss of one species could impact on other species because of interdependence;
disruption of ecosystems could lead to soil erosion / flooding / weather pattern changes;
disruption of water cycle / nutrient cycles;
intrinsic value / existence value beyond usefulness to humans;
cultural importance of species to indigenous groups;
ensures access of future generations to the wealth of today;

**[7]**

**14.** damages organic molecules in living organisms;
damages genetic material / causes mutations;
increases mortality of phytoplankton / algae in oceans;
reduces yield among terrestrial crop plants;
destroys nitrogen-fixing bacteria in soil;
increases incidence of skin cancer among humans;
depresses immune system in humans;
causes cataracts in humans;

**[3]**



**15.** (a) 79 % ± 2 % 1

(b) Gulf of Mexico / Atlantic 1

(c) total number of Caribbean endemic species is greater than in the Pacific / 425 and 450;
no Caribbean endemic species occur in great numbers / >32 compared to the Pacific / which has about 45;
the number of Caribbean endemic species occurring in small numbers /
1–2 is more than twice that in the Pacific / about 280 and 120; 2 max

(d) the Caribbean region will have a greater extinction rate;
because of the great number of endemic species
occurring in small numbers;
small numbers of a species are more vulnerable
to extinction than high numbers;
for Caribbean ubiquitous species the percentage of
species occurring in high numbers /
>32 is lower than in the Pacific; 2 max

(e) the Arctic; 1

**[7]**

**16.** *Rhizobium* adds nitrogen to the soil whereas
*P. denitrificans* releases nitrogen from the soil;
*Rhizobium* fixes nitrogen into nitrates /
ammonia whereas *P. denitrificans* converts nitrates into nitrogen;
*Rhizobium* lives as a symbiont in root nodules of
leguminous plants whereas
*Pseudomonas* lives as a free-living bacteria in water-logged soil;
*Rhizobium* lives in aerobic conditions and
*Pseudomonas* in anaerobic conditions;

**[3]**

**17.** (a) (i) capture–mark–release–capture / capture–recapture / cohort method; 1

(ii) *To receive full marks there must be reference to the use of Lincoln index / similar equation.*
capture animals;
mark / tag animals;
release again;
recapture after an appropriate time period *e.g.* next night, a few nights later;
use of Lincoln Index equation / similar type of equation;
***or***
count the number of pits made by a bandicoot in a night;
count the total number of pits made in a night;
estimate the number of bandicoots based on number of pits made in
a night; 3 max

(b) primary consumer / second trophic level;
feeds on plant material;
secondary consumer / third trophic level;
feeds on invertebrates; 2 max

**[6]**

**18.** (a) (i) asbestos cement;
grows closest to city centre on asbestos cement roofs;
only grows on asbestos cement roofs between concrete / cement and asbestos lines;
2 max

(ii) acid rain is neutralized by alkaline building materials; 1

(b) gives a measure of acid rain levels / indicator species allow a variable to be measured;
monitoring of environmental change / shows if conditions are getting worse or better;
shows if pollution control / conservation projects are working;
organisms are there all the time so give a longer-term measure / not just at an instant; 3 max

**[6]**

**19.** (a) *in situ* is conservation of species in their habitats and *ex situ* is conservation of species removed from their habitat; 1

(b) (captive) breeding programs (in zoos);
cultivation of plants (in botanic gardens);
storage of seeds (in seed banks);
storage of sperm /ova / micro-organisms; 3

(c) international limits on sizes of catches / quotas for each national fleet;
minimum mesh sizes to prevent catching of immature fish / disallow dragnets;
protection of nursery areas / closed seasons during which no fishing takes place;
fish can swim in and out of national waters so international measures needed;
most sea area is outside territorial waters so international measures needed;
international control / laws on pollution levels; 3 max

**[7]**

**20.** (a) total amount of energy / $CO_2$ fixed by photosynthesis / plants / organic matter produced; 1

(b) net production is gross production minus respiration;
all species respire; 2

(c) gross production rises;
as small plants are replaced by larger plants;
eventually stabilizes;
more stratification as leaf area index increases; 2

**[5]**

**21.** C

**[1]**

**22.** energy enters from (sun)light;
chloroplasts / plants / producers / autotrophs capture (sun)light;
energy flows through the trophic levels / stages in food chain;
energy transfer is (approximately) 10 % from one level to the next;
heat energy is lost through (cell) respiration;
energy loss due to material not consumed / assimilated / egested / excreted;
labelled diagram of energy pyramid;
energy passes to decomposers / detritivores / saprotrophs in dead organic matter;

nutrient cycles within ecosystem / nutrients are recycled;
example of nutrient cycle with three or more links;
nutrients absorbed by producers / plants / roots;
nutrients move through (food chain) by digestion of other organisms;
nutrients recycled from decomposition of dead organisms;
nutrients from weathering of rocks enter ecosystem;
nutrients lost by leaching / sedimentation (*e.g.* shells sinking to sea bed); 8 max

*(Plus up to [2] for quality)*

**[8]**

**23.** electromagnetic radiation / wavelengths of 200 to 400 nm;
mutations in DNA / forms free radicals;
(pyrimidine) dimer formation / bend or kink in DNA;
DNA repair system not functioning;
(benign and malign) tumors / skin cancer / xeroderma pigmentosum;
sunburn / cataract / destruction of folic acid;
UV light converts (ergosterol) to vitamin D / sun tan / radiotherapy;

