

There is a natural climate phenomenon that occurs in the equatorial Pacific Ocean because of periodic fluctuations in sea surface conditions and atmospheric circulation. This phenomenon happens every few years, resulting in shifts in temperature and precipitation in many parts of the world.

Figure 1 shows temperature and precipitation patterns associated with one phase of this phenomenon in the equatorial Pacific Ocean. Figure 2 shows the associated temperature and precipitation patterns that occur over North America.

Figure 1. Effects of Changes in Sea Surface Conditions in Equatorial Pacific Ocean

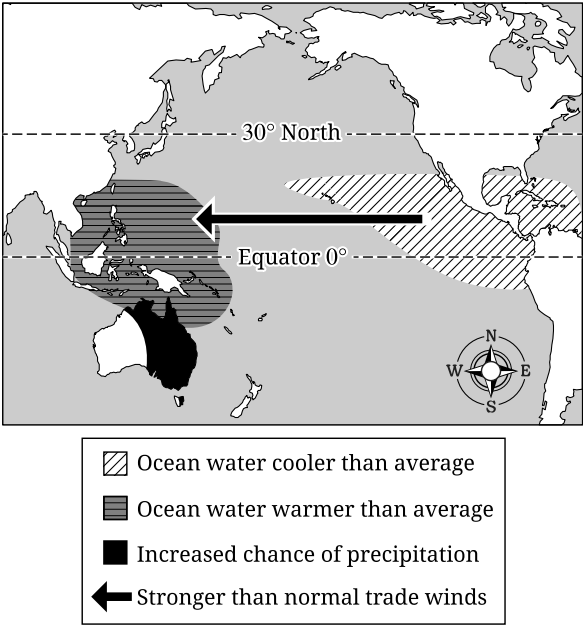
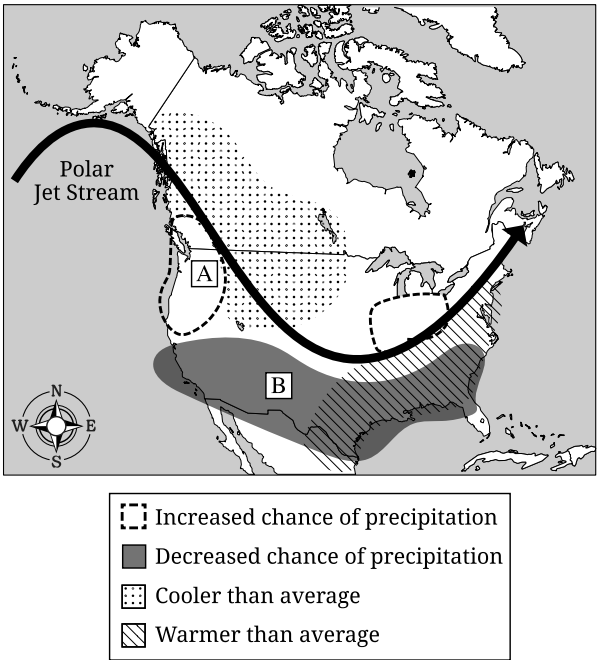


Figure 2. Polar Jet Stream and Climate Conditions in North America

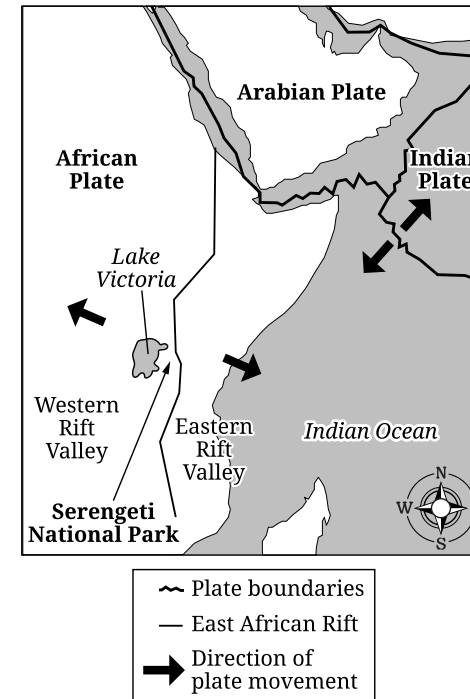


2. Respond to parts A, B, C, D, E, F, G, H, I, and J.

- A. **Identify** the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1.
- B. Based on the information in Figure 1, **identify** the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean.
- C. Based on the information in Figure 2, **describe** a difference in climate patterns between the regions A and B.
- D. Increases in regional precipitation can lead to increased flooding in certain locations. **Describe** one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation.
- E. **Propose** a realistic solution a city could implement to decrease the risk of flooding in urban areas.
- F. **Justify** the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding.
- G. Terrestrial biomes are primarily determined by temperature and precipitation patterns. **Describe** one difference between the climate of a temperate seasonal forest and that of a savanna.
- H. Droughts are one environmental problem that can affect the frequency and severity of forest fires. **Identify** the ecological process that occurs following a forest fire that leaves the soil intact.
- I. **Describe** one way burning forests contribute to atmospheric pollution.
- J. **Describe** one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires.

