

Week 9

AP Environmental Science

Homework bundle for this week

本周作业合集

exercises.lol

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AP Environmental Science

Name: _____ Score: _____

1. **Plate tectonics** is the idea that...

- ☐ Earth's outer shell is broken into moving plates
- ☐ the Earth is completely solid
- ☐ continents never move
- ☐ the oceans are drying up

2. Soil forms when weathering breaks down...

- ☐ rock into smaller and smaller pieces
- ☐ water into gas
- ☐ air into liquid
- ☐ the Sun

3. Soil **texture** is determined by...

- ☐ the mix of sand, silt, and clay particle sizes
- ☐ the colour of the soil
- ☐ the temperature
- ☐ the number of worms

4. Earth's **atmosphere** is...

- ☐ the layer of gases surrounding the planet
- ☐ the solid rock inside Earth
- ☐ the oceans
- ☐ the Moon

5. What ultimately drives global wind patterns?

- ☐ uneven heating of Earth by the Sun
- ☐ the Moon's gravity
- ☐ ocean tides
- ☐ earthquakes

6. Where plates move apart and new crust forms, the boundary is called _____.

7. The removal of soil by wind or water is called _____.

8. The smallest particles, which hold water tightly, are _____.

9. The layer above the troposphere, which holds the protective ozone layer, is the _____.

10. Dry air sinking around 30 degrees latitude creates many of the world's _____.

AP Environmental Science

1. **Earth's outer shell is broken into moving plates**

Plate **tectonics**: Earth's rigid outer shell is broken into **tectonic plates** that slowly move.

2. **rock into smaller and smaller pieces**

Soil starts as **weathered** rock — broken down over long times into mineral particles.

3. **the mix of sand, silt, and clay particle sizes**

Soil **texture** comes from the proportion of **sand**, **silt**, and **clay** it contains.

4. **the layer of gases surrounding the planet**

The **atmosphere** is the blanket of gases (mostly nitrogen and oxygen) around Earth.

5. **uneven heating of Earth by the Sun**

The Sun heats the equator more than the poles; this **uneven heating** drives the winds.

6. **divergent**

At a **divergent** boundary plates pull apart, and new crust rises to fill the gap.

7. **erosion**

Erosion carries soil away — and it happens far faster than soil forms.

8. **clay**

Clay particles are tiny with tiny gaps, so they hold water and can waterlog.

9. **stratosphere**

The **stratosphere** contains the **ozone layer**, which absorbs harmful ultraviolet rays.

10. **deserts**

The sinking dry air near 30 degrees gives little rain, forming deserts like the Sahara.

4.1 Plate Tectonics

Name: _____ Class: _____ Date: _____

Total: 11 marks**KEY WORDS** plates 板块 • plate boundaries 板块边界 • soil 土壤 • plate tectonics 板块构造

Objective

Build the skills to answer exam questions on **plate tectonics**.

You must be able to:

- describe **plate boundaries** 板块边界 (divergent, convergent, transform)
- link boundaries to earthquakes, volcanoes, and mountains
- explain the effect on ecosystems and hazards

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The three boundaries

Earth's **plates** move over the mantle. Where they meet:

- **Divergent** — plates move **apart**; new crust forms (mid-ocean ridges).
- **Convergent** — plates move **together**; one may subduct, forming volcanoes, mountains, and deep trenches.
- **Transform** — plates **slide** past each other; earthquakes (e.g. San Andreas Fault).

■ Hazards

Boundaries are where **earthquakes** and **volcanoes** concentrate. Convergent zones build **mountains** and cause explosive volcanoes; transform faults cause earthquakes.

■ Effect on life

Volcanic soil is fertile; new islands create habitats; but hazards (eruptions, quakes, tsunamis) also disrupt ecosystems and human settlements.

■ A worked identification

Two plates colliding, with a chain of volcanoes and a deep ocean trench, is a **convergent** boundary.

2 Practice

Now apply the methods above.

2.1 Name the three types of plate boundary. [3]

2.2 Which boundary forms new crust? [1]

2.3 Which boundary mainly causes earthquakes as plates slide past? [1]

3 Exam-style questions

3.1 Volcanoes and mountain ranges most often form at [1]

- **A** divergent boundaries
- **B** convergent boundaries
- **C** transform boundaries
- **D** the plate centers

3.2 A region has a chain of volcanoes and a deep ocean trench.

(a) Name the boundary type. [1]

(b) Explain how it forms these features. [2]

3.3 Explain one benefit and one hazard of living near a plate boundary. [2]

Solutions

2.1 Divergent, convergent, transform.

2.2 Divergent.

2.3 Transform.

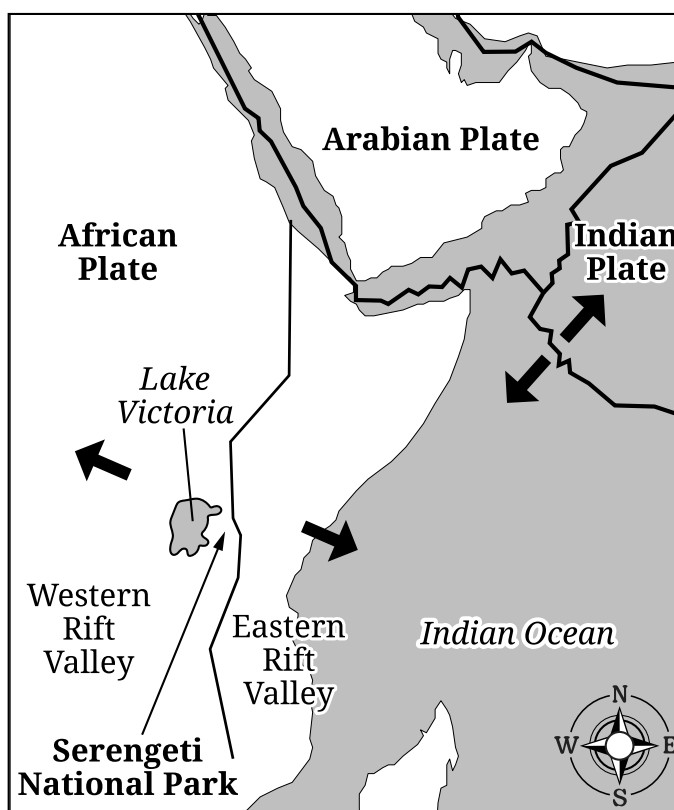
3.1 B — convergent boundaries.

3.2 (a) Convergent. (b) One plate subducts beneath the other, forming a deep trench; the descending plate melts, feeding volcanoes above.

3.3 Benefit: fertile volcanic soil (or geothermal energy); hazard: earthquakes/volcanic eruptions.

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.

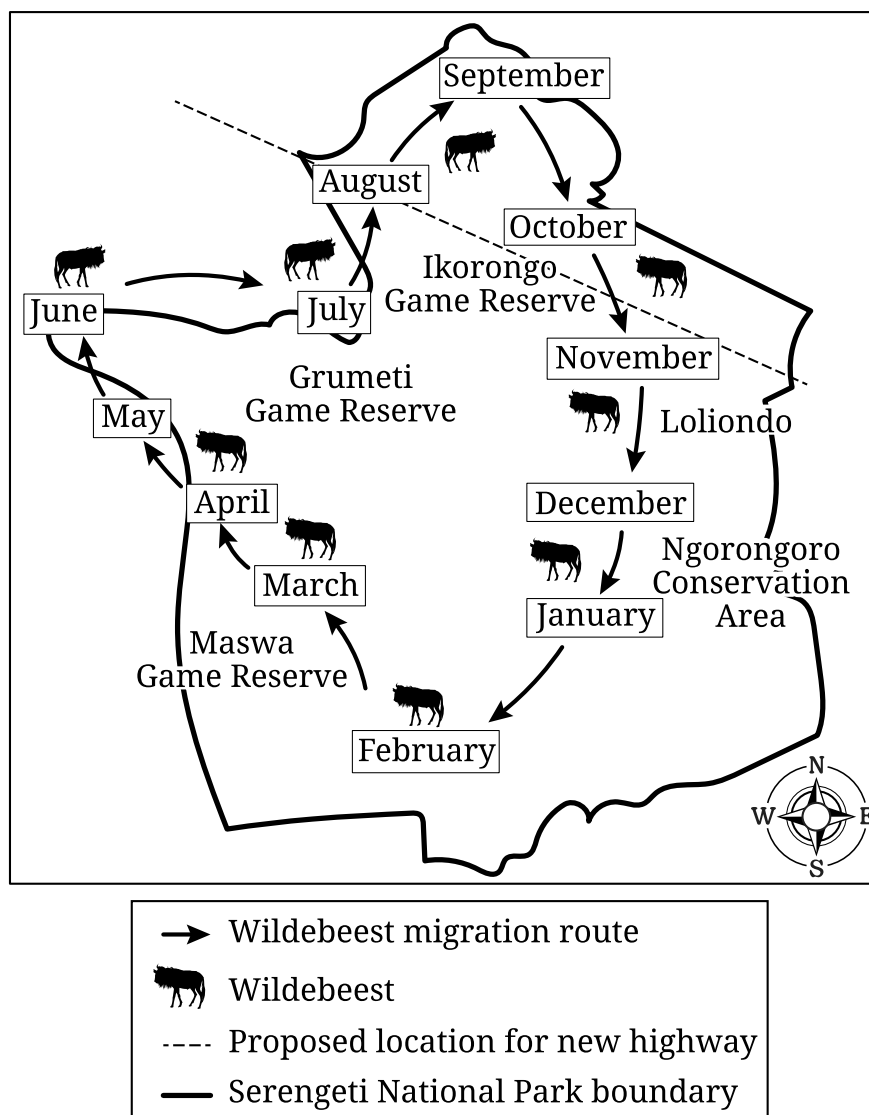
Figure 1. Tectonic Plate Movement near East Coast of Africa



- ~ Plate boundaries
- East African Rift
- ➔ Direction of plate movement

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.

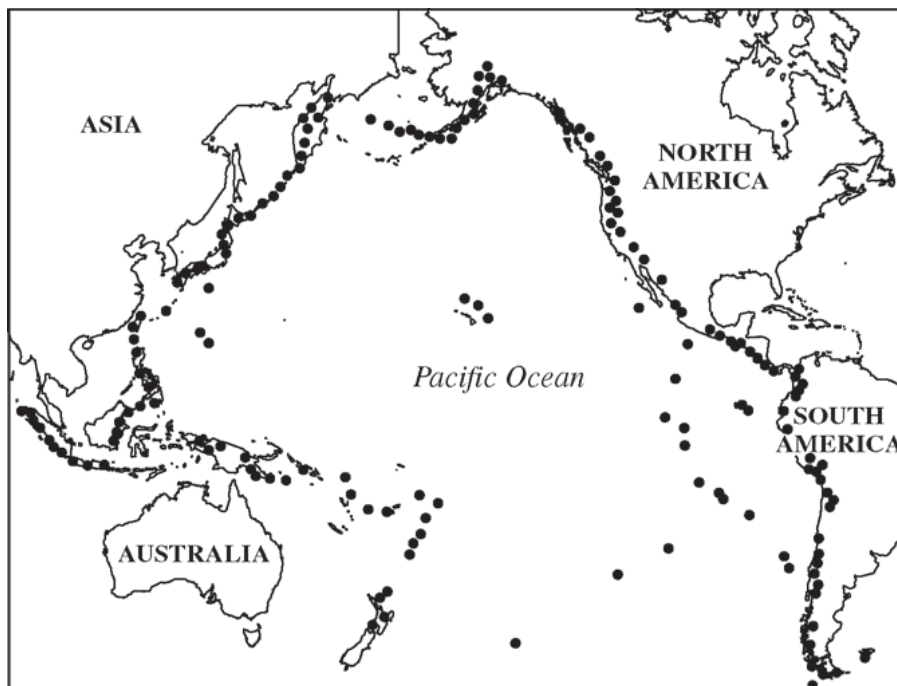
- E.** The Tanzanian government plans to build a highway across the northern portion of the Serengeti, as shown in Figure 2.