**[4]**

**24.** anaerobic / oxygen free;
fermentation tank;
warm temperature; (30–40 °C);
raw material organic wastes / excreta / leafy remains / straw / bagasse / peelings of fruit / vegetables;
organic molecules (proteins, carbohydrates, fats) transformed into alcohol, carbon dioxide, fatty acids and hydrogen / hydrolysis of organic molecules;
formation of acetic / ethanoic acid by acidogens;
methanogenic bacteria (*Methanoccocus, Methanobacterium, Methanospirillum,* others);
methane produced from (reducing) $CO_2$ and $H_2$ / $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$;
acetate / ethanoic acid split to produce methane (and $CO_2$) / $CH_3COOH \rightarrow CH_4 + CO_2$;
(*balanced equation not required*)
affected by detergents / high fatty acid concentrations / heavy metal ions / low pH;

**[6]**

**25.** (a) 30 (± 1) squirrels hectare $^{-1}$; 1

(b) population decreases from 12 (± 1) squirrels hectare $^{-1}$ to 2 (± 1) in food addition area; in food addition plus predator exclusion area decreases from 30 (± 1) to 2 (± 1);
reaches same level as control (in 2 years);
other numerical comparison; 2 max

(c) addition of food and exclusion of predators results in more squirrels as conditions are ideal;
squirrels can feed well <u>and</u> are not predated / higher reproduction rate;
food addition alone also results in more squirrels;
because food affects population growth more than predator exclusion (squirrels climb, hide);
no additional food but predator excluded does not confirm the hypothesis; 3 max

**[6]**

**26.** (a) organic matter of organism after respiration (and metabolism) have been fuelled;
net production = gross production – respiration; 1 max

(b) A: decomposers / saprophytes / putrefying bacteria;
B: nitrifying bacteria / *Nitrobacter*;
C: nitrogen fixing bacteria / *Rhizobium* (symbiotic) / *Azotobacter* (free-living) cyanobacteria (blue-green algae) / other nitrogen fixing bacteria; 3

**[4]**

**27.** (a) (i) with time, the atmospheric concentration of $CO_2$ has increased; 1

(ii) the increased use of fossil fuels / more automobiles;
increased deforestation; 1 max
*Do not accept greenhouse effect.*

(b) (i) any trough, clearly labelled at the bottom; 1

(ii) $CO_2$ is a raw material for photosynthesis;
there is an increase in the rate of photosynthesis in the summer;
therefore less $CO_2$ in the air during the summer as it is being used for photosynthesis;
increase in $CO_2$ in winter because less photosynthesis due to trees losing leaves in autumn-winter / lower temperatures / shorter days with less light; 2 max

(c) CFCs / $CH_4$/ $N_2O$; 1
*Names are acceptable e.g. methane, nitrous oxide. Do not accept $SO_2$ .*

**[6]**

**28.** (a) a group of individuals that could interbreed;
to produce fertile offspring;
individuals that share a common gene pool; 2 max

(b) *Any **three** of the following.*
animalia / animals;
plantae / plants;
prokaryotae/monera;
protoctista;
fungi; 1 max

(c) genus and species; 1
*Both are needed for [1].*

**[4]**

**29.** (a) (i) 1450 m (± 20) m; (*mark lost if this is the first time the units are omitted*) 1

(ii) 980 m (± 20) m; (*mark lost if this is the first time the units are omitted*) 1

(b) shark 2 turns / changes direction more often than shark 1 / vice versa 1 max

(c) shark 1 swims in water where the zooplankton levels are low;
shark 2 swims in water where the zooplankton levels are higher;
shark 2 turns more often because it is feeding in plankton / food rich water / shows highest degree of turns where zooplankton levels are highest;
shark 1 turns less often because it is still searching for food / there is not much to eat; 3 max

(d) water temperature;
other sharks / competitors;
mates;
water currents;
pollution;
any other possible reasons; 2 max

**[8]**

**30.** (a) provide dead organic matter when they die / produce waste;
aerate the soil when they burrow through it;
roots of plants prevent soil erosion;
decompose dead organic matter to form humus;
enrich with minerals (*e.g.* nitrifying bacteria); 2 max

(b) tropical rainforest conservation is an example of in situ conservation / cheaper than *ex situ* conservation;
tropical rainforest species provide valuable timber;
tropical rainforest species are sources of new pharmacological molecules / new medicines;
tropical rainforest are a source of revenue through ecotourism;
tropical rainforest provide employment for local people;
tropical rainforests managed to maintain high diversity and to provide sustainable yield of materials; 3 max

**[5]**

**31.** (a) (i) D decreases; 1

(ii) stable ecosystem / absence of changes;
ecosystem not under stress;
ancient / well established ecosystem; 1 max

(b) biotic indices use a range of species;
of varying degrees of tolerance;
to measure an abiotic factor;
example of factor (*e.g.* organic water pollution, air pollution);
example of index (*e.g.* fresh water benthic invertebrates, lichens);
biotic indices can reveal long-term effects of environmental stress; 3 max

**[5]**

**32.** (a) *Must include statements of **both** mass and density for full marks.*
in mass there is an inverse relationship with density;
in height there is an inverse relationship with density;
at low *Populus* density, the mass is high / maximum / about 155 g;
mass decreases from 160 g to 40 g;
at low *Populus* density, the height is maximum / high / 19 cm;
height decreases from 19 cm to 10 cm; 3 max

(b) *Tamarix* density has very small/no effect on *Populus* height at any density / high or low density; 1

(c) better underground / root growth;
to compete for water;
competition for minerals / nutrients;
greater resistance to drought / protection against dehydration / lower water needs;
resistance to higher salinity / changes in pH; 2 max

