2022 ASSESSMENT REPORT

ESS315118 - ENVIRONMENTAL SCIENCE

GENERAL COMMENTS

The written exam was well received by students and teachers. The results showed most students felt the exam 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, students provided very good answers. Where students didn't perform as well, it was mostly due to inadequate or incorrect detail in their response. Students 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 students to attempt all questions.

Students 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.

Students 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. Students 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.

Students are reminded that the Information Sheet should be used as a reference to assist them in constructing their responses. Responses that are written word-for-word from the Information Sheet reveal little understanding of the required knowledge, and often yield little if any credit. Students should use the information and apply it to the question. It is also advisable for future students to equip themselves with an approved English dictionary; this 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 students' performance. Markers have offered suggested answers to each question, followed by specific comment on aspects such as how the question was assessed, where students gained or lost marks, where they had difficulty in interpreting the question, or where students failed to comprehend what was required to successfully answer the question. The suggested answers are by no means prescriptive. Students providing different but valid answers were rewarded accordingly as noted by the examiners.

Suggested Answers and Comments

Section 1 (Criterion 2)

QUESTION 1

a) Independent variable = Length of cold exposure given to seeds (1) OR, time spent by seeds in refrigerator (1).

b) Dependent variable = Number of seeds germinating (1) OR, proportion of seeds germinating (1).

c) Hypothesis: Increasing cold exposure of E. regnans seeds will increase the number of seeds germinating OR Changing the length of time to which E. regnans seeds are exposed to cold will affect the proportion germinating, with an optimum period of cold exposure OR A minimum period of cold exposure is required in order for germination of E. regnans seeds.
Other similar formulations of the hypothesis are also acceptable. Marks were allocated as follows – (1) mark for causal relationship between independent and dependent variables, (1) mark for identifying the direction of the response/optimum period of cold exposure/minimum period of cold exposure.

d)

i. Any two of: Light environment of lab bench; temperature in laboratory; amount of water provided to each petri dish; size of petri dish; position in refrigerator; source of E. regnans seed – there are many possible answers. (½) mark for each of two correct controlled variables.

ii. Other variables need to be controlled in order to isolate the independent variable (½) and ensure that it is the only factor affecting the dependent variable (½).

e) The results generally support the hypothesis (½) – a greater proportion of seeds germinate with cold exposure (½). It appears that a minimum period of at least 2 weeks of cold exposure is needed for any germination (½) and it is possible that prolonged exposure of more than 2 months may impact germination in a negative manner (½) although it not possible to tell due to the small sample size (½).

f) There is only a single replicate for each cold treatment which could mean the results have been affected by chance (½) – using multiple replicates for each treatment (at least 3 petri dishes) would reduce the effects of random chance (½).

Increase the range of treatment groups (i.e., more time points) such as 5, 6, 7 weeks, 3, 4, 6 months (½) would identify whether a minimum period of cold exposure was required (½) and whether prolonged cold exposure decreases germination (½).

Use a control group which is not given any exposure to cold (½) to ensure the changes are due to cold exposure (½).

Other answers are also possible and were given credit.

Comments

a) The majority of students answered well. Half marks were given if no specific reference to seeds was made.

b) The majority of students answered well. Half marks were given if the answer only stated germination without any reference to amount, success rate, or increase/decrease.

c) Many students gained part or full marks. Students needed to include species or common name of plant.

d) Most students were able to give two appropriate variables needed to be controlled, however in item ii, they did not clearly make the link with having change solely due to the independent variable.

e) This item generally scored part marks as the majority of students stated that increasing cold exposure time increases germination, but did not indicate that the germination rate slows down after 4 weeks.

f) Most students performed well in this item.

QUESTION 2

a) Kick sampling in rivers and streams (½). A large net, with a fine mesh and straight bottom edge is placed downstream (½) of an individual who disturbs the substrate of the stream (½), causing invertebrates to be carried into the net (½). These are washed from the net into a white tray for collection and identification (½).

Other possible techniques include leaf-pack sampling, fine-meshed dredges, grabs and cores. (½ mark for naming technique, up to 1½ marks for accurate description).

b) Indicator species (1), Index species (1), biological indicator (1), bioindicator (1), sentinel species (½).

c)

i. Any two of: temperature, light exposure, substrate type, phosphate levels, nitrate levels or pH (½ for each).

ii. Appropriate technique for the abiotic variable chosen e.g., pH probe/indicator strips for pH, temperature probe/thermometer for temperature, chemical test kit for phosphate and nitrate.

d) From 1997-2009, the SIGNALT score fluctuates with no clear pattern (1), generally remaining in the three low pollution categories (½). From 2009 onwards there seems to be decrease in the SIGNALT score (1) although there is significant variation (½). 2017 and 2021 are the most heavily polluted samples (½).

e) Monitoring the same site over a long period allows the identification of long-term systematic trends (1) and estimation of natural levels of variability (1). It can also provide a baseline (½) to indicate the impact of anthropogenic or natural changes e.g., land use or extreme weather (1).

Comments

a) Only a few students achieved full marks for this item. Many responses gave inappropriate techniques such as capture, mark, recapture, and did not actually define how to collect invertebrates.

b) Answered well with the majority of students gaining the full mark.

c) Generally answered well by students with large number of full marks awarded.

d) Students often oversimplified responses to this item without acknowledging the random fluctuations across the data set. Many responses said the score remained stable. Many students did not actually make reference to the data, or the axis used on the graph.

e) Most students answered this item well and were able to link the long-term data with observing trends or significant changes.

QUESTION 3

Answer needs to include mention in each category for full marks.

