

AP[®] ENVIRONMENTAL SCIENCE

2010 SCORING GUIDELINES

Question 3

(a) Why are zebra mussels located primarily in areas in the eastern United States rather than in the western United States?

One point can be earned for any acceptable explanation:

- The animal was introduced in the eastern U.S. and is still spreading across the continent.
- The eastern states have more surface waters available for colonization and to act as corridors to dispersal; the western states have fewer such habitats.
- The western mountain ranges (e.g., the Rockies) serve as a natural barrier to dispersal.
- Humans spread the animal, and human population density is generally higher in the East.

(b) How are zebra mussels introduced into isolated lakes? Describe one viable method for preventing the spread of zebra mussels into isolated lakes.

Two points can be earned: 1 point for a mechanism by which the mussels are spread and 1 point for a method to prevent mussel introductions. The two responses need not be linked.

Mechanisms of zebra mussel introduction

- Transport of boats or boat trailers with mussels attached
- Carried in water in boats (excluding ballast, which implies oceangoing vessels)
- Inundation of isolated lakes with floodwater containing mussels
- Building canals or other waterways between previously isolated lakes
- Transport by animal vectors (migratory waterfowl, etc.)
- Brought with fish used to stock water bodies

Methods to prevent spread of zebra mussels

- Thorough inspection/cleaning of boats before transport or launch
- Flushing or draining of water between water bodies
- Refraining from building connecting waterways
- Education/information campaigns to discourage practices causing spread
- Prohibiting transport of boats to unaffected lakes

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Question 3 (continued)

(c) Identify and explain one impact that zebra mussels can have on aquatic ecosystems.

One point can be earned for naming an impact, and 1 point can be earned for an appropriate explanation. The identification and explanation must be linked.

Impact on Ecosystem	Explanation
Increased water clarity/transparency	Mussels are filter feeders, removing solids from water as they feed.
Increased light penetration in water column	Remove suspended matter from water.
Increased photosynthesis/primary productivity	Results from increased water clarity.
Increased populations of other species (certain fish, waterfowl, etc.)	Results either from greater primary productivity (base of trophic pyramid) or greater ability of fish that are visual feeders to see their prey.
Competition from zebra mussels for available resources	Decreased populations of other species (mollusks, insects, etc.).
Decreased populations of other species (mollusks, insects, etc.)	Competition from zebra mussels for available resources.
Altered water chemistry	Mussels change biogeochemistry through filtering and digestion of food; shells sequester/store minerals.
Disrupts food chains/trophic dynamics	Eats food required by other species.

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Question 3 (continued)

(d) Identify another invasive species, either terrestrial or aquatic, and describe one negative impact it has had.

One point can be earned for naming a species, and 1 additional point can be earned for an appropriate explanation of its impact. The identification and explanation must be linked.

Acceptable examples include:

Invasive Species	Negative Impact
Cane toad	Toxin kills native predators.
Rats	Eat bird's eggs; spread disease.
Purple loosestrife	Crowds out native plant species in wetlands.
(Eurasian) water milfoil	Crowds out native plants, clogs waterways.
Snakehead fish	Preys on native fish, reducing populations.
Rabbits	Clear vegetation.
Kudzu vine	Smothers other vegetation.
Emerald ash borer	Burrowing and feeding kill trees.
Sea lamprey	Predation harms other fish.
Nutria	Eats marsh vegetation, destroying wetlands.
(Brazilian) pepper tree	Tissues are toxic; shades out other plants.
Pythons, constrictors	Eat native species, lowering populations.
Japanese/Asian beetles	Eat native plant species.
Pigeon/rock dove	Nuisance in cities; vectors of disease.
(European) starlings	Compete with native birds for nest sites.
Feral domestic animals (e.g., boar, cat)	Predators of native species.
Ice plant	Competes with native plant species.
Africanized ("killer") bees	Attacks people/animals; displaces honeybees.
Boll weevil	Important crop pest.

Note: A correct response must identify a specific organism. General categories of biota (e.g., "snakes") are not acceptable.

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Question 3 (continued)

- (e) **One strategy for controlling an invasive species has been to introduce another nonnative species to control it; this strategy can often have unintended results. Give a specific example of the use of this strategy and discuss a negative impact of introducing a nonnative species to control an invasive species.**

One point can be earned for identifying a specific example of biological control, and 1 additional point can be earned for an appropriate explanation of a potential negative impact. The two responses need not be linked.