**[6]**

**33.** (a) in mutualism two members benefit / neither suffer;
in parasitism one benefits and one suffers; 2

(b) control of alien species / control of predators / control of herbivores;
restoration of degraded areas;
promotion of recovery of threatened species;
control of human exploitation; 2

**[4]**

**34.** eutrophication of bodies of water;
excess nutrients for algal growth / bloom;
death of algae;
decomposition of algae / sewage;
increase in decomposers / bacteria;
deoxygenation of water;
decrease in population of oxygen sensitive species / lowering of diversity;
increase in BOD;
pathogens in bathing or drinking water / public health risk;
unpleasant smells / sight;

**[4]**

**35.** add artificial / chemical / synthetic fertilizers;
provide nitrates / ammonium;
easily absorbed / oxidized and absorbed;
expensive;
degrade soil;
both easily leached;
use of manure and compost;
must be decomposed by microorganisms;
less expensive;
improve soil quality / humus;
improve aeration of soil;
improve drainage of soil;
plowing / digging to mix earth (control weeds);
allow decomposition of organic matter in soil;
crop rotation as different crops have different nitrogen requirements;
use of legumes to release nitrates into the soil;
nitrogen-fixing bacteria / *Rhizobium* in root nodules;

**[6]**

**36.** light is the initial source of energy for almost all communities;
plants absorb light and use it in photosynthesis;
plants produce food / organic matter;
plants are the main producers in most communities;
energy flows along food chains / webs from plants;
first consumers eat plants / producers;
second consumers eat first consumers that have eaten plants / producers;
plants produce oxygen;
oxygen needed for cell respiration by many organisms;
dead plants / parts of plants available to saprotrophs / fungi and bacteria / detritivores;
plants provide a habitat for other organisms / epiphytes;

**[6]**

**37.** use quadrats;
position them randomly;
count the number of individuals of the plant (species) in each quadrat;
as many quadrats as possible;

$$\text{total (density)} = \frac{\text{mean number per quadrat} \times \text{total area}}{\text{area of quadrat}}$$

**[4]**

**38.** natality / births / reproduction increases populations;
as long as natality is higher than mortality;
abundant food allows increase / food shortage causes decrease;
low level of predation allows increase / high level causes decrease;
low level of disease allows increase / high level causes decrease;
immigration increases populations;
as long as immigration is greater than emigration;
population rise until a plateau is reached;
carrying capacity of the environment;
when the resources of the environment cannot support any more individuals;
graph of sigmoid population growth;
environmental factor and its consequence (*e.g.* flood causes decrease); 8 max
*(Plus up to [2] for quality)*

**[8]**

**39.** (a) (i) potassium/K 1

(ii) sub-arctic forest 1

(b) K and Ca has greater MRT in chaparral (than temperate forest);
K has the shortest MRT of all nutrients in both biomes;
C, N, P and Mg greater MRT in temperate forest than chaparral;
MRT values for K and C show little variation between these areas (chaparral and temperate);
P shows the greatest range/difference in MRT;
temperate forest has higher MRT for all nutrients except K and Ca;
average MRT for all nutrients in the temperate forest is 3.8 and for the chaparral is 3.5;
temperate forest and chaparral have similar values for all nutrients compared to the other biomes; 2 max

(c) generally plant productivity increases while MRT decreases / negative correlation;
tropical rainforest biome with shortest MRT (for nutrients) has highest plant productivity / sub-arctic has low plant productivity and long MRT;
(but) chaparral has lower plant productivity than sub-arctic forest but shorter MRT for nutrients / there are exceptions to the relationship;
there is no relationship that holds true for all four biomes; 2 max
*Do not accept no correlation.*

(d) higher temperatures in tropical rainforest / lower temperatures in sub-arctic forest;
greater decomposition in tropical rainforest / more saprophytes;
water availability; 1 max

(e) a community (biotic) and its abiotic environment / interacting populations and their physical environment 1

(f) (relatively) constant/slight increase until June 1963;
peaks in June 1964;
decreases until December 1964;
rise and fall of Cs-137 happens within a year (1964);
increases again until June 1965; 2 max

(g) (i) *lichens:* producers/autotrophs/first trophic level;

(ii) *Inuit*: secondary consumer/third trophic level; 2

(h) caribou eat lichens and accumulate Cs-137;
Inuit eat caribou and accumulate (more) Cs-137;
toxins build up in food chain/bioaccumulation/magnification (other concepts of additive nature); 1 max

**[13]**

**40.** (a) (i) 70 (%) / 45 (%) and 25(%) 1

(ii) 101 (±1) 1

(b) fire;
flood;
logging/deforestation;
hurricanes/strong winds;
drought;
land clearance;
climatic changes;
pollution; 2 max
*Accept other appropriate answers.*

(c) small size more likely to suffer from habit loss;
large size from persecution / predation; 2

(d) remove predators / persecution;
may be *in situ* or *ex situ* conservation;
national parks / nature reserves;
hunting seasons;
captive breeding (in zoos);
legislation (*e.g.* endangered species list, quotas);
agencies / examples; 3 max

**[9]**

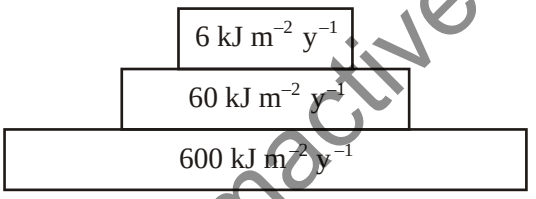
**41.** (a) light;
water;
soil pH;
salinity;
soil drainage;
mineral nutrients; 1 max