- Independent variable = concentration of herbicide (measured in mg/L) (1).
- Dependent variable = decreased growth of tadpoles (measured in length in mm) (1).
- Controlled variables = size of tank, water source, volume & quality (levels of nutrients), temperature, light environment, number of tadpoles in each tank and food supplied (1).
- Experimental treatments: replicate (3-5) small tanks (*e.g.,* 5-20L volume) each containing specified number of tadpoles (1-10). Water in each tank is identical except for the amount of herbicide. Tadpoles are placed in each tank, fed and measured at intervals over a specified period (at least 2 weeks, possibly up to 2 months).
- Control treatment = no herbicide in water (1). Experimental treatments = herbicides at different levels e.g., 1, 2, 5, 10mg/L (1).
- Replication and repeats (extra sample size) to ensure accuracy and validity (1).

Comments

The majority of students were able to gain part marks on this question, however very few were awarded the full seven marks. Responses often missed one or more of the required factors stated in the prompt such as control or replication. Marks were awarded for mentioning ethical considerations and justified answers about using a field study instead of a laboratory experiment.

QUESTION 4

a) Flowers are easier to spot and thus identify plants compared with non-flowering plants (1).

b) More appropriate and clear weather for flying drones and capturing images (1).

c) Any two of the following: cheaper than using people to cover same area; can access remote and dangerous areas; can cover larger areas quickly; provide archive record; can automate process (therefore more efficient). (1 mark for each advantage explained).

d) To cover all of Tasmania need to consider: representation of different habitat types (e.g., rainforest, grassland, wet and dry sclerophyll and others) – need to have sufficient replication in each habitat type; geographical coverage – all areas of the state need to have some sampling, particularly if foxgloves are expanding from one area. (½ mark for identifying factor and ½ for description).

Comments

a) The majority of students answered correctly and gained the full mark.

b) The majority of students gained at least one mark, but often lacked a second clear advantage or simply reworded their first advantage in a very similar manner.

c) Very few students gained marks on this item. There was a clear lack of understanding about monitoring different habitats around the state and needing a sample from each region. Many students also misinterpreted the question as meaning an actual opinion survey questionnaire instead of collecting data samples. A large number of responses discussed in detail the weather conditions for flying drones or the cost required.

QUESTION 5

a) Suitable quadrat size would range from 50x50cm up to 200x200cm (1). Has to be at least 50cm to include dandelions and >200cm would be impractical.

b) Two possible answers:

Random sampling (½), points are selected by some kind of random selection procedure (½) e.g., drawing N-S/E-W co-ordinates (1) for bottom left corner of quadrat from a hat or by computer (½).

OR

Systematic sampling (½), quadrats are regularly spread over entire sports field (½), with 5 rows of 4 quadrats each 12.5m apart or similar (1).

c) Advantages: greater coverage (in area) of sports ground, increasing reliability; can identify if there is systematic variation due to underlying gradient in water, soil or other variable.

Disadvantages: might over/underestimate numbers if there is different human use of area between goals vs edges of field; will take more time & effort due to increased area covered

(1) mark for each (require both advantage & disadvantage for both marks).

Comments

a) The majority of students answered this question well and gained the full mark.

b) This item was not answered well by the majority of students. Many responses suggested that quadrats should be placed where there are more dandelion plants, or in areas that the students used more often, completely missing the requirement of randomising or systematically taking samples.

c) Generally answered well by majority students.

Suggested Answers and Comments

Section B (Criterion 5)

QUESTION 6

a)

A. Respiration/decomposition (½)

B. Photosynthesis (½)

C. Predation/consumption (½)

D. Combustion/burning (½)

b) Any of the following: CO2 dissolving in the oceans/ocean acidification; formation of carbonate minerals; other photosynthetic organisms (forests, agricultural crops etc.); fossilisation; (1) mark for any appropriate answer.

c) Plants directly use carbon (in the form of carbon dioxide) from the atmosphere (½) in their leaves/stems (½) through the process of photosynthesis (½) to create glucose; in contrast, nitrogen cannot be directly used from atmosphere as N2 (½) – it must be fixed into ammonia or nitrate/nitrite by microorganisms (½) or provided by artificial fertiliser (½) and then taken up in aqueous solution by the roots (½)

Comments

a) Well answered – most students got a least two correct answers and many got all four. Arrow C had the most incorrect answers, often answered as death/decay.

b) Well answered – the majority of student responses identified CO2 dissolving in the ocean as a major process removing CO2 from the atmosphere.

c) Many answers were correct but incomplete – failing to identify the source of C (atmosphere) or the site of uptake (leaves for C, roots for N).

QUESTION 7

a) Phytoplankton (1)

b) Baleen whales directly eat krill (½) and therefore populations of krill would be expected to increase (½), at least initially. The only organism which directly feeds on baleen whales are smaller toothed whales (½), whose number might be expected to decrease due to a lack of prey (½). Indirect effects: other predators of krill (e.g., fish, squid, other birds) would have a large population of prey (½) and therefore their numbers might be expected to increase (½).

c) There are many possible answers for this question.

Phytoplankton (producer)àKrill (1st order consumer)àFish (2nd order consumer)àLeopard seal (3rd order consumer)àSmaller toothed whales (4th order consumer)

(1) mark for correctly identifying five organisms in appropriate order, (½) mark for indicating energy flow through arrows in correct direction, (½) mark for labels indicating trophic level.

d) Energy cannot be created or destroyed, merely converted from one form to another (½), however no energy transfer is 100% efficient (½). At each trophic level in a food chain/pyramid only about 10% of energy is available for biomass production (½). There would not be a high enough density (½) of sperm whale/smaller toothed whale prey available (½) for a super-predator to be able sustain itself (½).

e) The food web is an open system (½) because it does not include the source of energy for the phytoplankton (½) i.e., solar radiation (½) nor the decomposer organisms (½) which recycle the nutrients from dead organisms (½).