Acceptable examples include:

Biological Control
<ul style="list-style-type: none">• Insects (stem borers, leaf eaters) to feed on purple loosestrife• Ladybird beetles (ladybugs) to feed on pest insects• Parasitoid wasps to control weevils• Bacteria (e.g., Bt) or viruses to control animal pests• Mongoose to hunt rats• Cane toads to prey on insect pests
Negative Impact
<ul style="list-style-type: none">• Predation of nontarget species• Competition with native species• Toxic to native predators, or reduces available food to native predators• Alters ecological interactions, e.g., food webs or biogeochemical cycles

Note: The “specific example” cannot be hypothetical or a general prescription, e.g., “introduce a predator of agricultural pests.”

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Question 3 (continued)

(f) Discuss TWO specific characteristics of invasive species that enable them to thrive in new environments.

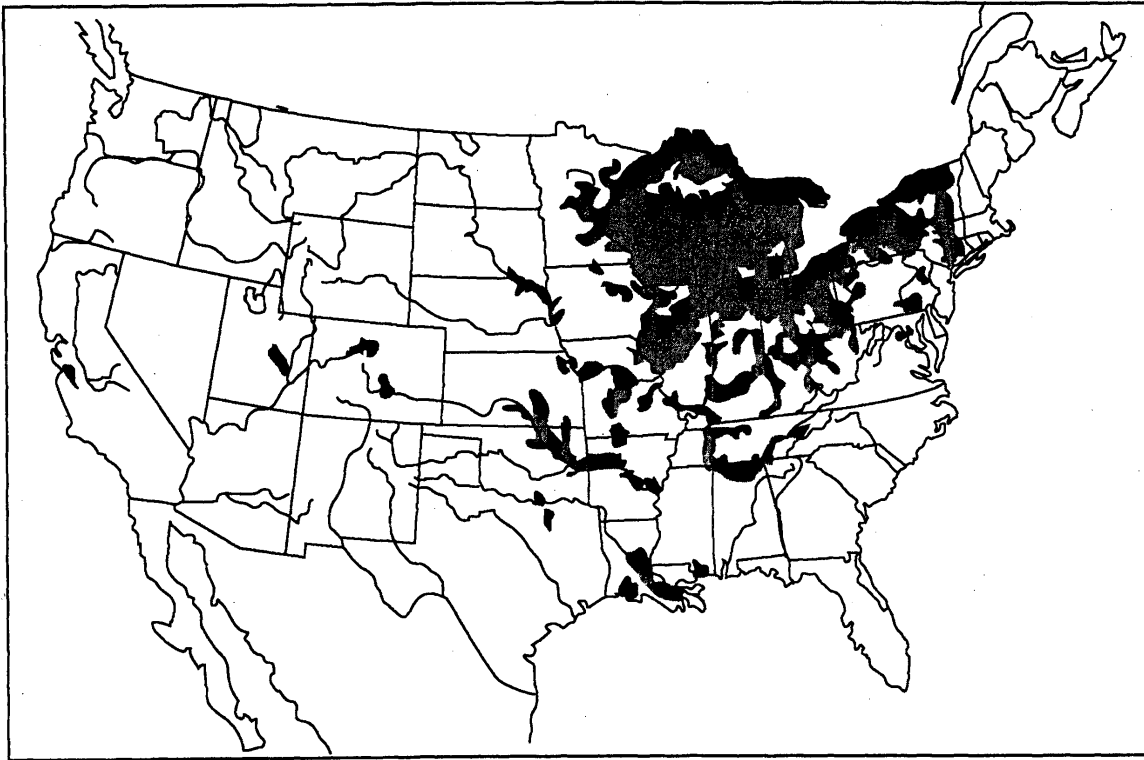
Two points can be awarded: 1 point for each specific characteristic.

- Generalist species
- Excellent dispersal mechanisms, allowing it to spread
- R-selected or r-strategist

OR any of the following characteristics:

- Large clutch size/many offspring produced
- Early onset of reproduction/early maturation
- Frequent reproduction
- Superior defenses against predators in new environment
- Superior skills as a predator in new environment

Note: Listed characteristics must be specific. Generic qualities or life-history strategies are not acceptable.



