2024 ASSESSMENT REPORT

ESS315118 ENVIRONMENTAL SCIENCE

General Comments

The written examination was well received by candidates and teachers. Most candidates felt the examination paper was accessible and allowed ample scope for them to demonstrate their knowledge. Teachers appreciated the varying range of complexity in questions from those that assessed basic understanding through to questions that required greater analysis of interrelated concepts, as is the nature of Environmental Science.

In most cases, candidates provided very good answers. Where candidates performed poorly, it was mostly due to inadequate or incorrect detail in their response. Candidates are advised to carefully read the questions, seek out exactly what is being asked of them and make connections to the course content they have covered during the year. This should provide scope for all candidates to attempt all questions.

Candidates are reminded to consider the command words (i.e. list, describe, explain) and highlight them during the reading time. Generally, answer 'explain' with the most amount of detail and as a rule of thumb, write in all the space provided.

Candidates can expect questions that have non-routine contexts – these are questions that use geographic areas or scenarios that are not covered in the course content. Candidates should read these questions carefully and identify exactly what is being asked and align this with content they have been taught and construct their response accordingly.

Candidates are reminded that the Information Sheet be used as a reference to assist them in constructing their responses. Responses that are written word-for-word from the sheet reveal little understanding of the required knowledge, and often yield little if any credit. Candidates should use the information and apply it to the question. It is also advisable for future candidates to equip themselves with an approved English dictionary, which may prove to be an invaluable asset if terms used in the question challenge their understanding of what is being asked.

Written Examination

The following section specifically comments on candidates' performance. Markers have offered suggested answers to each question, followed by specific comment on aspects such as how the question was assessed, where candidates gained or lost marks, where they had difficulty in interpreting the question, or where candidates failed to comprehend what was required to successfully answer the question. The suggested answers are by no means prescriptive. Candidates providing different but valid answers were rewarded accordingly as noted by the examiners.

Section A (Criterion 2)

Question 1

a. ½ mark for each empty box.

Hypothesis	Valid (Y/N)	Explanation
Fire makes plants grow better	N	Vaguely worded. No definition of independent variable.
Why do plants grow better after a burn? Because there are more nutrients available	N	Worded as a question and answer, rather than as a testable statement.
Burns in autumn and winter make plants grow better than burns in spring	N	Vaguely worded with no definition of independent and dependent variables.
Smoke water increases seed germination in Banksia species	Y	Testable specific statement with independent variable, dependent variable, and direction of response.

b. Any two of the following (1 mark each, ½ mark for just stating and not describing):
   - No pre-burn/baseline survey. The number of species or plants could have been very different in the different burned areas with knock-on effects on regeneration.
   - Differences in abiotic conditions – burned areas may have different aspect, rainfall, soil type, etc, all of which will influence the regeneration in different ways.
   - No data on intensity of burn. High-intensity fires will impact the seed bank and soil conditions in a different way to low-intensity fires.

Comments

a. Most candidates performed well on this question. This was a very approachable start to the exam. Alternatives 'Y' or 'N' to those shown were not accepted, as each box was only worth ½ mark. The explanation to the third hypothesis was marked generously if candidates mentioned the comparison of time was not equal (awarded ½ mark).

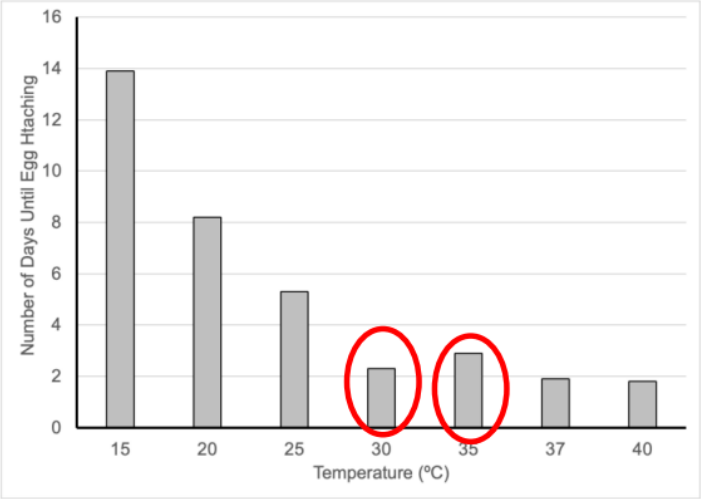
b. This was also a very approachable question. As this question asked for a 'description' of two potential issues and many answers were possible, thus most candidates performed very well and were awarded full marks.

Question 2

a. There was general decrease in the time until hatching as temperature increased (1), with the greatest effect in the 15-30°C range (½) and little change above 30°C (½).

b.

   i. Two possible correct responses: 30°C anomalously small or 35°C anomalously large (1 mark for either response)



ii. Repeat experiment (½) at least two more times (i.e. n≥3) (½), preferably n≥5 (½), particularly for potentially anomalous temperatures (½) and determine spread of data (½).

c.

i. x-axis scale does not show the same interval between temperature (½) whereas other independent variable intervals are 5°C (½). Also accepted the graph lacks a trend line (½) that makes it difficult to see the trend or pattern (½).

ii. Scatter plot (½) or line graph (½) with added trend line (½) an even x-axis scale (½) with clearly spaced temperature increments (½).

d. Several hypotheses are possible (1½ for causal statement linking independent and dependent variable, ½ for direction of relationship, ½ for including species name i.e. black soldier fly):

- Increasing temperature will decrease the hatching time for black soldier fly eggs
- An increase in temperature will cause a decrease in the number of days to hatching
- Decreasing temperatures cause an increase in the time until hatching of black soldier fly eggs.

e. Other variables in an experiment such as this are known as controlled variables (½). These include number of eggs per treatment, source of eggs (same genetic stock), light environment, size and shape of container, air/oxygen levels, etc. (1 mark maximum for naming examples of controlled variables). It is important to control these to be as identical as possible between treatments (½) as they may have independent effects (½) on the independent variable (½), altering the time until hatching (½) and making it impossible to determine a fair test (½) or determine unambiguously (½) that the independent variable being tested is responsible for the results observed (½).