Comments

a) Well answered – a high proportion of students identified phytoplankton as the producer.

b) Generally, well answered – the majority of students identified direct causal link between populations of krill and baleen whales. Most also recognised indirect links – the most common omission was failing to discuss the effect on the population of the organism involved.

c) Very well answered – most students received at least one mark. The most common omission was failing to identify the trophic level of each organism. A few students omitted the arrows or placed them the wrong way round. Some students created smaller food webs rather than food chains and a few included four or six organisms.

d) Many students identified the conversion of energy and the '10% rule' as important in answering the question but did not fully explain the consequences for the density of top-order predators nor the energy density required for a super-predator.

e) Few students received full marks for this item. Many incorrectly identified the system as closed, with no mention of energy input from external sources (sunlight) and those who did identify it as open, often only mentioned movement of other species in and out of the system shown.

QUESTION 8

a) Negative (½). Increased grass will provide more food for rabbits (½), thus their numbers will increase (½) and thus decreasing the biomass of grass (½). In turn, following a lag period (½), populations of foxes will increase (½), eating the rabbits (½) and causing their numbers to decrease (½). Response occurs in opposite direction to the change (½).

b) Positive (½). Methane in the atmosphere causes the temperature to increase through the greenhouse effect (½). As microorganisms produce methane, the temperature will increase (½), in turn this increases the production of methane (½) and so a runaway effect will occur (½). Response occurs in same direction as the change (½).

Comments

This question was generally well answered with the majority of students identifying the feedback response correctly. If the student used the wrong term but explained the feedback, they could gain up to two marks per item. Students who did not fully explain the feedback lost a half or one mark.

QUESTION 9

a) The population of a particular species that can exist or be sustained in a certain area and persist over a longer time period. (½) mark for each correct row.

Description	*Effect on species 1*	*Effect on species 2*	*Type of interaction*
Shark & seal	+	-	Predation
Cherry & blue gum	+	-	Parasitism
Pistol shrimp & goby	+	+	Mutualism
White gum & stringybark	-	-	Competition

b)

i. Royal spoonbill (1)

ii. Bill of spoonbill is an unusual shape (½) suggesting its specialised use in foraging for food (½) – in this case sieving water for invertebrates (½).

c) This is Gause's exclusion principle (½) – any small advantage in one species (½) will mean that it will outcompete (½) another species. If two species have exactly the same requirements (i.e., ecological niche) (½), then this advantage will mean that the weaker species will be driven to extinction (½).

Comments

a) Most students correctly identified at least two of the interactions described in the table. Predation & mutualism were correctly identified with higher frequency than parasitism or competition. A significant number of students identified the correct effects for native cherry/blue gum but described the interaction as 'herbivory' – this was not awarded the half mark available. Competition was the interaction that was correctly identified least.

b) Students who incorrectly identified the Australian shelduck as the specialist but who provided a reasonable explanation were awarded one mark.

c) Many students correctly described an ecological niche but failed to fully explain competitive exclusion while a number of others only referred to niche with respect to the two species shown in item (b) and therefore talked about niche separation and lost marks.

QUESTION 10

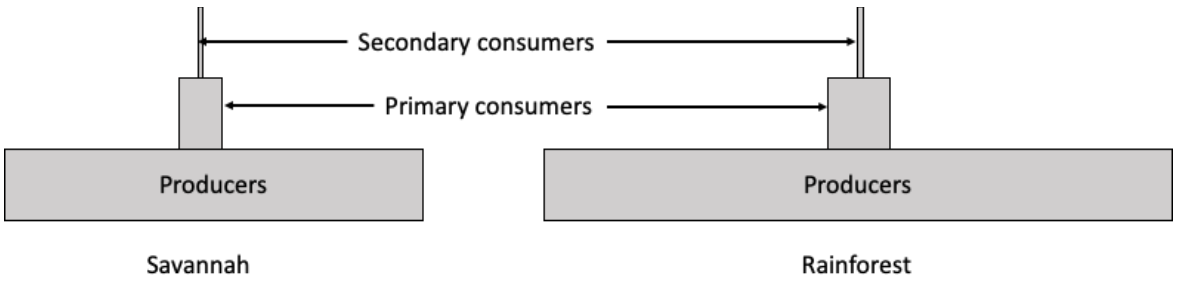
a)

i. Ecosystem A = Savannah (½)

Ecosystem B = Rainforest (½)

ii. In rainforest, individual producers are large (trees) and primary consumers are small (insects) (½). Many 1000s of insects can be supported by a single tree (½). Secondary consumers are also relatively small (½). In the savannah, producers are small (grass), whereas the primary & secondary consumers are large (½). Each antelope requires many grass plants and each lion requires only a few antelope (½).

b) Pyramids of biomass should look reasonably similar to pyramids of energy; each trophic level should be about 10% of the previous level (1). Both pyramids of biomass should look similar (1). However, rainforest has more standing biomass than savannah so the overall size of the pyramid will be bigger (1).



(Up to 2 marks for diagram if there is annotation/explanation)

However, there may be situations where the relative size of the biomass pyramid will vary depending on rate of turnover of the individual organisms e.g., grass in a savannah may have a lower standing biomass due to more rapid production.

Explanations which discussed the rates of turnover or production of biomass were also given credit.

Comments

a)

i. Very well answered – a large majority of students correctly identified the two ecosystems.

ii. Also generally well answered although students needed to discuss the relationship between the size of producers and consumers in both ecosystems for full marks. Where students incorrectly identified the ecosystem but provided an appropriate response about the size of producers vs consumers, they were given credit.

b) There was a very wide range of answers for this item, with few students receiving full marks. Students often failed to recognise the connection between biomass and numbers of organisms, or produced illogical conclusions such as higher amounts of biomass in lions than antelopes in the savannah ecosystem. Many failed to recognise that the biomass of thousands of insects could be greater than that of vertebrate consumers.