(b) to see if there is (significant) difference between means of two populations;
a null hypothesis is stated / alternative hypothesis says data are different;
mean heights found;
a table is used according to degrees of freedom;
if value is greater than critical value, there is (significant) difference / reject the null hypothesis;
so temperature does make a difference;
if value is not greater temperature has no effect; 3 max

**[4]**

**42.** (a) plant respiration = gross production – net production /
$6 \times 10^2$ kJ $m^{-2}$ $y^{-1}$ – $5 \times 10^2$ kJ $m^{-2}$ $y^{-1}$;
= $1 \times 10^2$ / 100 kJ $m^{-2}$ $y^{-1}$; 2
*Units required.*

(b)




correct pyramid shape;
6kJ $m^{-2}$ $y^{-1}$ (*correctly calculated as energy passed to secondary consumer*);
producer and primary consumer values correctly inserted; 3 max

*Award [2 max] if there are units omitted. Award [2 max] if a bar is included for the solar energy. Do not deduct marks if the areas of the bars are not proportional to the values, although they should get smaller going up.*

**[5]**

**43.** (a) 25 (±1) (%) 1

(b) in 1960, the capture was the same in both oceans;
more fish caught in the Pacific Ocean than Atlantic Ocean after 1960;
% increase greater in Pacific Ocean than Atlantic Ocean;
in 2000, Pacific Ocean yield more than doubled Atlantic Ocean yield;
between 1980 and 1990 decrease in Atlantic Ocean capture and increase in Pacific Ocean;
from 1970 to 1980 no change in Pacific Ocean but increase in Atlantic Ocean yield; 3 max

(c) *Atlantic Ocean*: quotas decreased / depleted stocks / consumer tastes / smaller fleet / yield decreased;
*Indian Ocean*: better technology / quotas increased / consumer tastes / more stocks / bigger fleet / yield decreased; 2

**[6]**

**44.** (a) gross production – respiration = net production 1
*Accept answer using initials.*

(b) energy per unit area per unit time / KJ hectare$^{-1}$ year$^{-1}$ (*or similar*) 1

(c) parasitism – the host suffers and the parasite benefits;
mutualism – both species benefit and neither suffers;
*e.g.* is tapeworm and human *etc.*;
tapeworm gains nutrients, human loses nutrients;
*e.g.* lichens;
algae photosynthesises food for both, fungus provides water and nutrients for both;
mycorrhiza – fungi and plant roots;
hydra and zoochlorella;
bacteria in ruminants stomach;
*e.g.* cleaner wrasse on damselfish; 4 max
*Accept similar named examples.*

**[6]**

**45.** (a) maintain natural habitat / biodiversity / protects other species cheaper than *ex situ* / organisms continue to evolve in their natural habitat 1

(b) dodo / passenger pigeon / Tasmanian Tiger / Carolina Parakeet;
hunting / competition with alien species / predation / habitat destruction / pollution; 2

(c) control of introduced or alien species;
restoration of degraded areas;
recovery of threatened species;
control of human exploitation / tourism;
population control / culling; 3 max

**[6]**

**46.** C

**[1]**

**47.** B

**[1]**

**48.** D

**[1]**

**49.** leaves release carbon dioxide when they respire;
when they are burned/combustion;
C passed to decomposers when they die;
C passed to detritus feeders from leaf litter;
C passed to consumers/herbivores in the food chain;
carbon removed from the carbon cycle when leaves are fossilized / turn to peat/coal; 4 max
*(Plus up to [2] for quality)*

**[4]**

**50.** (a) diversity index determines species richness of ecosystem;
higher the index the greater the diversity;
changes in the index indicate environmental change;
so community B has a higher species richness; 3 max

(b) the role/functional position of an organism in its environment;
spatial habitat where species live;
feeding activities / how food is obtained;
interactions with other organisms in community;
no two species can occupy the same niche; 2 max

**[5]**

**51.** *Do not award a mark if a factor is mentioned but not explained.*
breeding sites – animals must breed and may need a special site;
food supply – may feed on specific foods / abundance;
territory – need to establish / defend for food/mates;
competition – for food/space may alter distribution/niche;
predation – can reduce the range of another species / be reduced by predation;
temperature/climate – need the proper range for survival;
water – need water to live in (aquatic) / proper amount for bodily functions;
natural (geographic) barriers – limit range/dispersion / natural disasters could destroy food supplies;
free of pollution/toxic substances - could cause death;

**[5]**

**52.** ozone in stratosphere absorbs some ultraviolet light / protects earth from UV;
UV light can damage tissues in living organisms;
UV light increases mutation rate / creates thymine dimers;
UV light can cause cancer / increase skin cancer;
UV light can cause cataracts;
UV light reduces photosynthetic rate in algae / terrestrial plants;
affects food chain *e.g.* kills phytoplankton/zooplankton/terrestrial food chains;
*Accept inverse statements for the positive role of the ozone layer in each case.*

**[4]**

**53.** index/D is a measure of species richness ;
a high value of D suggests a stable/ancient site;
a low value of D could suggest pollution / recent colonization / agricultural management / environmental stress;
the index is normally used in studies of vegetation diversity (but can also be applied to comparisons of animal / all species diversity);
involves collecting data on variety of species;
and relative numbers;

