

Week 28

AP Environmental Science

Homework bundle for this week

本周作业合集

exercises.lol

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9. Global Change

Starter Quiz · 课前小测

AP Environmental Science

Name: _____ Score: _____

1. The **ozone layer** high in the atmosphere is important because it...

- ☐ blocks harmful ultraviolet (UV) rays from the sun
- ☐ gives us oxygen to breathe
- ☐ makes it rain
- ☐ creates gravity

2. The **Montreal Protocol** was a global agreement to...

- ☐ phase out CFCs and other ozone-destroying chemicals
- ☐ build more factories
- ☐ burn more coal
- ☐ cut down forests

3. The **greenhouse effect** is when gases in the atmosphere...

- ☐ trap heat and keep the planet warm
- ☐ block all sunlight
- ☐ cool the planet down
- ☐ create oxygen

4. The biggest human source of carbon dioxide is...

- ☐ burning fossil fuels
- ☐ breathing out
- ☐ ocean waves
- ☐ volcanoes only

5. What is the difference between weather and climate?

- ☐ Weather is day-to-day; climate is the long-term average
- ☐ They mean exactly the same thing
- ☐ Climate is only about rain
- ☐ Weather lasts for centuries

6. A thinner ozone layer lets more harmful _____ radiation reach the ground.

7. Because CFCs were banned, the ozone layer is slowly starting to _____.

8. The main greenhouse gas released by burning fossil fuels is carbon _____.

9. Cutting down forests raises CO₂ both by releasing carbon and by removing the trees that _____ it.

10. As ice melts and warm water expands, global sea _____ rises.

1. **blocks harmful ultraviolet (UV) rays from the sun**

The **ozone layer** absorbs most of the sun’s harmful UV rays, shielding life below.

2. **phase out CFCs and other ozone-destroying chemicals**

The **Montreal Protocol** (1987) had countries agree to phase out CFCs — a rare global success.

3. **trap heat and keep the planet warm**

The **greenhouse effect** is greenhouse gases trapping heat, keeping Earth warm enough for life.

4. **burning fossil fuels**

Burning fossil fuels for energy and transport is by far the largest human CO2 source.

5. **Weather is day-to-day; climate is the long-term average**

Weather is what happens on a given day; **climate** is the long-term average over decades.

6. **UV**

Less ozone means more **UV** reaches us, raising skin cancer and eye damage.

7. **recover**

With CFCs falling, the ozone layer is beginning to **recover** — proof that global action works.

8. **dioxide**

Carbon **dioxide** (CO2) is the main greenhouse gas humans add by burning fossil fuels.

9. **absorb**

Forests **absorb** CO2; cutting them releases stored carbon *and* removes a carbon sink — a double hit.

10. **level**

Melting ice and expanding warm water both raise the sea **level**, threatening coastal cities.

9.1 Stratospheric Ozone Depletion

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS ozone 臭氧 • cfc 氯氟烃 • the ozone hole 臭氧洞

Objective

Build the skills to answer exam questions on **stratospheric ozone depletion**.

You must be able to:

- explain how **CFCs** 氯氟烃 destroy stratospheric **ozone** 臭氧
- distinguish “good” (stratospheric) from “bad” (ground-level) ozone
- describe the effects of ozone loss

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.

■ Good vs bad ozone

- **Stratospheric** (“good”) **ozone** shields Earth from UV.
- **Ground-level** (“bad”) **ozone** is a pollutant in smog that harms lungs.

This subtopic is about **depletion of the good, stratospheric** ozone.

■ How CFCs destroy ozone

CFCs (once used in aerosols, refrigerants) drift up to the stratosphere, where UV breaks them apart to release **chlorine**. Each chlorine atom destroys **many** ozone molecules in a chain reaction.

■ The ozone hole

Depletion is worst over **Antarctica** (the “ozone hole”), where cold conditions speed the reactions.

■ Effects

Less ozone lets more harmful **UV** reach the surface, increasing **skin cancer**, cataracts, and harming crops and plankton.

2 Practice

Now apply the methods above.

2.1 Which chemicals are the main cause of ozone depletion? [1]

2.2 What atom released from CFCs destroys ozone? [1]

2.3 State one effect of increased UV from ozone loss. [1]

3 Exam-style questions

3.1 Stratospheric ozone is important because it [1]

- **A** causes smog
 - **B** absorbs harmful UV radiation
 - **C** warms the ground
 - **D** is a greenhouse gas only
-

3.2 CFCs from old refrigerators reach the stratosphere.

(a) Explain how they destroy ozone. [3]

(b) State one health effect of the resulting UV increase. [1]

3.3 Distinguish “good” stratospheric ozone from “bad” ground-level ozone. [2]

Solutions

2.1 CFCs (chlorofluorocarbons).

2.2 Chlorine.

2.3 Any one: skin cancer, cataracts, crop/plankton damage.

3.1 B — absorbs harmful UV radiation.

3.2 (a) CFCs rise to the stratosphere; UV breaks them, releasing chlorine; each chlorine atom destroys many ozone molecules in a chain reaction. (b) Skin cancer (or cataracts).

3.3 Good ozone is in the stratosphere and shields Earth from UV; bad ozone is at ground level, a smog pollutant that harms lungs.

9.2 Reducing Ozone Depletion

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS montreal protocol 蒙特利尔议定书 • greenhouse gases 温室气体 • cfc 氯氟烃
• ozone layer 臭氧层 • the ozone hole 臭氧洞

Objective

Build the skills to answer exam questions on **reducing ozone depletion**.

You must be able to:

- describe the **Montreal Protocol** 蒙特利尔议定书
- explain the switch from CFCs to substitutes
- evaluate the recovery of the ozone layer

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 Montreal Protocol

The **Montreal Protocol** (1987) was an international agreement to **phase out CFCs** and other ozone-depleting substances. It is often called the most successful environmental treaty.

■ Substitutes

CFCs were replaced with **HCFCs** and then **HFCs**, which do far less (or no) ozone damage. (Some HFCs are strong greenhouse gases, now also being phased down.)

■ Recovery

Because CFCs persist, the ozone layer recovers slowly, but the ozone hole is now **shrinking** and is expected to heal over decades — showing global cooperation can work.

■ A worked evaluation

The Montreal Protocol shows that a coordinated global ban on a harmful chemical can reverse an environmental problem, given time for the long-lived pollutant to decline.

2 Practice

Now apply the methods above.

2.1 What did the Montreal Protocol do? [1]

2.2 What replaced CFCs? [1]

2.3 Is the ozone layer recovering? [1]

3 Exam-style questions

3.1 The Montreal Protocol is considered successful because it [1]

- **A** increased CFC use
- **B** phased out ozone-depleting substances globally
- **C** banned all refrigerators
- **D** had no effect

3.2 After the Montreal Protocol, CFC use fell sharply.

(a) Explain why the ozone layer still took decades to recover. [2]

(b) State one lesson this treaty offers for other global problems. [1]

3.3 Explain one drawback of some CFC substitutes (HFCs). [2]

Solutions

2.1 Phased out CFCs and other ozone-depleting substances.

2.2 HCFCs / HFCs.

2.3 Yes (slowly).

3.1 B — phased out ozone-depleting substances globally.

3.2 (a) CFCs are persistent, so those already in the atmosphere kept destroying ozone for decades before declining. (b) Global cooperation can solve a shared environmental problem.