QUESTION 11

a) Period A (1)

b) 105 Devils (100 -110 acceptable answer) (1)

c) Period A: there is a low population of devils in a new environment with lots of prey and no competitors (½). Numbers increase exponentially, only limited by breeding rate (½). Period B: as the numbers increase, prey is reduced (½) and intraspecific competition becomes important (½). Rate of increase slows down (½). Period C: an equilibrium is reached (½), varying around carrying capacity (½), dependent on random fluctuations related to weather, disease etc. (½).

Comments

a) Very well answered – a large majority of students correctly identified exponential growth phase.

b) Very well answered.

c) Many students just described the pattern of numbers over the three periods without providing any explanation and so received no marks. For full marks students had to correctly identify the processes occurring in each of the three phases.

Suggested Answers and Comments

Section C (Criterion 6)

QUESTION 12

a)

i. Change in amount of solar radiation (½), varying continuously from full dark (night) to full daylight (midday) OR water depth (½) varying over course of tidal cycle (½) OR air exposure (½) varying from 24hr at extreme high water to 0hr at extreme low water (½).

ii. Water/air temperature (½) varying from minimum in late winter to maximum in late summer (½) OR solar radiation (½) varying from minimum in mid-winter to maximum in mid-summer (½). Other answers possible e.g., extent of East Australian Current.

iii. El Niño/La Niña (½), changes in amount of freshwater runoff/temperature (½). Other answers possible involving weather patterns and effect on temperature/salinity.

b) Diurnal changes on organisms might include drying out as a result of exposure to the air (e.g., limpets, sea anemones) (1) or heating up and associated physiological stress during periods of maximum solar radiation (1) or exposure to terrestrial/aquatic predators at different periods of tidal cycle (1). Seasonal changes include: exposure to heat/cold stress at different times of year (1) or movements of predators due to abiotic factors (1). There are many possible answers for this question.

c) Biodiversity is the total variation across a geographical area in terms of genes, species and ecosystems (½). For the GSR, this will include genetic variation within each species (½), the total number of species (½), the number of endemic species/genera/families (½) and the variety of ecosystems represents – low profile reef, high profile reef, patch reef or others (½).

Comments

a) Most students performed well on this item, with tides and changes in light (day/night) being the most common answers for item i. Temperature changes due to seasonal variation was the most common answer for item ii. Item iii was more difficult for students and pollution or 'oil spills' were awarded no marks, as the question clearly asked for 'natural' abiotic changes. Biotic factors were also given no marks. Many students only stated three abiotic factors and unfortunately did not 'describe' them for full marks. Only stating a factor, however, is a good strategy when rushed for time, as this gained one and a half out of the three marks.

b) Most students performed well on this question, with changes in temperature with the seasons being the most common answer.

c) This item was surprisingly not answered well. Most students copied from the Information Sheet which at most was awarded half a mark. Without relating to the GSR full marks were not awarded. Listing all three types of biodiversity also was not enough for full marks as this question asked to 'explain' the concept.

QUESTION 13

a) 280ppm (270-295ppm accepted) for (1) mark, 250 or 300ppm for (½). Units are needed for full marks.

b) Temperature has varied more or less cyclically over the past 800,000 years (½), although the cycles are not as defined to about 500,000 years (½) from a low of -8°C to a maximum of 2°C (½) with a period of about 50,000 years (½) with about 8 cycles (½). There is a strong positive correlation between CO2 levels and temperature (1) i.e., when CO2 levels are high, temperature is also high (½). There has not yet been a corresponding temperature increase related to spike in CO2 in the last 200 years (½).

c) Past levels of CO2 can be determined by drilling ice cores (½) and extracting air bubbles from different depths in the ice (½). The deeper the ice, the older it is (½). The CO2 levels can be measured directly from the bubbles (½) or Oxygen (½) with a gas sensor. Proxy analysis of the temperature (½) can also be determined from the ancient (½) gas. Absolute age of the ice can be determined from annual rings, mathematical models or chemical analysis (½) OR isotope analysis (½).

d) The dotted line shows CO2 released into the atmosphere through anthropogenic (½) combustion/burning (½) of fossil fuels (½) such as coal, oil and natural gas (½) since the start of the Industrial Revolution (½).

e) Many answers possible including reduction in amount of sea ice reducing foraging distance for land-based organisms such as penguins (1) or change in breeding success for ice-dependent organisms (e.g., seals, emperor penguins) (1); increased melting of glaciers and freshwater input changing primary production (1) or salinity-driven currents (1); increased temperatures/more open water increasing rates of primary production (1) and consumers such as krill or baleen whales (1).

Comments

a) Most students performed well on this item and included units (ppm) for full marks. Many students used no lines or drew freehand 'wobbly' lines on the graph which resulted in an incorrect answer. Including a ruler as writing equipment for the exam is important and would have assisted students with this question.

b) This was not answered well as many students only briefly considered the graph and wrote a great deal about the greenhouse effect. This was awarded no marks. Stating that 'temperatures have increased' was also awarded no marks as there are large cyclic fluctuations in temperature over the 850 thousand years. Students should be reminded that 'analysing, interpreting and drawing conclusions' from graphs should be studied as it may be tested in each of the five sections.

c) This item was also not answered well as many students did not know a 'past' method of measuring temperature or CO2 or other Paleoclimate. Ice core drilling in Antarctica was the most common answer. Dendrochronology (tree ring analysis) or sediment drilling (oxygen isotope analysis on Foraminifera tests or ancient pollen analysis) or other correct methods, if they were described well, also gained full marks.

d) Most students performed well on this item; however, students are reminded to consider the great amount of detail that is required to 'explain' for full marks. Students are reminded that Cattle (and other ruminants) emit methane (not CO2) and were awarded no marks if they did not state this correctly.

e) Most students performed reasonably well on this question. Students are reminded that Polar Bears do not live in Antarctica and were awarded half a mark at most for this impact, unless they also included how penguins living on ice are impacted by it melting. Students who stated, 'habitat loss from ice melt' gained no marks unless they correctly wrote how species rely on ice. 'Habitat loss from sea ice melt' is correct, and this clarification was needed, as when Antarctica ice is completely lost land is exposed.

