

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

(a) Based on the data in the graphs, **identify** the amount of land required to produce 1 kilogram of chicken protein. **1 point**

- 50 m²

(b) Based on the information provided, **identify** the type of survivorship curve exhibited by the darkling beetle. **1 point**

- Type III

(c) **Explain** why the reproductive strategy of the darkling beetle is an advantage for using mealworms as an alternative protein source for the rapidly growing human population. **1 point**

Accept one of the following:

- Darkling beetles reproduce quickly, which allows for a large amount of protein to be produced in a short period of time.
- Darkling beetles have many offspring, which allows for a large amount of protein to be produced in a short period of time.

(d) Based on the data in the graphs, **explain** whether producing 1 kilogram of chicken protein or 1 kilogram of pork protein would cause less environmental damage. **1 point**

Accept one of the following:

- Chicken production has a lower global warming potential than pork production, so it would cause less environmental damage because chicken production releases less greenhouse gas.
- Chicken production has a lower land use than pork production, so it would cause less environmental damage because there would be less deforestation/habitat destruction/soil erosion/fossil fuel use.

(e) Based on the data in the graphs, **explain** why the production of 1 kilogram of beef protein has a different impact on global warming than the production of 1 kilogram of protein from any of the other animals studied would have. **1 point**

Accept one of the following:

- Beef has a larger impact because methane has a high global warming potential.
 - Beef has a larger impact because methane is a greenhouse gas.
 - Beef requires more land use, which results in loss of forests/habitat/grasslands leading to release of CO₂/reduction in carbon storage.
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(f)	Describe how water quality can be altered by cattle grazing that occurs near a stream or river.	1 point
	Accept one of the following:	
	• Cattle cause erosion, which increases sedimentation/turbidity in water. • Cattle feces can add nutrients/nitrogen/phosphorus to waterways. • Cattle feces may contaminate waterways with bacteria.	
(g)	Propose a solution to reduce the negative impacts on waterways that result from cattle grazing, while still allowing cattle to graze.	1 point
	Accept one of the following:	
	• Practice rotational grazing/alternate grazing parcels. • Eat a diet with less meat/beef. • Fence/barricade the riparian zone. • Provide other water sources for the cattle.	
(h)	Crop production can cause soil erosion. Describe a sustainable agricultural practice used to reduce soil erosion.	1 point
	Accept one of the following:	
	• Switch crops to perennial plants. • Plant crops on terraces. • Implement contour plowing/farming. • Use no-till farming/cover crops.	

- (i) **Justify** the use of the sustainable practice described in part (h) by describing an additional advantage, other than the reduction of soil erosion. **1 point**

Accept one of the following:

Solution proposed in (h)	Justification of solution with additional advantage other than the reduction of soil erosion
Switch to perennial plants	- Reduces the use of fossil fuels. - Reduces the cost of farming. - Increases/maintains carbon storage in soils. - Preserves habitats for organisms in soils.
Plant crops on terraces	- Allows areas to be farmed that are otherwise too steep. - Sediments and other contaminants settle out behind the terrace ridge reducing the amount of soil that runs off. - Increases groundwater absorption.
Implement contour plowing/farming	- Allows areas to be farmed that are otherwise too steep. - Increases groundwater absorption.
Use no-till farming/cover crops	- Reduces the use of fossil fuels. - Reduces the cost of farming. - Increases/maintains carbon storage in soils. - Preserves habitats for organisms in soils. - Cover crops can be used as green manure.

- (j) Crop production around the world is affected by climate change. **Describe** how crop production could be negatively affected by climate change. **1 point**

Accept one of the following:

- Crop production/yields could decrease because of:
 - Increased drought
 - Increased flooding
 - Increased insect infestation from warmer temperatures
 - Increased temperature
 - Changes in seasonal rain patterns (or temperatures)
 - Expansion of geographic range of invasive pests/species
 - Climate may be outside range of tolerance of crops

Total for question 2 10 points

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

(a) **Identify** the ecological change over time illustrated in the diagram. **1 point**

- Primary Succession

(b) **Identify** the stage in which pioneer species first appear. **1 point**

- II/2

(c) **Describe** how soil forms from stage II to stage III. **1 point**

Accept one of the following:

- Wind/rain/weather can erode the rock/parent material.
- Wind/rain can break down rocks.
- Pioneer species (lichen/algae/fungi) die off adding small amounts of organic material.
- Pioneer species (lichens/algae/fungi) help break down rocks.