3.3 Some HFCs, though ozone-safe, are potent greenhouse gases that contribute to climate change.

9.3 The Greenhouse Effect

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS greenhouse effect 温室效应 • greenhouse gases 温室气体 • cfc 氯氟烃
• methane 甲烷 • ultraviolet 紫外线

Objective

Build the skills to answer exam questions on the **greenhouse effect**.

You must be able to:

- explain the **greenhouse effect** 温室效应
- name the main **greenhouse gases** 温室气体
- distinguish the natural effect from the enhanced (human) one

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 it works

The **greenhouse effect**: the Sun warms Earth, which re-emits **infrared (heat)** radiation. **Greenhouse gases** absorb some of this heat and re-radiate it back, keeping the surface warmer than it would otherwise be.

■ The natural effect is essential

The **natural** greenhouse effect keeps Earth's average temperature livable (about 15°C instead of freezing). Without it, Earth would be too cold for life.

■ The enhanced effect

Human emissions **add** greenhouse gases, strengthening the effect (the **enhanced greenhouse effect**), trapping more heat and warming the planet.

■ The main gases

- **Carbon dioxide (CO₂)** — burning fossil fuels.
- **Methane (CH₄)** — livestock, landfills.
- **Nitrous oxide, water vapor**, and CFCs.

2 Practice

Now apply the methods above.

2.1 What type of radiation do greenhouse gases absorb? [1]

2.2 Name two greenhouse gases. [2]

2.3 Why is the natural greenhouse effect important? [1]

3 Exam-style questions

3.1 Greenhouse gases warm the Earth by absorbing and re-emitting [1]

- **A** visible light
- **B** infrared (heat) radiation
- **C** ultraviolet only
- **D** sound

3.2 Human activity is strengthening the greenhouse effect.

(a) Explain the difference between the natural and enhanced greenhouse effect. [2]

(b) State the main gas responsible and its main source. [2]

3.3 Explain why the natural greenhouse effect is necessary for life on Earth. [2]

Solutions

2.1 Infrared (heat) radiation.

2.2 Any two: CO₂, methane, nitrous oxide, water vapor, CFCs.

2.3 It keeps Earth warm enough for life.

3.1 B — infrared (heat) radiation.

3.2 (a) The natural effect keeps Earth livably warm; the enhanced effect is the extra warming from human-added greenhouse gases. (b) CO₂, mainly from burning fossil fuels.

3.3 Without greenhouse gases trapping heat, Earth's average temperature would be well below freezing, too cold for most life.

9.4 Increases in the Greenhouse Gases

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS methane 甲烷 • global warming potential 全球变暖潜能
 • global warming potential (gwp) 全球变暖潜能值 • greenhouse gases 温室气体

Objective

Build the skills to answer exam questions on **increases in greenhouse gases**.

You must be able to:

- link human activities to specific greenhouse gases
- compare gases by **global warming potential** 全球变暖潜能
- describe trends in CO₂

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.

■ Sources of each gas

- CO₂ — burning fossil fuels, deforestation.
- Methane (CH₄) — livestock, rice paddies, landfills, natural gas leaks.
- Nitrous oxide — fertilizers, combustion.

■ Global warming potential (GWP)

GWP compares how much heat a gas traps versus the same mass of CO₂. **Methane** has a much higher GWP than CO₂ (traps far more heat per molecule) but lasts a shorter time.

■ Rising CO₂

Atmospheric CO₂ has risen steadily since industrialization (measured continuously, e.g. at Mauna Loa), closely tracking fossil-fuel use.

■ A worked comparison

A kilogram of methane traps far more heat than a kilogram of CO₂, so even smaller methane leaks matter a lot for warming.

2 Practice

Now apply the methods above.

2.1 Name one human source of methane. [1]

2.2 What does global warming potential compare? [1]

2.3 Which traps more heat per kilogram: CO₂ or methane? [1]

3 Exam-style questions

3.1 Compared with CO₂, methane has a [1]

- **A** much lower global warming potential
- **B** much higher global warming potential per molecule
- **C** identical effect
- **D** cooling effect

3.2 A country has large livestock herds and burns much coal.

(a) Name the main greenhouse gas from each activity. [2]

(b) Explain why methane leaks are a concern despite being smaller in volume than CO₂ emissions. [2]

3.3 Explain why atmospheric CO₂ has risen since the Industrial Revolution. [2]

Solutions

2.1 Any one: livestock, rice paddies, landfills, natural-gas leaks.

2.2 How much heat a gas traps relative to the same mass of CO₂.

2.3 Methane.

3.1 B — a much higher global warming potential per molecule.

3.2 (a) Livestock → methane; coal → CO₂. (b) Methane has a much higher global warming potential, so even small amounts trap a lot of heat.

3.3 Industrialization greatly increased the burning of fossil fuels (and deforestation), releasing CO₂ faster than natural processes remove it, so it accumulates.

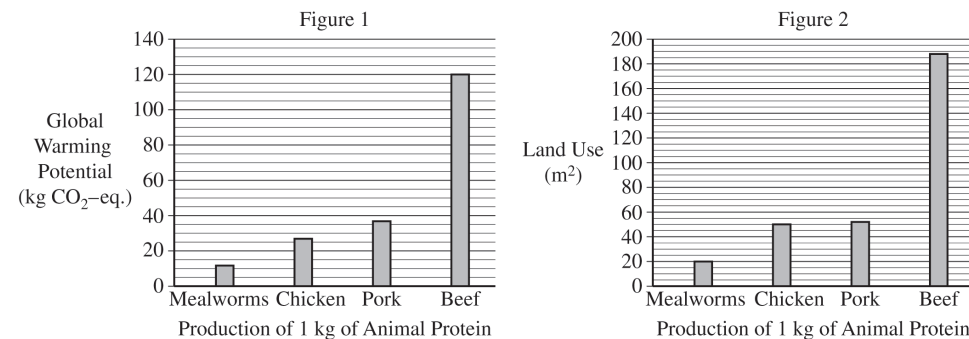
Name: _____

AP Environmental Science: 2024 Set 1

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 (kg CO₂-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 (m²).

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.

3. Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

- (a) **Identify** a fuel used in a nuclear power plant.
- (b) **Describe** a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants.
- (c) In 2021, 4.1×10^{12} kilowatt hours (kWh) of commercial electricity was generated in the United States. Nuclear power accounted for 18.9% of the total commercial electricity. **Calculate** the amount of electricity in kWh generated by nuclear power in the United States in 2021. **Show** your work.

Another approach to reduce greenhouse gas emissions is to switch from coal-burning power plants to natural gas power plants.

- (d) In addition to reducing greenhouse gas emissions, **describe** how switching from coal-burning power plants to natural gas power plants will improve air quality.

Researchers have proposed large-scale tree planting as a solution to reduce the effects of fossil fuel combustion on global climate change.

- (e) **Justify** the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases.
- (f) 7.4×10^7 cubic meters of natural gas were extracted from a large deposit in 2020. An average of 4.76 kWh of electricity can be generated from each cubic meter of natural gas combusted. In 2020, an average home consumed 10,715 kWh of electricity. **Calculate** how many homes could have been provided with electricity by natural gas extracted from the large deposit in 2020. **Show** your work.
- (g) In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants. **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

3. Human activities generate large amounts of solid waste, including organic waste. The decomposition of organic waste in landfills can result in the release of methane into the atmosphere.