**[3]**

**54.** indicator species are organisms that need particular environmental conditions;
diversity/abundance/groups of species/relative numbers of indicator species can be used to construct a biotic index;
biotic indices are used to monitor environmental change/status;
only organisms sensitive to specific environmental condition are included in the biotic index;

example of indicator species and condition to which it is sensitive;
*e.g. stonefly lives in highly oxygenated water.*
*tubifex lives in poorly oxygenated water.*
*crustose lichens, tolerant to air pollution.*
*fruticose lichens, intolerant to air pollution.*
*other example.*

any change in the environment will be seen as a change in numbers of these species/groups;
indicator species/biotic indices can be used to indicate pollution;
pollution can be seen by overall decrease in diversity / increased in numbers of tolerant species;
examples of biotic index (*e.g.* lichens communities and air pollution, fresh water invertebrates and organic water pollution);

**[6]**

**55.** (a) *Award [1] for each of the following processes correctly placed and labelled.*
nitrogen fixation (free-living, symbiotic, lightning and industrial) / $N_2$ converted to $NH_3$;
denitrification;
nitrification / $NH_3$ converted to $NO_2^-$ / $NO_3^-$;
feeding;
excretion;
root absorption;
putrefaction (ammonification); 3 max
*Do not accept decomposition.*

(b) methane;
wood;
ethanol; 2 max
*If the candidate gives more than two answers for this question mark **only** the first two given. Do not accept coal or petroleum.*

**[5]**

**56.** (a) (i) (increased by) one species / from six to seven species 1

(ii) (increased by) four species / from one to five species 1

(b) in Chile there were more rodents at low levels of rainfall / up to 50 mm than in the USA;
the numbers in the USA were higher than in Chile at 100 to 110 mm rainfall;
the numbers in the USA have a greater range;
>200 mm there were more species in Chile; 2 max

(c) plants in Chile grow better with less rain and provide more food in drier conditions than in the USA;
rodents in Chile have a broader diet of organisms that survive drought/dry conditions;
rodents in Chile more mobile to search for food outside area studied;
more varied food chains in the USA / longer food chains are involved; 2 max

**[6]**

**57.** (a) decrease / lack of sufficient reproduction in overfished populations / extinction of fish;
decrease in predators of specific fish;
increase in prey numbers of specific fish; 2 max

(b) loss of energy / biomass at each stage of a food chain;
energy lost due to respiration / excretion;
a smaller amount of total biomass of food available;
cannot support large numbers of organisms; 2 max

**[4]**

**58.** (a) done outside of the natural habitat of the organisms;
captive breeding of animals;
*e.g.* panda bears, *etc.*;
botanic gardens;
seed banks;
to protect the genetic pools / biodiversity; 3 max

(b) (i) the habitat of an organism, its nutrition / feeding habits and interactions / relationships with other organisms / other organisms / the role of an organism in a habitat / ecosystem 1
*Award [0] for habitat alone.*

(ii) localization of named animal in its habitat;
description of spatial habitat;
description of feeding habitat: type of food;
time of day;
interactions with other organisms: prey;
predators;
competition;
reproductive strategies;
breeding sites; 4 max

**[8]**

**59.** A

**[1]**

**60.** ring species;
subspecies may be isolated in niches / minor differences in gene pool / potentially able to interbreed but do not;
some species reproduce asexually / parthenogenesis;
interspecific hybridization / artificial methods / IVF technology;
species definition cannot be applied to bacteria;
species still evolve / cannot be applied to fossils;
difficult to know if geographically separated populations can interbreed;
some individuals are infertile;

**[4]**

**61.** (a) proportion of rats in diet decrease with length / inversely proportional / negative correlation 1

(b) (i) no/little difference 1
*Do not award marks to responses just stating values.*

(ii) proportion of rats in diet of females is lower than for males 1

(c) larger snakes eat larger prey;
feeding frequency can be reduced if larger prey is eaten;
females shift earlier to larger prey to prepare for gestation;
larger snakes move to different habitats;
larger snakes may not be able to catch rats; 2 max

(d) sample is biased / 22 females versus 13 males, so results not reliable;
small sample size;
no males collected above 400 cm;
time and date of capture not known;
seasonal change in feeding patterns;
smaller males more active in foraging therefore greater chance of capture;
not all snakes had full stomachs at the time of capture / prey availability not known;
some snakes may have been kept in captivity / artificial or forced diet;
larger prey takes longer to digest / rats are digested more quickly;
snakes collected or captured in different habitats; 2 max

**[7]**

**62.** fish conservation requires accurate data to determine fish quota;
fish migration difficult to monitor;
notification of catches by fishermen often biased as it directly interferes with their income;
fish migration (patterns) influenced by climatic effects (*e.g.* El Niño);
observation and counting of fish / determining fish population is difficult;
tagging / other population estimation techniques are not efficient for very large numbers;
not all nations have ratified international fishing treaties / commercial interests interfere;
fish populations migrate in and out of international waters;

**[3]**

**63.** *Rhizobium* / nitrogen-fixing bacteria lives in root nodules / symbiotic relationship with legumes;
fixes nitrogen into ammonia;
using energy from ATP;

*Azotobacter* / nitrogen-fixing bacteria lives free in soil;
fixes nitrogen into ammonia;

*Nitrosomonas* / nitrifying bacteria converts ammonia to nitrite;

*Nitrobacter* / nitrifying bacteria converts nitrite to nitrate;
*Nitrosomonas* and *Nitrobacter* live in well aerated soil / require good supply of oxygen;

*Pseudomonas denitrificans* /denitrifying bacteria converts nitrate to nitrogen;
nitrate is used as terminal electron acceptor instead of oxygen;
carries this out in low oxygen / badly aerated soil; 6 max
*Responses must include at least three types of bacteria to achieve full marks.*
*Award [0] for responses with just the name of bacterium.*

