

2021

AP<sup>®</sup>

 CollegeBoard

---

# AP<sup>®</sup> Environmental Science

## Scoring Guidelines Set 2

© 2021 College Board. College Board, Advanced Placement, AP, AP Central, and the acorn logo are registered trademarks of College Board. Visit College Board on the web: [collegeboard.org](https://collegeboard.org).

AP Central is the official online home for the AP Program: [apcentral.collegeboard.org](https://apcentral.collegeboard.org).

**Question 1: Design an Investigation****10 points**

---

**(a) (i) Identify** the scientific question that resulted in the data presented in the graph. **1 point**

Accept one of the following:

- What is the relationship between slope and annual erosion rate for four different land use types?
- Does crop rotation/tilling/not tilling/using cover crops on various slopes increase/decrease/change erosion rates?

---

**(ii) Identify** the agricultural practice that could be used on a 15% slope without leading to a higher than tolerable loss of soil. **1 point**

- Crop rotation

---

**(iii) Describe** the effect of adding a cover crop compared to using the no-till method. **1 point**

Accept one of the following:

- Adding a cover crop reduces the annual rate of soil erosion compared to using the no-till method.
- Adding a cover crop allows planting on greater sloped land before reaching tolerable loss as compared for the no-till method.

---

**(iv) Identify** one natural mechanism of soil erosion. **1 point**

Accept one of the following:

- Moving/flowing water
- Rainfall
- Wind

---

**Total for part (a) 4 points**

---

**(b) (i) Identify** the dependent variable stated in the hypothesis. **1 point**

Accept one of the following:

- The amount of sediment discharge
- The amount of sediment run-off

---

**(ii) Describe** one way to add a control to improve the design of the study. **1 point**

Accept one of the following:

- Add a plot that is bare/does not have straw bales or grass (no ground cover).
- Measure sediment discharge/runoff prior to placing straw bales or planting grass compared to discharge after the bales/grass are in place (pre-/post-tests).

- 
- (iii) **Identify** one variable that was not discussed that could affect the results of the study. **1 point**

Accept one of the following:

- Slope of the plots
- Amount of rainfall
- Composition of the roads
- Distance of the plots from road/stream
- Size of the plots
- Type of soil at the plots
- When the data are collected at the plots (how quickly after rainfall)

- 
- (iv) Based on the data in the table above, **make a claim** about the stated hypothesis. **1 point**

Accept one of the following:

- The stated hypothesis is rejected as more sediment resulted from straw bale plots (plot A) than grass planted plots (plot B).
- The data in the table shows that the grass is more effective at reducing sediment runoff. The hypothesis should be rejected.

---

**Total for part (b) 4 points**

- 
- (c) (i) **Describe** the type of survivorship curve expected for these fish species. **1 point**

Accept one of the following:

- Low survival rate in early life, followed by increased chances of survival as the organism matures.
- Most offspring die at a very young age and few reach maturity.

- 
- (ii) **Explain** why the input of sediment to a stream can negatively affect reproduction of fish that lay their eggs in the gravel of the streambed. **1 point**

Accept one of the following:

- Sediment can cover/bury eggs, which reduces the amount of oxygen, causing them to die.
- Sediment takes away usable habitat/space resulting in fewer areas for them to lay eggs causing fewer eggs to survive.
- Sediments can carry toxic/poisonous chemicals, which can negatively impact the eggs and decrease egg survival.
- An increase in sediment can increase the water temperature and result in less dissolved oxygen/too warm water, which can decrease the viability of the eggs that have already been laid.
- Sediment can increase water turbidity, which decreases fish navigation/ability to forage/efficiency of oxygen use which decreases the amount of eggs laid.