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. Plate-tectonic theory states that the Earth's lithosphere is broken into very slowly moving pieces or plates. Plate movements over vast stretches of time have led to the current orientation of our continents and oceans. Individual events along plate boundaries, such as earthquakes and volcanic eruptions, pose periodic threats to human activity and ecosystems. The "Ring of Fire" is a term that describes the location of increased seismic and volcanic activity around the margins of the Pacific Ocean basin. On the map above, each dot represents a volcano or an earthquake.
- (a) Japan, Indonesia, and the Philippines are examples of volcanic island chains that have formed along subduction zones between plates in the western Pacific.
 - (i) **Describe** what happens when two tectonic plates collide along a subduction zone.
 - (ii) **Explain** how subduction leads to volcanic activity.
 - (b) Although the landscape following a volcanic eruption may appear unable to support ecological communities, over time the area can be transformed through succession.
 - (i) What is primary succession?
 - (ii) **Explain** how primary succession can lead to soil formation on a newly formed volcanic landscape.
 - (c) In addition to volcanic activity, highly destructive tsunamis are generated along Pacific Plate subduction zones.
 - (i) **Explain** how a tsunami is generated along a subduction zone.
 - (ii) **Describe** one negative ecological impact that tsunamis have on coastal environments.
 - (d) Southern California experiences periodic devastating earthquakes along the San Andreas Fault, which is a transform boundary located along the eastern edge of the Pacific Plate.
 - (i) **Describe** what happens to the tectonic plates along a transform boundary at the moment when an earthquake occurs.
 - (ii) **Describe** what happens to the tectonic plates along a transform boundary during the time between earthquakes.

4.2 Soil Formation and Erosion

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS erosion 侵蚀 • horizons 土层 • weathering 风化 • soil horizons 土壤层 • soil 土壤

Objective

Build the skills to answer exam questions on **soil formation and erosion**.

You must be able to:

- describe how **weathering** 风化 and decomposition form soil
- identify **soil horizons** 土壤层 (O, A, B, C)
- explain causes and effects of **erosion** 侵蚀

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ How soil forms

Soil forms slowly as rock is broken by **weathering** (physical and chemical) and mixed with **organic matter** from decomposed organisms. It takes hundreds of years to form a few centimeters.

■ Soil horizons

A soil profile has layers (**horizons**):

- **O** — organic litter on top.
- **A** — topsoil, rich in humus (most fertile).
- **B** — subsoil, accumulated minerals.
- **C** — weathered parent rock.

■ Erosion

Erosion is the removal of topsoil by **water and wind**, worsened by removing plant cover (deforestation, overgrazing, plowing). It removes the fertile **A horizon**.

■ Effects

Erosion reduces fertility, lowers crop yields, and washes sediment (and nutrients) into waterways, causing pollution and sedimentation.

2 Practice

Now apply the methods above.

2.1 What two processes form soil from rock? [2]

2.2 Which soil horizon is the fertile topsoil? [1]

2.3 Name one human activity that increases erosion. [1]

3 Exam-style questions

3.1 Soil erosion is most damaging because it removes the [1]

- **A** C horizon (parent rock)
- **B** fertile A horizon (topsoil)
- **C** bedrock
- **D** groundwater

3.2 A farmer plows a sloped field and removes all vegetation.

(a) Explain why this increases erosion. [2]

(b) State one effect of the eroded soil on a nearby river. [1]

3.3 Explain why soil is considered a slowly renewable (nearly non-renewable) resource. [2]

Solutions

2.1 Weathering (of rock) and decomposition (of organic matter).

2.2 The A horizon (topsoil).

2.3 Any one: deforestation, overgrazing, plowing.

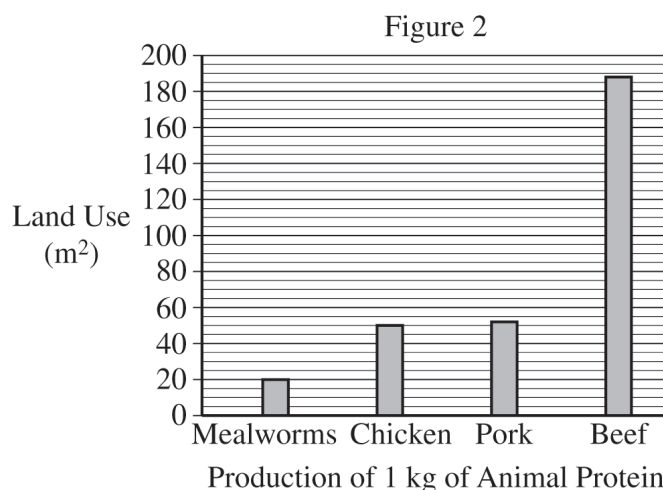
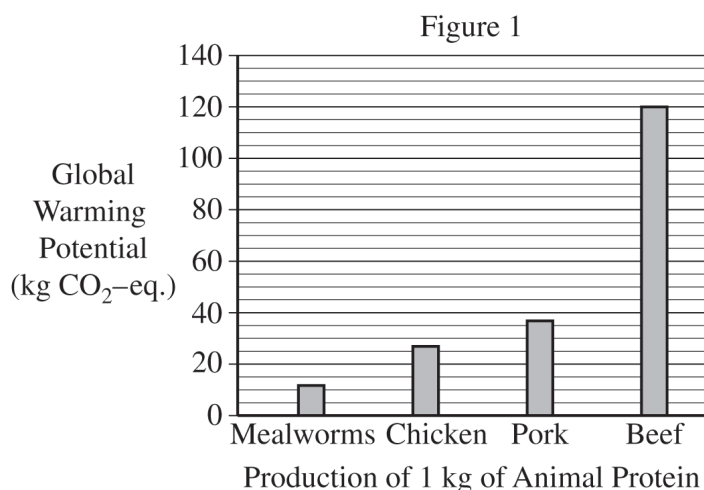
3.1 B — the fertile A horizon (topsoil).

3.2 (a) Removing plant cover exposes the soil, and roots no longer hold it; on a slope, water washes the loose topsoil away. (b) Sediment (and nutrients) enter the river, causing sedimentation or eutrophication.

3.3 Soil forms extremely slowly (hundreds of years for a few cm), so once eroded it cannot be replaced within a human lifetime.

2. As the human population continues to grow, the demand for animal protein is expected to double by 2050. Animal protein can be obtained from conventional livestock and other sources. The production of all animal protein has environmental costs, as shown in the following graphs. In Figure 1, global warming potential (GWP) is measured in kilograms of carbon dioxide equivalent ($\text{kg CO}_2\text{-eq.}$). Carbon dioxide equivalent is a measure of the warming effect of a gas relative to that of carbon dioxide. In Figure 2, land use is measured in meters squared (m^2).

Global Warming Potential and Land Use from Animal Protein Production



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

Mealworms, the larvae of the darkling beetle, consume grains and decaying plant material. Darkling beetles are an *r*-selected species, and the entire mealworm can be consumed by humans for protein.

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

- (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.

An individual's diet choices affect greenhouse gas emissions and land use.

- (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.

Cattle emit methane from fermentation in their digestive systems. The other animals do not emit methane.

- (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.

Agricultural practices can have negative impacts on rivers and streams.

- (f) **Describe** how water quality can be altered by cattle grazing that occurs near a stream or river.
- (g) **Propose** a solution to reduce the negative impacts on waterways that result from cattle grazing, while still allowing cattle to graze.
- (h) Crop production can cause soil erosion. **Describe** a sustainable agricultural practice used to reduce soil erosion.
- (i) **Justify** the use of the sustainable practice described in part (h) by describing an additional advantage, other than the reduction of soil erosion.
- (j) Crop production around the world is affected by climate change. **Describe** how crop production could be negatively affected by climate change.

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.

ENVIRONMENTAL SCIENCE

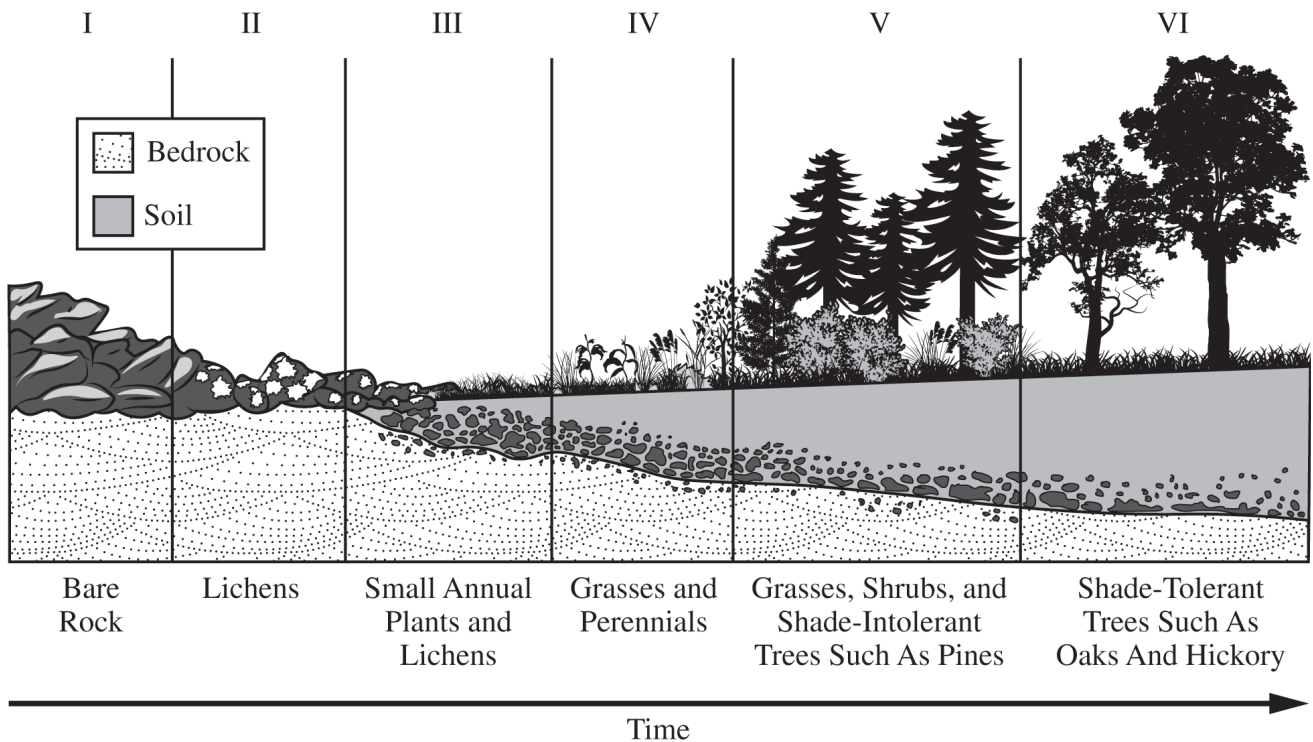
SECTION II

Time—1 hour and 10 minutes

3 Questions

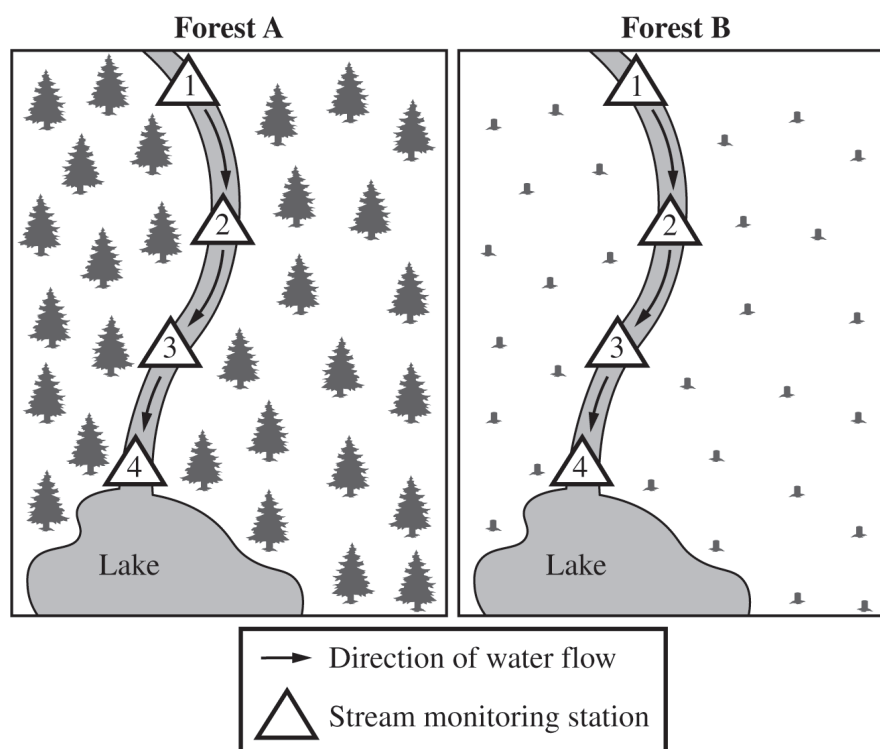
Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response booklet. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is 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. The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.