Comments

a. Where no data was included in a candidate's answer, one mark was the maximum possible. Data had to include both x axis (Temperature) and y axis (Number of days) values. Approximately half of the candidates did not include data in their answer.

b.

i. Almost all candidates performed well on this question.

ii. A few candidates suggested that anomalous data could be compared to a 'trend' or 'pattern' and were awarded a maximum of ½ mark.

c. i. and ii. In general, few candidates performed well in this question (both parts). No marks were awarded for 'table' in ii.

d. Most candidates performed well on this question. It is suggested that candidates simply use the same words for the independent variable and dependent variable as given on graph axis, for the hypothesis. Candidates became muddled when using 'faster' or 'speed' for dependent variable and often did not gain full marks for their hypothesis.

e. As this question asked to 'explain the importance...in the experiment', a full 3 marks were allocated to explaining how controlled variables are important for a fair test. Many candidates only explained how variables might be controlled (and not why) and gained one mark. It is suggested that candidates consider carefully each word, especially in higher value (4 marks) questions.

Question 3

a. (½ mark each)

ABIOTIC BIOTIC

PHYSICAL CHEMICAL

b. 2.5 µg/L (accept 2-3 µg/L) (½ for value, ½ for units).

c. Surface water samples remained approximately constant (½) at 2-3µg/L zinc over the period 2007-2020 (1), with no apparent trend in the line of best fit (½). Bottom water samples showed an overall decline (½) in zinc levels from 25µg/L to 11µg/L from 2007-2020 (1) with a period with an interval of relative stability (½) from 20-11µg/L from 2011-14 (1).

d. There is obviously very high variability (½) in the levels of zinc measured in the water samples, probably influenced by storm events (½) and associated runoff (½) or other examples (½). The trend line shows the average (½) changes and smooths (½) out this variability to show underlying patterns (½).

Comments

a. Most candidates performed well on this question.

b. Most candidates performed well on this question.

c. Most candidates struggled with this question as they did not pay attention to the legend. Candidates could describe the trend well but forgot to include data in their answer (thus gaining 1 mark maximum). Data needed to include both x and y axis values (year and µg/L) for one mark. Candidates that switched surface and bottom water answers gained ½ mark.

d. This was a challenging question for many candidates. The mention of high variability (½) of the data was required for full marks.

Question 4

a. Many possible responses, examples include (1 mark for stating problem, 1 mark for elaboration):
   - These uncontrolled variables can influence the growth of the cucumber plants affecting the validity of results
   - No information is given about the husbandry conditions provided by the students – amount and period of watering/fertilisation. If these are different, growth will be influenced by these other variables

- There is no replication. Results from single plants could be due to stochastic variability and unrelated to the different wavelengths of light
- No baseline measurement. The size of the two cucumber plants was not measured before the experiment began – the larger plant could have been larger to start with.

b. Need to provide at least 2 to 4 dot points for full marks. Many responses possible.
   - Replication (½) e.g. Obtain 10 (½) cucumber plants and randomly (½) assign to each wavelength of light
   - Baseline measurement (½) to measure the stem length in mm (½) of all cucumber plants at beginning of experiment (½)
   - Controlled environment (2 marks max.) e.g. Place 5 cucumber plants at distance of 30cm from red light and 5 cucumber plants at distance of 30cm from blue light. Water and fertilise every other day with same amounts
   - Control treatment (½) – place 5 cucumber plants in natural (½) sunlight/total darkness/ same distance from multispectral or multi colour light (½).

c. Generally, it would be concluded that there is no control (½). A control is a baseline (½) against which to compare (½) experimental treatments. Could use natural sunlight as control (½) but this has problems as it varies uncontrollably (½) or use absence of light (½), but this also has problems as plants would not photosynthesise (½) so could not be used for a valid comparison (½) or controlled multicoloured light (½).

Comments

a. Most candidates performed well on this question.

b. Most candidates performed well on this question. Some candidates were awarded no marks for elements that were copied from the first experiment, as the answer required a 'better' design.

c. Most candidates performed well on this question, but a few did not fully 'explain' and thus did not gain full marks. A few candidates were unsure of which experiment and thus a well explained answer to either experiment, was awarded full marks. If uncertain, candidates should clearly state which experiment they are referring to and continue to answer to the best of their ability.

Question 5

a. Many responses possible, examples include (1 mark for reason, 1 mark for elaboration):
   - Track progress of disease – the disease started in one location and the scientists want to know how it has spread across the state
   - Estimate prevalence of the disease – the number of devils with the disease at each site can be used to estimate the percentage of the population with the disease
   - Estimate numbers of devils for the whole state – trapping at each site can provide an estimate of the number of devils which can be scaled for the whole state.

b. Many responses possible, examples include (1 mark for each):
   - Need to check traps regularly – devils left in traps may suffer from thirst or hunger if they remain in the trap for too long
   - Design of traps – devils can injure themselves with poorly designed traps (e.g. sharp edges, protruding wire, etc.)
   - Other species caught incidentally – stress to other species and what to do if you catch feral species (e.g. cats)

- Dealing with diseased devils – is it ethical to release diseased devils or should they be euthanised?

Comments

a. Candidates were familiar with Tasmanian Devils and DFTD and thus most candidates performed well on this question. If two reasons were given with no elaboration a maximum of one mark was awarded.

b. Candidates were less familiar with what 'ethical issues' meant and thus several candidates did not perform well on this question.

Section B (Criterion 5)

Question 6

a. Process A: photosynthesis (½)
Process B: respiration (½).

b. Methane/CH_4 (1) OR carbon monoxide/CO (1).

c. All living organisms in the oceans respire (½) releasing carbon dioxide (½) which can then be exchanged with the atmosphere, while other organisms (e.g. algae, diatoms, other phytoplankton) also photosynthesise (½) removing carbon dioxide from the atmosphere (½).

d. Need to have at least one similarity and one difference for full marks. ½ mark for just stating a similarity or difference without elaboration. Full mark for each of the following:

Similarities:

- Nitrogen and carbon cycles both involve atmospheric pool in gaseous form.
- Both nitrogen and carbon cycles involve living organisms as the main process transforming gaseous form into solid/aqueous form.
- All three cycles involve elements that are essential for growth, reproduction or repair of living organisms (C, N, P).
- All biogeochemical cycles involve large pools of the elements which can be transferred from one into the other. All biogeochemical cycles have inorganic and organic forms of the element.

Differences:

- Phosphorus cycle does not have an atmospheric pool of the element (compared with nitrogen & carbon cycles).
- Different organisms are involved in the transformation processes (e.g. nitrifying/denitrifying bacteria in the N cycle vs. plants in the C cycle).
- Relative ratios of different pools vary (most nitrogen in atmosphere vs. most carbon in living organisms).