---

**Total for part (c) 2 points**

---

**Total for question 1 10 points**

**Question 2: Analyze an Environmental Problem and Propose a Solution****10 points**

---

**(a) (i) Identify** the latitudinal range with the greatest amphibian species richness. **1 point**

Accept one of the following:

- Between the Tropic of Cancer and the Tropic of Capricorn
- The range between 30 degrees N and 30 degrees S latitude
- The range between 10 degrees N and 15 degrees S latitude

---

**(ii) Identify** what biome this range most likely represents. **1 point**

- Tropical Rainforest

---

**(iii) Describe** one reason amphibian species richness would tend to be highest in this region. **1 point**

Accept one of the following:

- More rainfall/warm temperatures year-round are the preferred conditions for amphibians.
- Greater biodiversity/higher NPP provides more habitat/food sources/niches.

---

**Total for part (a) 3 points**

---

**(b)** There are many environmental threats facing amphibians today, such as deforestation. **1 point**

**Describe** one possible anthropogenic reason for deforestation.

- Human demand for agriculture/housing/firewood/forest products (medicine/food/lumber).

---

**(c) (i) Explain** how the species richness of an ecosystem influences its response to environmental stressors. **1 point**

- An ecosystem with greater species richness/diversity is more resilient/resistant to environment stressors because some species will survive helping to restore/stabilize the ecosystem.
-

---

**(ii) Explain** why amphibian biodiversity is declining globally, other than from deforestation. **1 point**

Accept one of the following:

- Increasing water pollution including:
  - Pollution from pharmaceuticals that cause reproductive harm/decrease reproductive success.
  - Pesticide pollution that is absorbed via the skin and is toxic to amphibians leading to death.
  - Endocrine disruptors (such as atrazine) can alter reproductive development leading to decreased number of successful offspring.
- Pesticide use reduces food sources for amphibians (insects), leading to decreasing population size.
- Microclimatic changes from overall global climate change (e.g., warmer, drier conditions in previously cool, moist areas, loss of wetlands) decreases available habitat leading to a decline in population size.
- Illegal amphibian trafficking removes species from an area leading to a decline in population sizes.
- Introduction of invasive species that compete for niche space leading to a decline in population sizes.
- Habitat fragmentation from human activity would limit range/reduce the ability to access resources, decreasing survival.
- Fungal infections (such as Chytrid) cause their skin to dry out, and they cannot breathe.

---

**Total for part (c) 2 points**

**(d) (i) Identify** one specific piece of legislation that has been designed to protect species threatened by extinction. **1 point**

Accept one of the following:

- Endangered Species Act (ESA)
  - Convention on the International Trade of Endangered Species (CITES)
  - Lacey Act
-

- (ii) Explain** how the requirements of the legislation identified in part (d)(i) specifically protect species threatened by extinction. **1 point**

Accept one of the following:

Legislation identified in (d)(i)	Explanation of requirements that specifically protect species threatened by extinction
<ul style="list-style-type: none"> <li>Endangered Species Act (ESA)</li> </ul>	<ul style="list-style-type: none"> <li>Lists endangered/threatened plant and animal species and prevents them from being killed or harmed.</li> <li>Designates/protects critical habitat to promote survival and recovery of listed species.</li> <li>Creates plans to restore populations to healthy sizes.</li> <li>Identifies species that are threatened before they become endangered to provide protections.</li> </ul>
<ul style="list-style-type: none"> <li>Convention on the International Trade of Endangered Species (CITES)</li> </ul>	<ul style="list-style-type: none"> <li>A global agreement that protects endangered/threatened plants and animals (including goods such as ivory, shark fins, or rhinoceros' horns) by banning/regulating the trade of these species.</li> </ul>
<ul style="list-style-type: none"> <li>Lacey Act</li> </ul>	<ul style="list-style-type: none"> <li>Prohibits the trade of wildlife, fish, and plants that have been illegally taken, possessed, transported, or sold.</li> </ul>

**Total for part (d) 2 points**

- (e) (i) Propose** a viable solution that will result in the protection of the endemic frog species while still allowing for maximum profit of the property development. **1 point**

Accept one of the following:

- Move/transplant the frog populations to an adjacent undeveloped area prior to development.
- A portion of the wetland can be designated as a park/preserve.
- Wildlife corridors (land/bridges) can be built/created on a portion of the wetlands.
- Restrict development within a minimum setback away from the wetland.
- Project developers can group buildings together/can build up, not out.

