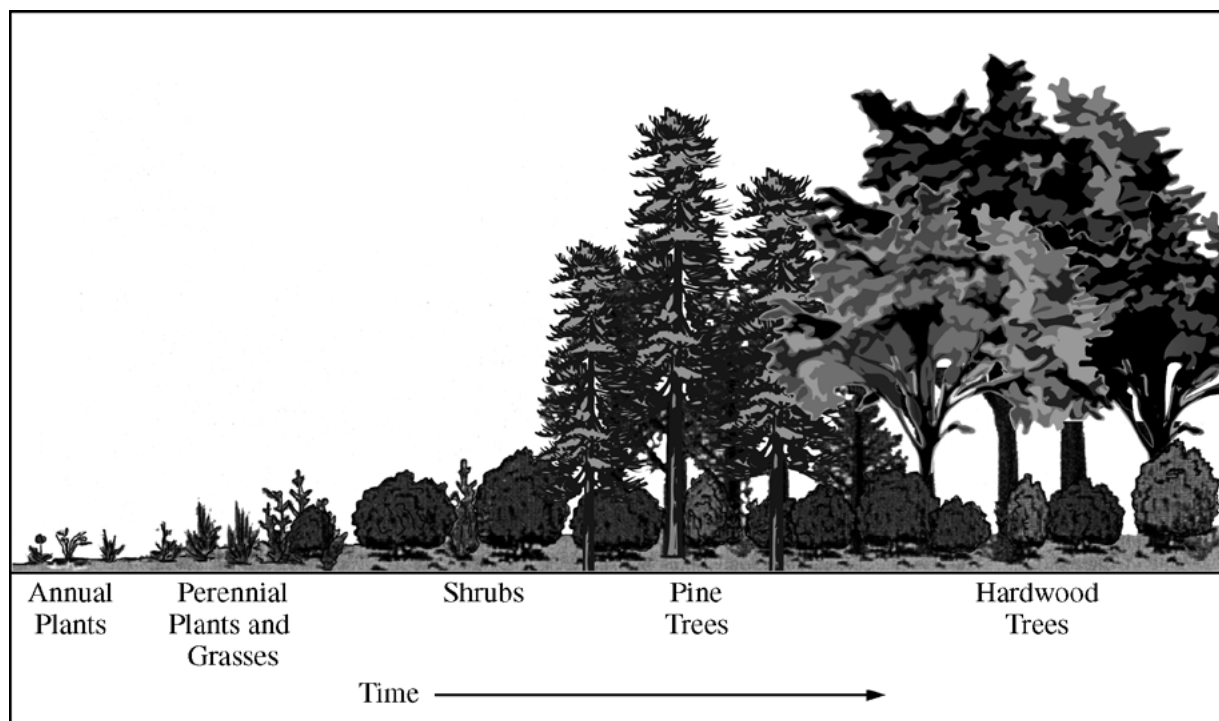


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Question 4



The diagram above shows the succession of communities from annual plants to hardwood trees in a specific area over a period of time.

- (a) **Discuss** the expected changes in biodiversity as the stages of succession progress as shown in the diagram above. **(2 points maximum; 1 point per bullet)**

Cannot simply list the organisms depicted (shrubs → gymnosperms → angiosperm hardwoods)

- Biodiversity increases (plants, animals, decomposers).

Explanation of why biodiversity increases/changes are observed:

- Some populations *facilitate* biodiversity/succession (by developing conditions more suitable for other species and/or developing conditions less suitable for their progeny).
- Some populations *inhibit* biodiversity/succession (by developing conditions less suitable for other species and/or developing conditions more suitable for their progeny).
- Increase in plant stratification (increased layering of plants; e.g., canopy, understory).
- More *niches/habitats* formed (plants, animals, decomposers).
- Pioneer plant species → dominants (more shade-tolerant plants emerge).
- Increase in producer diversity brings about increase in consumer diversity.

Other:

- Shift from more opportunistic (*r*) to more equilibrium (*k*) species.

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Question 4 (continued)

- (b) **Describe** and **explain** THREE changes in abiotic conditions over time that lead to the succession, as shown in the diagram above. **(6 points maximum)**

It is not enough to say the condition (e.g., light, temperature, humidity) changes. The description/explanation must be of a directional change (increase/decrease) in abiotic conditions and must be of a type that would lead to the changes shown in the diagram.