QUESTION 14

a) Any two of the following (1 mark each): Closed canopy of mature rainforest trees in rainforest vs open canopy of eucalypts in dry sclerophyll; almost continuous ground cover in dry sclerophyll vs few ferns/saplings in rainforest; different height canopy of trees in dry sclerophyll vs even height in rainforest; greater density of trees in rainforest vs lower density in dry sclerophyll.

b) Dry sclerophyll forest experience frequent fire (< every 25 years) (½) which is generally of low intensity (½). Trees are fire-resistant (½) and regrow quickly after fire (½). Wet eucalyptus forests experience more intense (½), less frequent (20-80 years) fires (½) which removes the dense understory (½) and creates gaps for germination of seeds (½). Rainforest species do not require fire to regenerate (½), instead relying on germination in shade (½) and growing when gaps appear (½). Fires in rainforest are very infrequent (every 500 years) (½) and high intensity (½), allowing invasion of other forest types (½).

Comments

a) Most students answered this very well. Closed and open canopy and the differences in the ground cover were the most common answers. Strong responses included headings and even underlined the headings, for the clearest answers.

b) This question was not answered well. Most students did not know the difference between fire intensity and frequency of all the three forest types. No matter how much was written about one forest type, only one mark could be allocated, as all three forest types were required for a full three marks.

QUESTION 15

a) This is a strong El Niño event (1) – shown by widespread drought conditions across southern and eastern Australia (½) with much lower rainfalls than average (½).

b) Any two of the following (1 mark each): increased coral bleaching where individual corals eject their symbiotic zooxanthellae due to temperature stress (1); coral bleaching causes a loss of habitat for the entire Great Barrier Reef marine ecosystem including crustaceans and fish (1); warmer water and marine heat waves can also cause direct death of other organisms beyond their physiological limits (1); droughts and less rainfall may improve water quality as less land runoff would reduce turbidity and would especially benefit plants and photosynthesis (1).

Comments

Most students performed very well on both items. The Great Barrier Reef has been a well-studied topic. Stronger responses in item b) noted that in an El Nino the Northern Australian waters are 'cooler than normal' (given in Information Sheet), but the much warmer air temperatures in the shallow reef areas causes marine heat waves and coral bleaching. Students that wrote that ocean acidification would increase were awarded no marks. Temperature does not directly cause ocean acidification. Increased warming of water generally liberates CO2 (comes out of solution into the atmosphere) and acidification will occur first in the very cold Southern Ocean around Antarctica, before tropical waters acidify. This is like how cold water holds more dissolved oxygen; more gas CO2 can be dissolved in cold water.

QUESTION 16

a) A threatened species is one that is experiencing population declines (½), has a small population size (½) or occupies a very limited geographical range (½) and/or a species that is listed on an official government/international list (½) as at risk of extinction (½).

b) Any two of the following (1 mark each): habitat loss can reduce the amount of a necessary resource e.g. food, breeding hollows which leads to lower survival and/or breeding success; habitat loss can increase the patchiness of a habitat, leaving

populations that are too small for long-term viability and vulnerable to random effects; habitat loss can increase the amount of edges relative to area, allowing spread of invasive weed species; habitat loss can reduce the amount of shelter for organisms making them more vulnerable to predation.

c) Any two of the following (1 mark each): climate change can change weather patterns e.g. making areas wetter or drier outside of the ecological range of species; climate change can increase the frequency of severe weather events such as cyclones or floods which can physically remove habitat; increased temperature will reduce the amount of alpine habitats within a particular temperature range; increased ocean acidification reduces the ability of carbonate-fixing organisms e.g. corals to make their skeleton & therefore decrease the amount of reef habitat available.

d) Many possible introduced species, both plant & animal e.g., prickly pear, Patterson's curse, banana passionfruit, foxes, cats or cane toads (1). Impact must match the invasive species – e.g., cane toads feed on native invertebrates directly reducing their populations (1) as well as being poisonous to native vertebrates that feed on them and thus reducing their numbers (1). Two described points for (2) marks.

e) Control methods include (1 mark each): trapping via baited traps and euthanasia; poisoning with 1080 or similar poisons that have lower effects on native organisms; direct culling by shooting; spraying of selective herbicides; introduction of biological control species (e.g., Cactoblastis moth for prickly pear).

Comments

a) Most students answered this very well.

b) Most students answered this reasonably well but did not give enough detail to gain full marks, as each negative effect had to be explained.

c) Most students answered this very well, but common errors were not linking the answer to habitat loss. Stating that 'warmer temperatures stress animals beyond their physiological tolerances' did not gain any marks as no habitat loss was mentioned.

d) This item was surprisingly not answered well, and most students did not gain full marks. Unfortunately, many students wrote about how the species reproduced quite well and why it was so successful, but this gained no marks as the question asked about impacts. Students are reminded to carefully highlight key words such as 'impact' during preparation time. Cane toads, foxes and feral cats were the most common species, however other species such as the Northern Pacific sea star (Asterias amurensis) and Long-spined Sea urchin (Centrostephanus rodgersii) have been well-studied.

e) Most students answered this very well.