- (ii) Justify** the solution proposed in (e)(i) by describing a potential advantage of the plan, other than frog protection. **1 point**

Accept one of the following:

Solution proposed in (e)(i)	Justification of how solutions offer potential advantages, other than frog protection
<ul style="list-style-type: none"> <li>Move/transplant frogs</li> </ul>	<ul style="list-style-type: none"> <li>Developers will only have a one-time disruption during the removal but will not have to deal with continued disruptions (such as increasing human population, increasing use of fertilizer/pesticides).</li> <li>Developer will have the maximum amount of land available.</li> </ul>
<ul style="list-style-type: none"> <li>Designate as a park/preserve</li> </ul>	<ul style="list-style-type: none"> <li>By protecting areas, animal species will have more food and space availability increasing survival rates.</li> <li>Potential educational/environmental draw of living near a park/preserve may allow the developer to charge higher rents for the apartments.</li> <li>There is aesthetic value of the wetland and its species for the people that live there.</li> <li>The preserved wetland area will help prevent flooding.</li> </ul>
<ul style="list-style-type: none"> <li>Use of wildlife corridors</li> </ul>	<ul style="list-style-type: none"> <li>By establishing corridors, the other species will also not be as greatly affected by multiple habitat fragments.</li> <li>The animal species can continue to move back and forth for food, shelter, and reproduction by way of the habitat corridors.</li> </ul>
<ul style="list-style-type: none"> <li>Setback</li> </ul>	<ul style="list-style-type: none"> <li>By establishing setbacks, a buffer zone will be created between the development and the wetland area, filtering runoff into the wetland.</li> <li>A buffer zone will add privacy for residents between the two developments.</li> </ul>
<ul style="list-style-type: none"> <li>Project development</li> </ul>	<ul style="list-style-type: none"> <li>By developing the apartments in groups/clusters and leaving preserved wetlands, the species will not be as affected by multiple habitat fragments.</li> </ul>

**Total for part (e) 2 points**

**Total for question 2 10 points**

**Question 3: Analyze an Environmental Problem and Propose a Solution****Doing Calculations****10 points**

---

**(a) Describe** why coal is considered a nonrenewable energy source. **1 point**

Accept one of the following:

- Nonrenewable energy sources like coal exist in a fixed/finite/limited amount.
- The formation rate of coal is less than the consumption/combustion rate of coal.

---

**(b) Describe** one potential environmental advantage of replacing a coal-fired power plant with a natural-gas power plant. **1 point**

Accept one of the following:

- Natural gas combustion emits fewer greenhouse gases/less CO<sub>2</sub>.
- Natural gas combustion does not emit mercury/lead/cadmium/uranium.
- Natural gas combustion emits less NO<sub>x</sub>/SO<sub>x</sub>/reduces acid precipitation.
- Natural gas combustion produces less/no particulate matter/soot/smog.
- Transport of natural gas destroys/fragments less habitat or requires less fossil fuel use than transport of coal.
- Habitat destruction due to the impoundment of coal ash or coal slurry is negated.
- Coal extraction destroys habitat by strip mining or mountaintop removal.

---

**(c) Describe** one economic advantage of using natural gas, rather than coal, in producing electricity. **1 point**

Accept one of the following:

- Transport of natural gas (in pipelines) costs less than transport of coal (by rail).
- Natural gas (methane) harvested from a decomposition reaction (landfills, wastewater treatment plants, biodigesters) costs less than coal.
- There are fewer health-related issues linked to the burning of natural gas than are linked to burning coal, leading to lower health care costs for individuals or society as a whole.
- There are fewer pollution controls needed for a natural gas powerplant, decreasing the cost of operation/construction/permitting.
- There are lower combustion-residue disposal costs from the operation of natural gas burning powerplants than from coal-burning power plants.
- Natural-gas-burning power plants are much more efficient (more electricity output from the same energy input) than coal-burning power plants leading to lower fuel costs.