*The following list is not exhaustive. **(2 points maximum per abiotic condition — i.e., any two cells from a single row below)***

Description of change in abiotic condition (1 point)	Explanation (why abiotic condition changes) (1 point)	Explanation (why it enhances succession) (1 point)
Increase in soil quantity	More detritus increases humus; decreased erosion because more plants hold soil in place.	Provides more anchoring for plants.
Improvement in soil quality	Soil gains organic matter (humus).	Provides more nutrients for plant growth.
More N available to ecosystem	Caused by decomposition and/or by nitrogen fixation.	Favors plants with higher nitrogen needs.
More P available	Caused by decomposition.	Favors plants with higher phosphorus needs.
Increase in water retained in soil	Increased organic matter retains water; increased shading reduces evaporation from the soil.	More water is available for plants.
Decrease in pH of soil	Acids released during decomposition lower pH.	Mobilizes cations facilitating mineral uptake (e.g., Fe ⁺⁺ , Ca ⁺⁺); favors acid-tolerant plants.
Increase in pH of soil	Soil gets more basic with increase in ammonia (NH ₃).	Favors plants with higher N requirement; favors alkaline-tolerant plants.
Decrease in light availability	Caused by shading.	Increased shading favors shade-tolerant species; inhibits shade-intolerant species.
Decrease in temperature	Caused by shading.	Favors species that are not heat tolerant; inhibits plants needing higher temperatures.
Higher humidity	Caused by more transpiration.	Facilitates transition from relatively xerophytic plants to more mesophytic plants.

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Question 4 (continued)

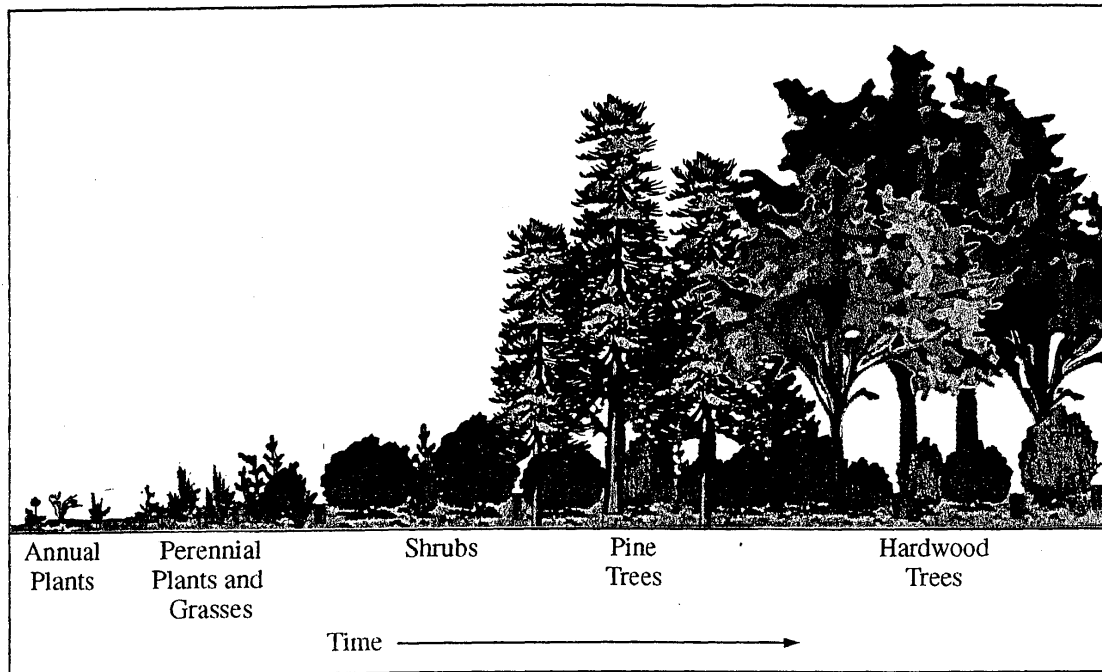
(c) For each of the following disturbances, **discuss** the immediate and long-term effects on ecosystem succession. **(4 points maximum)**

- (i) A volcano erupts, covering a 10-square-kilometer portion of a mature forest with lava.
- (ii) A 10- square-kilometer portion of a mature forest is clear-cut.