(d) **Identify** a cultural ecosystem service that may be provided by a mature forest. **1 point**

Accept one of the following:

- Recreation
- Aesthetic enjoyment
- Spiritual use
- Ecotourism
- Education

(e) **Identify** a testable hypothesis being investigated by the researchers. **1 point**

Accept one of the following:

- The removal of trees/clear-cutting will lead to an increase/decrease in water quality (temperature/turbidity/dissolved oxygen).
- The removal of trees/clear-cutting will have no effect on water quality (temperature/turbidity/dissolved oxygen).
- Water quality (temperature/turbidity/dissolved oxygen) will increase/decrease between stations.
- Water quality (temperature/turbidity/dissolved oxygen) will not change between stations.

(f) **Identify** the independent variable in the experiment. **1 point**

Accept one of the following:

- Presence or absence of clear-cutting
- Intact or clearcut forest
- Location of stream monitoring stations

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- (g)** **Describe** the purpose of forest A in the experiment. **1 point**
- Accept one of the following:
- Forest A/It is included so the researchers can compare the temperature/turbidity/water quality in clear-cut areas (forest B) to intact areas.
 - Forest A/It acts as a control so researchers can compare intact areas/Forest A to clear-cut areas/Forest B.
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- (h)** **Explain** why the water temperature might change because of clear-cutting trees in forest B. **1 point**
- Accept one of the following:
- Water temperature will increase because there will be no/fewer trees to block the sunlight.
 - Water temperature will increase because there will be additional sediment from erosion.
 - Water temperature will increase because more sunlight will reach the water surface.
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- (i)** **Explain** why an indicator of water quality other than temperature could be altered by the golf course in forest B. **1 point**
- Accept one of the following:
- There could be a decrease in dissolved oxygen because fertilizer runoff leads to algal blooms/eutrophication.
 - There could be a decrease in sedimentation/turbidity because the grass will decrease erosion compared to the clear-cut land.
 - There could be an increase in nitrates/phosphates due to fertilizer runoff resulting in algal growth/bloom.
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- (j)** **Explain** how the aquatic organisms living in the lake illustrated in the diagram of forest B are likely to be affected by the new golf course. **1 point**
- Accept one of the following:
- Aquatic organisms would die off from a lack of oxygen created by the decomposition of algae/eutrophication.
 - Aquatic organisms would survive at a higher rate because there is less sediment to suffocate them/clog their gills.
 - Aquatic organisms would die off due to increased toxicity from pesticide runoff.
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Total for question 1 10 points

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

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- (a) Based on the information given, **identify** a body of water invaded by Asian carp that is labeled on the map. **1 point**

Accept one of the following:

- Mississippi River
- Lake Erie
- Missouri River
- Ohio River

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- (b) Based on the information shown in the map, **describe** the change in the distribution of Asian carp since their introduction in the 1970s. **1 point**

Accept one of the following:

- They are more widely distributed/found in most of the watershed/in a larger area than they were in the 1970s.
- They have moved up/down the Mississippi river.
- They have moved up the Missouri River/Ohio River.
- They have moved northwest and northeast up the rivers.