- (a) **Identify** the ecological change over time illustrated in the diagram.
- (b) **Identify** the stage in which pioneer species first appear.
- (c) **Describe** how soil forms from stage II to stage III.
- (d) **Identify** a cultural ecosystem service that may be provided by a mature forest.

Researchers are interested in investigating the effect of the removal of trees on the water quality of nearby waterways. To conduct their experiment, the researchers locate two identical forest watersheds, both with a river running through them. Forest A is an intact forest and forest B is a clear-cut forest. Four stream monitoring stations are set up in each forest study area. Each station monitors a variety of water quality indicators, including water temperature, at various locations along the river. The experimental setup is shown in the following diagrams. The arrows shown in the rivers represent the direction of water flow. The triangles in the river show the location of the stream monitoring stations.



- (e) **Identify** a testable hypothesis being investigated by the researchers.
- (f) **Identify** the independent variable in the experiment.
- (g) **Describe** the purpose of forest A in the experiment.
- (h) **Explain** why the water temperature might change because of clear-cutting trees in forest B.

After the experiment was completed, land developers constructed a golf course in the clear-cut area of forest B. To prepare the land, developers removed any remaining stumps and newly grown trees and began planting and fertilizing new grass. The researchers are interested in the effect the golf course may have on the water quality of the river. To monitor the river in forest B, the researchers repeated the experiment once the golf course had been constructed.

- (i) **Explain** why an indicator of water quality other than temperature could be altered by the golf course in forest B.
- (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.

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.

ENVIRONMENTAL SCIENCE

SECTION II

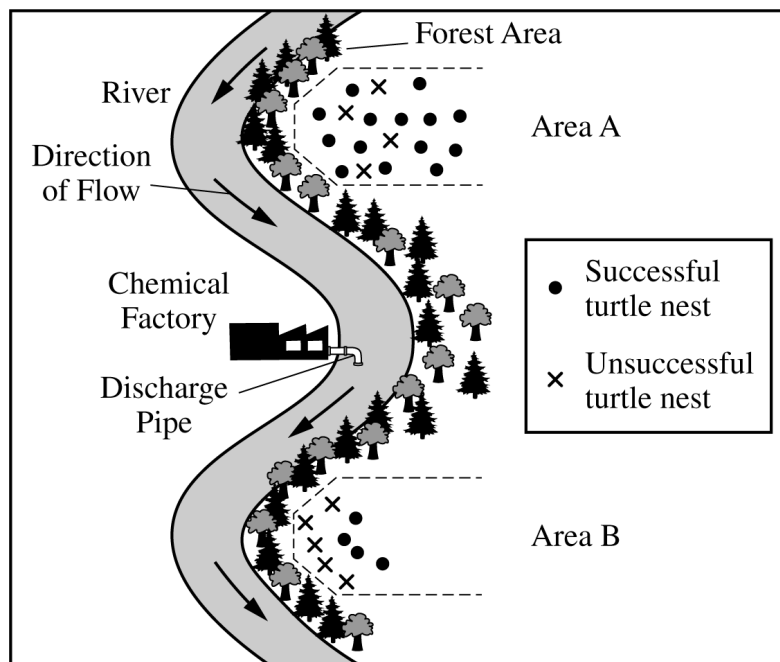
Time—1 hour and 10 minutes

3 Questions

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1. Common snapping turtles, *Chelydra serpentina*, are primarily aquatic, but they lay their eggs on land. Researchers are interested in understanding the impact of pollution on turtle nesting sites. The researchers examined nesting sites at two agricultural areas along the floodplain of a river upstream and downstream from a chemical factory that is a known source of aqueous mercury pollution. Turtle eggs, soil, and vegetation samples taken from areas around turtle nests downstream from the chemical factory showed high levels of mercury in a previous study. Mercury was not detected in samples taken upstream from the chemical factory.

DISTRIBUTION OF TURTLE NESTS ALONG RIVER

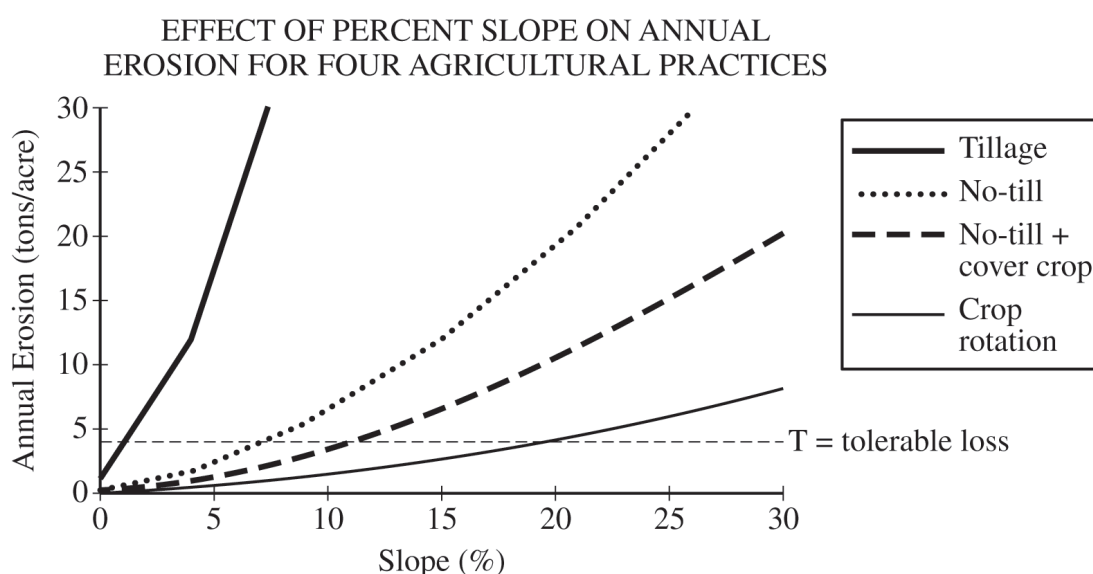


- (a) The map shows locations of both successful and unsuccessful turtle nests.
- (i) **Identify** the area with the greatest nest success rate, based on the information in the diagram.
 - (ii) **Identify** the dependent variable in the study.
 - (iii) Based on the information provided, **identify** a likely scientific question for the study.
 - (iv) **Describe** why researchers measured mercury levels in locations upstream from the factory.
 - (v) There are plans to remove trees and other vegetation along the river bank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B.
- (b) Mercury can affect organisms and ecosystems in many ways.
- (i) **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism.
 - (ii) **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem.
 - (iii) Researchers measured methylmercury in a location downstream from the factory. **Explain** how methylmercury could be present in the stream.
 - (iv) Researchers claimed that the soil nearest to the river has higher levels of mercury than the field has, and those elevated levels have affected the nesting success for turtles. **Explain** how the pattern shown in the diagram supports or refutes this claim.
- (c) The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area.

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.

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. Soil erosion is one of the most serious soil-degrading processes. Each year tons of soil erode from cropland, pastures, forests, and other places. The amount of erosion varies dramatically among various land-use types. The figure above shows the effects of different agricultural practices and slopes on annual erosion rates.

(a) Refer to the graph above for the following.

- (i) **Identify** the scientific question that resulted in the data presented in the graph.
- (ii) **Identify** the agricultural practice that could be used on a 15% slope without leading to a higher than tolerable loss of soil.
- (iii) **Describe** the effect of adding a cover crop compared to using the no-till method.
- (iv) **Identify** one natural mechanism of soil erosion.

(b) Sediment from erosion can enter streams and affect water quality. One way sediment can enter a stream is from nearby road construction. Two methods to reduce sediment run-off in streams are to either put down straw bales or plant grass. The hypothesis to be tested is that straw bales reduce more sediment run-off than planted grass does. To test the hypothesis, two plots near a road under construction are measured. On one plot (A), straw bales are used to cover the soil, while a second plot (B) is planted with grass. The sediment discharge from each plot is measured after rainfall.

(i) **Identify** the dependent variable stated in the hypothesis.

(ii) **Describe** one way to add a control to improve the design of the study.

(iii) **Identify** one variable that was not discussed that could affect the results of the study.

Sediments reaching streams affect water clarity, which is tested by determining turbidity. Turbidity can be determined by measuring the depth at which a submerged object can no longer be seen from the surface.

Sample Group	Turbidity
Straw bale plots (plot A)	12 cm
Planted grass plots (plot B)	28 cm

(iv) Based on the data in the table above, **make a claim** about the stated hypothesis.

(c) Several fish species lay their eggs in the gravel in the streams under investigation in the study.

(i) **Describe** the type of survivorship curve expected for these fish species.

(ii) **Explain** why the input of sediment to a stream can negatively affect reproduction of fish that lay their eggs in the gravel of the streambed.

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.

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.

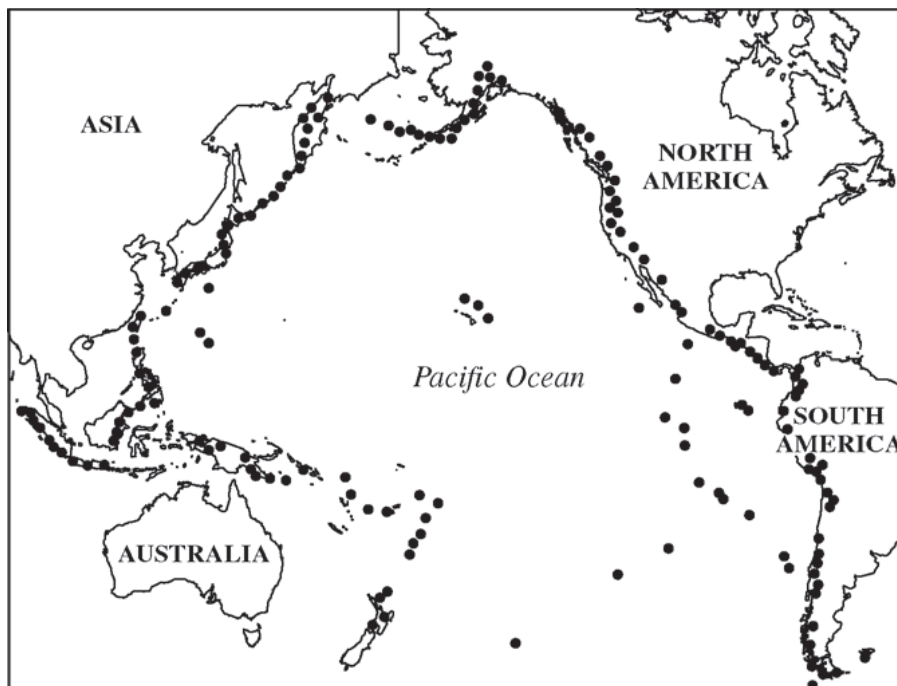
- (a) **Describe** how TWO climate factors affect the rate of soil formation.
- (b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.
 - (i) **Identify** one specific biotic component of the A horizon.
 - (ii) **Identify** one abiotic component of the A horizon.

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

- (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.
 - (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) **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.