Comments

a. This question was answered well by most candidates. Several wrote "breathing" instead of respiration and were not awarded the half mark. Some candidates had the two responses the wrong way around or wrote "consumption" for Process B and were not awarded credit.

b. This was answered well. Most candidates were able to name methane or carbon monoxide, although answers such as "smoke" and "calcium carbonate ions" were common, with no credit being awarded. CFCs were also named, and this was given a mark.

c. Generally, candidates struggled to get full marks for this question. Many responses did not relate their answers to the processes of respiration and photosynthesis occurring in the oceans. Some responses were too brief or vague such as “oceans release carbon” or discussed the water and carbon cycles and ocean acidification. Candidates that mentioned the ocean being a carbon sink were awarded half mark only.

d. This question was answered well by most candidates. At least one similarity and one difference in detail were needed, and most were able to provide at least two or three. However, candidates lost marks with responses that were too brief, overlapped or were repeated, or were too vague and general e.g. “all cycles have the same processes”. Some responses were simply incorrect e.g. “all three cycles exist in the atmosphere”. Many responses included human influence in all three cycles or that the C and N cycles are relatively faster cycles than the P cycle (awarded one mark).

Question 7

a. Any two of: phytoplankton, coral, seagrass, seaweed (½ each).

b. 1st order consumer: any one of zooplankton, parrotfish, damselfish, coral, hermit crab, sea cucumber (½).

c. 3rd order consumer: any one of tiger shark, barracuda, reef squid (½).

d. Detritus is material produced by the decomposition of organic matter, often by micro-organisms. It includes faecal matter and dead remains of organisms (1).

e. The tiger shark eats a variety of organisms (½), each of which has a different trophic level. It can therefore exist in multiple trophic levels (½).

f. These organisms are the apex (top) or higher order predators in this ecosystem (½). Their removal will lead to the ‘release’ of their prey organisms (smaller fish such as parrotfish, damselfish, angelfish) (½) and it is likely that their populations will increase (½). In turn, this will decrease the population of their food sources such as coral, crabs or seagrass (½). This ‘trophic cascade’ will impact the whole ecosystem.

g. This food web does not indicate the ultimate source of energy for the autotrophs i.e. sunlight (½). This external input of energy is needed in this system to provide the energy for the whole food web (½). The food web may be closed in terms of matter (½) as all the components can be transformed into detritus on death, and ultimately recycles with the system (½). However, the system may be considered open to the input of matter from outside the food web via migratory species and detritus (½).

Comments

a. This question was answered well by candidates. Some responses incorrectly included detritus.

b. Most candidates were able to correctly list one first order and one third order consumer with little difficulty. Some common errors were reef squid and angelfish listed as first order consumers and parrotfish named as a third order consumer.

c. Candidates answered this question well, but it was obvious there were some candidates unaware of what detritus is and incorrectly named it as an organism that fed on the remains of other organisms. Some answers were also too general in nature stating that detritus comes

from “all of the ecosystem”. The terms organic matter/faecal matter or the remains of dead organisms was needed for the full mark.

d. Well answered by candidates stating that the shark ate a variety or organisms in different levels. Answers that explained the 10% rule as a limitation to tropic levels received no marks. Some stated that the shark was a top order predator or was at the top of the food web and left their answer as that without any further explanation (no mark awarded).

e. For two marks, candidates needed to explain the trophic cascade effect that removing the higher order consumers will have on the whole food web. This question was answered quite well, but where candidates lost marks were in responses that were too general or vague, or stating that the prey of these consumers would “thrive” when not being preyed upon. The opposite usually happens due to increased competition. Candidates needed specific impacts for the full two marks.

f. This question was answered poorly. Very few candidates connected the fact that this food web needs an energy input from the sun to provide energy for the producers and hence the whole web. Often, it was stated that energy was needed but no explanation was given as to the source of this energy. The fact that matter could enter this system from outside the web was rarely mentioned. More commonly it was stated that matter needed no external input as it could be recycled in the system.

Question 8

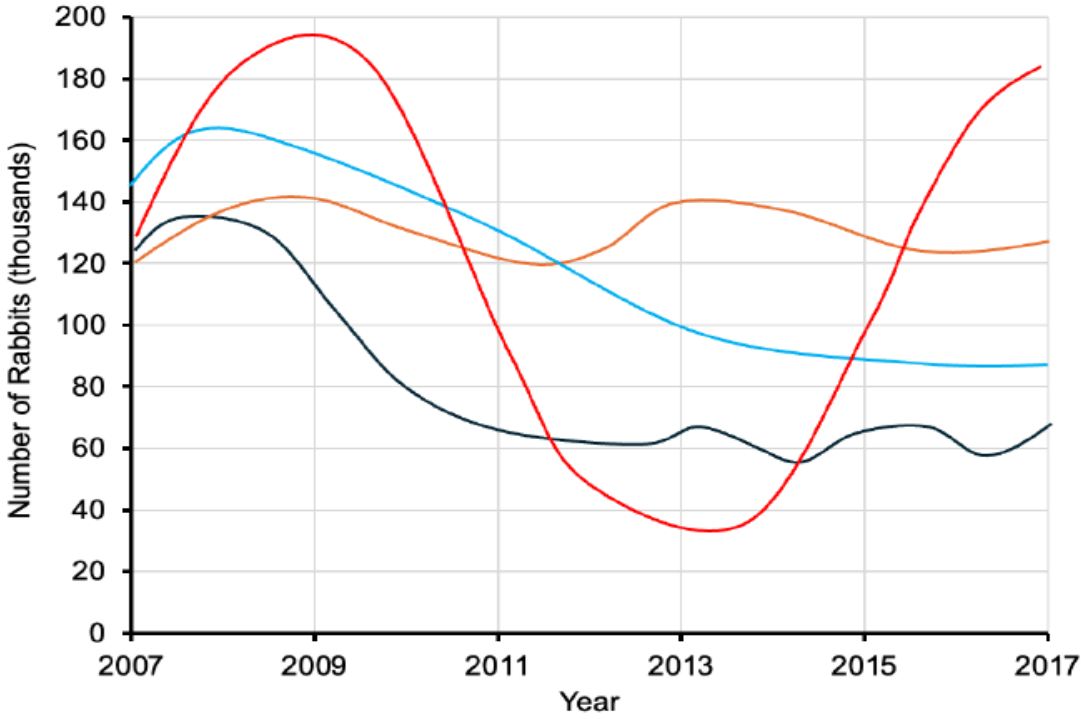
a. Approximately 10 thousand rabbits (5 to 15 acceptable) (1).