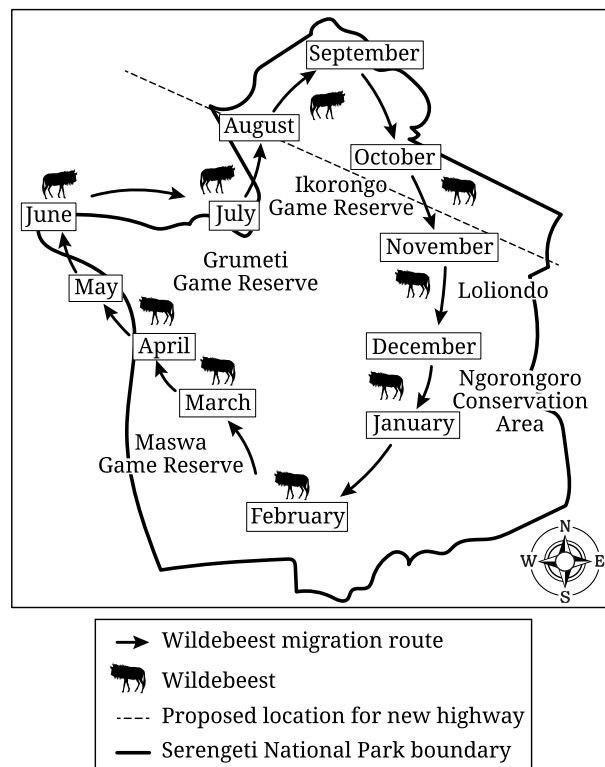
Serengeti National Park is located in Tanzania, Africa. The park is located in a valley along a tectonic plate boundary called the East African Rift. Figure 1 shows the East African Rift and other plate boundaries near the east coast of Africa.

Figure 1. Tectonic Plate Movement near East Coast of Africa



Serengeti National Park contains a variety of tropical habitats but is dominated by wideopen lands that include a variety of grass species with scattered trees and shrubs. Most grass growth occurs after the March through May rainy season. Many of the park's herbivores, such as wildebeest and zebra, migrate through the park in an annual cycle following the growth of new grass (Figure 2).

Figure 2. Annual Migration of Wildebeest in Serengeti National Park



2. Respond to parts A, B, C, D, E, F, G, H, I, and J.

- A. Based on the information in Figure 1, **identify** the type of plate boundary that runs beneath Serengeti National Park.
- B. Based on the information provided, **identify** the dominant biome within the Serengeti.
- C. Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, **identify** the location in the Serengeti where wildebeest are most likely to give birth.
- D. The Serengeti has two primary types of grasses: long and short. The two grass types provide similar levels of nutrition for animals. Wildebeest primarily consume long grasses, while other herbivores such as gazelle consume the short grasses. These two similar species coexist in Serengeti National Park.

Explain why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.

- E. The Tanzanian government plans to build a highway across the northern portion of the Serengeti, as shown in Figure 2.

Describe one way the planned highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.

- F. **Propose** a solution to the negative effect created by the planned highway described in part E.
- G. Many organisms live in grasslands. One weed species, the spotted knapweed, was introduced at one location in North America in the 1890s and is currently found throughout the rangelands of the western United States. The spotted knapweed poses several environmental problems in North America. Farmers often use crop rotation to control populations of pests like the spotted knapweed. A more traditional method of controlling pests involves spraying pesticides.

Describe a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species.

- H. **Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations.
- I. **Describe** an environmental problem associated with controlling pest populations with large amounts of pesticide.
- J. **Propose** a solution to controlling pests, other than pesticides or crop rotation.

3. The Rocky Mountains, the headwaters for the Colorado River, have experienced a severe drought for many of the past twenty years. States and cities downstream that depend on the river water have had to find solutions to the reduced water flow.

One city located downstream from the Rocky Mountains is Las Vegas, Nevada. In Las Vegas, one solution to reduce the amount of water used for irrigation is to remove landscaping and lawns that use grasses not native to the local area and replace them with desert-tolerant landscaping.