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- (c) **Describe** one impact the introduction of Asian carp could have on the ecosystem services provided by the Great Lakes region. **1 point**

Accept one of the following:

- Improved drinking water quality as carp consume algae.
 - Decreased recreational opportunities (boating/swimming) from the increased population of carp in the water interfering with activities.
 - Decreased fishing due to carp outcompeting native fish species.
 - Decreased drinking water quality as carp displace filter feeders like native mussels in the food chain/web.
 - Decreased algae population resulting in decreased photosynthesis and increased greenhouse gases/global warming/climate change.
 - Decreased algae population resulting in decreased photosynthesis and decreased oxygen production.
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- (d) Propose** a realistic solution to help reduce the spread of the Asian carp from their current distribution. **1 point**

Accept one of the following:

- Offer incentives for fishers to catch and kill carp.
- Encourage consumption of carp.
- Build fencing/netting between waterways.
- Use shock treatment (dispersal barrier system).
- Create/Use an Asian-carp specific poison/deterrent (carpicide, CO₂, microparticles).
- Implement high-frequency sound deterrent system.
- Prohibit transfer of bait or ballast water from one body of water to another.

- (e) Justify** the solution proposed in part (d) by providing an additional advantage. **1 point**

Accept one of the following:

Solution proposed in part (d)	Justification of solution with additional benefit
Build fencing/netting between waterways.	• Create jobs in the Great Lakes fishing industry.
Create/Use an Asian-carp specific poison/deterrent (carpicide, CO ₂ , microparticles).	• Little to no harm to native animal/plant populations in watershed.
Implement high-frequency sound deterrent system.	• Reduce negative impacts carp have on the feeding relationships in the Mississippi/Great Lakes watershed.
Use shock treatment (dispersal barrier system).	• Maintain revenue for existing fishing industry/tourism of Great Lakes.
Encourage consumption of carp.	• Increase revenue in the Great Lakes fishing industry/sale of carp. • Reduce negative impacts carp have on the feeding relationships in the Mississippi/Great Lakes watershed. • Provide new food source (domestically/internationally)/combat hunger issues worldwide. • Allow the return of native species resulting from less competition from the Asian carp.

Offer incentives for fishers to catch and kill carp.	• Create jobs in the Great Lakes fishing industry. • Increase revenue from the sale of Asian carp. • Reduce negative impacts carp have on the feeding relationships in the Mississippi/Great Lakes watershed. • Provide new food source (domestically/internationally)/combat hunger issues worldwide. • Allow the return of native species resulting from less competition from the Asian carp.
Prohibit transfer of bait or ballast water from one body of water to another.	• No harm to native animal/plant populations in watershed. • Reduce negative impacts carp have on the feeding relationships in the Mississippi/Great Lakes watershed. • Maintain revenue for existing fishing industry/tourism of Great Lakes.

- (f) **Identify** the primary consumer in the Great Lakes food chain. **1 point**
- Zooplankton
- (g) **Describe** what the arrows in the aquatic food chain represent. **1 point**
- Accept one of the following:
- The flow of energy/energy flow.
 - The flow of matter/matter flow.
- (h) **Describe** one possible effect of the introduction of the Asian carp on the Great Lakes food chain. **1 point**
- Accept one of the following:
- There will be fewer zooplankton/macrobenthos/yellow perch/rainbow trout.
 - There will be less food for other species at the same trophic level on the food chain.
 - There will be less food for species that don't eat carp and are higher on the food chain.

(i) **Describe** one way that overfishing of blue pike illustrates the tragedy of the commons. **1 point**

Accept one of the following:

- The blue pike are a shared resource that were depleted/went extinct due to unregulated access.
- The blue pike are a common resource that were depleted by fishers, maximizing profits/catching as many as possible.

(j) One potential solution to reduce overfishing is to use aquaculture. **Describe** one disadvantage of this solution. **1 point**

Accept one of the following:

- Aquaculture contaminates water with excess organic waste/antibiotics.
- Fish that escape from facilities compete or breed with wild fish.
- Fish in aquaculture facilities can spread diseases to wild fish.
- The high density of fish in aquaculture facilities can lead to increased disease.
- Loss of jobs in the fishing industry.
- Excess pressure on fisheries/wild stocks used to create food pellets.
- Decrease in genetic diversity of farm raised fish.
- Habitat degradation from conversion of ecosystems to fish farms.
- Overuse of antibiotics in farmed fish (create antibiotic resistant bacteria that can be harmful to humans).

Total for question 2 10 points