b. Any of the following (1 mark for stating the reason, 1 mark for explanation):
- Stochastic fluctuation in environmental conditions – good or bad weather may influence the growth of plants that the rabbits feed.
- Systematic fluctuation in environmental conditions – natural cycles such as El Nino or Southern Annular Mode will cause changes in temperature, rainfall, etc. which will affect food sources and breeding success.
- Natural predator-prey cycles – numbers of rabbits will decrease when there are more predators (cats) which in turns leads to a decrease in these numbers and then a subsequent increase in rabbits again (negative feedback loop).
- Disease outbreaks – density dependent diseases can reduce population size and/or breeding success.

c. Exponential growth (1), J-shaped growth curve (½).

d.

i. Number of possible answers – might have shown a decline down to carrying capacity (lack of resources) or stabilisation at carrying capacity, both overlaid with random fluctuations or show 'boom & bust' cycles. 1 mark for showing some kind of equilibrium (static or fluctuating), 1 mark for plausible trajectory and value. Possible population change plots shown in graph below should be coupled with explanation in ii.



ii. Explanation needs to relate to shape of the graph drawn in part d) i, for 1 of the possible 3 marks. E.g. Population of rabbits increases due to lack of predators (1) and abundant food. Subsequently, the rabbits deplete the food source and are limited by growth rates of plants, leading to starvation and population decline (1). Eventually, the population stabilises around an equilibrium level (1).
Or
Population may undergo cycles where they increase rapidly (1), deplete the food source and then undergo population crash (1) allowing food source to increase again, creating 'boom and bust' (1).

Comments

a. This was answered well with most candidates reading off the graph the equilibrium level as somewhere between 5 to 15 thousand rabbits. Some answers left off the "thousands" and were awarded no mark.

b. For 2 marks, candidates were required to explain one reason for the fluctuating rabbit population between 1984 and 1998. Better responses made correct links to the predator-prey relationship between cats and rabbits, or related rabbit peaks and troughs to increased or decreased availability of resources. Common loss of marks included reference to the environments carrying capacity but lacked specific detail in the answer or linked the population of sea birds to rabbit population (no marks awarded). Many candidates confused cats as a biological control measure; these answers were not awarded marks unless linked to a predator-prey cycle (partial marks). Some described rather than explained what was shown in the graph. Overall, candidates struggled to achieve full marks for this question.

c. The term “exponential growth” was required for 1 mark. Most candidates correctly answered this, although some said, “a rapid increase” (no mark) or J-curve (½ mark awarded only).

d.

i. For 2 marks, graphs should have started somewhere between 120-160 thousand (not at zero), shown an initial rise then either fluctuated steadily (small yearly fluctuations or a larger more dramatic fluctuation), or slowly declined to 2017. Some graphs were ruled with a ruler which is not required and takes time but were still correct. Graphs that showed a steady increase were awarded only half a mark if starting at between 120-160 thousand. Some graphs had the words “carrying capacity” in the correct general area of the graph but failed to actually show this line. If they referenced ‘carrying capacity’ in question 8d) ii but did not show this on the graph, they could not be awarded the full 2 marks. Overall, many candidates did not achieve full marks.

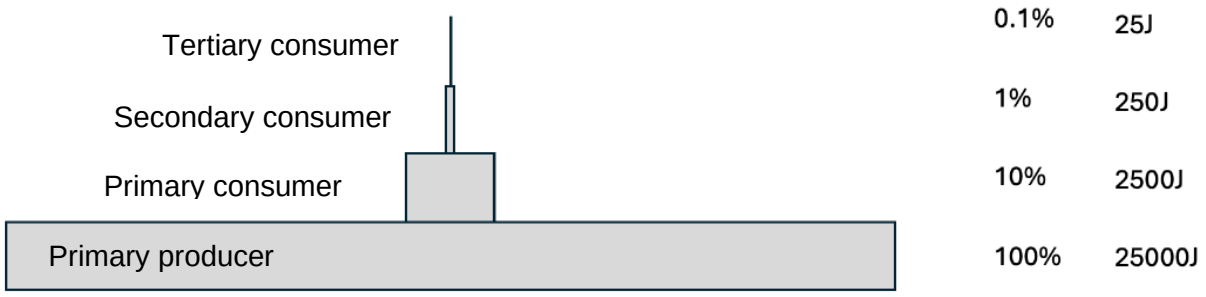
ii. An explanation of the graph that candidates drew was needed in this question, but most answers were simply descriptions of the shape of the graph. They needed to reference why their graph dropped after 2007, and why it fluctuated after this time. If the response included reference to the environments carrying capacity and this was not shown on their graph, the full 3 marks could not be awarded. Very few received the full 3 marks for this question based on too little information.

Question 9

a. Solar radiation, energy from the sun, or sun (1).

b. Neither of the pyramids correctly represents the proportions relative to each other (1) in the different trophic levels (1) OR the size of each trophic level is not proportional (1) to the values for that trophic level (1) i.e. bottom level should be many times larger compared to the top level.

c. Similar to that shown below – 1½ marks for the approximate correct proportions and ½ mark for indication of 10% transfer between trophic levels (could be written underneath).



d. The laws of thermodynamics state that energy cannot be created nor destroyed, only transformed (½) and that no transformations are 100% efficient (½). In biological systems, this means that not all energy in food can be assimilated (½) and energy is lost from organisms during respiration (½). In practice therefore only about 10% of the energy from the trophic level below is available to the next trophic level (½), no matter the type or size of the organism (½).

Comments

a. The sun or sunlight/solar energy provides the energy needed for this ecosystem. Many candidates answered incorrectly with “primary producers” or “plants” to this question using the information provided in the diagram. Some candidates also incorrectly stated “primary consumers”.

b. This question proved to be difficult for candidates with few achieving the full 2 marks. Many responses were too general and were not specific to the pyramids shown. Common responses that the size of the species or individuals is not taken into account or that the biomass pyramid does not account for the reproduction rate of the organisms are not relevant in this question. Some candidates stated that the numbers were not realistic and did not match the weights shown in the biomass pyramid.

c. Candidates’ energy pyramids were generally completed well, but many showed inaccurate reduction by 90% of each consecutive trophic level (10% of the previous level). This was needed for 1½ marks. Some pyramids included more trophic levels than was shown in the question, were drawn upside down, were not correctly labelled or not labelled at all. Half a mark was lost if trophic levels were not labelled or if there was no indication of 10% energy loss.

d. This question was answered well by most candidates with most being able to relate the first and second laws of thermodynamics to the reason why energy pyramids will look the same. A detailed explanation was needed for the full two marks. Candidates lost marks due to providing broad statements such as “in all systems only 10% of energy is transferred” without any further information or made incorrect statements such as “10% of energy is lost as heat or respiration”.