- **1 point** for time *comparison* that primary succession takes longer than secondary succession
- **1 point** per box

	Immediate	Long-term
i. Volcano erupts	<ul style="list-style-type: none"> • Primary succession/no soil. 	<ul style="list-style-type: none"> • Lava must be degraded by weathering, microbes, lichens, fungi to form soils. • Lots of light is available (photophilic organisms will thrive when soil is present).
ii. Mature forest is clear-cut	<ul style="list-style-type: none"> • Secondary succession/ soil present. • All life is not destroyed. • Seed banks are present. • Different/other habitats/ niches open/close. 	<ul style="list-style-type: none"> • Loss of trees may lead to erosion and soil loss. • Lots of light is available. • Many smaller plants actually benefit.

Note: A student must earn points from all three sections to earn the full 10 points on the question.



4. The diagram above shows the succession of communities from annual plants to hardwood trees in a specific area over a period of time.
- Discuss** the expected changes in biodiversity as the stages of succession progress as shown in the diagram above.
 - Describe** and **explain** THREE changes in abiotic conditions over time that lead to the succession, as shown in the diagram above.
 - For each of the following disturbances, **discuss** the immediate and long-term effects on ecosystem succession.
 - A volcano erupts, covering a 10-square-kilometer portion of a mature forest with lava.
 - A 10-square-kilometer portion of a mature forest is clear-cut.

a. In the beginning, small plants, such as nitrogen fixers arrive, and over time, as richer soil builds up, bigger plants start arriving. Eventually trees and then hardwoods. As the plant biodiversity builds up, so does the diversity of the animal population. It starts with insects or small rodents, and as the ecosystem supports more life, bigger and more animal species show up. The biodiversity builds upon itself.

b. ~~Describe~~ The first factor is the amount of nitrogen in the soil. To start, there might not be any nitrogen, but as the amount of nitrogen increases,

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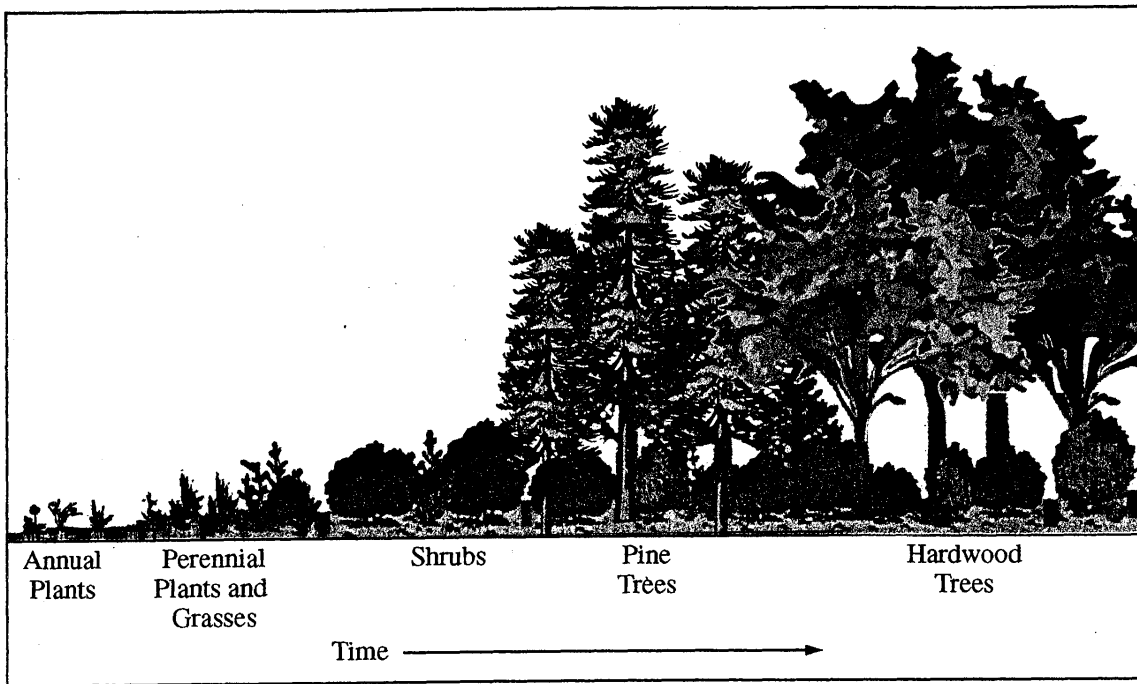
ADDITIONAL PAGE FOR ANSWERING QUESTION 4