(a) **Describe** one environmental problem associated with the release of methane into the atmosphere.

There are biological and physical factors that can affect the decomposition of the solid waste in a landfill and the release of methane in the atmosphere.

(b) **Describe** one factor that could affect the decomposition of the solid waste in a landfill.

(c) **Propose** a solution to decrease the amount of methane released from landfills into the atmosphere.

(d) **Justify** the solution proposed in part (c) by describing an additional advantage, other than decreasing the amount of methane released from landfills.

Another anthropogenic activity that releases methane is raising beef cattle. In 2021, 31.2 million beef cattle were raised in the United States.

(e) The average cow releases 150 liters of methane per day. **Calculate** the amount of methane that was released by all beef cattle raised in the United States in 2021. **Show** your work.

Another environmental concern with raising beef cattle for food is that it is not as efficient as growing crops for food.

(f) A typical beef cow needs 11.8 kilograms of food per day, and each hectare of cattle pasture produces 26.2 kilograms of grasses. **Calculate** the number of hectares of pasture that would be needed to support all beef cattle raised in the United States for one day. **Show** your work.

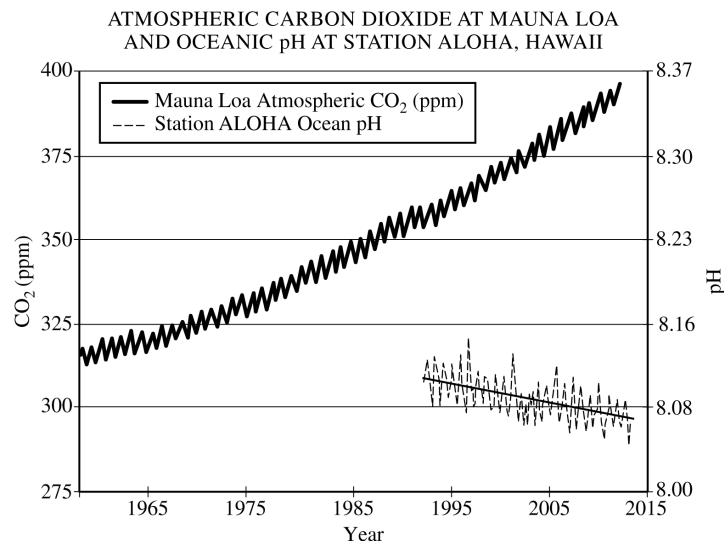
(g) The average American consumes 2,250 kilocalories of food per day. Beef cattle can produce 2.7 million kilocalories per hectare of land. Corn can produce 30.4 million kilocalories per hectare of land. **Calculate** how many more American people could be fed if 150 hectares of land was used to grow corn instead of raising beef cattle. **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

3. The graph shows measurements of atmospheric levels of carbon dioxide (CO_2) at Mauna Loa Observatory, Hawaii, and the measurements of pH levels in the ocean nearby at Station ALOHA. Measurements of pH began in 1992.



- (a) Use the graph above to answer the following questions.
- Determine** the concentration of CO_2 (in ppm) recorded at Mauna Loa in 2005.
 - Determine** the pH recorded at Station ALOHA in 2005.
- (b) Changes in atmospheric carbon dioxide affect Earth's oceans.
- Predict** the effect of increased concentration of atmospheric CO_2 on the concentration of CO_2 in the ocean.
 - Based on the data, **identify** the relationship between the concentration of atmospheric CO_2 and the pH of ocean water.
 - Provide** the complete chemical equation that represents the reaction between oceanic carbon dioxide (CO_2) and water (H_2O).
 - Identify** the specific environmental problem that directly results from the decrease in pH of Earth's oceans.
- (c) Changes in pH in the world's oceans pose a risk to many marine organisms.
- Explain** why certain organisms, in particular those with calcium carbonate shells or exoskeletons, are threatened by the decreasing pH levels measured in seawater.
 - Other than threats posed by decreasing pH, **identify** an additional anthropogenic threat to the world's coral reef ecosystems and **describe** how the threat damages the coral reefs and coral reef ecosystems.

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 Fremont Plaindealer May 1, 2013

Last night the county council discussed a motion to support the construction of a new nuclear power plant on the Fremont River to address the rising demand for electrical power in Fremont County. Councilperson Pamela Kull spoke in support of the plant, remarking that “nuclear power plants produce no dangerous solid waste” and “using nuclear power avoids the release of

greenhouse gases.” Councilperson Chinh Serach said that Dr. Kull’s remarks were incorrect and then introduced a different motion to provide funding to help Fremont homeowners and businesses reduce electricity use. He stated that such steps could make building the nuclear plant unnecessary.

- (a) State whether you agree or disagree with each of the following remarks made by Dr. Kull. For each remark, provide one justification for your position.
- “Nuclear power plants produce no dangerous solid waste.”
 - “Using nuclear power avoids the release of greenhouse gases.”
- (b) If the plan for a nuclear power plant in Fremont is approved, it will take several years for the plant to be built. **Describe** TWO environmental problems that could result from the construction of the plant (i.e., prior to operation).
- (c) Suppose that the nuclear power plant is constructed on the Fremont River site.
- Identify** the most likely pollution threat that the plant will pose to the Fremont River as a result of the plant’s normal daily operation.
 - Discuss** one potential ecological consequence of the pollution threat that you identified in part (i).
 - Identify** a system often used in nuclear power plants to reduce the pollution you identified in part (i).
- (d) **Describe** TWO specific steps that Fremont residents and/or businesses could take to reduce the use of electricity.
- (e) **Identify** a specific nuclear power plant at which a major accident has occurred. **Explain** one environmental consequence (other than effects on human health) of a nuclear power plant accident.

4. Biogeochemical cycles describe the movement of certain elements (typically bound with other elements in compounds) through Earth's atmosphere, hydrosphere, biosphere, and lithosphere. These elements and their compounds are necessary components of all life, and because they cycle, they can be used repeatedly by new generations of organisms. Each biogeochemical cycle has different pathways with various reservoirs (sources and sinks) where elements may reside for days or millions of years.

- (a) The atmosphere is one important carbon reservoir.
 - (i) **Describe** a biological process by which carbon is removed from the atmosphere and converted to organic molecules.
 - (ii) **Describe** a biological process by which carbon is converted from organic molecules to a gas and returned to the atmosphere.
- (b) Oceans and terrestrial systems are also important carbon reservoirs.
 - (i) **Explain** how atmospheric carbon is incorporated into two oceanic sinks.
 - (ii) **Identify** one terrestrial sink, other than fossil fuels, that stores carbon for thousands to millions of years.
- (c) The burning of fossil fuels has been shown to increase the concentration of carbon in the atmosphere. **Discuss** TWO other human activities that increase the concentration of carbon in the atmosphere.
- (d) **Identify** an environmental problem that results from elevated atmospheric carbon concentrations. **Discuss** one consequence of the problem you identified.
- (e) Phosphorus is another element important to all organisms.
 - (i) **Describe** one major way in which the phosphorus cycle differs from the carbon cycle.
 - (ii) **Identify** one reason that phosphorus is necessary for organisms.