**[6]**

**64.** in food webs organisms often occupy two levels / eat at different trophic levels;
some organisms eat prey from different trophic levels;
not all feeding habits of all organisms are known;
feeding habits may vary seasonally / during life cycle;
*e.g.* chimpanzees feed on fruit, termites and monkeys / other examples;
second example;
as you move up the food chain, less energy is available / only 10–20 % of energy is passed to the next trophic level;
broad diet to ensure adequate energy intake;

**[4]**

**65.** (a) April 1

(b) biomass of algae levels vary/fluctuate more than changes in day length;
day length gets longer at the same time as biomass of algae increases / biomass of algae peaks before the day length peaks;
from (late) April biomass of algae drops off, while day length continues to increase;
from January to April day length increases linearly while biomass of algae increase exponentially;
in May, biomass of algae reaches a minimum while day length continues to rise;
mid May to June, biomass of algae starts to increase again while day length rises to its maximum; 3 max
*Only credit answers which include a comparison.*

(c) low food (in 7 out of 8/most cases);
day length does not appear to show a clear pattern;
in three of the four groups, low food and short day results in resting egg production;
low food and long day always result in egg production;
high food never results in resting egg production; 3 max

(d) in April there is high food which does not result in resting egg production 1

(e) high food to low food 1
*Do not credit "low food" only.*

(f) *Advantages of sexual reproduction*: ***[2 max]***
sexual reproduction produces resting eggs when food conditions worsen / high to low food / weather conditions worsen;
resting eggs remain dormant / survive during bad weather conditions/ drought/cold temperatures;
increases chance of population surviving bad weather conditions/ drought/cold temperatures;
sexual reproduction increases variety;
variety increases the chances of the population surviving bad weather conditions/drought/cold temperatures;
day length changes represent seasonal weather changes;

*Advantages of asexual reproduction****: [2 max]***
asexual reproduction faster when weather conditions are good/ in warmer temperatures / water is available;
asexual reproduction is faster than sexual reproduction;
asexual reproduction does not require the need to find a mate; 3 max

**[12]**

**66.** (a) a sample where every member of a population has an equal

chance of being selected / sample selected without bias 1

(b) axes correctly labeled ($x$ = time, $y$ = number of individuals/population size);
carrying capacity/plateau correctly labelled;
transitional/lag phase correctly labelled;
exponential growth phase/stage correctly labelled; 3 max

(c) (i) 24.6 g / 24.63 g *(units needed)*
*Award **[0]** for 25 g or significant figure errors.* 1

(ii) standard deviation is a measure of variability /
degree of spread around the mean;
a small standard deviation indicates the data is spread
closely around the mean value /
a large standard deviation indicates a wider spread around the mean;
population 2 has greater variability, therefore, it has a greater
standard deviation/ *vice versa*;
. 1 standard deviation from the mean represents
68 % of the data /
. 2 standard deviations from the mean represent
95 % of the data; 2 max

**[7]**

**67.** population is a group of members / organisms of one species;
that live in the same area / same ecosystem;
at the same time;
community is a group of populations / all of the living organisms;
that live in the same area / same ecosystem;
interacting with each other;

**[4]**

**68.** *either:*
capture-mark-release-recapture method;
capture a sample of the population;
example of method of capture;
mark each captured individual and release;
allow to settle back into the environment /
wait for at least 24 hours / until randomly dispersed;
recapture as many individuals as possible;
count the marked and unmarked individuals;
number marked originally x recaptured

$$\text{calculate} = \frac{\text{number marked originally} \times \text{recaptured}}{\text{number marked and recaptured}}$$

*Accept this formula using symbols with a key or alternative formula.*

*or*:

choose an appropriate habitat;
can use quadrats to sample the habitat;
count burrows / nests / other sites;
count number of individuals per site / sites per individual;
multiply number per site/quadrats × number of sites/quadrats;
more repetitions will produce a better mean;
make counts of individuals at different times of day;

**[6]**

**69.** energy enters as light / sunlight;
trapped by plants / producers / autotrophs;
converted to chemical energy in photosynthesis;
passed to first consumers when they eat plants;
passed from consumer to consumer / passed along the food chain by feeding;
lost from the community as heat;
lost as a result of cell respiration/metabolism/movement;
approximately 90 % lost / 10 % passed on between trophic levels;
number of trophics levels limited by amount of
energy entering into the ecosystem;
energy is lost between trophic levels as defecation/loss of feces/excretion;
passed to decomposers after death of organisms / parts of organisms;
energy is lost between trophic levels due to uneaten parts;

**[8]**

*Credit may be given to a suitably annotated diagram.*

**70.** (a) (i) 55 (. 1) kg (*units needed*) 1

(ii) 1988 / <u>end</u> of 1987 1

(b) greater fluctuations in the northern area;
no data before 1979 for the northern area,
so comparison is difficult;
negative correlation between year and body mass /
downward trend over time in southern area not
evident in northern area;
large decrease in southern area in late 1990s
not seen in northern area; 2 max

(c) as both animals vary similarly,
it supports the hypothesis (in northern area);
hypothesis not supported in southern area in some years;
many other factors may influence the fluctuations;
*e.g.* weather, competition, predation etc.;
no data on bilberries, so cannot say; 2 max

**[6]**

**71.** (a) *Award **[1]** for any two factors.*
temperature/climate;
water;
food supply;
territory/space;
predation;
breeding sites; 1 max

(b) two closely related species/interspecific competition;

experiments by Gause with two species of
*Paramecium* / other example;
competition for limiting resources eliminates inferior
competitor / only one of the species survives in the niche;
competition restricts niche;
two species cannot coexist if niches identical; 3 max