- (a) **Identify** a typical type of plant that would be used in desert-tolerant landscaping.
- (b) **Justify** the removal of landscaping and lawns that use grasses not native to the local area by describing an additional advantage, other than reducing the amount of water needed for irrigation.

Warmer seasonal temperatures in the Rocky Mountains have led to earlier mountain snowmelt and an increased risk of forest fires as soil and vegetation dry out.

- (c) **Describe** how a prescribed burn would reduce the severity and spread of forest fires.
- (d) **Describe** a disadvantage of a prescribed burn in a forested ecosystem.

Lake Powell is a large reservoir on the Colorado River. Lake Powell is formed by a dam with a hydroelectric power plant. At full capacity or full pool, Lake Powell contains 25.16 million acre-feet (maf) of water. Currently, Lake Powell is at 36% full capacity.

- (e) **Calculate** the number of million acre-feet (maf) of water currently in Lake Powell. **Show** your work.

In 2021, after years of drought, Lake Powell held 7.9 million acre-feet (maf) of water. One million acre-feet is equivalent to 3.26×10^{11} gallons.

- (f) The watershed of the Upper Colorado River contributes an average of 9.60 maf of water to Lake Powell annually. The melted mountain snow found in the watershed contributes 50% of the average river flow into Lake Powell. In 2021, the river flow was 36% of the annual average. Assuming that all resources to that flow contributed the same proportions as in prior years, **calculate** the amount of water (in million acre-feet) that was contributed by the melted mountain snow in 2021. **Show** your work.

- (g) The average household in the United States consumes 5.0×10^4 gallons of water in a year. **Calculate** the number of households that could be supported for one year by the average flow of 9.60 maf of water into Lake Powell. **Show** your work.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

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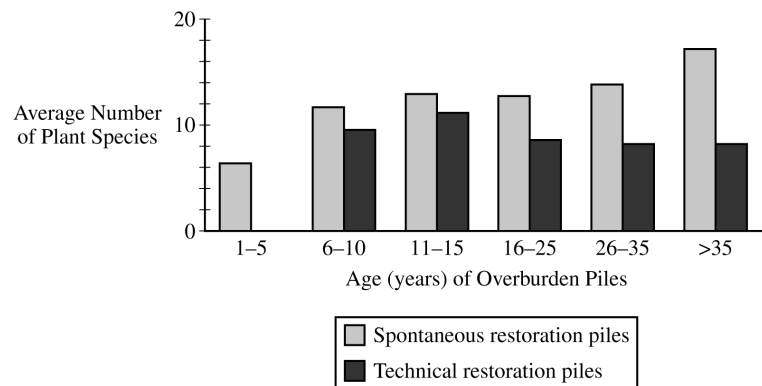
END OF EXAM

ENVIRONMENTAL SCIENCE
SECTION II
Time—1 hour and 10 minutes
3 Questions

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response booklet. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples. You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. Two restoration methods designed to reclaim the overburden piles removed from open pit coal mines in temperate forests of eastern Europe were studied over several years. The first method was spontaneous restoration, where the soil and rock were dumped in noncompacted, random piles and not replanted with vegetation. The second method was technical restoration, where the land was leveled by heavy machinery, organic material was added, and eight plant species were added. Technical restoration started 5 years after the piles were formed, so no bar is included in the 1–5 year range in the graph.

Number of Plant Species in Spontaneous and Technically Restored Overburden Piles over Time



- (a) Based on the data in the graph, **identify** the average number of species found in technically restored piles 16–25 years after restoration started.
- (b) Based on the data in the graph, **describe** the relationship between the average number of species and the age of the spontaneous restoration piles.

Scientists hypothesized that after 35 years, the number of animal species in the spontaneously restored piles would be higher than the number of animal species in the technically restored piles.

- (c) Using the data in the graph, **make a claim** that supports or refutes the hypothesis that the number of animal species in the spontaneously restored piles would be higher than the number of animal species in the technically restored piles.
- (d) **Describe** a characteristic of a plant species that would have been present in the spontaneous restoration piles from years 1 to 5.
- (e) **Explain** how the return of plant life would have been altered in the spontaneous piles if the mining had taken place in the tundra rather than in temperate forests.