STOP

END OF EXAM



AP ENVIRONMENTAL SCIENCE • EXERCISE SHEET

9.5 Global Climate Change

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

KEY WORDS sea levels 海平面 • positive feedback loops 正反馈 • global climate change 气候变化
• methane 甲烷

Objective

Build the skills to answer exam questions on **global climate change**.

You must be able to:

- describe effects (rising temperatures, sea level, extreme weather)
- explain **positive feedback loops** 正反馈 (ice-albedo, permafrost)
- distinguish weather from 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.

■ Weather vs climate

Weather is short-term (today's conditions); **climate** is the long-term average pattern. Climate change is a shift in the long-term averages.

■ Effects of climate change

- **Rising temperatures** and heatwaves.
- **Sea-level rise** (melting ice + thermal expansion).
- **More extreme weather** (stronger storms, droughts, floods).
- **Shifting species ranges** and ecosystem disruption.

■ Positive feedback loops

Feedbacks **amplify** warming:

- **Ice-albedo** — melting ice exposes dark ground/water that absorbs more heat, melting more ice.
- **Permafrost** — thawing releases methane/CO₂, causing more warming.

■ A worked feedback

As Arctic ice melts, the dark ocean beneath absorbs more sunlight (less is reflected), warming the water and melting still more ice — a positive feedback.

2 Practice

Now apply the methods above.

2.1 Distinguish weather from climate. [1]

2.2 Name two effects of climate change. [2]

2.3 What does a positive feedback loop do to warming? [1]

3 Exam-style questions

3.1 The ice-albedo feedback amplifies warming because melting ice exposes surfaces that [1]

- A reflect more sunlight
- B absorb more sunlight
- C produce ice
- D cool the ocean

3.2 Sea levels are rising globally.

(a) State two causes of sea-level rise. [2]

(b) Explain the permafrost feedback loop. [2]

3.3 Explain why a single cold day does not disprove climate change. [2]

Solutions

2.1 Weather is short-term conditions; climate is the long-term average.

2.2 Any two: rising temperatures, sea-level rise, extreme weather, shifting species.

2.3 It amplifies (increases) it.

3.1 B — absorb more sunlight.

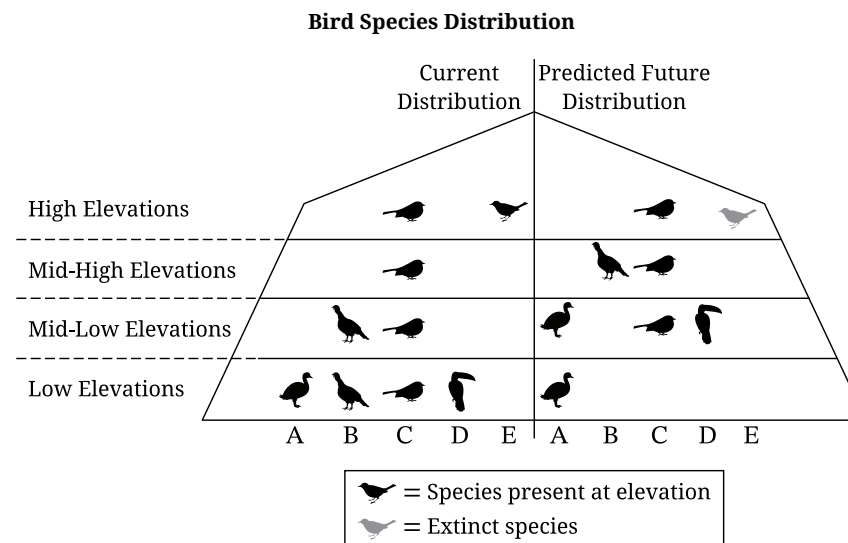
3.2 (a) Melting land ice and thermal expansion of warming seawater. (b) Thawing permafrost releases methane and CO₂, which cause more warming, which thaws more permafrost — a positive feedback.

3.3 Climate is a long-term average; a single cold day is weather, and short-term variation does not change the long-term warming trend.

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.

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

- Based on the data in the graph, **identify** the number of Common Tern breeding pairs in 1995.
- Based on the data in the graph, **describe** the trend in the number of Common Tern breeding pairs from 1995 to 2008.
- A group of students hypothesized that sea level rise will lead to an increase in Common Tern populations. **Describe** one way that the data in the graph refute this hypothesis.
- Explain** how climate change can lead to sea level rise.
- Wading birds are a group of large-bodied birds that inhabit coastal wetlands all over the world. Researchers monitored the number of wading bird species at four coastal locations experiencing rising sea levels over a 5-year period. The data are shown in the following table.

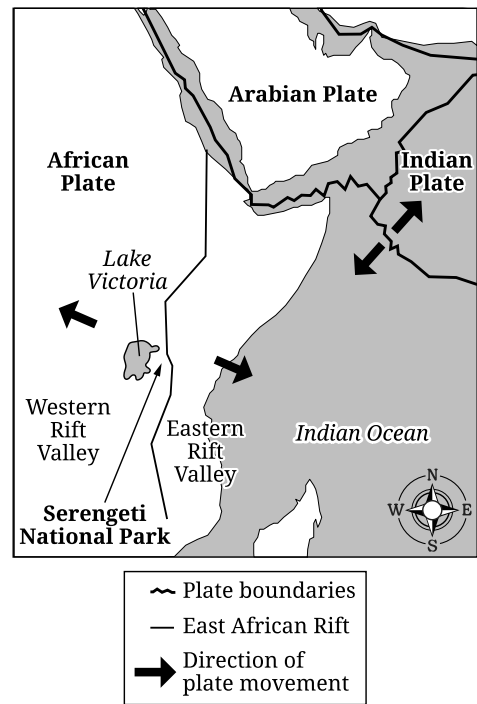
Sea Level Rise and Number of Wading Bird Species at Four Coastal Locations

Year	Increase in Sea Level (m)	Location A	Location B	Location C	Location D
1	0.05	1	5	3	4
2	0.08	2	4	3	6
3	0.10	6	7	5	5
4	0.12	5	7	7	7
5	0.15	7	8	9	8

- Identify** a hypothesis that researchers are likely investigating in the wading bird study.
 - Identify** the dependent variable in this study.
- One year after the completion of the study of wading bird species described in Part E, locations A and B experienced an increase in the concentration of PCBs, known to be a persistent organic pollutant, running off into the water.
If the researchers repeated their study, **explain** how this environmental change could affect the results of the study.
 - Describe** a regulating ecosystem service that can be provided by wetlands.
 - Since 1990, there has been an increase in urbanization around the coastal wetlands that wading bird communities inhabit. Most of these bird species eat fish and locate prey visually while walking through shallow water. An increase in sediment was discovered in a wetland located near an urban area.
Explain how increased sediment might lead to a change in the size of the wading bird populations.
 - Describe** an environmental problem, other than an increase in sediment, that can occur in wetlands that is associated with increased urbanization and development.

