

**AP<sup>®</sup> ENVIRONMENTAL SCIENCE  
2016 SCORING GUIDELINES**

**Question 4**

Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and provide ecosystem functions.

(a) **Describe** how TWO climate factors affect the rate of soil formation.

*(2 points: 1 point for each correct description of how a climate factor affects the rate of soil formation. Only the first two descriptions can earn a point.)*

Climate Factor		Effect
Temperature	High	Increases rates of biological activity (decomposition) and chemical activity – increases rates of soil formation
	Low	Decreases rates of biological activity (decomposition) – decreases rates of soil formation Increases the rate of weathering (frozen water expands, breaking rock) – increases the rate of soil formation
Precipitation/ Humidity	High	Increases biological activity and weathering – increases the rate of soil formation Increases erosion, runoff – decreases the rate of soil formation
	Low	Decreases biological activity and weathering – decreases the rate of soil formation
Wind		Can carry in particles – increases rates of accumulation Can hasten rates of soil erosion – decreases rates of accumulation

(Note: No point earned for merely identifying a climate factor.)

- (b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.
- (i) **Identify** one specific biotic component of the A horizon.
  - (ii) **Identify** one abiotic component of the A horizon.

*(2 points: 1 point for a correct identification of a specific biotic factor and 1 point for a correct identification of an abiotic factor.)*

<b>Examples of components include:</b>	
Biotic	Humus, microorganisms, bacteria, earthworms, macroinvertebrates, roots, fungi, beetles, decomposers, insects
Abiotic	Sand, silt, clay, water, air, nutrients (N,P, K compounds), decomposing parent material, minerals, rocks, pebbles

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**Question 4 (continued)**

- (c) Nitrate levels exceeding the United States Environmental Protection Agency’s primary drinking water standard have been found in the groundwater of areas with intensive agriculture.
- (i) **Identify** one agricultural practice that can lead to elevated nitrate levels in groundwater.  
(1 point for a correct agricultural practice that leads to elevated nitrate levels in groundwater.)
- Application of fertilizer
  - Improper sealing of feedlots
  - Improper construction or maintenance of animal waste lagoons
- (ii) **Describe** how the practice you identified in (c)(i) leads to elevated nitrate levels in ground water.  
(1 point for a correct description linked to the practice identified in part (c)(i).)
- Nitrates infiltrate/percolate/seep into ground water.
  - Nitrates entering surface waters that recharge aquifers (must connect surface with ground water).
- (d) Acid deposition has affected soil quality in many parts of the northeastern United States.
- (i) **Explain** one way acid deposition onto soil can affect plant health.  
(1 point for a correct explanation of one way acid deposition onto soil can affect plant health.)
- Increased soil acidity may be outside of the optimal range of tolerance for the plant, resulting in poor plant growth or death.
  - Acid can leach cations/metal ions/nutrients from soil, making them less available to plants, thus decreasing growth.
  - Aluminum is released and can be toxic to plants.
  - Acid can diminish the ability of soil to buffer, leading to poor plant growth.
  - Increased soil acidity can damage plant root systems, stressing plants.
  - Sulfur and nitrogen from acid deposition can build up to levels toxic to plants (or can fertilize the soils).
- (ii) **Describe** one method for remediating soil affected by acid deposition.  
(1 point for a correct description of a method of remediation.)
- Add crushed limestone / lime / marble dust / bone meal / crushed egg shells or oyster shells
- (e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world’s biomes. **Describe** TWO ways that climate change can degrade soil.  
(2 points: 1 point for each correct description of how a change in climate has resulted in soil degradation.)
- Increased global temperatures and decreased precipitation cause desertification.
  - Increased temperatures lead to increased evaporation of irrigation water, resulting in soil salinization.
  - Increased erosion and/or leaching can result from increased precipitation in certain areas.
  - Increased temperature can lead to faster breakdown of organic matter (less organic matter in the soil).
  - Increased temperatures and shifting climatic belts result in longer growing seasons, which can deplete nutrients from the soil.
  - Rising sea levels can result in flooding of coastal areas, leading to salinization of soil and increased soil erosion.
  - Increased temperatures can lead to soil desiccation.

4. Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.

- (a) **Describe** how TWO climate factors affect the rate of soil formation.
- (b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.
  - (i) **Identify** one specific biotic component of the A horizon.
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Resources such as soil and water can be degraded by human activities.

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- (d) Acid deposition has affected soil quality in many parts of the northeastern United States.
  - (i) **Explain** one way acid deposition onto soil can affect plant health.
  - (ii) **Describe** one method for remediating soil affected by acid deposition.
- (e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. **Describe** TWO ways that climate change can degrade soil.

A. Higher temperatures increases the rate at which organic matter decomposes, therefore increasing the rate of soil formation from humus to topsoil. Increased precipitation may cause erosion, removing soil and preventing its formation if humus from established vegetation is not present. If vegetation and humus are present, increased precipitation will increase the decomposition rate of organic matter and accelerate soil formation.