Suggested Answers and Comments

Section D (Criterion 7)

QUESTION 17

a)

i. Renewable resources are those that are continuously produced through natural processes and will regenerate after harvesting or there is an infinite supply (½); non-renewable resources do not regenerate after harvesting or there is a finite supply (½).

ii. Many answers possible *e.g.,* renewable: wood; paper; fish; latex: hydro/water (½); non-renewable: oil, gas, coal, iron, uranium (½).

b)

Category	Definition (½ each)	Specific forest example (1) for each example. (½) marks if one word answer *e.g.*, wood.
Provisioning	Products obtained from ecosystem	*e.g.*, timber for construction or paper; edible products such as brazil nuts or animals that are hunted; other usable products such as rubber; genetic resources.
Regulating	Benefits obtained from regulation of ecosystem processes	*e.g.*, water regulation as water is absorbed by soil and released slowly; water purification as it passes through the soil and associated microfauna; climate regulation through evapotranspiration, or carbon sequestration – forests act as a carbon sink.
Supporting	Services necessary for the production of all other ecosystem services	*e.g.*, microbial breakdown and release of nutrients from organic debris; soil production by physical & chemical weathering; mycorrhizal uptake of materials and communication between plants.

Cultural	Non-material human benefits obtained from ecosystems	*e.g.*, recreation & tourism – hiking, swimming; aesthetic pleasure and mental health benefits; educational benefits; cultural & traditional ceremonies.

Comments

a)

i. Most students could distinguish between renewable and non-renewable resources and provided a reasonable definition for each.

ii. Students generally gave an example and linked it to the type of resource. No credit was given to manufactured products being identified as a non-renewable resource.

b) The Information Sheet was a valuable resource for this item, although some students did not use this information for guidance when needed and made no attempt to complete the table. Many achieved full marks. The specific forest example section of the table required more than one word to obtain one mark.

QUESTION 18

a) Australia is a developed country with a high GDP (½). Citizens can afford to buy food and goods from all over the world (½), live in larger houses (½) and use more energy for their day-to-day activities (½). The Philippines is a less developed country with low-moderate GDP (½). Citizens spend a much higher proportion of their income on food (½), much of which is local and thus has less embedded energy (½). Houses are smaller (½), citizens have fewer possessions (½) and use less energy per capita (½). Two marks not gained unless the Philippines are discussed.

b) During this period, Malaysia has increased its GDP and development status (½). Individuals are now wealthier which means that they can afford more possessions (½), requiring more energy to produce (½). Consumption of meat and other food with greater ecological footprints has increased (½). In Australia, awareness of the ecological impact of consumption has increased (½) leading to changes in diet (less meat) (½) and more efficient use of energy (½). Production processes of many items have been made more efficient (½). Two marks not gained unless both Australia and Malaysia were discussed.

c) Milk is an animal product (½), relying on the conversion of primary productivity (grass) (½). Only about 10% of the energy, and thus water, used by the grass to grow is available for production of the milk (½), as well as the water needed directly by the cow (½). Conversely, tea is produced directly from a plant product (½) and thus only the water used by the tea plant is embedded in the cup of tea (½). Students were rewarded for

referring to the amount of virtual water embedded in milk processing, that included the production of feed and manufacturing of containers.

d) Any two of the following (1 mark each):

- reduce the amount of meat or dairy consumed in the diet
- swap from food produced by irrigation (*e.g.,* rice) to food produced through natural rainfall
- reduce purchase of clothing and/or choice of material (*e.g.,* irrigated cotton)
- reduce total consumption of manufactured products (*e.g.,* electronics and paper)

Comments

a) It was essential that when explaining the reasons for a country's footprint that the country be named. To gain two marks both countries had to be included in the answer. All too frequently Australia was discussed in isolation with little or no mention of the Philippines. Some students misunderstand how a global footprint is measured, and it was clearly stated in global hectares per person. As a result, population size was often given to explain the differences between Australia and the Philippine's footprint.

b) Mistakes were made in this item when students misread the question and kept discussing the Philippines instead of Malaysia. Many students correctly identified that Australians were starting to adopt more sustainable practices in order to reduce their footprint.

c) This produced a variety of answers but many concentrated on the fact that cows require a lot more water to produce milk because of their mass, the fact they eat grass/grain which needs water to grow, water is needed for processing and cleaning the dairy. This then had to be compared to a cup of tea to gain full marks.

d) Students were very comfortable with this item and it was generally well-answered.

QUESTION 19

a) (½ each)

1. Primary pollutant
2. Diffuse source of pollution
3. Non-biodegradable
4. Persistent

b) This is an example of biological magnification (½). At each stage in the food chain, the concentration of DDT increases (½) because it is persistent and not broken down by the organisms involved and it accumulates in the tissues of the consumer (bioaccumulation) (½). Concentrations of DDT at lower trophic levels are not toxic to

the organisms (½) but there is a three-order of magnitude increase to the top predator, the fish-eating birds (½). These concentrations are high enough to kill the birds (½).

c) This is an example of resistance (½) through evolution (artificial selection) (½). Insects which have genetic variations (½) that allow them to survive and reproduce and pass their genes to their offspring (½). Over time these genes spread through the populations leading to high levels of resistance (½).

d) Any two of the following (1 mark each): Biological control by predators through direct introduction of predatory organisms (ladybirds, frogs etc.) or creating favourable habitat nearby; biological control by parasitoids or microbes – parasitoid wasps or flies can be released into the crop or specific fungal or bacterial pathogens; crop rotation – different crops are grown in each field in different years, reducing the ability of pest insect populations to establish and grow; growing the crop under cover, polyculture or permaculture to reduce the number of a particular insect population concentrating on one crop; companion planting with a plant which is noxious to the insect; hand removal of the insect, despite this being time consuming and expensive.