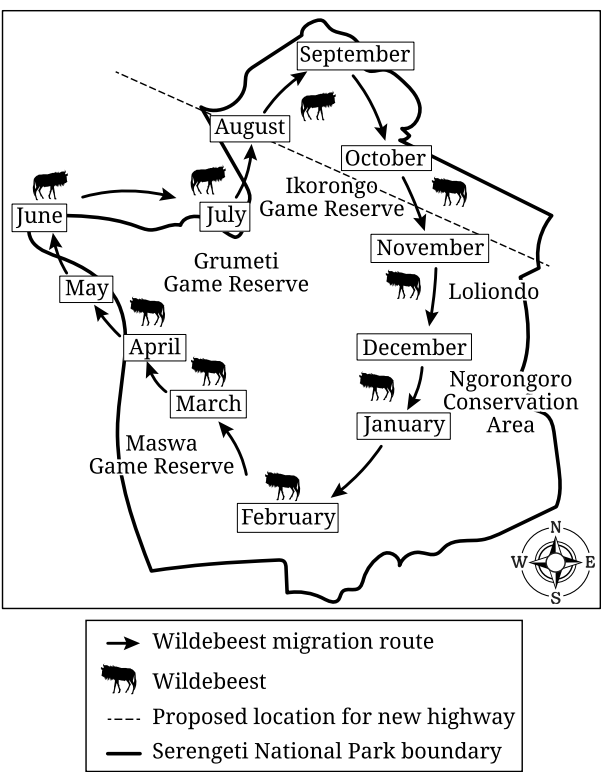
Serengeti National Park is located in Tanzania, Africa. The park is located in a valley along a tectonic plate boundary called the East African Rift. Figure 1 shows the East African Rift and other plate boundaries near the east coast of Africa.

Figure 1. Tectonic Plate Movement near East Coast of Africa



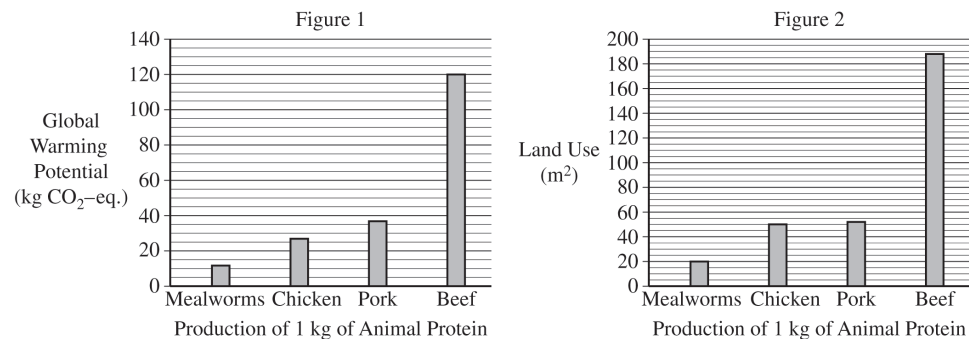
Serengeti National Park contains a variety of tropical habitats but is dominated by wideopen lands that include a variety of grass species with scattered trees and shrubs. Most grass growth occurs after the March through May rainy season. Many of the park’s herbivores, such as wildebeest and zebra, migrate 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. 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 (kg CO₂-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 (m²).

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.

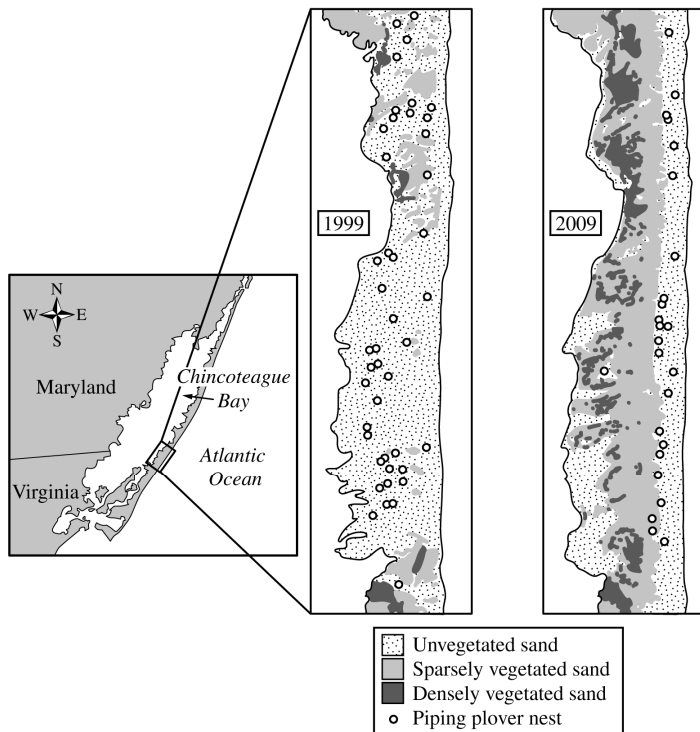
ENVIRONMENTAL SCIENCE**SECTION II****Time—1 hour and 30 minutes****4 Questions**

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. The piping plover is a globally threatened species, with perhaps as few as 2,000 nesting pairs remaining in the Atlantic population of these migratory shorebirds. Plovers were nearly hunted to extinction in the nineteenth century.

Plovers prefer to nest and search for food on open sandy beaches between sparsely vegetated sand dunes. Washovers, where sand is washed up from the beach and buries vegetated areas during big storms, are also important to plovers because they provide moist and undisturbed habitat for plover adults and their chicks. Ecologists with the Elliott Oceanographic Institute mapped the distribution of plover nests during two seasonal surveys of nesting sites over a ten-year period on Assateague Island. This is a barrier island, a long, narrow island running parallel to the Atlantic coast of Virginia.

SPRING PIPING PLOVER NESTING SITES
ON ASSATEAGUE ISLAND, VIRGINIA

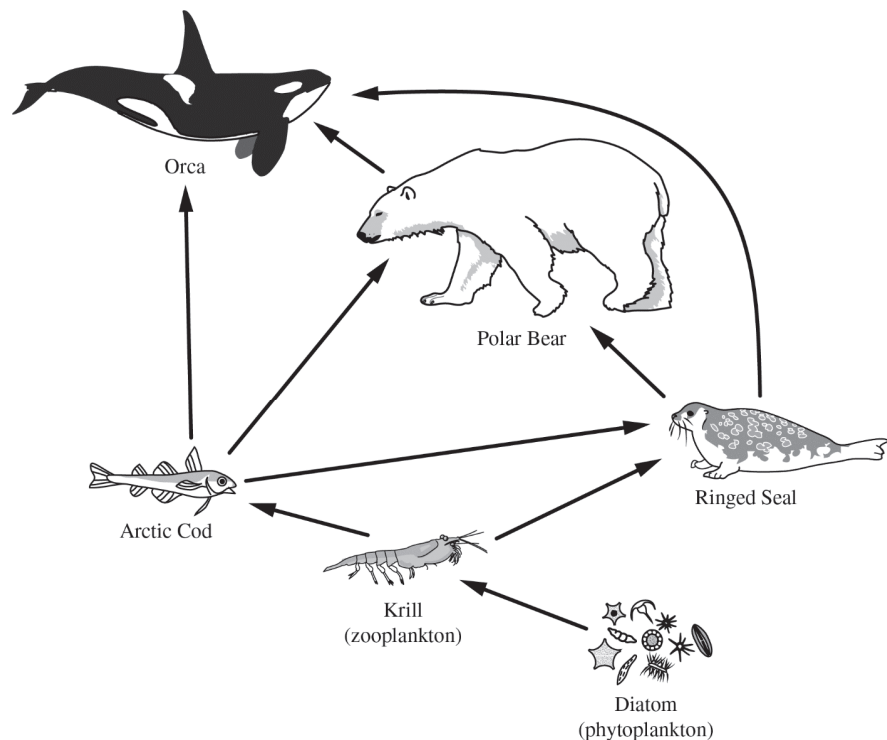


- (a) Use the maps provided to answer the following questions.
- Identify** the preferred nesting habitat for piping plovers.
 - Describe** the change in the number of piping plover nests on Assateague Island between 1999 and 2009.
 - Describe** one likely reason for the change in the number of piping plover nests between 1999 and 2009.
- (b) Coastal species are affected by more than just natural events.
- Special beach restrictions can help piping plovers during nesting season. **Describe** one restriction that could reasonably be implemented to help prevent the destruction of plover nests by human actions.
 - In addition to providing habitat for piping plovers, barrier islands (and closely related landforms) are important for other reasons. **Explain** one way that these features help to preserve and protect the environment in coastal regions.
 - Identify** one human action that directly threatens coastal habitats and **describe** one impact on species, other than the piping plover, that use the habitat.