3. The zebra mussel, a mollusk native to Eurasia, was first discovered in the Great Lakes of North America in 1988. Zebra mussels attach to solid substrates and are filter feeders. Adult zebra mussels can survive for several days or even weeks out of water if the temperature and humidity are favorable. An adult female zebra mussel can produce as many as one million eggs per year. The recent range of occurrence of zebra mussels in the United States is indicated by shading in the map above.
- Why are zebra mussels located primarily in areas in the eastern United States rather than in the western United States?
 - How are zebra mussels introduced into isolated lakes? Describe one viable method for preventing the spread of zebra mussels into isolated lakes.
 - Identify and explain one impact that zebra mussels can have on aquatic ecosystems.
 - Identify another invasive species, either terrestrial or aquatic, and describe one negative impact it has had.
 - One strategy for controlling an invasive species has been to introduce another nonnative species to control it; this strategy can often have unintended results. Give a specific example of the use of this strategy and discuss a negative impact of introducing a nonnative species to control an invasive species.
 - Discuss TWO specific characteristics of invasive species that enable them to thrive in new environments.

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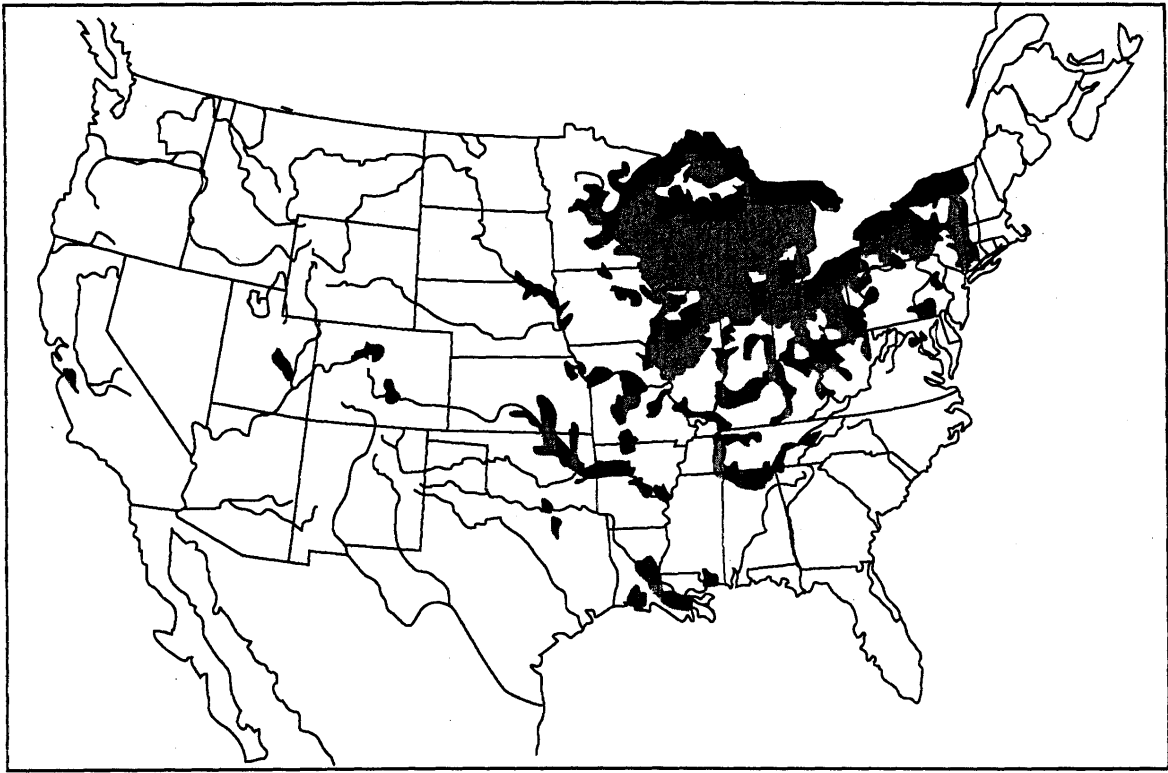
- a) Because the species was introduced into the Great Lakes, from there, it ~~can~~ spread to bodies of water connected to the Great Lakes. Most of these bodies of water are in the eastern United States, not the west.
- b) They may be carried to isolated lakes by humans traveling between bodies of water. ~~They could be~~ A human could ~~accidentally~~ accidentally pick up ~~a~~ a few of the zebra mussel eggs, and later deposit them in another lake where they hatch. To prevent this, people could wash their clothes and equipment before going to a different body of water.
- c) They could occupy the niches of native species of shellfish, ~~they~~ competing with them for resources. This could result in a decline of native shellfish populations.
- d) The Veined Rapa Whelk, which has established itself in the Chesapeake Bay, preys on shellfish in the area and competes with native whelks for resources.
- e) The Cane Toad was introduced into Australia, where it was used to control some sort of crop pest. The Cane Toad did not eat the pest, but did reproduce rapidly, establish a sizeable population in Australia, and