STOP

END OF EXAM



3. Plate-tectonic theory states that the Earth's lithosphere is broken into very slowly moving pieces or plates. Plate movements over vast stretches of time have led to the current orientation of our continents and oceans. Individual events along plate boundaries, such as earthquakes and volcanic eruptions, pose periodic threats to human activity and ecosystems. The "Ring of Fire" is a term that describes the location of increased seismic and volcanic activity around the margins of the Pacific Ocean basin. On the map above, each dot represents a volcano or an earthquake.
- (a) Japan, Indonesia, and the Philippines are examples of volcanic island chains that have formed along subduction zones between plates in the western Pacific.
 - (i) **Describe** what happens when two tectonic plates collide along a subduction zone.
 - (ii) **Explain** how subduction leads to volcanic activity.
 - (b) Although the landscape following a volcanic eruption may appear unable to support ecological communities, over time the area can be transformed through succession.
 - (i) What is primary succession?
 - (ii) **Explain** how primary succession can lead to soil formation on a newly formed volcanic landscape.
 - (c) In addition to volcanic activity, highly destructive tsunamis are generated along Pacific Plate subduction zones.
 - (i) **Explain** how a tsunami is generated along a subduction zone.
 - (ii) **Describe** one negative ecological impact that tsunamis have on coastal environments.
 - (d) Southern California experiences periodic devastating earthquakes along the San Andreas Fault, which is a transform boundary located along the eastern edge of the Pacific Plate.
 - (i) **Describe** what happens to the tectonic plates along a transform boundary at the moment when an earthquake occurs.
 - (ii) **Describe** what happens to the tectonic plates along a transform boundary during the time between earthquakes.

4.3 Soil Composition and Properties

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS permeability 渗透性 • porosity 孔隙度 • texture 质地 • soil 土壤

Objective

Build the skills to answer exam questions on **soil composition and properties**.

You must be able to:

- classify soil by **texture** 质地 (sand, silt, clay) using the soil triangle idea
- link texture to **water-holding** and drainage
- describe **porosity** 孔隙度 and **permeability** 渗透性

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Soil particle sizes

Soil texture depends on particle size: **sand** (largest), **silt** (medium), **clay** (smallest). **Loam** is a balanced mix and is best for most crops.

■ Texture and water

- **Sandy** soil — large pores, drains fast, holds little water.
- **Clay** soil — tiny pores, drains slowly, holds much water but can waterlog.
- **Loam** — good balance of drainage and water retention.

■ Porosity and permeability

- **Porosity** — the fraction of pore (empty) space; how much water it can hold.
- **Permeability** — how easily water flows through; high in sand, low in clay.

■ A worked reasoning

A sandy soil drains quickly and dries out fast (high permeability, low water retention), so it needs more frequent watering.

2 Practice

Now apply the methods above.

2.1 Which soil particle is the largest? [1]

2.2 Which soil type holds the most water? [1]

2.3 What is porosity? [1]

3 Exam-style questions

3.1 Sandy soil drains quickly because it has [1]

- **A** small pores and low permeability
 - **B** large pores and high permeability
 - **C** no pores
 - **D** high water retention
-

3.2 A gardener compares sandy soil and clay soil.

(a) State which drains faster and which holds more water. [2]

(b) Explain why loam is often best for crops. [2]

3.3 Explain the difference between porosity and permeability. [2]

Solutions

2.1 Sand.

2.2 Clay.

2.3 The fraction of empty (pore) space in the soil.

3.1 B — large pores and high permeability.

3.2 (a) Sandy soil drains faster; clay holds more water. (b) Loam balances drainage and water retention (and holds nutrients), so roots get enough water and air without waterlogging.

3.3 Porosity is how much empty space (water capacity) the soil has; permeability is how easily water flows through it.

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. Researchers interested in sustainability developed three new varieties of genetically modified green beans designed to produce higher yields in arid regions. Four plots (A–D) were set up on a floodplain of a river to grow beans. Plots A, B, and C were each planted with seeds of different types of genetically modified strains of green beans. Plot D was planted with seeds of unmodified green beans. Each plot was given equal amounts of fertilizer, which contains phosphorus and nitrogen, and water and was irrigated using spray irrigation for one hour per day. Throughout the growing season, researchers measured the amount of green beans harvested within each plot. The plots with genetically modified beans had higher crop yields than the plot with unmodified beans.

- (a) **Identify** the control group in this experiment.
- (b) **Identify** the scientific question for the investigation.
- (c) Researchers repeated the experiment by modifying the length of time for the spray irrigation to 20 minutes per day. **Explain** how the results of the experiment could be altered with this modification.

Researchers also monitored the amount of sediment and fertilizer washing into the river from each plot in the original study. The soil temperature was also measured in each plot at the same depth and at the same time each day approximately 0.05 meters below the surface of the soil.

Genetically Modified Green Bean Experimental Results

Plot	Sediment Runoff (mg/L)	Phosphorus Runoff (mg/L)	Nitrogen Runoff (mg/L)	Soil Temperature (°C)
A (Type 1 GMO beans)	2.4	0.11	1.07	18.6
B (Type 2 GMO beans)	2.1	0.02	0.56	18.3
C (Type 3 GMO beans)	0.9	0.04	0.68	18.3
D (Unmodified beans)	3.5	0.15	1.24	17.6

- (d) Based on the data in the table, **identify** the plot with the lowest soil temperature.
- (e) **Describe** how sediment runoff and fertilizer runoff compare between the unmodified green beans and the genetically modified green beans.

- (f) The Type 2 GMO beans in Plot B were developed to grow more quickly than the unmodified beans in Plot D. Researchers have hypothesized that the Type 2 beans would use fertilizer more completely than the other varieties. Based on the data in the table and the experimental design, **explain** whether the researchers' hypothesis was supported or refuted.

Once the experiment was concluded, the researchers burned the plots to remove the crops that had been planted. After a few years, the researchers returned to the plots and observed a variety of plants, insects, and bird species living there.

- (g) **Describe** the ecological process that occurred on the plots after the crops were burned.

A survey indicated that one of the plots had twice the plant diversity that the other plots had. Over the next five years, the river occasionally flooded the plots, killing off many of the species that inhabited the plots.

- (h) After each flooding event, the plot with twice the plant diversity returned to its prior level of biodiversity more quickly than the other plots did. **Explain** why a community with more plant diversity will recover more quickly from the flooding.
- (i) After the last flooding event, a beetle not previously known in the area appeared in one of the plots with less plant diversity. Over a period of a few months, the new beetle population increased, whereas the existing beetle species in the plot had declining populations. **Explain** why the new beetle species could be better able to successfully populate this plot than the existing beetle species could.
- (j) **Describe** one realistic method to prevent the new beetle from spreading beyond the experimental plot.

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.

ENVIRONMENTAL SCIENCE

SECTION II

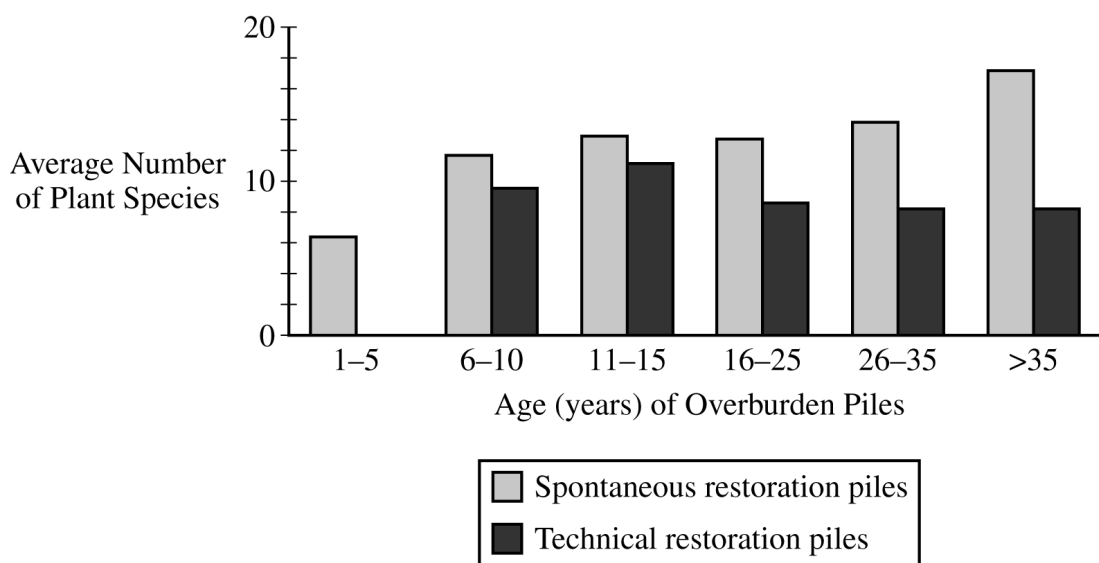
Time—1 hour and 10 minutes

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

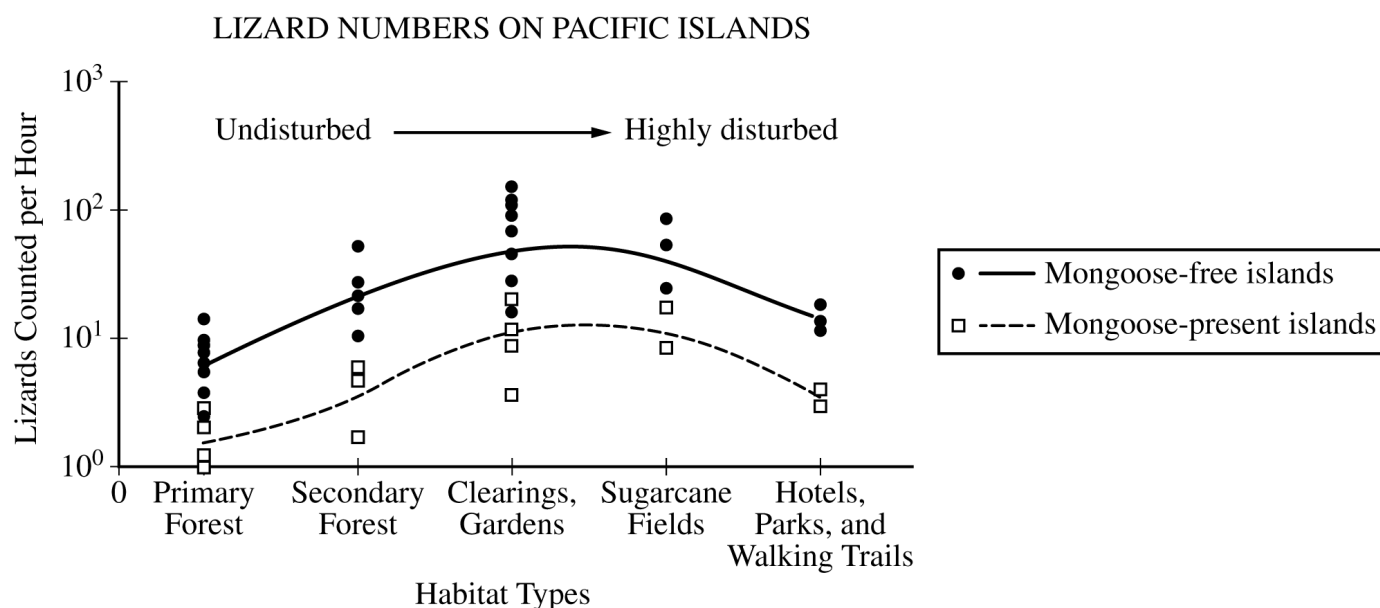
- (f) **Identify** the scientific question for the investigation.
- (g) **Identify** a dependent variable in the experiment.
- (h) **Explain** how the results of the experiment would likely have been altered if the soil had contained a higher percentage of sand, which has the largest particle size of 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.

2. Biologists collected data on the abundance of lizards on several Pacific islands with and without mongoose populations. The surveys were conducted at different locations on the islands by counting the number of lizards observed per hour and included habitats with both undisturbed areas and anthropogenically disturbed areas.



- (a) The graph shows data collected by biologists on lizard numbers on several Pacific islands.
- Based on the data in the graph, **identify** the habitat type with the greatest number of lizards.
 - Based on the data in the graph, **describe** the relationship between the lizard numbers observed on islands with and without mongoose populations.