Comments

a) Overall, this was generally well answered. although students did not always make their choice clear.

b) Many students were familiar with the concept of bioaccumulation and biomagnification and made some attempt to explain why DDT became toxic to fourth level consumers.

c) The concept of pest resistance was well understood by most students, although to gain two marks the answer often needed more detail.

d) Two alternatives to DDT were required to gain two marks. The most common alternative noted was to use a biological control. Students were penalised if they only gave one alternative or if the solution was illogical.

QUESTION 20

a) 1990: capture fisheries are about 80 million tons, aquaculture production is about 95-80 = 15 million tons (½); 2015 capture fisheries remain about 80 million tons, aquaculture production is 170-80 = 90 million tons (½). Therefore, increase in aquaculture is 90-15 = 75 million tons (1) (accept range of 70-80 million tons).

b) Capture fisheries have remained approximately constant since 1985 because existing fisheries have been fished at maximum sustainable levels (½) or overfished (½) and there are no or few new fisheries left to exploit (½). Some fisheries have collapsed (e.g., cod in Newfoundland) (½) which have compensated for expansion in new fisheries (e.g. Antarctic krill) (½).

c) Potential problems for aquaculture (½ mark for each): pollution/eutrophication by faeces and uneaten food; unsustainable sources of food; overuse of antibiotics; reduction of oxygen levels by overstocking; disease and parasites spreading to wild fish; pesticides to kill sea lice affect crustacean population; local seal population caught in nets or shot with pellet guns; overfishing of fish stocks to provide fish meal for the aquaculture industry.

Potential solutions (must match problem for ½ mark each): fallowing of lease sites and more efficient feeding techniques; location of aquaculture leases in areas of high-water exchange; use of plant-based foods, particularly from waste material; land-based, recirculation aquaculture; regulation e.g., banning prophylactic use of antibiotics.

Comments

a) This item proved difficult for most students, both in terms of interpreting and calculating data from the graph. Very few answers showed the correct calculation, although ironically an acceptable answer could be calculated using the data for the total fish catch per year for 1990 and 2015. One mark was awarded for answers between 70-80 million tonnes even if the data extracted for the calculation was incorrect. Students almost always chose data for the total fish catch rather than for the tonnage that was aquaculture and gained only half marks. Half marks were awarded if units were not included.

b) Very few students gained two marks for this item. Most provided one reason for the fish catch remaining constant. Many noted that it was because aquaculture had increased therefore the captured fish catch remained unchanged. Some suggested that there was less demand for captured fish.

c) Each problem was allocated half a mark. The remaining half marks were obtained by providing a potential solution for each problem. There were a large number of possible solutions to the problems. A common solution provided by students was to base fish farms on land to prevent dead zones below nets.

QUESTION 21

Pollutants: NOx, SOx, CO2, methane, ozone, particulate matter (½ for named pollutant).

Origin (½): NOx from combustion of fossil fuels, lightning, microbial processes; SOx from combustion of high-sulfur fuels or smelting of mineral ores; CO2 from combustion of fossil fuels; methane from livestock & anaerobic decay; ozone from combustion engines.

Effects on humans & other organisms (1): respiratory distress, climate change, acid rain.

Potential mitigation measures (1): reduction in combustion of fossil fuels, scrubbing of emissions from power plants and internal combustion engines; reduction in the use of high-sulfur minerals.

Comments

This question expected students to name two specific atmospheric pollutants and answer three questions about each pollutant. These were clearly stated and all had to be answered in order to gain three marks per pollutant. Much of the detail required for each pollutant is on the Information Sheet. It was disappointing to see several students make no attempt to answer this question.

Mitigation strategies are not, however, found on the Information Sheet and many students avoided answering this part of the question per pollutant. Several students discussed mobile and stationary pollution without naming a specific pollutant. Credit was given if the remainder of their description answered any part of the question. Smog was often used as the pollutant with some students recognising it as a secondary pollutant. Credit was given if the answer mentioned the pollutant/s generating the smog, provided the rest of the question was answered.

Suggested Answers and Comments

Section E (Criterion 8)

QUESTION 22

a) The common resource is space on the road/time taken to destination/ability to travel freely (1). A tragedy of the commons is when individual access to a common resource (½) degrades that resource for others (½). In this case, each person who chooses to use the road (½) creates more congestion for everyone else (½) until, ultimately, everyone is impacted and their ability to travel freely is compromised (½).

b) Any one of: road pricing; taxation of private vehicles; subsidisation of public transport; encouragement for car-pooling, bicycle lanes, closing roads to cars and making pedestrian only.

Comments

a) This question was not answered well. Many students were confused about 'congestion' as a term that described air quality and atmospheric pollution. Partial credit was awarded where students correctly explained the concept of tragedy of the commons but misidentified the 'commons'.

b) Overall, well answered, half marks were awarded for widening roads, more lanes, or city planning as these were not the most effective of the many possible ways to reduce traffic congestion.

QUESTION 23

a) Any of the following (1 mark): discarded plastic can be washed into waterways and hence into the ocean; plastic can be blown from landfill sites directly into the ocean; direct dumping of plastic material at sea.

b) Individuals who discard plastic into the ocean or on land which ends up in the ocean do not pay the economic cost of their actions (1). The impact of plastic in the GPGP kills or reduces the health of sea creatures (½) and allows bioaccumulation of microplastics in human food (½). These costs are mostly borne by others (½).

c) Full-cost pricing is when the entire life-cycle costs of an object or service is incorporated in the costs charged to the consumer (1). In this case, plastic objects on land or fishing materials would be priced considerably higher than at present (1) to incorporate the costs involved in preventing plastic entering the ocean (½) or removing plastic from the ocean (½).

d) Any of the following:

Reduction of plastic use (1). Many current uses of plastic are not necessary (½) and could be removed e.g., plastic packaging of fruit (½). Changes in supply chains (½) and education campaigns (½) encouraging consumers to bring their own containers to use (½).