the succession progresses. The initial plants and bacteria work to add nitrogen to the soil. This is the nitrogen used by later plants. Another factor is the soil level. The initial plants die and decompose to make soil, as the succession progresses, more plants die, making more soil. This allows the success to move onto more plants, which in turn add to the soil. ~~Another~~ The third factor is sunlight. As ~~the~~ bigger plants and eventually trees grow, they crowd out smaller plants from earlier in the progression. These plants cannot survive w/o sunlight and die out.

C. i This is an example of primary succession. There is no soil or anything for plants to grow, so the first things in the succession are lichen and things which don't use soil or roots. These build up a tiny soil layer as nitrogen fixers and plants to build soil. This succession will take a long time to reach completion because it starts with nothing.

ii This is an example of secondary succession. The plants were simply removed. Because the trees are gone, there may be some erosion. But because it isn't starting with nothing ~~there~~ succession might start with grasses or small scrubs.

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 - A volcano erupts, covering a 10-square-kilometer portion of a mature forest with lava.
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A) Biodiversity is the number of different species existing in a particular area. As the stages of succession progress, the biodiversity is expected to increase since new species are appearing while the previous ones still remain.

B) As primitive species colonize the area, they increase the fertility of the soil as they become decaying matter and leave minerals behind. This allows species that are more selective of their environment to come into the area. The amount of water available is also an important part of

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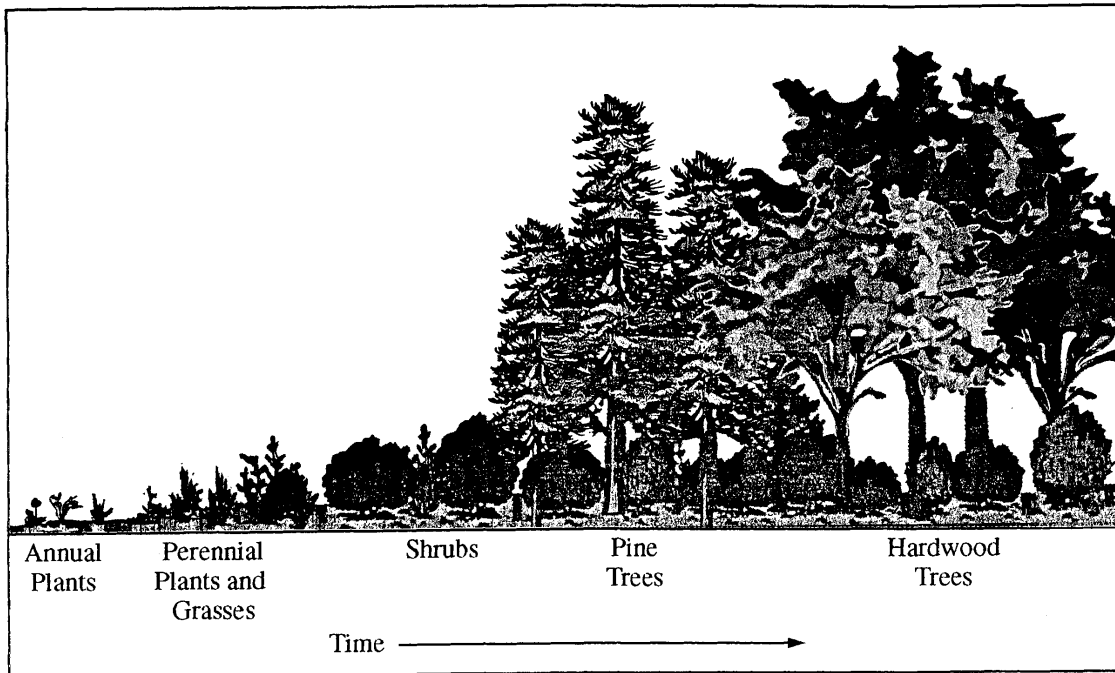
ADDITIONAL PAGE FOR ANSWERING QUESTION 4

succession, since more complex organisms usually require more water. Annual/perennial plants and grasses prevent water run-off, keeping it trapped in the soil. This allows larger plants, such as shrubs and trees, to ~~move~~ ^{move} onto the land. Another factor that plays an important role in succession is the availability of sunlight. Sunlight is required for plants to carry out photosynthesis and larger/more complex plants require more sunlight.