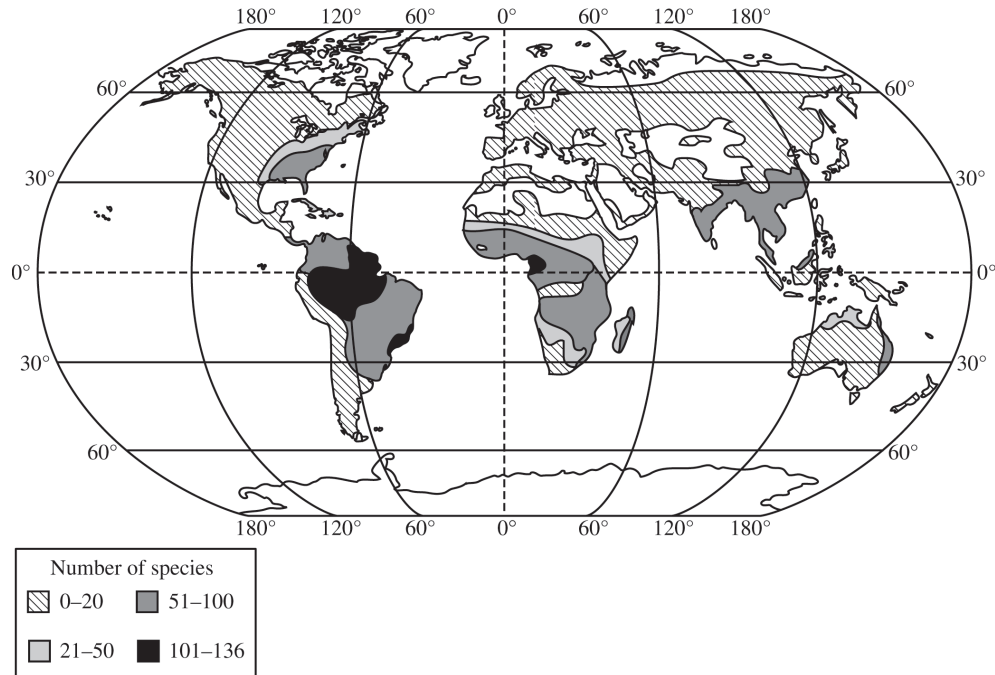
Limiting runoff on disturbed land improves soil and water quality. To model water runoff, students set up three large plastic trays and filled each tray with loam soil to 1 centimeter below the edge. Loam soil is a balance of sand, silt, and clay soil. One tray was seeded with wheatgrass and grown for 30 days, one tray was covered with small wood chips, and one tray was soil only. Five hundred milliliters of water was sprinkled evenly onto the soil surface of each tray. All three trays were placed on a slight slope, and water that ran off the surface was collected. The results are shown in the following table.

Tray	Water Collected (mL)	Water Appearance
Wheatgrass grown in soil; no small wood chips	190	Clear
Small wood chips covered soil; no wheatgrass	300	Transparent; light brown
Soil only; no wheatgrass or small wood chips	360	Cloudy; dark brown

- (f) **Identify** the scientific question for the investigation.
- (g) **Identify** a dependent variable in the experiment.
- (h) **Explain** how the results of the experiment would likely have been altered if the soil had contained a higher percentage of sand, which has the largest particle size of the components of loam.
- Runoff from mining waste can also affect water quality.
- (i) **Describe** one ecological impact that could result from the drainage from mine waste into nearby waterways.
- (j) **Describe** one strategy to reduce the drainage from mine waste into waterways downstream from mines.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

GLOBAL AMPHIBIAN SPECIES RICHNESS



2. Biodiversity around the world is changing as a result of anthropogenic influences.

(a) The map represents species richness of amphibians around the globe. Use the map to answer the following questions.

- Identify** the latitudinal range with the greatest amphibian species richness.
 - Identify** what biome this range most likely represents.
 - Describe** one reason amphibian species richness would tend to be highest in this region.
- (b) There are many environmental threats facing amphibians today, such as deforestation. **Describe** one possible anthropogenic reason for deforestation.
- (c) Many factors influence biodiversity.
- Explain** how the species richness of an ecosystem influences its response to environmental stressors.
 - Explain** why amphibian biodiversity is declining globally, other than from deforestation.
- (d) Currently, wildlife species are going extinct at an alarming rate. To combat this threat, governments around the world have enacted legislation and signed treaties to protect species threatened by extinction.

- Identify** one specific piece of legislation that has been designed to protect species threatened by extinction.
 - Explain** how the requirements of the legislation identified in part (d)(i) specifically protect species threatened by extinction.
- (e) A town is considering selling an undeveloped parcel of land along its border for residential developments. The square parcel of land consists of approximately 30% wetland and 70% pasture. The wetland runs through the middle of the property for its entire width and is home to three native frog species.
- Propose** a viable solution that will result in the protection of the native frog species while still allowing for maximum profit of the property development.
 - Justify** the solution proposed in (e)(i) by describing a potential advantage of the plan, other than frog protection.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.