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compete with native amphibians for resources.

A) They are usually generalists, able to eat an array of things so they can live almost anywhere. Also, they usually reproduce quickly and in large numbers, so the population is difficult to eradicate.

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3. The zebra mussel, a mollusk native to Eurasia, was first discovered in the Great Lakes of North America in 1988. Zebra mussels attach to solid substrates and are filter feeders. Adult zebra mussels can survive for several days or even weeks out of water if the temperature and humidity are favorable. An adult female zebra mussel can produce as many as one million eggs per year. The recent range of occurrence of zebra mussels in the United States is indicated by shading in the map above.

- (a) Why are zebra mussels located primarily in areas in the eastern United States rather than in the western United States?
- (b) How are zebra mussels introduced into isolated lakes? Describe one viable method for preventing the spread of zebra mussels into isolated lakes.
- (c) Identify and explain one impact that zebra mussels can have on aquatic ecosystems.
- (d) Identify another invasive species, either terrestrial or aquatic, and describe one negative impact it has had.
- (e) One strategy for controlling an invasive species has been to introduce another nonnative species to control it; this strategy can often have unintended results. Give a specific example of the use of this strategy and discuss a negative impact of introducing a nonnative species to control an invasive species.
- (f) Discuss TWO specific characteristics of invasive species that enable them to thrive in new environments.

a) Zebra mussels are located mainly in the eastern United States because of favorable conditions. The

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Temperature is cooler in the northeast and the humidity is more favorable. Also, in the east are the largest bodies of freshwater, the Great Lakes, in the United States. The zebra mussel thrives in freshwater systems, and the east provides abundance of this. Also, the zebra mussel was introduced in the eastern part of the U.S., where it became an invasive species. It attaches to boats and is easily transported to foreign homes where it begins to take over. The mussel has yet to be introduced to the west.

b) Zebra mussels are introduced from boats where they may attach to hulls and then release themselves into the lakes. Also they can be found in the water that boats retain during long journeys. One viable method for preventing their spread is to prevent boating in the lakes, especially boats that have traveled in the sea. However, local boats can still be used as long as they have not traveled ~~anywhere~~ anywhere where zebra mussels may be found. Also, stricter boating regulations would help, forcing boaters to check their hulls and ~~also~~ captured water for signs of zebra mussels. Regulations may be more viable than ~~preventing boating~~ preventing boating, but the regulations must be ~~maintained~~ maintained and ~~enforced~~ enforced.

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c) Zebra mussels outcompete native mussels for food and habitat resources. They reproduce rapidly and consume ~~the~~ similar foods ~~that~~ that native mussels eat. Their quick reproduction allows them to colonize an aquatic ecosystem, thereby taking over. Also, they ~~lay~~ ^{produce} many eggs, so their populations grow quickly. With more zebra mussels comes a higher use of food and habitat. They take away food from native mussels, forcing the native mussels to starve and die. This decreases native mussels' populations as well as other native filter feeders. Without these native species the ecosystem is thrown off balance.

d) Another invasive species is the kudzu vine which was introduced to ~~to~~ reduce erosion, but it has taken ~~it~~ over the southern United States. It is known as "the plant that ate the south." It grows rapidly and may kill trees or destroy houses. Also, it blocks sunlight from reaching other plants, causing those plants to ~~to~~ die. It grows so rapidly that it has been known to ~~to~~ swallow houses and other buildings. This destroys people's houses and requires money to fix. The kudzu ~~to~~ vine creates economic problems because some money is needed for its ~~removal~~ removal.