(c) an area with no vegetation / barren area /
volcanic rock is colonized by a variety of species;
these species are gradually replaced by others;
interaction between living organisms and
abiotic environment / increase in soil organic matter /
improves soil structure;
eventually a stable community develops /
climax community; 2 max

**[6]**

**72.** (a) measure of the richness of species / the health of ecosystems;
high diversity indicates good health / stable site / ancient site; 1 max
*Do not accept just "measure of diversity" or the formula only.*

(b) raise funds to protect threatened species / areas /
establish nature reserves;
political lobbying;
education;
monitors endangered species; 2 max

(c) limit amount/quotas of fish to be caught /
prevent over-exploitation;
no/reduced fishing during reproductive seasons;
monitoring of environmental/abiotic factors;
monitoring stocks and reproductive rates;
control of pollution of seas/lakes/rivers;
control of net type/mesh size;
smaller fleet sizes / exclusion zones;
education - change in eating non-threatened species;
need for / difficulties in establishing agreements between countries; 3 max

**[6]**

**73.** (a) primary consumer 1

(b) June to August 1994 (± 1 month);
May to June 1993 (± 1 month); 1 max

(c) there is a rise in the population starting every (Antarctic) summer;
every year numbers remain low from March until November /
from fall until the beginning of summer;
no data available for spring 1994;
increase in numbers coincides with increase in light;
decrease in numbers during fall / autumn; 2 max

(d) (i) lowest sea water temperature is associated with
highest numbers of larvae;
larvae numbers increase when temperature
drops below –1.5°C°
no larvae at temperatures above –1.5 C °
bigger increase in numbers during July / September 1993
than in July / September 1994
although temperatures the same; 2 max

(ii) global warming causes rise in sea water temperature;
lower numbers of larvae;
because larvae only present at sea water
temperature below –1C ° 2

**[8]**

**74.** (a) *Award three correct **[2]** and for one or two correct **[1]**.*
temperature / climate;
water;
breeding sites;
food supply;
territory;
human interference 2 max

(b) two closely related species / interspecific competition;
experiments by Ganse with two species of *Paramecium* /
other example;
competition for limiting resources eliminates
inferior competitor / only one of the species
survives in the niche;
competition restricts niche;
two species cannot coexist if niches are identical; 3 max

**[5]**

**75.** (a) leads to decline of fish stocks;
destroys food chains;
secondary / tertiary / consumers shift to other prey to survive;
species may shift to another habitat /
start showing preference for other habitats,
upsetting those habitats as well; 2 max

(b) indicator species can be used to assess particular conditions,
*e.g.* some species prefer low oxygen content / *vice versa*;
example of an indicator specie *e.g.*. lichen for air pollution
indicator species need a particular environment to survive /
lack of a particular species indicates a
change in the quality of the ecosystem;
changes in quality can lead to the disappearance /
occurrence of species;
changes can be monitored over a longer period;
changes can lead to adequate measures to protect the environment; 3 max

**[5]**

**76.** C

**[1]**

**77.** *Award **[4 max]** for method for animal species.*
Lincoln index;
capture a random sample of individuals;
example of method of capture;
(count) mark and release individuals;
recapture a random sample of individuals;
$$\text{calculate } \frac{\text{number caught and marked originally} \times \text{total number in 2nd sample}}{\text{number of marked individuals in 2nd sample}} = \text{population estimate;}$$
*Accept this formula using symbols with a key.*

*Award **[4 max]** for method for plant species.*
(stationary) population assessed using quadrat method;
sample areas of fixed size from a larger area chosen;
samples chosen by line/belt transect /
throwing frame/random number generation;
number of individuals in sample counted;
average number in all samples of same size determined;
average number multiplied by number of quadrats in entire area (gives population estimate);

**[7]**

**78.** sun is source of energy for most ecosystems;
energy is fixed by producers /
photosynthesis brings energy into the food chain;
energy passed through the food chain;
from producer to consumer;
energy transfer to next trophic level is only about 10 % efficient;
because of losses due to cellular respiration/heat/metabolic activity/undigested material;
losses limit the length of the food chain;
energy in detritus utilized by saprotrophs;

**[5]**

**79.** (a) loggerheads / *Caretta caretta* 1

(b) all three species nest over the same range of latitudes
on the same beaches/areas;
density of loggerheads is greatest and leatherbacks is lowest;
similar relative densities/numbers on the different beaches / latitudes;
all three had most nests on Jupiter;
more loggerheads at northern end of range / around 28 (°N) / on Melbourne; (*Do not accept answers giving the range 26–28 or 26–30.*)
2 max

(c) artificial lighting of beaches;
*(Reject if human activity or other factors are also varied.)*
lighting of an area/some areas/beaches
but not others (at the same time);
keep other variables constant /
use similar areas/beaches;
measure nesting density / number of nests per kilometre;
*(Reject count nests unqualified.)* 2 max

(d) turtles (only) nest opposite / behind /
in front of apartment blocks;
*Do not accept answers only relating to tall buildings.*

turtles nest close to the buildings;
no / few nests opposite gaps between buildings; *(Do not accept converse.)*
light from inland penetrates between buildings;
greater density of nests opposite tall(er) buildings;
tall(er) buildings cast more shade /
block more light; *(Do not accept larger buildings.)*
more nests by Whitehall South /
Stratford Arms <u>and</u> fewer by Villa del Mar / Arvita; 4 max