- (d) When natural gas is used to heat homes, it can produce carbon monoxide gas, which can lead to carbon monoxide poisoning in humans. **Propose** a solution to reduce the incidence of carbon monoxide poisoning in humans. **1 point**

Accept one of the following:

- Install/use/replace/update carbon monoxide detectors/alarms/sensors or replace the batteries within these devices.
- Perform regular maintenance on natural gas furnaces to ensure that minimal carbon monoxide is created or that the combustion products are properly vented/exhausted to the building exterior.
- Create laws or regulations that mandate that carbon monoxide detectors must be installed in all homes of any type.
- Use PSA's, billboards, or other methods to inform/educate the public about carbon monoxide poisoning.
- Change the home heating system to a method that does not include the combustion of a fuel that may produce carbon monoxide.

- (e) **Calculate** the percent change in the average annual PM<sub>2.5</sub> concentration in the air from 1990 to 2016. **Show** your work. **1 point**

One point for the correct setup (must include units and multiplication by 100 to yield a true percentage) to calculate the percent change:

- $$\frac{(188 \mu\text{g}/\text{m}^3 - 85 \mu\text{g}/\text{m}^3)}{85 \mu\text{g}/\text{m}^3} \times 100$$

One point for the correct calculation of the percent change: **1 point**

- 121%
- 120%
- 121.2%

**Total for part (e) 2 points**

- (f) Trees can remove PM<sub>2.5</sub> from the atmosphere when particulates settle on the leaves and are subsequently washed onto soil by rain. The average annual removal of PM<sub>2.5</sub> is 2.3 kilograms per hectare. **Calculate** the decrease in PM<sub>2.5</sub> removal in kilograms if logging reduced a forested area from 50,000 hectares to 43,000 hectares. **Show** your work. **1 point**

One point for the correct setup (must include units) to calculate the number of kilograms of PM<sub>2.5</sub>:

- $$(50,000 \text{ ha} - 43,000 \text{ ha}) \times \frac{2.3 \text{ kg}}{\text{hectare}}$$
- $$50,000 \text{ ha} \times 2.3 \text{ kg/ha} = 115,000 \text{ kg}; 43,000 \text{ ha} \times 2.3 \text{ kg/ha} = 98,900 \text{ kg}$$
  
$$115,000 \text{ kg} - 98,900 \text{ kg}$$

---

One point for the correct calculation of the number of kilograms of PM<sub>2.5</sub>: **1 point**

- 16,100 kilograms of PM<sub>2.5</sub>
- 16,000 kilograms of PM<sub>2.5</sub>

---

**Total for part (f) 2 points**

**(g)** Research has shown that hospital admissions for cardiovascular problems increase 1% with every 10% increase in PM<sub>2.5</sub> concentration. A city experienced a 23% increase in PM<sub>2.5</sub> concentration and had 7,390 hospital admissions for cardiovascular issues over a one-year period. **Calculate** the anticipated increase in the number of hospital admissions for cardiovascular issues during the next year if the PM<sub>2.5</sub> concentration continues to rise at an identical rate. **Show** your work. **1 point**

Research has shown that hospital admissions for cardiovascular problems increase 1% with every 10% increase in PM<sub>2.5</sub> concentration. A city experienced a 23% increase in PM<sub>2.5</sub> concentration and had 7,390 hospital admissions for cardiovascular issues over a one-year period. **Calculate** the anticipated increase in the number of hospital admissions for cardiovascular issues during the next year if the PM<sub>2.5</sub> concentration continues to rise at an identical rate. **Show** your work.

One point for the correct setup to calculate the increase in hospital admissions:

- $\frac{0.23}{0.10} \times 0.01 \times 7,390$  admissions
- $\frac{0.23}{0.10} \times \frac{1}{100} \times 7,390$  admissions
- $\frac{23\%}{10\%} \times 1\% \times 7,390$  admissions

---

One point for the correct calculation of the increase in hospital admissions. **1 point**

Accept one of the following:

- 169 more admissions
- 170 more admissions

---

**Total for part (g) 2 points**

---

**Total for question 3 10 points**