Question 10

a. Niche, ecological niche, realised niche (1).

b. Intraspecific competition (1). Competition (½).

c. Gause’s competitive exclusion principle (½) states that no two species/forms can occupy the same niche (½) as one will be outcompeted and become extinct. This applies to the three forms of the Arc-eye hawkfish in question. Although these three different forms live in the same habitat, they use different resources (1) e.g. some combination of food and/or abiotic conditions which reduces intra-specific competition (½).

Comments

a. The majority of candidates answered with “tolerance range” or “zone of tolerance” for this question which was awarded half a mark. It is possible the use of the word “range” in the question confused candidates. Very few answered correctly with “niche”.

b. Candidates answered this question well, with most at least responding with “competition” for half a mark. Fewer were able to name “intraspecific competition”.

c. This question was generally answered poorly. Many left the question blank. Most answers gained at least one or one and a half marks, but many answers lacked specifics from the question stem, such as stating why the three forms of fish were able to live in the same habitat. Some answers simply stated because “no two species can have the same niche” and gave no further details. Some answers went into complex detail in reference to the diagram showing the overlap of resources used by the fish.

Section C (Criterion 6)

Question 11

a. Many responses possible, examples include (½ mark for stating factor,1½ for description of daily change):
   - Solar radiation will be zero overnight, starting at a minimum at sunrise (at 5-7am), rising to a maximum during the middle of the day (at 12-1pm) and decreasing again at sunset (at 5-9pm).
   - Temperature will generally increase during the day from a minimum usually just after sunrise to a maximum in mid-late afternoon and declining until sunset. This will also be dependent on various weather systems.
   - Wind/rainfall will change on a daily basis dependent on weather factors such as air pressure, warm and cold fronts and other variables. These are not consistent on any particular day.

b. Many possible answers. Accept any of the following (½ mark for stating factor, ½ for justification):
   - Temperature – plant and animal metabolism is highly dependent on temperature, so growth and reproduction will generally be lowest in colder months (winter) and higher in warmer months (summer).
   - Solar radiation – plant photosynthesis is often limited by solar radiation with increased photosynthesis and growth during spring and summer. This in turn influences food available for animals.
   - Rainfall – if rainfall is highly seasonal, then plants may not be able to grow during periods of water stress e.g. droughts over summer and highest growth will occur in wetter seasons e.g. spring.

Comments

a. Some candidates did not read the question carefully. “On a daily basis” was the important information. Weather was mentioned as an abiotic factor, even though weather is comprised of a variety of factors, such as temperature, humidity and precipitation, to name a few.

b. Similar to part a) “seasonal” was the important information. Some candidates mentioned one specific season only.

Question 12

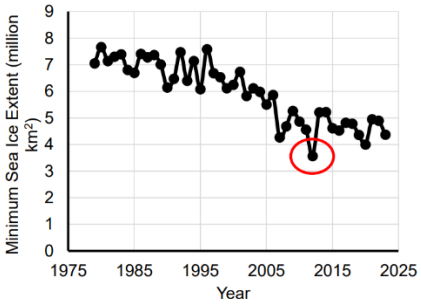
a. Global temperature anomaly (GTA) was relatively constant during the period 1850-1910 (½) fluctuating around -0.3°C, albeit with some large fluctuations in individual years (e.g. 1877) (½). From 1910 to 1940 there was an increase in GTA to about 0.0°C (½), followed by a small decline back to -0.2°C (½). From 1960 onwards there has been a steady increasing trend (½) from -0.2 to 1.1°C. (½).

b. Any two of the following (½ mark for stating method, 1 for explanation):
   - Ice core analysis – ice in glaciers and other permanent ice traps particulates, chemicals and air bubbles containing different isotopes, all of which provide evidence of the climate when they were deposited.
   - Tree ring analysis – trees grow at different rates due to water availability and temperature. In cool areas the width of the tree ring is usually proportional to temperature, so measuring the width of the rings can be used to estimate temperature.

- Pollen core analysis – different plants thrive in different temperatures. Pollen grains for most plants are distinctive and can be retrieved from cores of sediment from freshwater lakes and identified under a microscope.
- Ocean sediment cores – different species of foraminifera grow in different water temperature and their shells are preserved in ocean sediments which can be cored and examined.
- Other answers possible include explanation of loess deposits, glaciers, or speleothems (i.e. mineral cave deposits).

c.

i. 2012.



ii. 3.5 million km2 (accept 3.2-3.8 million km2).

d. Ice cover loss is an example of positive feedback (1). As global temperature increases, ice melts (½) revealing darker coloured water (½) and decreasing albedo. Open water in turn reflects less solar energy (½) and absorbs heat increasing temperature further (½), creating a feedback loop (½).

Comments

a. General comments. Some candidates used both graphs (global temperature anomaly and maximum sea ice extent) to draw conclusions. It is important to distinguish between different types of ice, such as sea ice, land ice, glaciers and ice shelves, as each plays a unique role in our climate system.

The graph showed global temperature anomaly (GTA) against time not temperature against time. Some candidates provided reasons for the global temperature anomaly over time but only had to summarise. A few candidates described GTA increase as exponential.

b. Many candidates only explained one example of how scientists can estimate global temperatures prior to direct temperature observations. Some candidates can improve by paying closer attention to the details of the question, particularly the geological time scales of "thousands to hundreds of thousands of years". Proxies like ice cores, tree rings and sediment layers provide valuable indirect evidence of past climates, which scientists interpret to estimate historical temperatures.

c.

i. Well answered.

ii. Well answered, except some candidates stated the year, or omitted the unit or the word ‘million’.

d. Only a few candidates recognised the positive feedback loop.

Question 13

a. Any two of the following: (½ each) carbon dioxide, methane, water vapour, nitrous oxide, fluorinated gases (IFCs, PFCs, SF_6, NF_3).

b. It is called the greenhouse effect because the exchange of incoming and outgoing radiation is similar to that in a domestic greenhouse (1) – incoming radiation passes through, but a large proportion of outgoing radiation is reflected back (1).

c. Require consideration of all three named gases for full marks:
   - Methane – humans have hugely increased (½) the amount of domestic ruminant animals (½) and created additional anaerobic decomposition in landfills and dams (½), all which produce methane.
   - Carbon dioxide – since industrialisation large amounts of fossil fuels (½) have been extracted and burnt to provide energy for human activities (½), which releases CO_2 (½) that has been trapped since those fuels were formed >300 million years ago.
   - Nitrous oxide – industrial agriculture (½), internal combustion engines (½), fossil fuel power plants (½) and industrial chemical production have all increased considerably since industrialisation, all of which produce N_20.