(e) more <u>variation</u> in direction with more light /
direction more random with more light;
hatchlings change direction more with more light /
go in circles with more light;
mean direction closer to direction of ocean ) *(Do not accept comments on whether*
with less light / go straight to ocean with ) *the hatchlings reach the ocean or not)*
less light; ) 2 max

(f) light / moonlight / starlight from ocean / moon /
stars reflected off ocean / darkness from inland 1
*Only accept answers referring to light or dark.*

(g) (i) light inhibits nesting/egg laying by females;
artificial light prevents the hatchlings from finding the ocean;
light increases risk of detection by predators;
turtles nest further up the beach so further
for hatchlings to reach ocean; 2 max

(ii) any method outlined to prevent /
reduce artificial light reaching the beach 1

**[15]**

**80.** shows how organisms are related /
to distinguish between organisms / compare organisms;
helps us to cope with the huge number of different organisms;
makes it easier to collect / store / find information about organisms;
makes it easier to find useful organisms (*e.g.* plants containing drugs);
makes it easier to identify organisms / find their scientific name;
allows predictions to be made (about characteristics of members of a group);
traces possible evolutionary links / identifies common ancestry;
identifies homologous structures;

**[4]**

**81.** (a) NY / urban 1

(b) 37 ( 1):16( 1)/2.3:1( 0.1) 1
*Do not need to show working. Accept percentages.*

(c) shoot biomass is always greater than root biomass in all three years;
shoot biomass was greatest for rural and urban sites in the first year;
root biomass was greatest for rural and urban sites in last year;
second year shows lowest increase in shoot and root biomass for rural and urban sites /
first and third years with greatest increase;
HV rural site had greater shoot and root biomass than LI site in first and third years;
urban site always has the highest biomass /
greatest shoot / root biomass; 3 max

(d) some bacteria (*e.g.* Nitrobacter) can convert $NO_2$ from car emissions into $NO_3^-$ (nitrates)
which can be used by plants;
more predation / herbivores / plagues in rural areas;
no information given of the location of one compared to the other / of the types of pollution;
extra care given (fertilizer / insecticides) by urban residents; 1 max

**[6]**

**82.** limits plant (tree) growth / kills plants (trees);
by making soil less fertile;
trees show premature leaf fall /
dieback of branches / wax cuticle destroyed so infections/disease can enter;
low pH of water can kill most aquatic organisms;
preventing eggs from hatching;
preventing young fish from developing normally;
destroys shells of animals;
acid rain leaches aluminium from soil;
damaging/killing aquatic organisms;

**[4]**

**83.** nitrogen-fixing bacteria in pioneer plants/lichen can introduce nitrate to soil;
taller plants provide shelter from lower temperatures/frost;
humus resulting from pioneer plants /
lichens adds organic matter to soil;
increased soil structure enables soil to retain moisture;
enabling new species to grow;
new species contribute more nitrogen to soil;
leaves and fallen trees can acidify alkaline soils;
low acid and higher nitrate levels in soil allow another species (spruce) to grow;
larger trees with deeper root systems can reduce soil erosion;
acid secretion of lichens help break down rock;
presence of plants lead to greater recycling of nutrients (fundamental in phosphorous cycle);

**[6]**

**84.** (a) 19 580kJm$^{-2}$yr$^{-1}$ *(units required)* 1

(b) (i) autotrophs lose 55 % of their gross products to heat compared with the heterotrophs which lose 96.3 % (96) of their food energy / 41 % more of hetertrophs; 1
*Numerical comparison required*

(ii) animals use a lot of energy to move / maintenance of body temperature / other valid reasons 1

(c) decomposers are responsible for the recycling of (inorganic) nutrients / breakdown of organic molecules to inorganic compounds 1

(d) autotrophs need nutrients (from the soil);
decomposers release these nutrients;
fewer decomposers will lead to slower / less recycling of nutrients;
limits growth of autotrophs;
limits (net/gross) productivity of autotrophs; 2 max

**[6]**

**85.** (a) no two species can coexist (in the same community) if they share the same (ecological) niche /
when two species compete directly for a limiting resource
one species eliminates the other 1

(b) cheaper than *ex situ* conservation;
species continues to evolve in the natural environment;
larger populations can be maintained bigger breeding pool / more genetic variation;
species will be behaving normally in the natural environment /
less stress / injury to animals during capture / transport;
species will not have to adapt to special diets;
species can have large territories/space; 3 max

**[4]**

**86.** *arguments for:* ***[4 max]***
50 % of known species found in tropical rainforests /
tropical rainforests contain other species yet to be discovered;
destroying tropical rainforests will cause extinction of species;
destroying tropical rainforest will cause climate change;
tropical rainforests are a sink for $CO_2$;
tropical rainforests prevent soil erosion / loss of top soil;
pharmaceuticals can be derived from tropical rainforests species;
ecotourism is a source of revenue for countries with tropical rainforests;
tropical rainforests provide food / materials for local populations;
provides organisms / environments for education / research;

*arguments against:* ***[4 max]***
conservation measures may slow economic development of countries with tropical rainforests;
clearing tropical rainforests provides land for agriculture;
tropical rainforests species can be reservoirs for pest species / species which transmit diseases;
clearing rainforests opens up communication routes;

**[6]**

**87.** addition of fertilizers containing plant material/compost /
plowing in stubble;
addition of fertilizers containing animal waste;
addition of fertilizers containing (synthetic) nitrates / ammonium salts;
plowing increases aeration for nitrification;
plowing increases drainage reducing denitrification;
crop rotation using nitrogen fixing crops/legumes;
letting fields go fallow periodically decreases denitrification /
increases nitrogen fixation;

**[4]**