Globally, islands vary in size, location, and habitat.

- (b) Based on the theory of island biogeography, **describe** the characteristics of an island with the greatest species diversity.
- (c) Island ecosystems are often threatened by invasive species, such as the mongoose populations studied in the survey.
- Describe** one environmental problem caused by invasive animal species.
 - Invasive species are often pests. **Make a claim** that proposes one way to control pest species.
 - Justify** the solution proposed in (c)(ii) by providing an additional benefit of the solution.
- (d) Islands provide humans with many ecosystem services. However, humans may alter ecosystems when they obtain these services. Large-scale commercial sugarcane farming on the Pacific islands has led to significant ecological damage.
- Identify** a provisioning ecosystem service provided by primary forests.
 - Based on the data in the graph, **explain** how replacing primary forests with sugarcane fields may have affected the number of lizards counted on the mongoose-free Pacific islands.
 - The long-term use of monocultures in commercial sugarcane farming is one cause of the ecological damage. **Describe** one problem associated with monocultures.

One solution to the ecological damage of monocultures is to use a form of crop rotation using legumes.

- (e) **Describe** an advantage of crop rotation using legumes on soil fertility.

3. North Carolina is one of the fastest-growing states by population in the United States, with most growth concentrated in major cities like Charlotte. Increased population leads to increased demands for resources such as power and water.

The majority of electrical energy in North Carolina is produced during the combustion of coal.

- (a) **Identify** one negative human health effect linked to the exposure to pollutants resulting from the combustion of coal.
- (b) Coal ash, the powdery, solid substance that remains after coal combustion, presents a variety of potential environmental issues. Disposal of toxic coal ash is a growing concern in the state. Coal ash can be mixed with water and disposed of in large, unlined pits or as dry ash in landfills.
- (i) **Describe** an environmental problem associated with coal ash waste disposal.
- (ii) A proposed solution is to dispose of North Carolina's coal ash in clay-lined pits. **Justify** this solution by providing one advantage of using clay soil.
- (c) The population of Charlotte, North Carolina, has grown over the last few decades. The table shows the increase in the population size of Charlotte from 2013 to 2019.

Population of Charlotte, North Carolina, 2013–2019

Year	Population
2013	757,278
2014	774,807
2015	792,137
2016	808,834
2017	826,060
2018	841,611
2019	857,425

- (i) **Calculate** the percent change in Charlotte's population from 2013 to 2019. **Show** your work.
- (ii) Based on Charlotte's 2019 growth rate of 1.88%, **calculate** the year when the population of Charlotte will double, assuming the growth rate stays the same. **Show** your work.
- (iii) The average Charlotte resident uses 90 gallons of water per day. **Calculate** the gallons of water used by the population of Charlotte in the year 2018. **Show** your work.
- (d) Drought periods are becoming more frequent in North Carolina, causing water resources to become more scarce. **Describe** one realistic action that citizens could take to reduce domestic outdoor water use.

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.

STOP

END OF EXAM

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.
 - (ii) **Identify** one abiotic component of the A horizon.

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

- (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.
 - (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) **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.

STOP

END OF EXAM

4.4 Earth's Atmosphere

Name: _____ Class: _____ Date: _____

Total: 10 marks**KEY WORDS** ozone layer 臭氧层 • stratosphere 平流层 • troposphere 对流层 • atmosphere 大气层

Objective

Build the skills to answer exam questions on **Earth's atmosphere**.

You must be able to:

- name the atmospheric **layers** 大气层 (troposphere, stratosphere)
- state the main gases
- locate the **ozone layer** 臭氧层 and weather

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Composition

The atmosphere is about **78% nitrogen**, **21% oxygen**, and small amounts of argon, CO₂, and water vapor.

■ The layers (bottom to top)

- **Troposphere** — lowest; where **weather** happens and we live; temperature falls with height.
- **Stratosphere** — above it; contains the **ozone layer**, which absorbs harmful UV; temperature rises with height here.
- (Higher: mesosphere, thermosphere.)

■ The ozone layer

The **ozone layer** in the stratosphere absorbs most of the Sun's harmful **ultraviolet (UV)** radiation, protecting life.

■ A worked identification

Weather and clouds occur in the **troposphere**; the protective ozone layer sits in the **stratosphere** above.

2 Practice

Now apply the methods above.

2.1 What are the two most abundant gases in the atmosphere? [2]

2.2 In which layer does weather occur? [1]

2.3 In which layer is the ozone layer found? [1]

3 Exam-style questions

3.1 The ozone layer protects life by absorbing [1]

- **A** visible light
- **B** ultraviolet (UV) radiation
- **C** carbon dioxide
- **D** oxygen

3.2 A weather balloon rises from the ground into the stratosphere.

(a) Name the two layers it passes through. [2]

(b) State what important feature it reaches in the stratosphere. [1]

3.3 Explain why the ozone layer is important for living things. [2]

Solutions

2.1 Nitrogen (~78%) and oxygen (~21%).

2.2 The troposphere.

2.3 The stratosphere.

3.1 B — ultraviolet (UV) radiation.

3.2 (a) Troposphere then stratosphere. (b) The ozone layer.

3.3 It absorbs most of the Sun's harmful UV radiation, which would otherwise damage DNA and cause skin cancer and harm other organisms.

4.5 Global Wind Patterns

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS coriolis effect 科里奥利效应 • global wind patterns 全球风带 • convection cells 对流环流

Objective

Build the skills to answer exam questions on **global wind patterns**.

You must be able to:

- explain **convection cells** 对流环流 (Hadley cells) and uneven heating
- link rising/sinking air to wet and dry regions
- describe the **Coriolis effect** 科里奥利效应

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Uneven heating drives circulation

The Sun heats the **equator** more than the poles. Warm air **rises** at the equator, cools, and **sinks** around 30° latitude, forming **convection (Hadley) cells**.

■ Rising = wet, sinking = dry

- **Rising** air cools and drops rain → **wet** regions (tropical rainforests near the equator).
- **Sinking** air warms and dries → **dry** regions (deserts near 30° latitude).

■ The Coriolis effect

Earth's rotation **deflects** moving air (and water): to the **right** in the Northern Hemisphere, to the **left** in the Southern. This curves winds into belts (trade winds, etc.).

■ A worked link

Most major deserts sit near 30°N/S because that is where dry, sinking air suppresses rainfall.

2 Practice

Now apply the methods above.

2.1 Where does warm air rise in the global circulation? [1]

2.2 Does rising air create wet or dry conditions? [1]

2.3 What causes the Coriolis effect? [1]

3 Exam-style questions

3.1 Deserts commonly form near 30° latitude because air there is [1]

- **A** rising and wet
 - **B** sinking and dry
 - **C** stationary
 - **D** always cold
-

3.2 Air rises at the equator and sinks near 30° latitude.

(a) State the climate (wet/dry) at the equator and at 30°. [2]

(b) Name this circulation pattern. [1]

3.3 Explain how uneven heating of Earth drives global wind patterns. [2]

Solutions

2.1 At the equator.

2.2 Wet.

2.3 Earth's rotation.

3.1 B — sinking and dry.

3.2 (a) Equator: wet; 30°: dry. (b) A convection (Hadley) cell.

3.3 The Sun heats the equator most; warm air rises there and sinks at higher latitudes, and Earth's rotation deflects the moving air, creating the global wind belts.

4.6 Watersheds

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS watershed 流域 • soil 土壤

Objective

Build the skills to answer exam questions on **watersheds**.

You must be able to:

- define a **watershed** 流域 (drainage basin)
- explain how land use affects water quality in a watershed
- describe runoff collecting into rivers

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ What a watershed is

A **watershed** (drainage basin) is all the land that drains into a **common body of water** (a river, lake, or ocean). Rain that falls anywhere in it flows toward that water.

■ Runoff collects

Water runs downhill, collecting into streams that join into rivers. Everything on the land — soil, fertilizer, pollutants — can be carried along with it.

■ Land use affects water quality

Because runoff carries whatever is on the land, **agriculture** (fertilizer, pesticides), **cities** (oil, sewage), and **construction** (sediment) all affect the quality of the water downstream.

■ A worked link

Fertilizer applied anywhere in a river's watershed can wash into the river, raising nutrient levels and causing eutrophication downstream.

2 Practice

Now apply the methods above.

2.1 Define a watershed. [1]

2.2 How does water move within a watershed? [1]

2.3 Name one land use that can pollute a watershed. [1]

3 Exam-style questions

3.1 A watershed is best described as the land that [1]

- **A** contains no water
 - **B** drains into a common body of water
 - **C** is always a desert
 - **D** cannot be polluted
-

3.2 A farm sits within a river's watershed.

(a) Explain how fertilizer from the farm can reach the river. [2]

(b) State one effect on the river. [1]

3.3 Explain why protecting an entire watershed, not just the river itself, is important for water quality. [2]

Solutions

2.1 All the land that drains into a common body of water.

2.2 It runs downhill, collecting into streams and rivers.

2.3 Any one: agriculture, urban/city runoff, construction.

3.1 B — drains into a common body of water.

3.2 (a) Rain washes fertilizer off the fields as runoff, which flows downhill through the watershed into the river. (b) Eutrophication / algal blooms (or nutrient pollution).

3.3 All land in the watershed drains to the same water, so pollution anywhere in it can reach the water; protecting the whole basin prevents that.

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.

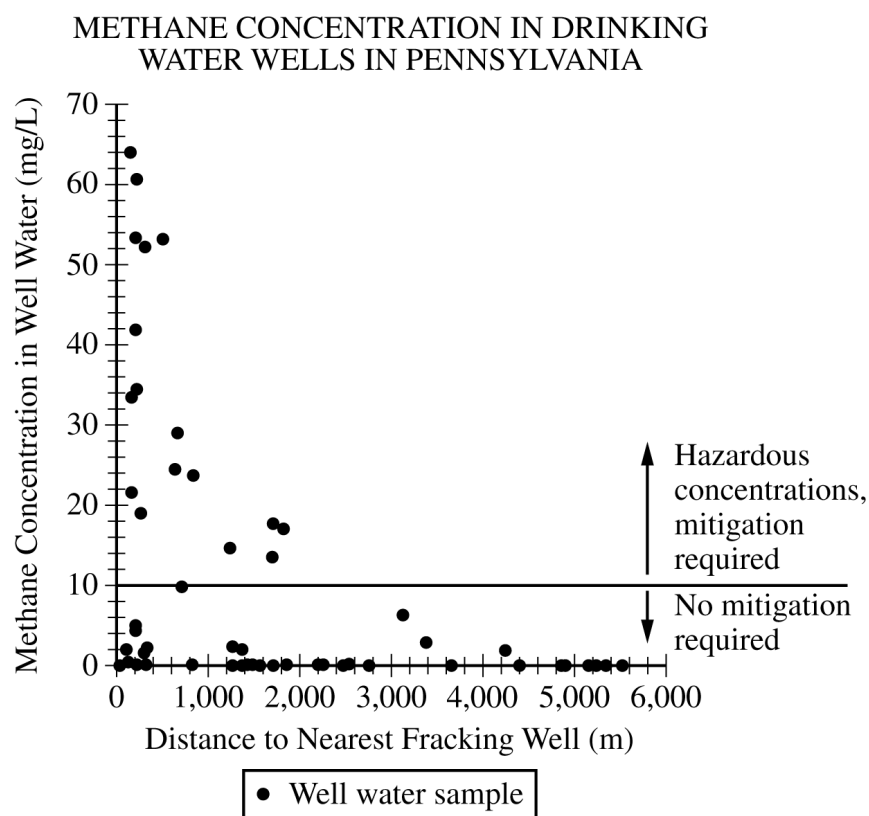
- (f) The watershed of the Upper Colorado River contributes an average of 9.60 maf of water to Lake Powell annually. The melted mountain snow found in the watershed contributes 50% of the average river flow into Lake Powell. In 2021, the river flow was 36% of the annual average. Assuming that all resources 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.

STOP

END OF EXAM

2. Developments in advanced hydraulic fracturing (fracking) technologies have allowed the total oil and gas production in the United States to increase rapidly.