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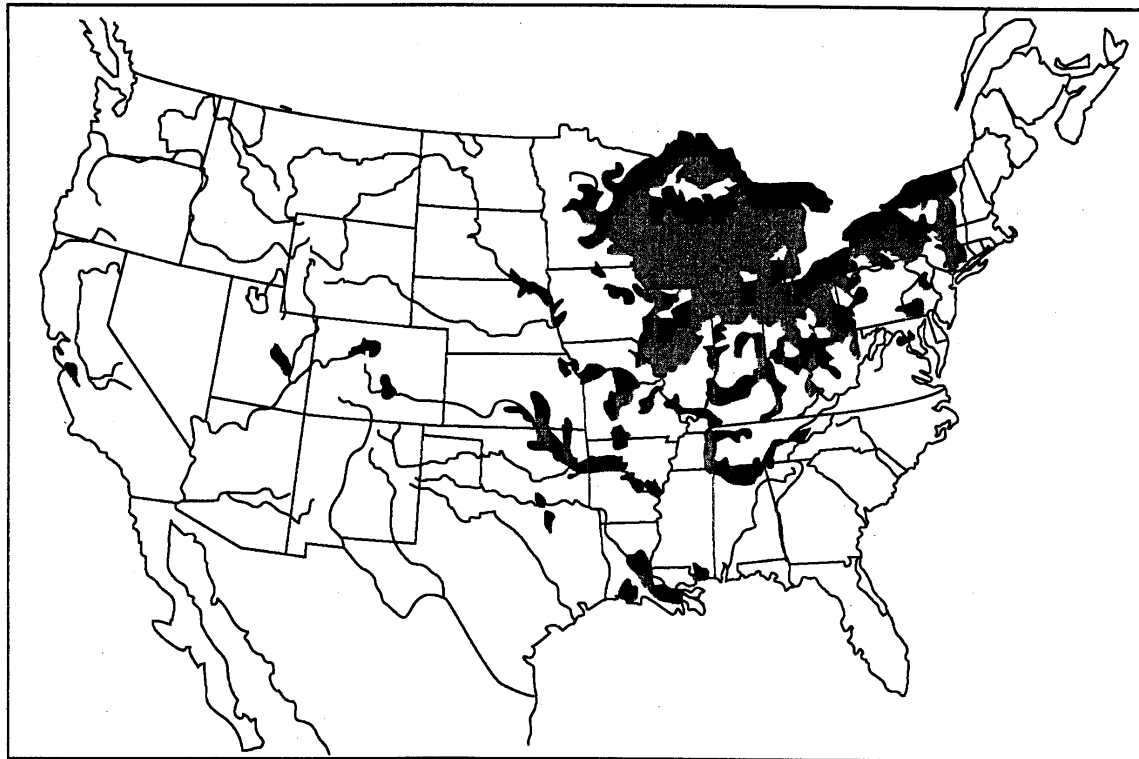
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~~Another example of this strategy is being considered in the Chesapeake Bay.~~

e) Nonnative species introduced to control invasive species may become invasive themselves. This would add to the problem rather than fix it. One example is using sea lamprey to limit trout populations. The sea lamprey has now become invasive and kills fish. Nonnative species may take away native species' food supplies and habitat spaces. Also, their populations may grow allowing them to become invasive.

f) Invasive species produce many offspring and are often generalist species. Their quick reproduction rates allow them to thrive in many places and since they are generalists they can survive in various habitats. Also, invasive species have large zones of tolerance and can survive in various conditions. They also can grow rapidly allowing them to reach reproductive ages quicker than other species. These ~~qualities~~ characteristics enable them to outcompete native species for food and habitat resources, eventually allowing them to take over.