Approximately 40% of the United States population resides in coastal areas, such as areas near Assateague Island, where sea level rise and shoreline erosion is occurring.

- Identify** one economic impact on coastal communities that has resulted from rising sea levels.
- Describe** TWO methods that may be used locally to protect coastal communities from rising sea levels.

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) Identify a primary producer	
(ii) Identify a primary consumer	
(iii) Identify a secondary consumer	

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

- Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.
- Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.
- Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.
 - Provide** one reason a species may migrate a long distance.
 - The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.
 - Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

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.

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

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

- 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.
 - Identify** one agricultural practice that can lead to elevated nitrate levels in groundwater.
 - Describe** how the practice you identified in (c)(i) leads to elevated nitrate levels in groundwater.
- Acid deposition has affected soil quality in many parts of the northeastern United States.
 - Explain** one way acid deposition onto soil can affect plant health.
 - Describe** one method for remediating soil affected by acid deposition.
- 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

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.
- Describe** how one specific human activity contributes to increased phosphorus levels in the Everglades.
 - Explain** one way in which an increase in phosphorus levels can adversely affect the Everglades ecosystem.
 - 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."
- Describe** one way that restoring water quantity and water quality in the Everglades is expected to improve the structure and function of the ecosystem.
 - Describe** one way that restoring the Everglades is expected to provide economic benefits to Florida.

4. Biogeochemical cycles describe the movement of certain elements (typically bound with other elements in compounds) through Earth's atmosphere, hydrosphere, biosphere, and lithosphere. These elements and their compounds are necessary components of all life, and because they cycle, they can be used repeatedly by new generations of organisms. Each biogeochemical cycle has different pathways with various reservoirs (sources and sinks) where elements may reside for days or millions of years.
- The atmosphere is one important carbon reservoir.
 - Describe** a biological process by which carbon is removed from the atmosphere and converted to organic molecules.
 - Describe** a biological process by which carbon is converted from organic molecules to a gas and returned to the atmosphere.
 - Oceans and terrestrial systems are also important carbon reservoirs.
 - Explain** how atmospheric carbon is incorporated into two oceanic sinks.
 - Identify** one terrestrial sink, other than fossil fuels, that stores carbon for thousands to millions of years.
 - The burning of fossil fuels has been shown to increase the concentration of carbon in the atmosphere. **Discuss** TWO other human activities that increase the concentration of carbon in the atmosphere.
 - Identify** an environmental problem that results from elevated atmospheric carbon concentrations. **Discuss** one consequence of the problem you identified.
 - Phosphorus is another element important to all organisms.
 - Describe** one major way in which the phosphorus cycle differs from the carbon cycle.
 - Identify** one reason that phosphorus is necessary for organisms.

STOP

END OF EXAM

9.6 Ocean Warming

Name: _____ Class: _____ Date: _____

Total: 10 marks**KEY WORDS** coral bleaching 珊瑚白化 • greenhouse effect 温室效应

Objective

Build the skills to answer exam questions on **ocean warming**.**You must be able to:**

- explain how oceans **absorb heat** and its effects
- describe **coral bleaching** 珊瑚白化
- link warming to sea-level rise and species shifts

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.

■ Oceans absorb heat

The oceans have absorbed most of the extra heat from the enhanced greenhouse effect, so **ocean temperatures are rising**.

■ Coral bleaching

Warmer water stresses corals, causing them to **expel** the symbiotic algae (zooxanthellae) that feed and color them — the coral turns white (**bleaches**) and can die.

■ Other effects

- **Thermal expansion** — warm water expands, raising **sea level**.
- **Species shifts** — marine species move toward cooler (polar/deeper) water.
- Lower **dissolved oxygen** in warmer water.

■ A worked link

A marine heatwave warms a reef; the corals bleach as they lose their algae, and if the heat persists, the reef dies — losing the habitat for many species.

2 Practice

Now apply the methods above.

2.1 Why are ocean temperatures rising? [1]**2.2** What happens to corals when water gets too warm? [1]**2.3** How does ocean warming contribute to sea-level rise? [1]

3 Exam-style questions

3.1 Coral bleaching happens when corals expel their [1]

- **A** symbiotic algae due to heat stress
- **B** skeletons
- **C** predators
- **D** eggs

3.2 A reef experiences a prolonged marine heatwave.

(a) Explain how bleaching occurs and why it can kill the reef. [3]

(b) State one wider consequence of losing the reef. [1]

3.3 Explain how thermal expansion of the ocean raises sea level. [2]

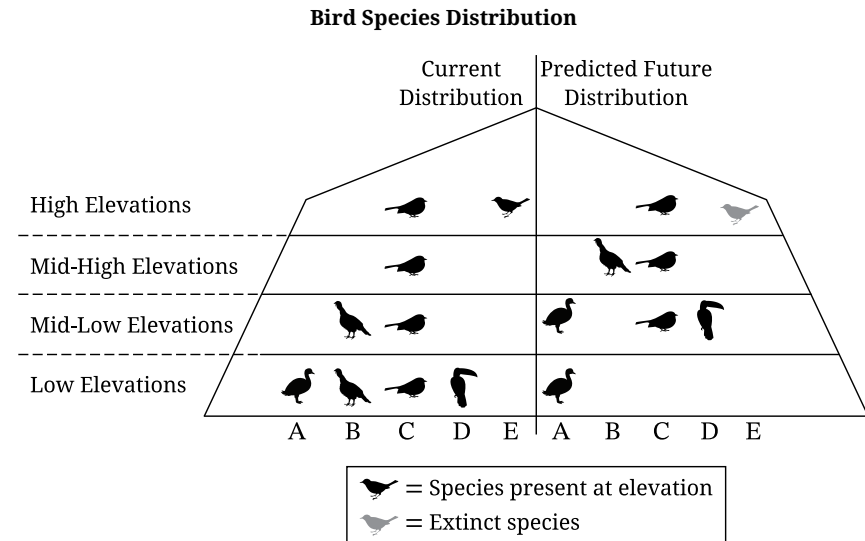
Solutions

- 2.1 They absorb most of the extra heat from the enhanced greenhouse effect.
- 2.2 They bleach (expel their symbiotic algae) and can die.
- 2.3 Warm water expands (thermal expansion).
- 3.1 **A** — symbiotic algae due to heat stress.
- 3.2 (a) Heat stress makes corals expel their symbiotic algae, so they lose their food source and color (bleach); if the heat persists they starve and die. (b) Loss of habitat/biodiversity (or fisheries, coastal protection).
- 3.3 As seawater warms it expands and takes up more volume, so the same amount of water rises higher, adding to sea-level rise.