- (a) The graph shows the methane concentration in drinking water from home wells and the distance to the nearest fracking well in Pennsylvania.
- Based on the data in the graph, **identify** the highest methane concentration found in well water in Pennsylvania.
 - Based on the data in the graph, **describe** the relationship between the concentration of methane in well water and the distance to a fracking well.
 - Based on the data in the graph, **identify** the minimum safe distance that a new water well should be located from an existing fracking well.
 - Explain** how fracking fluid is used to access oil and natural gas in sedimentary rock, such as shale, during the fracking process.
 - Identify** one negative geologic effect in an area where hydraulic fracturing (fracking) occurs.
- (b) The volume of water used for oil and gas extraction is 28 times greater than it was fifteen years ago. Much of the water used for oil and gas extraction comes from groundwater sources in arid or semiarid regions. This increased use of water for fracking may mean that less water is available for local use.
- The use of groundwater for fracking is an example of individuals using a shared resource for their own self-interest. **Identify** the environmental concept illustrated by this example of overuse of a shared resource.
 - Describe** one environmental problem that may result from increased use of groundwater for fracking in arid or semiarid regions.
 - Describe** how overuse of coastal groundwater supplies can result in water that is unsuitable for human consumption.

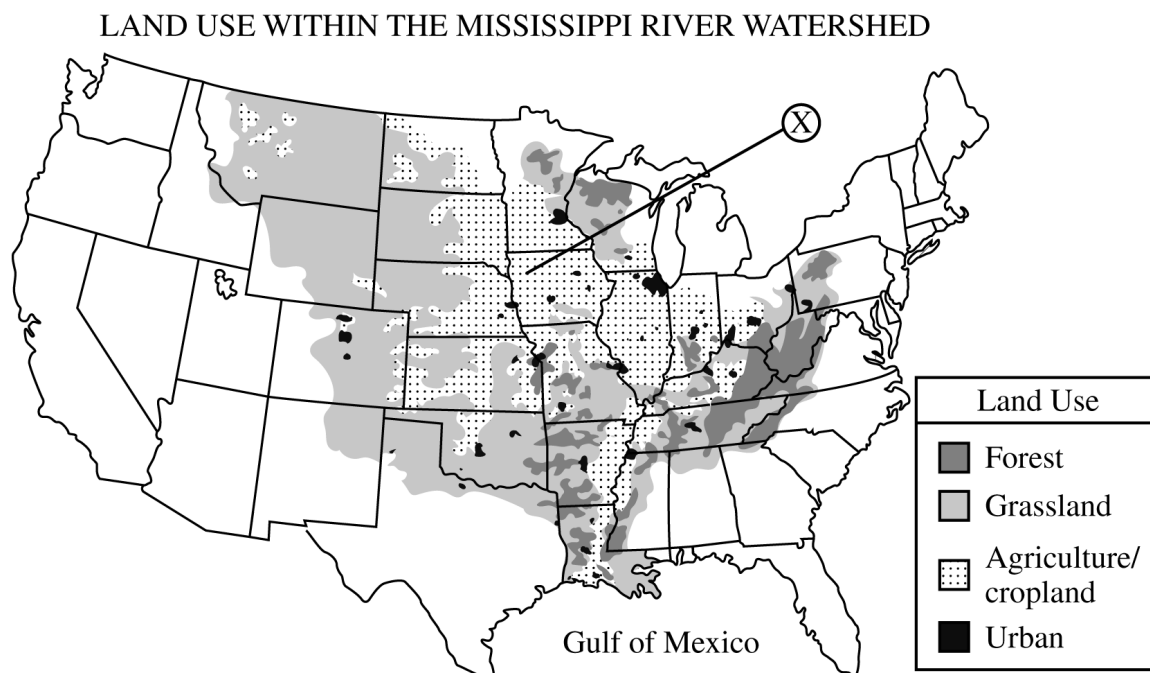
- (c) In addition to water quality issues caused by fossil fuel extraction, air quality can also be negatively affected by combustion of oil and natural gas.
- (i) **Make a claim** for a realistic governmental action to improve air quality by reducing consumption of oil.
 - (ii) **Justify** the action proposed in part (c)(i) by stating a potential environmental advantage of that action, other than slowing global climate change.

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.

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. The dead zone in the Gulf of Mexico occurs every summer when winter snow melts and spring rain flows into the Mississippi River. Recent studies have shown that both the total area covered by algae and the depth of the algal mass in the dead zone are increasing.



- (a) Various land use practices can have different effects on the waters that surround a dead zone.
- (i) **Identify** the land use that covers the least amount of area in the Mississippi River watershed, based on the diagram.
 - (ii) **Describe** one way that the land use practice at location X in the diagram could contribute to the dead zone in the Gulf of Mexico.
 - (iii) **Describe** one way that urban areas in the Mississippi River watershed could contribute to the dead zone in the Gulf of Mexico.

- (b) The dead zone in the Gulf of Mexico has both economic and environmental effects for coastal communities.
- (i) **Describe** how a dead zone affects marine organisms living in the Gulf of Mexico.
 - (ii) **Describe** one economic effect on communities along the Gulf of Mexico that can result from the presence of the dead zone.
 - (iii) **Describe** one factor that causes the area of the dead zone in the Gulf of Mexico to increase in the summer months.
- (c) Researchers want to examine the effect of riparian vegetation buffers on water quality in streams in agricultural areas. Researchers will measure the water nutrient concentrations over the course of one year. The study sites are located 100 meters downstream from areas either with or without riparian vegetation buffers.
- (i) **Identify** a testable hypothesis for the study.
 - (ii) **Describe** a control that the researchers could use in the study.
 - (iii) **Identify** one water quality test, other than measuring nitrates or phosphates, that the researchers could use to evaluate how riparian vegetation buffers affect water quality.
 - (iv) During the investigation, researchers discovered that some of the land next to one of the streams with a riparian vegetation buffer is going to be converted from cornfields into a large-scale concentrated animal feeding operation. **Explain** one way that this change in land use could alter the results of the study.

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.

3. North Carolina is one of the fastest-growing states by population in the United States, with most growth concentrated in major cities like Charlotte. Increased population leads to increased demands for resources such as power and water.

The majority of electrical energy in North Carolina is produced during the combustion of coal.

- (a) **Identify** one negative human health effect linked to the exposure to pollutants resulting from the combustion of coal.
- (b) Coal ash, the powdery, solid substance that remains after coal combustion, presents a variety of potential environmental issues. Disposal of toxic coal ash is a growing concern in the state. Coal ash can be mixed with water and disposed of in large, unlined pits or as dry ash in landfills.
- (i) **Describe** an environmental problem associated with coal ash waste disposal.
- (ii) A proposed solution is to dispose of North Carolina's coal ash in clay-lined pits. **Justify** this solution by providing one advantage of using clay soil.
- (c) The population of Charlotte, North Carolina, has grown over the last few decades. The table shows the increase in the population size of Charlotte from 2013 to 2019.

Population of Charlotte, North Carolina, 2013–2019

Year	Population
2013	757,278
2014	774,807
2015	792,137
2016	808,834
2017	826,060
2018	841,611
2019	857,425

- (i) **Calculate** the percent change in Charlotte's population from 2013 to 2019. **Show** your work.
- (ii) Based on Charlotte's 2019 growth rate of 1.88%, **calculate** the year when the population of Charlotte will double, assuming the growth rate stays the same. **Show** your work.
- (iii) The average Charlotte resident uses 90 gallons of water per day. **Calculate** the gallons of water used by the population of Charlotte in the year 2018. **Show** your work.
- (d) Drought periods are becoming more frequent in North Carolina, causing water resources to become more scarce. **Describe** one realistic action that citizens could take to reduce domestic outdoor water use.

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.

STOP

END OF EXAM

3. Haiti shares a border with the Dominican Republic on the Caribbean island of Hispaniola.
- (a) The border between the two countries can be seen using satellite images because of the severe deforestation in Haiti.
 - (i) **Provide** one reason why deforestation commonly occurs in a less developed country such as Haiti.
 - (ii) **Describe** one realistic strategy to reduce deforestation in a less developed country.
 - (b) Deforestation can affect water quality. **Identify** one change that can occur in the water quality of streams within a watershed that has been deforested. **Explain** how deforestation can lead to this change.
 - (c) **Identify** TWO environmental benefits, other than those related to water quality, of maintaining forest ecosystems.

The table below contains demographic data for Haiti in 1995 and 2015.

DEMOGRAPHIC DATA FOR HAITI

Measure	1995	2015
Fertility rate (number of children per woman)	5.2	2.7
Life expectancy (years)	55	64
Infant mortality (deaths per 1,000)	85	48

- (d) **Identify** and **discuss** one factor in a less developed country that could contribute significantly to a change in life expectancy, similar to what occurred in Haiti from 1995 to 2015.
- (e) **Identify** and **discuss** one economic or cultural factor in a less developed country that could contribute significantly to a change in the fertility rate, similar to what occurred in Haiti from 1995 to 2015.

4. Dams are built by humans for various purposes including hydroelectric power generation and control of downstream flooding.
- (a) **Explain** how electricity is generated at a hydroelectric dam.
 - (b) **Identify** TWO economic benefits, other than hydroelectric power generation and control of downstream flooding, associated with dams.
 - (c) **Describe** one ecological benefit of seasonal flooding of the floodplain of a free-flowing river.
 - (d) Some dams have been removed from rivers.
 - (i) **Explain** how removal of a dam can benefit fish populations.
 - (ii) **Describe** one negative environmental consequence of removing a dam from a river (other than effects on fish populations).
 - (e) Dams are also built by beavers, a keystone species in some North American ecosystems.
 - (i) **Define** keystone species.
 - (ii) **Describe** how dams built by beavers can make beavers a keystone species in some ecosystems.

STOP

END OF EXAM

ENVIRONMENTAL SCIENCE**SECTION II****Time—90 minutes****4 Questions**

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this book. 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.

1. Read the article below and answer the questions that follow.

The Floridian Daily**May 21, 2013**

The small community located on the edge of the magnificent wetlands of Florida's Everglades was the site of a press conference today where Governor Gayle Moss announced that the restoration of the Everglades is successfully underway. She noted that the Everglades ecosystem has suffered threats to its water quality, water quantity, and habitats in recent decades. Moss noted that intensive urban and agricultural development in adjacent areas has diverted substantial amounts of

freshwater resources and impaired water quality. Governor Moss then emphasized that the preservation and enhancement of the Everglades, key goals of the restoration program, are absolutely essential for the continued environmental and economic health of the state. She closed the press conference by saying, "The Everglades is a gem not only for Florida but for the entire world. Each of us has the responsibility to do our part to preserve this magnificent resource."

- (a) **Describe** how TWO human activities, other than those that result in anthropogenic climate change, have resulted in a decrease in the amount of freshwater flowing into the Everglades ecosystem.
- (b) In addition to water quantity problems, the Everglades is faced with a variety of water quality issues. For example, phosphorus concentrations in the Everglades have increased since the 1960s.
- (i) **Describe** how one specific human activity contributes to increased phosphorus levels in the Everglades.
 - (ii) **Explain** one way in which an increase in phosphorus levels can adversely affect the Everglades ecosystem.
 - (iii) **Describe** one step that could be taken to reduce phosphorus inputs from the activity you identified in part (i).
- (c) Climate change could have a variety of impacts on water quantity, water quality, and habitat. For EACH of these three factors, **identify and describe** one specific example of an impact on the Everglades likely to result from climate change.
- (d) The article states that Governor Moss believes that the "preservation and enhancement of the Everglades, key goals of the restoration program, are absolutely essential for the continued environmental and economic health of the state."
- (i) **Describe** one way that restoring water quantity and water quality in the Everglades is expected to improve the structure and function of the ecosystem.
 - (ii) **Describe** one way that restoring the Everglades is expected to provide economic benefits to Florida.

4.7 Solar Radiation and Earth's Seasons

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS axial tilt 地轴倾斜

Objective

Build the skills to answer exam questions on **solar radiation and Earth's seasons**.