Comments

a. Well answered by most candidates.

b. Many candidates used a definition similar to that in the Information Sheet.

c. Most candidates did not explicitly link a human process to one of the three greenhouse gases.

Question 14

a. (½ each for each correct rank)
   - orange-bellied parrot: 1
   - humpback whale: 3
   - blue gum: 4
   - forty-spotted pardalote: 2

b. Any of the following (1 mark): disease, predators, introduced species, hunting, climate change or habitat loss.

c. (½ mark for stating factor, 1½ for explanation)
   EITHER: genetic biodiversity – populations of organisms have different genetic profiles and the sum of all of the different alleles is the total genetic biodiversity for the population.
   OR: ecosystem biodiversity – different ecosystems each have different composition of species.

Comments

a. Well answered by most candidates.

b. Well answered by most candidates.

c. Some candidates did not consider genetic diversity or ecosystem diversity.

Question 15

a.

i. El Niño

ii. In El Niño years there is a weakening or reversal of east to west trade winds (½) leading to warmer temperatures (½), increased temperature extremes (½) and reduced rainfall in eastern Australia (½). This in turn increases fire risk as fires are more likely to start and spread in these conditions (½).

b. There are three main types of forest types in Tasmania – cool temperate rainforest, wet sclerophyll and dry sclerophyll (½). Rainforests do not require fire to regenerate (½) and may only burn once in 500 years (½). Both wet and dry sclerophyll forests require fire removal of canopy for regeneration of eucalyptus species (½) with burn intervals of 20-150 years for wet sclerophyll (more intense burns) (½) and <25 years for dry sclerophyll (less intense burns) (½). If fire frequency increases this will increase dry sclerophyll (½) and reduce wet sclerophyll and especially rainforest (½).

Comments

a.

i. Well answered by most candidates.

ii. Well answered by most candidates.

b. Candidate responses to this question revealed a range of understandings. Candidates are reminded of the importance to present answers in a clear and organised manner. Structuring your responses will help convey knowledge more effectively.

Question 16

a. Any two of the following (1 mark each):
- Reduction of populations of predators (quolls, antechinus) that are directly poisoned by eating cane toads.
- Decrease in populations of invertebrates and other organisms eaten by cane toads.
- Decrease in populations of native amphibians due to interspecific competition or acting as vector for diseases.

b. Native predators cannot eat any life history stage of the toads (1) due to the toxins present which will cause death (1) and make the predators averse to future encounters (½). In South America various snakes and caimans eat cane toads.

c. Cane toads are native to tropical areas, thus requiring warm, humid environments for successful growth and reproduction (1). It is likely that conditions in Tasmania would not be suitable for survival or reproduction of cane toads (1).

Comments

a. One of the simplest biodiversity indicators is species richness. When describing the impact of something, candidates can enhance their answers by clearly identifying whether the impact on species numbers is positive (increasing), negative (decreasing), or neutral (remaining the same). It is important for candidates to conclude their statements by explicitly stating the impact, rather than just providing related information. This approach ensures their arguments are complete and focused, helping them achieve full marks.

b. Well answered by most candidates.

c. Overall, the question was mostly answered well by candidates. However, some ventured outside the scope of Criterion 6, which focuses on applying concepts and processes of ecosystem change, and into Criterion 8, which pertains to applying principles and processes related to ecologically sustainable management of the environment. While it's commendable that students are eager to provide comprehensive answers, it's important to stay focused on the specific criteria being assessed. To maximise their marks, students should ensure their answers are aligned with the relevant criteria and avoid including extraneous information that, while insightful, may not directly address the question at hand.

Section D (Criterion 7)

Question 17

a. Approx 0.53 scallop m^{-2} (0.51-0.55 accepted range).

b. The scientists had noticed that the numbers of scallops were declining very rapidly (1) and likely to be overexploited (½), they closed the fishery to prevent further declines (½) and protect the stock (½).

c. Many responses possible, any two of the following (1 mark each):

- minimum, maximum or slot size limits
- catch limits (e.g. maximum 10 scallops per person)
- season limit – only open for limited period of time
- input limits – only provide certain number of licences
- artificial stocking of smaller scallops.

Comments

a. Most candidates gained the 1 mark allocated for this question.

b. Most candidates performed well in this question. Several focused on the closure due to the fishing company going bankrupt rather than the scientists closing it.

c. This question was answered well. Majority of candidates gained full marks.

Question 18

a. SGAR (1).

b. Owls might be particularly affected because they eat the parts of the rat with the highest amounts of poison (1), which then accumulates in their bodies (1).

c. If the SGAR are persistent (½) and do not easily biodegrade (½) they will stay in the environment and be washed into waterways through runoff (½). They can then be taken up by aquatic organisms (½) which the fish then feed on (½) and bioaccumulate in their tissues (½).

d. Any of the following (1 mark):

- baited traps without poison in the bait
- predators such as domestic cats
- ultrasonic or pheromone repellents to deter rats from entering
- securing food that might attract rats in rodent-proof containers.

Comments

a. Most candidates gained the 1 mark allocated for this question. Many students incorrectly identified FGAR as the poison that accumulates.

b. Most candidates gained at least part marks for this question. Many did not explain in enough detail why the owl was affected by the poison and often missed discussing accumulation properties or consumption of the whole rat.

c. Very few candidates were able to link the properties of the poison with its ability to end up in fish tissue. Majority of responses simply stated that poison inside animal waste ended up in the water and was eaten by fish.

d. This question was answered well. Majority of candidates gained full marks.

Question 19

a. South Africa per person: approximately 3.3 global ha/person (accept 3.1-3.4) (½)
Germany total: approximately 400 million global ha (accept 350-450) (½).

b. Any four of the following (½ each):
- power generation/power stations
- agriculture
- transport – cars, trains, trucks, airport
- building construction
- mining/resource extraction.

c. Australia has a much smaller population that the other countries represented in the figures (1) (<30 million individuals vs more than 65 million for all the other countries) but each individual uses a lot more resources to support their lifestyle than developing countries like South Africa, India or Nigeria (1).

Comments

a. Majority of candidates gained part or full marks for this question. Some responses did not include units with their data and did not receive full marks.

b. This question was generally answered well. Some candidates gave factors that were relevant to an individual's ecological footprint rather than a whole country.

c. Most candidates answered this question well and made a strong connection between Australian individuals being small in total number but using excessive resources.