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

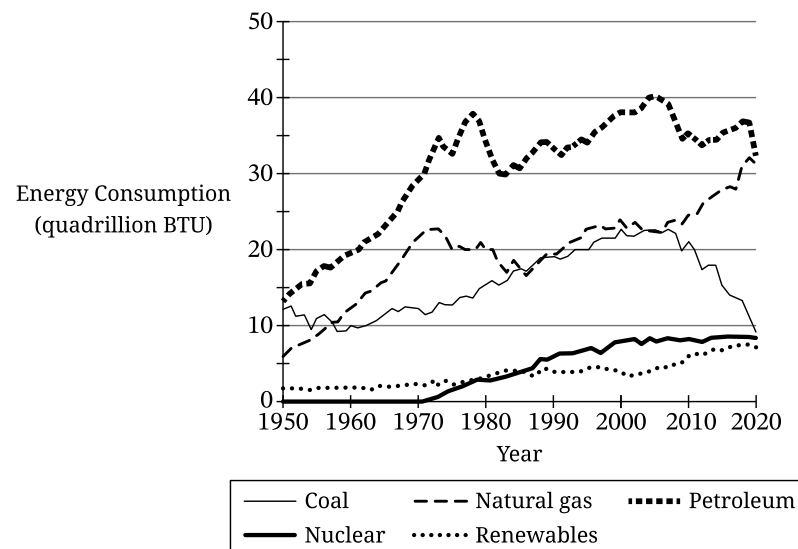
Describe one problem that Arctic species, such as polar bears or ringed seals, face because of warming in polar regions.



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

The following graph shows the number of quadrillion British thermal units (BTUs) that were consumed in the United States using five different energy sources from 1950 to 2020.

Energy Consumption by Source in the United States, 1950–2020



The following information applies to parts H and I.

Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

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

Part A

Identify one renewable energy source that is used to generate electricity.

Part B

Based on the data in the graph, **identify** the energy source that had the highest consumption in 2010.



Part C

Based on the data in the graph, **describe** the pattern in the energy consumption from coal in the United States from 1960 to 2020.

Part D

Based on the data in the graph and your knowledge of energy consumption, **explain** one likely reason why the use of coal for energy changed between 2010 and 2020.

Part E

Explain how fossil fuels are used to generate electricity.

Part F

In addition to fossil fuels, nuclear power can be used to generate electricity. **Identify** one negative impact associated with nuclear energy.

Part G

Fossil fuel combustion leads to ocean warming. **Describe** one environmental problem other than coral bleaching that is associated with warming oceans.

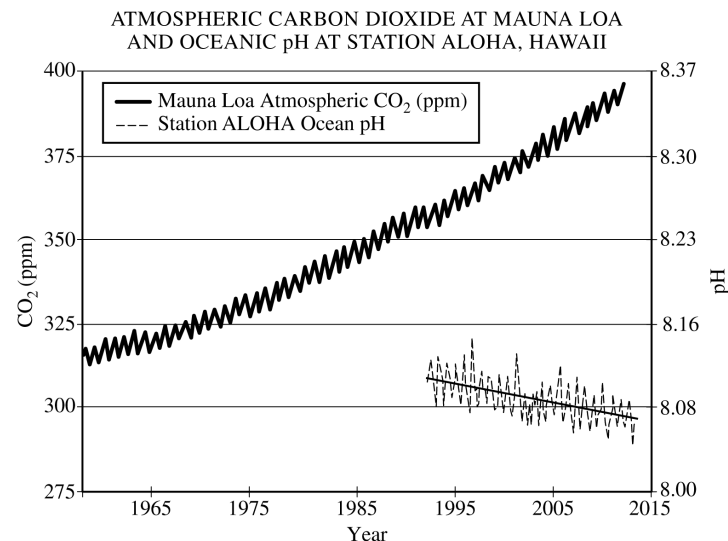
Part H

Explain how an increase in nutrients, such as nitrates and phosphates, can negatively affect an aquatic ecosystem.

Part I

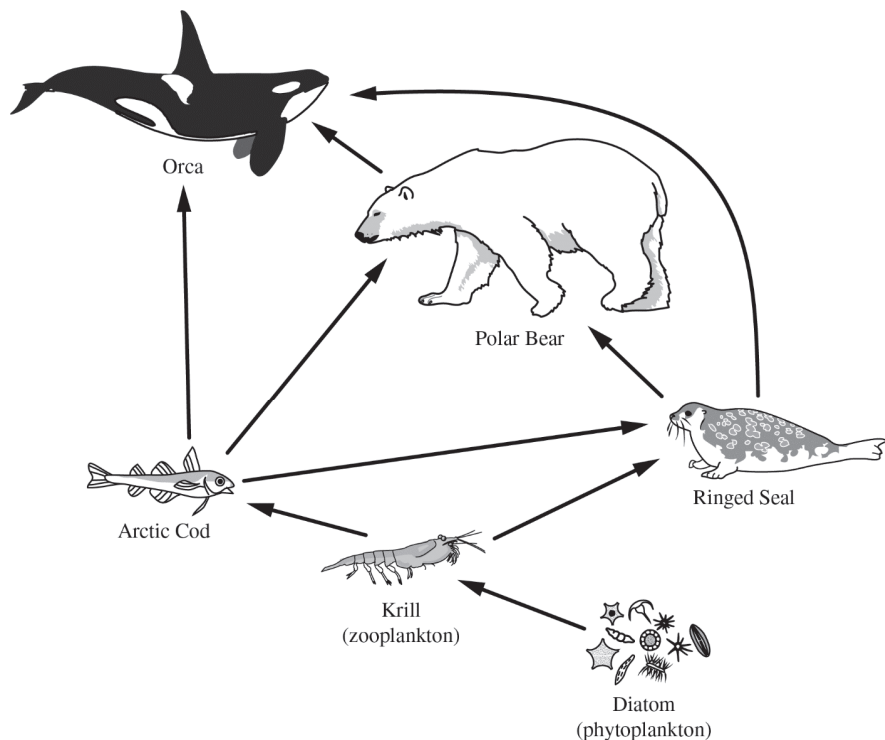
- i. **Propose** a realistic solution that would reduce nutrient pollution of waterways, while still allowing cultivation of crops.
- ii. **Justify** the solution proposed in part I (i) by explaining one potential advantage other than reducing nutrient runoff.

3. The graph shows measurements of atmospheric levels of carbon dioxide (CO_2) at Mauna Loa Observatory, Hawaii, and the measurements of pH levels in the ocean nearby at Station ALOHA. Measurements of pH began in 1992.



- (a) Use the graph above to answer the following questions.
 - (i) **Determine** the concentration of CO_2 (in ppm) recorded at Mauna Loa in 2005.
 - (ii) **Determine** the pH recorded at Station ALOHA in 2005.
- (b) Changes in atmospheric carbon dioxide affect Earth's oceans.
 - (i) **Predict** the effect of increased concentration of atmospheric CO_2 on the concentration of CO_2 in the ocean.
 - (ii) Based on the data, **identify** the relationship between the concentration of atmospheric CO_2 and the pH of ocean water.
 - (iii) **Provide** the complete chemical equation that represents the reaction between oceanic carbon dioxide (CO_2) and water (H_2O).
 - (iv) **Identify** the specific environmental problem that directly results from the decrease in pH of Earth's oceans.
- (c) Changes in pH in the world's oceans pose a risk to many marine organisms.
 - (i) **Explain** why certain organisms, in particular those with calcium carbonate shells or exoskeletons, are threatened by the decreasing pH levels measured in seawater.
 - (ii) Other than threats posed by decreasing pH, **identify** an additional anthropogenic threat to the world's coral reef ecosystems and **describe** how the threat damages the coral reefs and coral reef ecosystems.