You must be able to:

- explain that seasons come from Earth's **axial tilt** 地轴倾斜
- link the angle of sunlight to intensity
- explain why the equator is warm year-round

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Seasons come from the tilt

Earth's axis is **tilted** about 23.5° . As Earth orbits the Sun, each hemisphere tilts **toward** the Sun (summer) or **away** (winter). Seasons are **not** caused by distance from the Sun.

■ Angle and intensity

Sunlight hitting at a **high angle** (near vertical) is concentrated → **more intense, warmer**. Sunlight at a **low angle** spreads over a larger area → **less intense, cooler**.

■ The equator

The **equator** receives near-vertical sunlight all year, so it is consistently warm with little seasonal change.

■ A worked reasoning

In a hemisphere's summer, it tilts toward the Sun, so sunlight strikes at a higher angle and days are longer, making it warmer.

2 Practice

Now apply the methods above.

2.1 What causes Earth's seasons? [1]

2.2 Does high-angle or low-angle sunlight deliver more energy per area? [1]

2.3 Why is the equator warm all year? [1]

3 Exam-style questions

3.1 Earth's seasons are caused by its [1]

- **A** distance from the Sun
 - **B** axial tilt
 - **C** rotation speed
 - **D** magnetic field
-

3.2 In June, the Northern Hemisphere experiences summer.

(a) Explain how the axial tilt causes this. [2]

(b) State how the angle of sunlight differs from winter. [1]

3.3 Explain why high-latitude regions are colder than the equator. [2]

Solutions

2.1 Earth's axial tilt (as it orbits the Sun).

2.2 High-angle sunlight.

2.3 It receives near-vertical (high-angle) sunlight all year.

3.1 B — axial tilt.

3.2 (a) In June the Northern Hemisphere tilts toward the Sun, so it receives more direct sunlight and longer days, making it warmer. (b) Sunlight strikes at a higher angle than in winter.

3.3 At high latitudes sunlight strikes at a low angle, spreading the energy over a larger area, so it is less intense and colder than the near-vertical sunlight at the equator.

3. Increasing global urbanization causes associated problems such as the formation of urban heat islands.

(a) **Describe** how urbanization leads to the formation of urban heat islands.

(b) Urban heat islands have been linked to a variety of environmental problems.

(i) **Propose** a reasonable solution that could help lower the temperature increases caused by urban heat islands.

(ii) **Justify** the solution proposed in part (b)(i) by providing one additional benefit other than reducing temperatures in urban heat islands.

(c) Urban areas are increasingly using solar energy to generate electricity for residences and businesses.

(i) As a result of improved technology, the efficiency of solar panels has changed over time. In 1992 a solar cell had a maximum efficiency of 15.9%. In 2017 a solar cell prototype capable of 44.5% efficiency was produced. **Calculate** the percent change in efficiency from the 1992 cell to the 2017 cell. **Show** your work.

(ii) The average home in the United States uses 12,900 kWh of electricity per year. The local power company is raising the cost of purchasing electricity from \$0.11 per kWh to \$0.13 per kWh. Assuming a home uses the average kWh of electricity in one year, **calculate** the change in electricity cost for one year for the homeowner. **Show** your work.

(iii) The roof of a typical house in the United States receives a total of four hours of sunlight per day that can be converted by solar panels into electricity. A house has 30 solar panels on its roof, and each panel generates a maximum output of 300 watts. **Calculate** how many kWh can be produced by the system at maximum output in one calendar year. **Show** your work.

(d) **Explain** why the Northern Hemisphere receives more solar energy from the Sun between June and August than the Southern Hemisphere receives between June and August.

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.

STOP

END OF EXAM

4.8 Earth's Geography and Climate

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS rain shadow 雨影 • rain shadow effect 雨影效应

Objective

Build the skills to answer exam questions on **Earth's geography and climate**.

You must be able to:

- explain the **rain shadow effect** 雨影效应
- describe how large water bodies moderate climate
- link elevation and latitude to climate

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The rain shadow effect

When moist air meets a mountain, it **rises**, cools, and drops rain on the **windward** side (wet). The now-dry air descends the **leeward** side, creating a dry **rain shadow** (often a desert).

■ Water moderates climate

Large bodies of water heat and cool slowly, so **coastal** areas have milder, more stable temperatures than inland areas, which have larger swings.

■ Elevation and latitude

Temperature **falls** with higher **elevation** and higher **latitude**. A tall tropical mountain can have cold, even snowy, peaks.

■ A worked link

A desert on the leeward side of a mountain range forms because the air lost its moisture climbing the windward side — a rain shadow.

2 Practice

Now apply the methods above.

2.1 On which side of a mountain does rain fall (rain shadow effect)? [1]

2.2 How do large water bodies affect nearby temperatures? [1]

2.3 What happens to temperature as elevation increases? [1]

3 Exam-style questions

3.1 A rain shadow desert forms on the mountain's [1]

- **A** windward (wet) side
 - **B** leeward (dry) side
 - **C** summit only
 - **D** base only
-

3.2 Moist air blows over a mountain range.

(a) Describe what happens to the air on the windward and leeward sides. [3]

(b) State the type of ecosystem likely on the leeward side. [1]

3.3 Explain why a coastal city has smaller temperature swings than an inland city at the same latitude. [2]

Solutions

2.1 The windward side.

2.2 They moderate them — milder, more stable temperatures nearby.

2.3 It falls (decreases).

3.1 B — the leeward (dry) side.

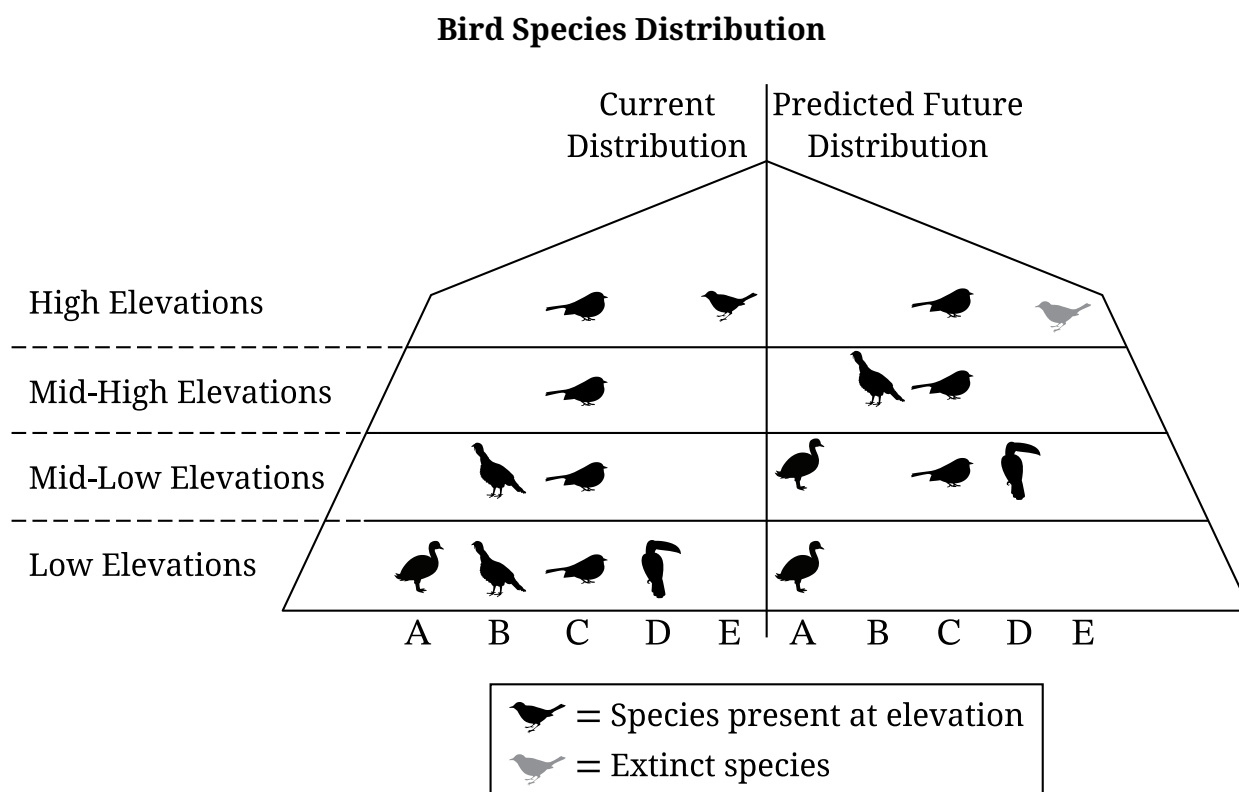
3.2 (a) On the windward side the air rises, cools, and drops rain; the dry air then descends the leeward side, warming and staying dry. (b) A desert (dry ecosystem).

3.3 Water heats and cools slowly, so the nearby coast stays milder; inland areas lack this buffer and have larger day-night and seasonal swings.

The following information applies to parts A, B, C, D, and E.

Climate change can affect both terrestrial and marine organisms. Researchers studying the effect of climate change on bird distribution mapped elevation zones at which five bird species lived within a tropical mountain range. Birds are distributed in part according to climate-related adaptations. Researchers modeled where the birds would most likely live in the future based on climate change predictions.

The results of this study are shown in the following diagram. Each unique shape in the diagram represents a different bird species, labeled A through E. Current distribution is shown on the left side of the figure, and predicted future distribution is shown on the right.

**The following information applies to parts F, G, and H.**

Some organisms such as birds can move in response to environmental changes, while other organisms such as corals cannot. Researchers studying the effect of climate change on marine organisms conducted two experiments involving photosynthetic algae that have a symbiotic relationship with corals.

In Experiment 1, the researchers placed photosynthetic algal colonies living in corals in three different saltwater tanks. The temperature of Tank 1 was set to 27°C, the average temperature at which most corals live. Water circulation in each tank mimicked natural ocean currents. After 30 days, the researchers counted the number of bleached corals. The tank setups are shown in the following list.

- Tank 1: 27°C and no sediment
- Tank 2: 32°C and no sediment
- Tank 3: 37°C and no sediment

In Experiment 2, the researchers used the same photosynthetic algae living in corals but modified the conditions of the tanks as shown in the following list. Water circulation kept the sediment in the tanks suspended. After 30 days, the researchers counted the number of bleached corals.

- Tank 1: 27°C and no sediment
- Tank 2: 27°C and moderate sediment
- Tank 3: 27°C and high sediment

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

Part A

Based on the information in the diagram, **identify** the elevation zone that has the highest species richness for the current distribution.

Part B

Describe a climate condition at high elevations that is different than it is at low elevations.

Part C

A predator at low elevations currently feeds on Species C and D. Based on the information in the diagram, **describe** what could happen to the predator species in the future in response to the predicted changes in the prey community.

Part D

Species C is considered a generalist, while Species E is considered a specialist. **Explain** why Species C and E are predicted to respond differently to climate change.

Part E

Based on the information in the diagram, **explain** why the bird community at low elevations in the future would be less likely to recover from natural disruptions than the current low-elevation bird community.

Part F

Identify the independent variable in Experiment 1.

Part G

Identify a likely scientific question for Experiment 1.

Part H

In Experiment 2 the temperature of the tanks was held constant, while the amount of sediment was varied. **Explain** how this modification could affect the results of this experiment.

Part I

Changes in climate also affect Arctic ecosystems. One impact of climate change is the loss of ice and snow in polar regions. **Describe** a positive feedback loop that results from the loss of ice and snow in polar regions.

Part J

Describe one problem that Arctic species, such as polar bears or ringed seals, face because of warming in polar regions.