B.(i) The A horizon contains many decomposers or macroinvertebrates such as millipedes, earthworms, and pillbugs.  
 (ii) The A horizon contains plant macronutrients such as nitrogen oxides, phosphorus compounds, and potassium ions.

C.(i) Fertilizing crops with inorganic, industrial nitrates can cause elevated nitrates in groundwater.  
 (ii) After irrigation, inorganic nitrate fertilizers enter agricultural runoff into bodies of water that feed groundwater, or dissolve in water and infiltrate

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into groundwater.

D. (i) ~~Acidic~~ <sup>Acids</sup> soil leaches nutrient ions (potassium, nitrates, and phosphorus)

from the soil and withhold them from plants, and deficiencies in these macronutrients, which are the determinants of plant growth, will cause diminished growth or premature death in plants.

(ii) Adding limestone to soil can remediate acid deposition, because limestone is primarily made of  $\text{CaCO}_3$ , and  $\text{CO}_3$  is the conjugate base to the acid  $\text{H}_2\text{CO}_3$ , so it will neutralize acid in the soil.

E. Climate change is causing global sea level rise, which ~~also~~ causes salt water intrusion. When salt water moves farther inland, the salinity of soil increases beyond the tolerance of many coastal plant species. Also, climate change is increasing the frequency of severe storms, and increased occurrences of severe flooding increases erosion, removing the nutrient rich topsoil and leaving bare subsoil behind. Therefore, climate change can degrade soil by increasing its salinity and eroding topsoil.

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(i) Explain one way acid deposition onto soil can affect plant health.

(ii) Describe one method for remediating soil affected by acid deposition.

(e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. Describe TWO ways that climate change can degrade soil.

A) ① Wind erosion reduces the rate of soil formation because it blows particles of loose soil away. ② Heavy rain also reduces rate of soil formation due to rapid erosion of soil particles.

B) i. In the A horizon there are living worms that break up soil & allow plants to breathe and obtain water  
ii. Also in the A horizon, nutrients like nitrogen, phosphorus etc are found which give nutrients to plants.

C) i. Excessive fertilization with fertilizers containing nitrogen <sup>before</sup> ~~forms~~ <sup>etc.</sup> can cause elevated levels of nitrate levels in ground water.

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ii. If a farmer fertilizes excessively before it rains with nitrogen containing fertilizers, ground water contamination is possible. This is because the heavy rains will leach the ~~was~~ fertilizers & thus the nitrogens through the soil through percolation. Eventually the percolating water & the leached fertilizers will make it into ground water supplies increasing nitrate levels.

D) i. Acid deposition onto soil affects plant health by leaching important nutrients & minerals from trees & the soil. This process can cause calcium deficiencies in trees ultimately reducing the health of the tree.

ii. One method to remediate the soil after a deposition event is to sprinkle ~~that~~ crushed limestone over the affected area. The limestone is broken down by the acid, however this process neutralizes the acid & returns the soil to a normal pH.

E) ① Climate change can degrade soil by intensifying storms. These powerful storms have the ability to strip the loam-rich O horizon of soils degrading them through the power of wind & rain erosion.

② Also, climate change can lead to desertification in 30° longitude, ~~by~~ through the formation of badley cells. This causes droughts in 20° latitude locations by

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having cooler air rest there after depositing its moisture at the equator. With this ~~due~~ intensified drought like affect, plants may die leading to faster soil erosion due to a lack of protection from plants. (Description)

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END OF EXAM

THE FOLLOWING INSTRUCTIONS APPLY TO THE COVERS OF THE SECTION II BOOKLET.

- MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE FRONT AND BACK COVERS OF THE SECTION II BOOKLET.
- CHECK TO SEE THAT YOUR AP NUMBER LABEL APPEARS IN THE BOX ON THE COVER.
- MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON ALL AP EXAMS YOU HAVE TAKEN THIS YEAR.

4. Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.

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Resources such as soil and water can be degraded by human activities.

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- (i) ~~(i)~~ Identify one agricultural practice that can lead to elevated nitrate levels in groundwater.
- (ii) ~~(ii)~~ Describe how the practice you identified in (c)(i) leads to elevated nitrate levels in groundwater.
- (d) Acid deposition has affected soil quality in many parts of the northeastern United States.
- (i) ~~(i)~~ Explain one way acid deposition onto soil can affect plant health.
- (ii) ~~(ii)~~ Describe one method for remediating soil affected by acid deposition.
- (e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. Describe TWO ways that climate change can degrade soil.

A. One climate factor is temperature. With soil formation, a cold temp could slow down the process of breaking down organic compounds to make soil. Precipitation is another factor with soil because it keeps the soil moist and rich with nutrients when it rains often.

Bi. A biotic component of the A horizon is that several earth dwelling creatures like worms and bugs dig into this area to call it home.

ii. An abiotic factor is the soil formation. This area has a good combination of silt, sand, and clay that allows water to easily travel through it.

Ci. The use of chemical fertilizers could cause high nitrate.

levels in ground water. When it rains, the fertilizer runs off into a body of water or sinks into the soil. With continued use, the nitrates would pile up over time.