C) I) A volcano eruption would eliminate all life in the area, making it nothing but bare rock. A volcanic eruption would lead to primary succession, where there is no soil present. Over time, the area would become home to primitive species, such as lichen, and succession would occur slowly.

II) Clear-cutting a portion of a forest would only eliminate some species, leading to secondary succession. Succession would occur more rapidly than in scenario I because the soil remains and simple plant species do too.

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 - For each of the following disturbances, **discuss** the immediate and long-term effects on ecosystem succession.
 - A volcano erupts, covering a 10-square-kilometer portion of a mature forest with lava.
 - A 10-square-kilometer portion of a mature forest is clear-cut.

A) With each stage of succession, new plants begin to grow ~~around~~ in the specific area. First, simple organisms like lichen and mosses move into the area. These organisms make the area habitable for more complex species, the annual plants. The annual plants die by the season, but the remaining nutrients make the soil more capable for plant growth. Thus, shrubs begin to grow in the specific area. These shrubs also

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ADDITIONAL PAGE FOR ANSWERING QUESTION 4

die, leaving nutrient behind. Furthermore, the shrubs begin to attract herbivores to the area. These herbivores make carbon dioxide more readily available for the plants, thus allowing for the growth of pine trees. With the pine trees come more animals, including possibly carnivores that eat the primary consumers but leave scraps behind that decompose into the soil making it more nutrient rich. Finally, hardwood trees arrive and the community has reached its climax. At this point, the area is most biodiverse.

B) Abiotic changes ultimately determine the succession in the area. First, the weather must become temperate for the succession to begin. Once this occurs, the pioneer species move into the area. With the decomposition of the simple organisms, the soil becomes more nutrient rich, the second change in abiotic conditions. Finally, once animals inhabit the area, carbon dioxide becomes more readily available for the plants.

C) i). If a volcano were to erupt and cover the a portion of a mature forest with lava, the immediate effect would be the death of the species living there. Primary succession would then begin with the migration of lichen into the area.

(ii) If the same section of the mature forest was

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4C3

ADDITIONAL PAGE FOR ANSWERING QUESTION 4

Clear cut, the immediate result would be the death
of the trees and shrubs. However, secondary
succession would soon occur because the soil
still remained after the event.

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Question 4

Overview

The diagram and caption in this question showed the ecological succession of plant communities from annual plants to hardwood trees in a specific area over a period of time. In part (a) students were expected to demonstrate an explanation of changes in biodiversity as succession proceeds based on the diagram given. In part (b) students were asked to describe and explain three changes in abiotic conditions over time, also in reference to the succession shown in the diagram. Students were expected to describe directional changes — that is, increases or decreases — of abiotic conditions. Part (c) provided students with the opportunity to discuss and compare the immediate and long-term effects on succession of two disturbances to a 10 km² mature forest: a volcano erupting and covering the forest with lava, and clear-cutting of the forest. In part (c) students were expected to demonstrate an understanding of the similarities and differences between primary succession and secondary succession.

Sample: 4A Score: 10

“In the beginning, small plants, such as nitrogen fixaters [*sic*] arrive, and over time, as richer soil builds up, bigger plants start arriving.” Using the diagram provided, the response immediately launches into a discussion as to how the quality of the soil improves, paving the way for larger plants, which leads to greater diversity. This earned 1 point. The student explicitly states that plant diversity increases, which earned the second point for part (a). The response also goes on to say that “[a]s the plant biodiversity builds up, so does the diversity of the animal population.” This would have earned the point for noting that an increase in producer diversity brings about an increase in consumer diversity, but the maximum 2 points for part (a) had already been earned.