Replacement of plastic use (1). Other materials, such as biodegradable polymers made from plants (½) could be used instead of plastic (½). This strategy could involve taxes on plastics (½) and/or incentives to use non-plastic materials (½).

Increased recycling (1). Plastic materials would be collected (½) and sent to processing plants (½) for conversion into new plastic feedstock (½). Again, incentives and/or taxes could be used (½) to promote increased use of recycled materials.

Comments

a) Well answered – most students got at least partial marks. Inadequate descriptions that did not clearly state the path of plastic waste to the ocean were awarded partial marks.

b) Not well answered – many students did not accurately explain or show understanding of a negative externality within the context of the question.

c) Many students could adequately describe the full cost principle but could not elaborate how this would lead to a reduction in plastic waste in oceans, therefore many students achieved partial marks but failed to get full credit.

d) Not well answered – many students seemed to confuse the intended verb usage of pollution with the noun usage of pollution. This meant that many focussed on the remediation strategies of removing plastic from oceans, rather than preventing the

plastic from being polluted in the first place. These answers received no credit. Some students focussed on the conservation strategies such as education or green economics and, if justified well, could achieve full credit. No marks were awarded for unrealistic solutions such as imprisonment for littering or heavy fines for actions that could not be enforced.

QUESTION 24

a) A Social License to Operate (SLO) is acceptance by all stakeholders of the necessity/benefit to conduct some kind of action (½). In this case, it would appear that a considerable number of stakeholders (½) do not see the benefit of fracking (½) and thus the SLO has not been given (½).

b)

Intergenerational equity

This principle concerns whether benefits for the current generation are at the expense of future generations (½). In this case, fracking for hydrocarbons could increase greenhouse gas generation (½), causing increased climate change (½), whose major effects would be on future generations (½). Fracking also uses freshwater unsustainably or can contaminate groundwater for future generations (½).

Intragenerational equity

This principle concerns the spread of benefits across the current generation (½). Revenues from fracking accrue to the companies/shareholders (½) but not to the landowners (½) whose land is also potentially degraded in use/value by the operation (½). Fracking also creates inequitable water use (½).

OR

This principle concerns the spread of benefits across the current generation (½). Fracking allows for the access of affordable energy (½) which is key for low-income families to power their homes (½) which allows for a fair spread of resources across society (½).

Ecological integrity

Ecology integrity is the ability of the ecosystem to continue to provide services as before (½). The effects of fracking on ecosystems are not fully understood (½), but there are possibilities of reducing or affecting groundwater supplies (½), contamination of water with chemicals (½) and earth movements (½). Fossil fuel extraction leads to increase in climate change (½) which severely impacts global ecological integrity (½).

Comments

a) Well answered. However, many students lost partial marks by not explicitly linking the concept of Social License to Operate to the question stem.

b) Few students received full marks for this item. Many lost marks in explaining how the principle is breached/upheld in the question stem. Although many students did not fully understand the environmental impacts of fracking, it was possible to achieve full marks without knowing the full impacts on ecosystems.

QUESTION 25

a) The purpose of an EIA is to determine the potential environmental, social and economic benefits of a proposed development (1),

b)

i. Any two of the following social issues (1 mark each): effect on the individuals/communities living along the proposed route – loss of amenity, reduced housing value, noise; Social License to Operate from stakeholders including residents, commuters, taxpayers; loss of amenity to general public through loss of green spaces.

ii. Any two of the following economic issues (1 mark each): effect on businesses along the current route; access to businesses/services from the new bypass; costs of building the bypass to ratepayers; employment potential from the bypass for local employees; increased economic activity due to shorter commute times.

iii. Any two of the following biophysical environmental issues (1 mark each): impact on stormwater runoff/water quality of rivers and oceans; impact on threatened species through loss of habitat; impact on threatened ecological communities.

c) Responses will vary depending on issue chosen.

Examples include: baseline monitoring of water quality in all catchments affected (½) for pH, nutrients, indicator organisms (½) for approximately six months to one year (½), repeated following construction at regular intervals e.g. every 6 months (½).

Comments

a) Well answered. However, a notable number of students failed to receive full marks as they only mentioned the environmental impact, not community/social, or economic.

b) Well answered – many possible answers. Most students achieved at least two marks. No marks were awarded for generic responses such as 'impacts on profits' or 'pollution from the bypass'. Any issues that lacked a clear explanation were awarded partial credit.

c) Not well answered. Many students failed to link their response to the proposed development i.e., did not have pre/during/post build into their monitoring, regardless of the issue. Timeframes were required for full marks. 'Monitoring' with little to no explanation received zero credit.

QUESTION 26

a) State government (1). (Federal government was also accepted as there are a small number of National Parks listed under Federal legislation).

b) Baseline studies are necessary to show current status (½) of various parameters including biodiversity, habitat distribution and water quality (½). Management plans need to take into account these conditions and indicate monitoring methods and frequency (½) to set targets for future improvements (½) or trigger actions if degradation occurs (½).

c) CAR systems require that sufficient areas of all habitat types are represented (½). takayna is a large tract of temperature rainforest (½), currently under-represented in the National Park system (½). Because of its size and habitat quality it would increase both the adequacy and representativeness of the system (½)

Comments

a) Full marks were awarded to any answer that had State or Federal government stated. As the process for establishing a National Park is not explicitly taught in the course and it is a complicated legal process, both answers were accepted. No marks were given for local government.

b) Not well answered. Most students failed to connect the management plan to the purpose of a baseline study. Although many students achieved partial marks, measurement parameters must be outlined for full marks.

c) Mostly well answered. Full marks were only awarded to answers that linked features of takayna to the CAR system.