Question 20

a. Any two of the following (½ each):
- difficulty in breathing
- reduced lung function
- eye irritation
- asthma
- chronic obstructive pulmonary disease (COPD)
- cardiovascular disease
- reduced growth of plants.

b. Photochemical fog is caused by the reaction of pollutants from the combustion of fossil fuels (cars or power plants) (½) in sunlight (½). Vehicles are driven more during daylight hours (½) and it takes some time for the reactions to progress (½) – both of these contribute to the buildup later in the day.

c. In the lower atmosphere, atmospheric ozone has negative health effects (1) on humans such as chest pain or throat irritation and can worsen lung conditions (½). However, in the upper atmosphere it reduces the amount of UVB radiation (1) reaching the surface which reduces the number of skin cancers, cataracts and immune deficiency disorders (½).

Comments

a. Most candidates performed well in this question and gained the 1 mark allocated.

b. Majority of candidates were able to identify that both vehicle use and sunlight levels increase throughout the course of the day; however, only a small number linked the two together and described the production of the listed pollutants. Some candidates incorrectly stated that vehicles produce these pollutants and did not mention it requires a reaction with sunlight.

c. This question was generally answered well; however, candidates that simply copied from the information sheet were given little credit. Candidates were required to explain the impacts of ozone rather than just state them.

Question 21

a. Any two of the following: improved water quality (½), denitrification (½), Carbon sink (½), water regulation (½), climate regulation (½).

b. One of any of the following (1 mark each, must have one similarity and one difference):

Similarities:

- Both act as carbon sinks due to uptake of carbon dioxide by plants
- Both may improve water quality – in forests, water percolating through soil
- Both may provide cultural service for recreation and enjoyment by humans.

Differences:

- Different biodiversity enhancement in each due to different species composition
- Different food production – fish in saltmarsh, berries/nuts in forest.

c. No supporting ecosystem services (1) are shown in the diagram such as nutrient cycling, pollination or waste assimilation (½) – these services are required to keep the ecosystem functioning correctly (1).

Comments

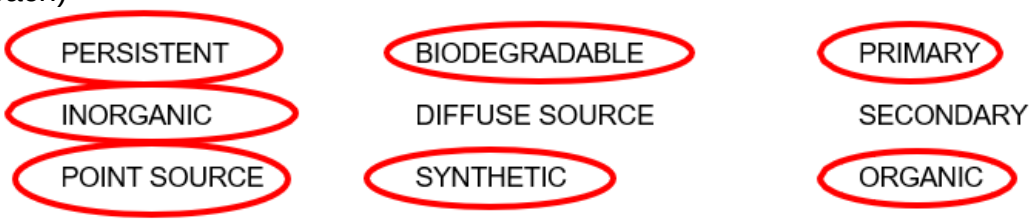
a. Most candidates performed well in this question.

b. Majority of candidates gained at least part marks for this question. Many responses only identified or stated the similarity and difference instead of describing it.

c. This question was answered well with most candidates correctly explaining why supporting services are needed. Some candidates misread the question and instead of listing a group of services they only chose a single service such as pollination and did not gain full marks.

Question 22

a. (½ each)



b. BOD represents the amount of oxygen consumed by micro-organisms while they decompose organic matter (½). High BOD generally indicates poor water quality (½). Downstream of the outflow, the additional organic matter provided by household waste will increase the BOD (1), possibly making the water anoxic (½) after a large storm event.

c. Any two of the following (½ mark for stating negative effect, 1½ for explanation):
   - Disease risk – the sewage may introduce human pathogens such as *E. coli* or other enteric bacteria into the water where they can pass into human users of the waterway directly or through food from the waterway and cause them to become ill.
   - Eutrophication – the additional inorganic nutrients and organic matter will provide nutrients for the growth of micro-organisms or algae which can deplete oxygen levels to zero, which will then lead to fish and other organism kills.
   - Lack of amenity – sewage spills can cause visual and olfactory effects which make recreational use of the waterway unpleasant or impossible.

Comments

a. Most candidates gained full marks for this question.

b. This question was not answered well. A significant number of candidates incorrectly wrote that BOD decreases and had confused the term with just oxygen levels. A number of candidates that correctly identified the change were then unable to describe the process.

c. A number of candidates left this question blank. Those that did complete it often gained part marks, but it was generally not answered well. Majority of responses lacked the detail required to gain the full four marks. Some responses did not explain two different negative effects and many just rewrote what they had listed in part b.

Section E (Criterion 8)

Question 23

a. User-pays or polluter-pays principle (1). Social corporate responsibility (½). No marks for full-cost pricing.

b. Fines are designed to act as deterrent (½) to prevent behaviour (such as spills of chemicals) (½) which can damage the environment (½). In addition, they can be used to support the costs (½) of remediation (½) following damage.
Responses required both deterrent and support for remediation for full marks.

c. Full-cost pricing looks at not only the direct costs (½) of producing goods or services but the also the indirect costs (½) involved with disposing of waste or remediating negative effects on the environment (½). For example, the cost of electricity sold from a coal-fired power station

would also include an additional amount (½) relating to the health & climate change effects (½) of the CO2 emission from that power station (½).
There are many different examples that could have been provided in this question.

Comments

a. Large majority of candidates identified correct response.

b. Generally, most candidates identified deterrent effect of fines; however, few (<10%) recognised the role of fines in supporting remediation.

c. Most candidates recognised some aspects of full-cost pricing but often struggled to explain coherently how those additional costs were incorporated into the final cost paid by the consumer. Most examples provided were appropriate, but some just provided a 'normal' economic analysis of costs involved in production without including any externalities. Few candidates received full marks.

Question 24

a. Any two of the following (½ mark each): Irrigation; drinking water; water for livestock; water for fracking/mining/industry, recreation, fishing, establishing environmental flows, habitat for aquatic organisms.
No credit was given for hydropower.

b. The GAB is a common resource with unrestricted access (½). If each individual/company/state took as much water as they wanted from the GAB (½) without an overall allocation strategy (½), extraction rates could exceed the rate of replenishment of water (½). Some uses (e.g. mining) might degrade the water quality (½). The overall amount of water available would decrease (½) and all users would suffer (½).

c. Any of the following (½ mark for stating strategy, 1½ mark for description):
- Water permits/quotas – any entity wishing to extract water from the GAB needs a permit and the overall amount is capped to a sustainable level.
- Ensure that surface waters/runoff that will replenish the GAB is not polluted – use regulations to limit chemical/effluent discharge.
- Monitor waters levels in the GAB – have a network of monitoring stations to provide rapid information on the status of water levels in underground aquifers which will allow restriction of water use if reserves are declining.