In part (b) the response identifies nitrogen as a factor and states “as the amount of nitrogen increases,” which earned the directional change point. The response goes on to explain how nitrogen increases in the ecosystem (“the initial plants and bacteria . . . add nitrogen to the soil”), earning the second point for this abiotic factor. A point could have been earned for stating how nitrogen increase enhances succession (“this is the nitrogen used by later plants” and “the succession progresses”), but each abiotic factor could earn a maximum of 2 points, which had already been earned for nitrogen. The response earned a point for explaining how the soil increases (“the initial plants die and decompose to make soil”) as well as a directional change point for stating that soil quantity increases. A point was earned for explaining how a decrease in light enhances succession: “The third factor is sunlight. As bigger plants and eventually trees grow, they crowd out smaller plants from earlier in the progression. These plants cannot survive w/o sunlight and die out.” This is not a statement about population density. The response identifies the third abiotic factor as sunlight, and the loss of that factor as being detrimental to smaller plants. The response earned 5 points out of a possible 6 for part (b).

In part (c) the response earned 1 point for correctly identifying primary succession following a volcanic eruption. Another point could have been awarded for describing the key component of this type of succession — “there is no soil or anything for plants to grow” — but each conceptual scenario (volcano/immediate effects, volcano/long-term effects, clear-cut/immediate effects, clear-cut/long-term effects) earned a point, and the point for volcano/immediate effects had already been awarded for identifying this scenario as requiring primary succession. The point for long-term effects following a volcanic eruption was earned for recognizing that in the long term soil must be built up, often with the help of lichens (“the first things in the succession are lichen and things which don’t use soil or roots. These build up a tiny soil layer.”). Regarding the clear-cutting of a mature forest, a point was earned for correctly identifying this type of succession as secondary. The response could have earned a long-term effect point for stating that “because the trees are gone, there may be some erosion,” but the maximum 10 points had already been received.

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Question 4 (continued)

Sample: 4B

Score: 8

The response earned the core point that “biodiversity is expected to increase,” which was the only point earned in part (a).

In part (b) the directional change point was earned for recognizing an increase in soil quality (“they increase the fertility of the soil”), as well as an explanation point for noting how the soil quality is improved (“as they become decaying matter and leave minerals behind”). This response could also have been awarded the point for explaining how soil enrichment allows new species “to come into the area,” but the maximum of 2 points per abiotic condition had already been earned. A point was earned for explaining how plants enable soil to hold more water (“Annual/perennial plants and grasses prevent water run-off”), and the directional change point was earned for noting the increase in water retained in the soil (“keeping [water] trapped in the soil”). This response could also have received a point for explaining how more water in the soil allows larger plants to colonize (“This allows larger plants, such as shrubs and trees, to move onto the land”), but the maximum 2 points per abiotic condition had already been earned.

In part (c) the response earned a point for correctly identifying primary succession following a volcanic eruption. Likewise, the response earned 1 point for correctly identifying secondary succession following a clear-cut. The response also correctly defines primary succession as starting in the absence of any soil (“primary succession, where there is no soil present”), and secondary succession as beginning with soil (“because the soil remains”), but only 1 point per conceptual scenario box was allotted, and those points had already been earned. The response earned the time comparison point for stating that primary succession takes longer than secondary succession (“Succession would occur more rapidly than in scenario I because the soil remains”).

Sample: 4C

Score: 6

The response earned the facilitation point in part (a) for recognizing that the death of annual plants provides nutrients, which “make the soil more capable for plant growth,” facilitating the arrival of shrubs, and so forth. Had the response not gone on to discuss shrubs following annual plants, this point would not have been earned. The response earned the explanation point for discussing how producer diversity brings about consumer diversity (“Furthermore, the shrubs begin to attract herbivores to the area”).

In part (b) the response begins by discussing the weather. Weather is abiotic, but the question is clear that this succession all occurs “in a specific area,” all of which would receive the same weather, so that is not a causative factor for this succession. The response did earn a point for explaining how soil improves (“[w]ith the decomposition of the simple organisms”) as well as the directional change point for noting the improvement in soil quality (“the soil becomes more nutrient rich”). Animal movement into the area would not significantly change the CO₂ level in such an open, terrestrial biome, so no point was earned for this statement. The response thus earned 2 points for abiotic factors in part (b).

In part (c) 1 point was earned for correctly identifying primary succession following a volcanic eruption. Another point was earned for correctly identifying secondary succession following a clear-cut. Had the response not mentioned secondary succession, it would have earned the point for noting that “the soil still remained.”