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- (d) Identify another invasive species, either terrestrial or aquatic, and describe one negative impact it has had.
- (e) One strategy for controlling an invasive species has been to introduce another nonnative species to control it; this strategy can often have unintended results. Give a specific example of the use of this strategy and discuss a negative impact of introducing a nonnative species to control an invasive species.
- (f) Discuss TWO specific characteristics of invasive species that enable them to thrive in new environments.

a) Zebra mussels are located in Eastern United States because they haven't been successfully introduced to other areas in the US since

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- are not many large bodies of still water in the western US.
- b) The zebra mussels were introduced into the isolated lakes by brackish water that was located on the bottom of boats that entered the lakes through the rivers when they came to the great lakes to trade. The water & bottom of the boats were contaminated by the mussel & were introduced into the lake during international trade.
- c) zebra mussels have impacted the aquatic ecosystem because they create more competition among native species. They consume food & land of native species, causing those species to die off & create an imbalance of the ecosystem.
- d) Another invasive species is the Brown Snake of Guam that was introduced during international trading. This snake had no competition thus allowing it to decimate populations of organisms on the island & reproduce at alarming rates. It had no enemies either so the population kept growing & ruined the rodent pops of Guam.
- e) An example of this strategy is when a ^{brown} trout was introduced to a lake to control the population of a certain fish that fed on algae that was introduced into the system. However, the brown trout became too big & completely ruined the pond because they had no predators. If a nonnative species is introduced they soon will become as big of a problem as the invasive species because they will not have any competition or predators to control their population, allowing them to become a problem.
- f) Two characteristics of invasive species that cause them to become a problem is that they have no predators to keep their

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populations in check if they have a high reproduction rate. Since the species have no predators, they become the top predator & have no risks of being killed or controlled. This leads to rapid population growth. High reproduction rates are characteristic of these species because they have no other organism that would destroy their young.

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2010 SCORING COMMENTARY

Question 3

Overview

This question afforded students an opportunity to demonstrate knowledge about a well-known invasive species, the zebra mussel. In addition to asking for basic information about the introduction of the zebra mussel and its effects on the ecosystem, the question asked students to consider more broadly the question of what makes a species invasive, and how humans have changed ecological dynamics through introductions and biological control measures. Notably, the question asked students to provide specific examples, thereby demonstrating the diversity in content across AP classrooms as teachers utilize local or regional examples in many cases.

Sample: 3A

Score: 10

This response earned the maximum of 10 points. In part (a) the student clearly states that “[m]ost of these bodies of water are in the eastern United States,” which clearly explains the zebra mussels’ prevalence in the region.

In part (b) the student refers to transport of zebra mussel eggs and to preventative measures, earning 2 points.

In part (c) the student mentions competition with native species for resources, earning 1 point, and notes the “decline of native shellfish populations,” which earned a second point.

Part (d) includes a real-life example (veined rapa whelk) and its effect as a predator, earning 2 points.

The reference to the cane toad in part (e) earned a point, as did the acceptable description of its impact on native amphibians.

Two points were earned in part (f): 1 point for stating that invasive species “are usually generalists” and 1 point for stating that “they usually reproduce quickly and in large numbers.”

Sample: 3B

Score: 8

In part (a) the student refers to atmospheric conditions that are not germane to the discussion of this aquatic species, earning no point. The subsequent mention of freshwater bodies is correct, but only the first response was scored.

The student earned two points in part (b): 1 point for stating that mussels “attach to hulls” of boats and 1 point for suggesting that a ban on outside boats entering a lake will address this problem.

In part (c) the student states that zebra mussels “outcompete native mussels for food and habitat resources,” earning 1 point, and later mentions that “[t]his decreases native mussels’ populations,” earning an additional point.

The kudzu vine example in part (d) earned 1 point, and an additional point was earned for stating that the species kills trees.

The description of sea lamprey as a biocontrol in part (e) is incorrect and earned no points.

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Question 3 (continued)

In part (f) 1 point was earned for mentioning that “[i]nvasive species produce many off spring” (high reproductive rate), and a second point was earned for pointing out that they “are often generalist species.”

Sample: 3C

Score: 6

The student earned one point in part (a) for implying that the eastern U.S. has more bodies of still water: “Zebra mussels are located in Eastern United States because they haven’t been successfully introduced to other areas ... since [there] are not many large bodies of still water in the Western US.”

Part (b) earned no points as it does not address the question of freshwater organisms.

Part (c) earned 1 point for mentioning competition for food and a second point for the impact (loss of native species).

In part (d) the description of the brown snake of Guam as an invasive species earned 1 point, and the explanation of its predation lowering small mammal populations earned another point.

Part (e) does not contain a valid example and earned no point.

Part (f) earned 1 point for citing “a high reproduction rate,” but having “no predators” is not a characteristic of a species (it is a characteristic of the community it invades), so the second example earned no point.