Comments

a) Large majority of candidates provided at least one valid use of water from the GAB.

b) Most candidates explained concept of common resources and overuse/degradation due to unrestricted access. Many failed to explicitly state that the impact is then felt by all users.

c) Generally well answered. Most candidates identified a valid strategy but often failed to provide a detailed description of how the strategy would ensure long-term sustainability.

Question 25

For both parts of the question, candidates could argue that lithium production satisfies or fails to satisfy the principle and could be awarded full marks.

i. Fails to satisfy: Lithium production is concentrated in only a few countries (½) – some developing and some advanced industrial nations (½). Lithium production has potential environment effects where it is mined including pollution, overextraction of water (½). The lithium is used in batteries over the entire world (½), but predominantly in the richer, industrialised nations (½). The environmental costs are not spread equally among the users of the resource (½).

   OR

   Lithium production is undertaken by multinational companies (½) that are generally not based in the countries where lithium is mined (½), thus income and profits accrue to only a few individuals (½), often in rich countries and at the expense of indigenous peoples (½).

   Satisfies: Lithium production is used in rechargeable batteries which can reduce the reliance of individuals/communities on other energy sources (½) and reduces (½) overall impacts of anthropogenic climate change (½). Lithium batteries are widely available due to mining in these countries (½).

ii. Fails to satisfy: It is not yet known what the ongoing and future costs (½) of disposal of lithium batteries may be (½). Similar to nuclear waste, this cost may be borne by future generations (½) who are not benefiting directly from the technology (½). Lithium supplies may become exhausted (½) leaving none available for future generations (½).

   Satisfies: Increased use of lithium (½) could reduce reliance on fossil fuels for energy (½), thus reducing GHG production (½) and reducing impacts of anthropogenic climate change (½). As batteries are rechargeable, they may continue to be used by future generations (½).

Comments

Some candidates confused intragenerational and intergenerational. In these cases, follow through marks up to 1 mark per question were awarded.

i. Large majority of candidates described some consideration of intrageneration equity but often failed to explain clearly how the distribution of lithium mining satisfied/failed to satisfy the principle.

ii. Most candidates identified effects on future generations but often failed to provide adequate detail.

Question 26

a. Many possible answers. 1 mark for any international convention/agreement, examples include: RAMSAR Convention, Montreal Protocol, World Heritage Convention, International Law of the Sea, London Convention on Dumping at Sea, United Nations Framework Convention on Climate Change (Paris Agreement), etc.

b. Full marks for comprehensive and accurate description of the particular example chosen in part (a):
   Up to 1 mark for objectives
   Up to 1 mark for history of convention e.g. location, participating countries, etc.
   Up to 3 marks for methods of operation e.g. domestic & international legislation, quota meetings, how compliance is ensured, penalties for breaches, etc.

c. Many human activities produce effects beyond the country where the activity takes place (½), often affecting global conditions (½) (e.g. CO_2 from power generation affects the entire world (½)). Similarly, lots of species migrate (e.g. bluefin tuna), or are found in multiple countries (½), so harvesting or other impacts have effects beyond country borders (½). In these cases, only agreements between countries can ensure long-term sustainability (½).

   Countries often operate in self-interest (½), international agreements can ensure accountability (½) through legal regulations and associated penalties (½) or diplomatic pressure (½). International agreements provide mechanism for financial transfer from wealthier to poorer countries (½).

Comments

a. The majority of candidates identified a relevant convention/agreement. Credit (½ mark) was given for inaccurate convention/agreement name if followed by appropriate description in part b. The few candidates who stated domestic legislation (e.g. EPBC Act) were given no marks.

b. Few candidates addressed all parts of this question and/or answers were not sufficiently detailed to achieve full marks.

c. Most candidates identified the need for cooperation between countries to achieve global outcomes and/or finance and accountability mechanisms. Very few candidates identified the global nature of climate systems or issues relating to migratory species which cannot be addressed by single countries.

Question 27

a. Social Licence to Operate/Social Licence/Social Acceptance (1).

b. (½ mark for each group):
   - Benefits groups: developer/salmon company; local workers; government (through taxation); suppliers of equipment & fish food
   - Negative impact groups: local tourism operators; recreational divers; wild-harvest fishers; local residents with visual or pollution impacts.

c. Proposal proponent/developer (1) via contracted consultant (1).

d.

   i. Legal status of the area: Ensure that the activity complies with relevant legislation e.g. EPBC (½), identifies potential conflicting use (½) and establishes appropriate tenure (½).

   ii. Management objectives: Provide benchmarks (½) against which activity can be measured to ensure compliance with approval conditions (½), provides clear description to all stakeholders (½) of all activities and anticipated impacts (½).

   iii. Baseline study: Provide a record of the conditions prior to the activity (½) against which to assess impact (½), records the presence of threatened species (½).

   iv. Ongoing monitoring: Ensure that any changes in environmental conditions or local species (½) are picked up early (½) to inform corrective responses (½), ensure compliance with legislation (½).

Comments

a. Overall, this question was answered strongly with many candidates gaining high marks.

b. About 50% of candidates identified a correct response. No credit was given if group appeared in both categories without explanation (e.g. local residents) or if group was general without explanation (e.g. East coast residents). Likewise, no credit was given for vague or ambiguous responses.

c. Generally very well answered by most candidates. No credit was given for local council, state or federal government.

d. Most candidates provided acceptable responses, but often lacked detail or were ambiguous.

Question 28

a. Any one of the following (1 mark):
   - protect particular species or ecosystem
   - protect geological features
   - protect significant archaeology
   - protect biodiversity
   - comply with UNESCO World Heritage Listing.

b. Comprehensive: examples of regional-scale ecosystems in each bioregion (½), Adequate: inclusion of sufficient levels of each ecosystem within protected area system to provide ecological viability and maintain integrity of populations, species and communities (½) Representative: inclusion of areas at finer-scale & encompass variability of habitats within ecosystems (½).

   Need geospatial record (½) of Tasmanian ecosystems at appropriate scale (e.g. TasVeg, species distribution maps, IBRA etc.) (½) and geospatial record (½) of National Parks and other protected areas (covenanted land, forestry reserves etc.) (½). Overlay these layers (maps) and evaluate whether there is coverage of all ecosystems/species (½).

Comments

a. Large majority of candidates identified a valid reason for the creation of an NP.

b. Many candidates identified Comprehensive Adequate Representative (CAR) principles from the Information Sheet for half marks. However, very few provided any description of how Tasmanian National Parks could be assessed against these principles using geospatial records (or other techniques).