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

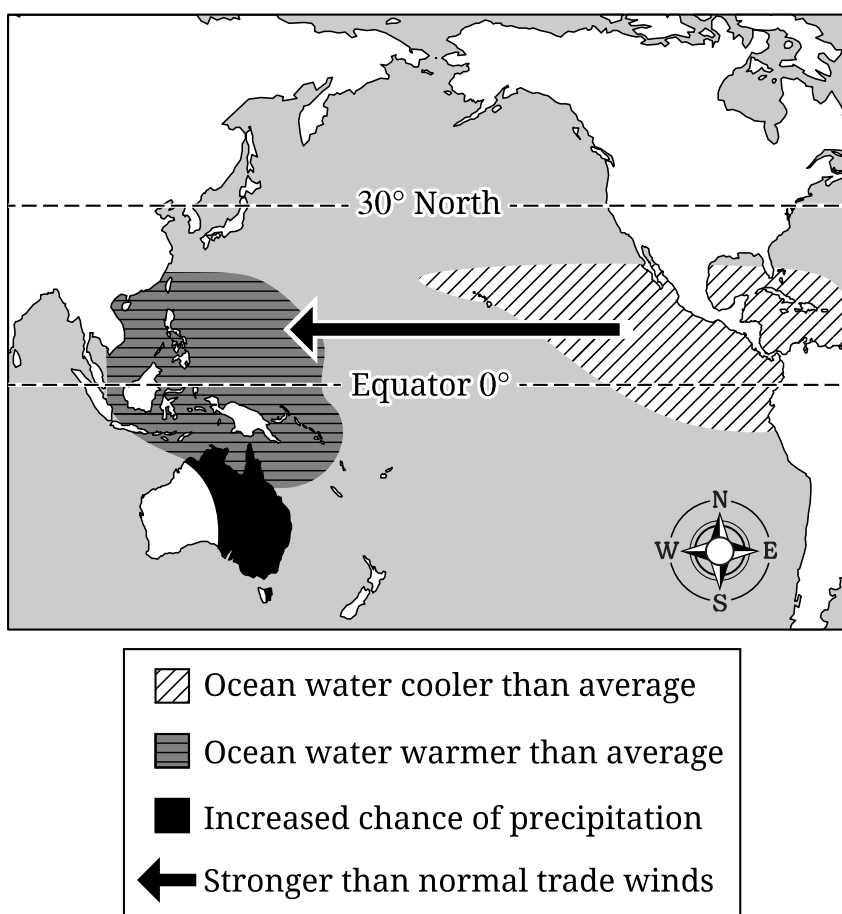
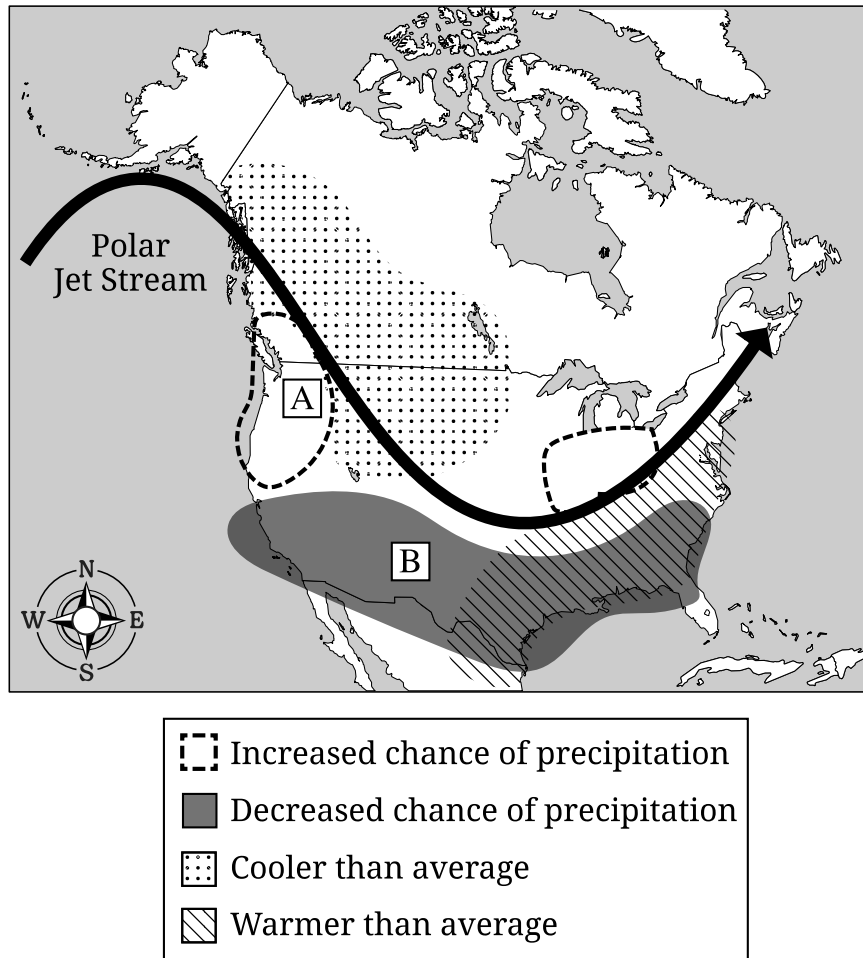


Figure 2. Polar Jet Stream and Climate Conditions in North America

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.

4.9 El Niño and La Niña

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS el niño 厄尔尼诺 • la niña 拉尼娜

Objective

Build the skills to answer exam questions on **El Niño and La Niña**.

You must be able to:

- describe **El Niño** 厄尔尼诺 and **La Niña** 拉尼娜
- link them to changes in ocean temperature and weather
- explain effects on ecosystems and fisheries

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The normal pattern

Normally, trade winds push warm surface water **west** across the Pacific, and cold, nutrient-rich water **upwells** off South America (supporting fisheries).

■ El Niño

In **El Niño**, the trade winds weaken, so warm water spreads **east**. Upwelling is suppressed, so nutrients (and fish) decline off South America; global weather shifts (droughts and floods in different regions).

■ La Niña

La Niña is the opposite — trade winds strengthen, warm water piles up in the **west**, and upwelling off South America is **stronger** (more nutrients).

■ A worked effect

During El Niño, reduced upwelling means fewer nutrients, so plankton and fish populations crash off Peru, hurting the fishing industry.

2 Practice

Now apply the methods above.

2.1 In El Niño, which way does warm water spread across the Pacific? [1]

2.2 What happens to upwelling off South America during El Niño? [1]

2.3 How is La Niña different from El Niño? [1]

3 Exam-style questions

3.1 During El Niño, the fishing industry off South America suffers because [1]

- **A** upwelling and nutrients decrease
 - **B** upwelling increases
 - **C** the water freezes
 - **D** trade winds strengthen
-

3.2 An El Niño year begins.

(a) Describe what happens to the trade winds and warm water. [2]

(b) Explain the effect on plankton and fish off South America. [2]

3.3 Explain why upwelling of cold water supports rich fisheries. [2]

Solutions

2.1 Eastward.

2.2 It is suppressed (reduced).

2.3 In La Niña the trade winds strengthen and upwelling off South America is stronger (the opposite of El Niño).

3.1 A — upwelling and nutrients decrease.

3.2 (a) The trade winds weaken, so warm surface water spreads eastward across the Pacific. (b) Warm water suppresses the cold nutrient upwelling, so plankton decline and fish populations crash.

3.3 Upwelling brings cold, nutrient-rich water to the surface, fueling plankton growth that supports fish and the whole food web.

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.

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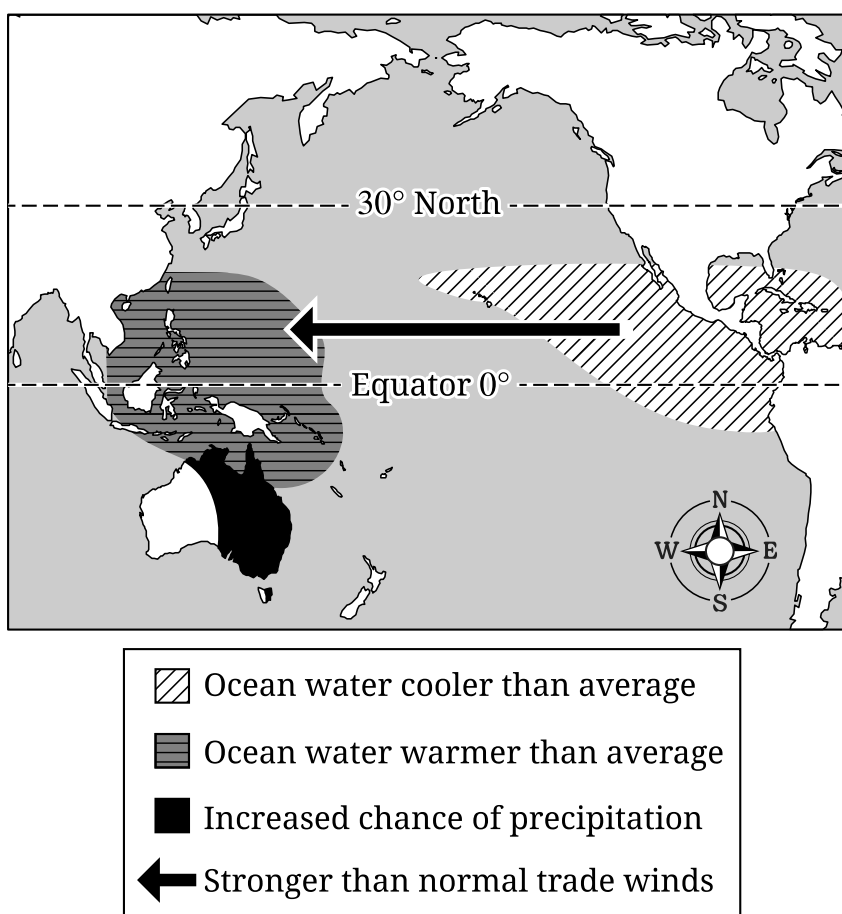
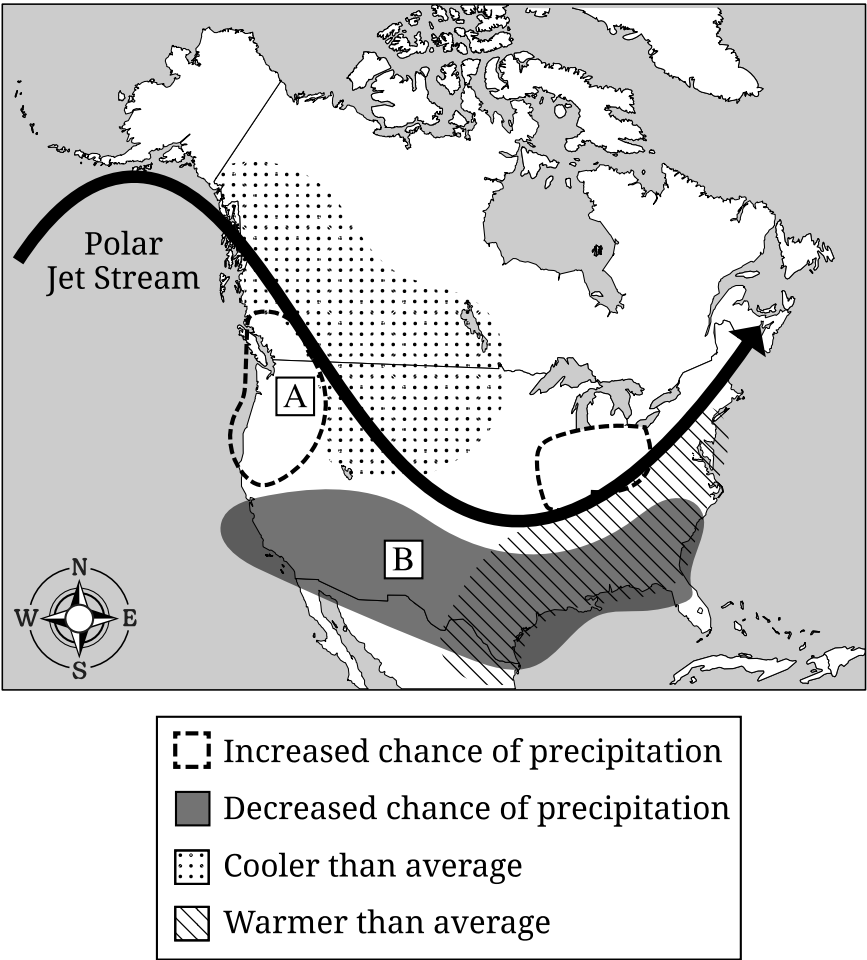


Figure 2. Polar Jet Stream and Climate Conditions in North America



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.
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- 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.
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- 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.