Di. Some plants cannot live when the soil pH gets too low. Acid deposition decreases the pH of soil and can eventually kill the plants.  
ii. One remedy would be to add limestone to the soil. Limestone cancels out the acidic value of the rain and can restore balance.

E. One way climate change can degrade soil is by changing from a tropic with lots of rain, into a desert with hardly any rain at all. The soil would become dry and erode away. Another change would be from a warm environment to a cold one. The cold would freeze the soil, eventually becoming permafrost.

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## Question 4

### Overview

The intent of this question was for students to identify and describe factors that influence soil formation, degradation, and soil quality. In part (a) students were asked to describe two climate factors that could affect the rate of soil formation. In part (b) students were asked to apply their knowledge of various soil horizons, and identify a specific biotic and an abiotic component of the A horizon. In part (c) students were asked to identify one agricultural practice that could lead to elevated nitrate levels in groundwater, and apply their knowledge of groundwater recharge to describe how this agricultural practice could elevate nitrate levels in groundwater. Acid deposition can affect soil quality. In part (d) students were asked to explain how acid deposition onto soil can affect plant health and to describe one method for remediating soil affected by acid deposition. Climate change has caused far-reaching ecosystems changes, which include soil degradation. In part (e) students were asked to describe two ways in which climate change could degrade soil.

### Sample: 4A

#### Score: 10

Two points were earned in part (a): 1 point was earned for describing that “Higher temperatures increases [*sic*] the rate at which organic matter decomposes, therefore increasing the rate of soil formation” and 1 point was earned for describing that “Increased precipitation may cause soil erosion . . . preventing its formation.” Two points were earned in part (b): 1 point was earned in (b)(i) for identifying decomposers “such as millipedes” as a specific biotic component of the A horizon, and 1 point was earned in (b)(ii) for identifying “macronutrients such as nitrogen oxides” as an abiotic component of the A horizon. Two points were earned in part (c): 1 point was earned in (c)(i) for correctly identifying “Fertilizing crops” as an agricultural practice that can lead to elevated nitrate levels in ground water, and 1 point was earned in (c)(ii) for describing that inorganic fertilizer dissolves in water and can then “infiltrate into groundwater.” Two points were earned in part (d). One point was earned in (d)(i) for correctly explaining that “Acids leach nutrient ions . . . from the soil” and the lack of those nutrients “will cause diminished growth . . . in plants.” One point was earned in (d)(ii) for describing that “Adding limestone to soil can remediate acid deposition” because “it will neutralize acid in the soil.” Two points were earned in part (e). One point was earned for describing that climate change is causing “global sea level rise” and that as the “salt water moves further inland, the salinity of the soil increases” degrading the soil quality. One point was earned for describing that climate change is “increasing the frequency of severe storms and . . . severe flooding increases erosion” that results in degraded soil quality.

### Sample: 4B

#### Score: 8

Two points were earned in part (a): 1 point was earned for describing that wind “reduces the rate of soil formation because it blows particles [*sic*] of loose soil away,” and 1 point was earned for describing that heavy rain can also slow the rate of soil formation “due to the rapid erosion of soil particles.” Two points were earned in part (b): 1 point was earned in (b)(i) for identifying “living worms” as a specific biotic component of the A horizon, and 1 point was earned in (b)(ii) for identifying “nutrients like nitrogen, phosphorous” as an abiotic component of the A horizon. Two points were earned in part (c): 1 point was earned in (c)(i) for correctly identifying “Excessive fertilization with fertilizers” as an agricultural practice that can lead to elevated nitrate levels in ground water, and 1 point was earned in (c)(ii) for describing that heavy rains “leach the fertilizers . . . through the soil through percolation . . . percolating the water and the leached fertilizer . . . into ground water supplies.” One point was earned in part (d): No point was earned in (d)(i) because acid deposition leaches nutrients from the soil, not from the trees, but 1 point was earned in

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**Question 4 (continued)**

(d)(ii) for describing “sprinkle crushed limestone over the affected area” as a method to decrease the acidity of the soil. One point was earned in part (e) for describing that climate change can degrade soil due to “intensifying storms” with the “ability to strip the ... soils ... through the power of wind and rain erosion.”

**Sample: 4C**

**Score: 6**

One point was earned in part (a) for describing that “a cold temp could slow down the process of breaking down organic compounds to make soil.” Two points were earned in part (b): 1 point was earned in (b)(i) for identifying “worms” as a specific biotic component of the A horizon, and 1 point was earned in (b)(ii) for identifying “silt” as an abiotic component of the A horizon. One point was earned in part (c)(i) for correctly identifying the “use of chemical fertilizers” as an agricultural practice that can lead to elevated nitrate levels in ground water. No points were earned in parts (c)(ii) or (d)(i). One point was earned in (d)(ii) for describing that one method to remediate soil affected by acid deposition is “to add limestone to the soil.” One point was earned in part (e) for describing that “changing from a tropic with lots of rain, into a desert with hardly any rain at all” will degrade soil quality.