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) Identify a primary producer	
(ii) Identify a primary consumer	
(iii) Identify a secondary consumer	

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

- (c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.
- (d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.
- (e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.
 - (i) **Provide** one reason a species may migrate a long distance.
 - (ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.
 - (iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

9.7 Ocean Acidification

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS calcium carbonate 碳酸钙 • ocean acidification 海洋酸化

Objective

Build the skills to answer exam questions on **ocean acidification**.

You must be able to:

- explain how CO₂ causes **ocean acidification** 海洋酸化
- describe the effect on **shell-building** organisms
- link it to the carbon cycle

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 it happens

The ocean absorbs about a quarter of human CO₂. Dissolved CO₂ reacts with water to form **carbonic acid**, **lowering the ocean's pH** (making it more acidic).

■ Effect on shells

Acidification reduces the **carbonate ions** that organisms need to build shells and skeletons of **calcium carbonate** — corals, shellfish, and plankton struggle to form or maintain their shells, which can even dissolve.

■ Wider impact

Because shelled plankton are the base of many food webs, acidification threatens whole marine ecosystems and fisheries.

■ A worked link

More atmospheric CO₂ → more dissolves in the ocean → more carbonic acid → lower pH → harder for oysters and corals to build shells.

2 Practice

Now apply the methods above.

2.1 What gas dissolving in the ocean causes acidification? [1]

2.2 What acid forms when CO₂ dissolves in seawater? [1]

2.3 Which organisms are most harmed by acidification? [1]

3 Exam-style questions

3.1 Ocean acidification makes it harder for organisms to [1]

- A swim
- B build calcium carbonate shells
- C photosynthesize on land
- D breathe air

3.2 Rising atmospheric CO₂ is acidifying the ocean.(a) Explain the chemistry linking CO₂ to lower ocean pH. [3]

(b) State one consequence for marine food webs. [1]

3.3 Explain why ocean acidification and ocean warming are both caused by rising CO₂ but are different problems. [2]

Solutions

2.1 Carbon dioxide (CO_2).

2.2 Carbonic acid.

2.3 Shell-building organisms (corals, shellfish, plankton).

3.1 B — build calcium carbonate shells.

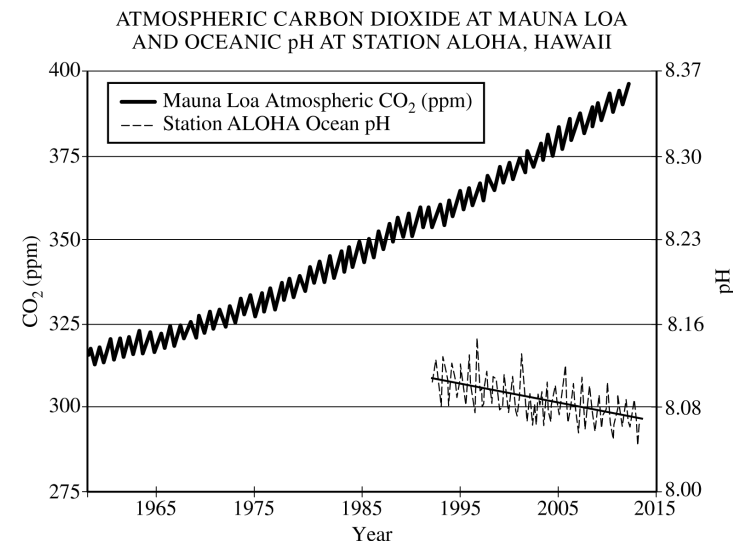
3.2 (a) The ocean absorbs CO_2 ; it reacts with water to form carbonic acid; this lowers the ocean's pH (makes it more acidic). (b) Harm to shelled plankton at the base of the food web disrupts the whole web/fisheries.

3.3 Both come from extra CO_2 , but warming is heat trapped by CO_2 in the air, while acidification is CO_2 dissolving into the water and lowering its pH — different mechanisms and effects.

Name:

AP Environmental Science: 2019

3. The graph shows measurements of atmospheric levels of carbon dioxide (CO_2) at Mauna Loa Observatory, Hawaii, and the measurements of pH levels in the ocean nearby at Station ALOHA. Measurements of pH began in 1992.



- (a) Use the graph above to answer the following questions.
- Determine** the concentration of CO_2 (in ppm) recorded at Mauna Loa in 2005.
 - Determine** the pH recorded at Station ALOHA in 2005.
- (b) Changes in atmospheric carbon dioxide affect Earth's oceans.
- Predict** the effect of increased concentration of atmospheric CO_2 on the concentration of CO_2 in the ocean.
 - Based on the data, **identify** the relationship between the concentration of atmospheric CO_2 and the pH of ocean water.
 - Provide** the complete chemical equation that represents the reaction between oceanic carbon dioxide (CO_2) and water (H_2O).
 - Identify** the specific environmental problem that directly results from the decrease in pH of Earth's oceans.
- (c) Changes in pH in the world's oceans pose a risk to many marine organisms.
- Explain** why certain organisms, in particular those with calcium carbonate shells or exoskeletons, are threatened by the decreasing pH levels measured in seawater.
 - Other than threats posed by decreasing pH, **identify** an additional anthropogenic threat to the world's coral reef ecosystems and **describe** how the threat damages the coral reefs and coral reef ecosystems.

9.8 Invasive Species

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS invasive species 入侵物种

Objective

Build the skills to answer exam questions on **invasive species**.

You must be able to:

- define an **invasive species** 入侵物种
- explain why they spread and their impacts
- suggest control methods

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 they are

An **invasive species** is a non-native species that spreads rapidly and harms the new ecosystem, economy, or health.

■ Why they succeed

They often have **no natural predators** in the new area, reproduce fast, and out-compete or prey on natives — so their populations explode.

■ Impacts

- **Outcompete** or eat native species (biodiversity loss).
- Disrupt food webs.
- Cause economic damage (crops, infrastructure).

■ Control methods

- **Prevention** (best) — inspections, ballast-water rules.
- **Mechanical/physical** removal, **biological** control (a natural predator, carefully chosen), and targeted chemicals.

■ A worked example

A fish introduced to a lake with no predators multiplies and eats native species, collapsing their populations — an invasive-species impact.

2 Practice

Now apply the methods above.

2.1 Define an invasive species. [1]

2.2 Why do invasive species often spread rapidly? [1]

2.3 State one method to control invasive species. [1]

3 Exam-style questions

3.1 Invasive species often thrive because they [1]

- **A** have many local predators
- **B** lack natural predators in the new area
- **C** reproduce slowly
- **D** are always producers

3.2 An invasive plant spreads across a wetland.

(a) Explain two impacts on the native ecosystem. [2]

(b) State the best long-term strategy against invasive species. [1]

3.3 Explain one risk of using biological control against an invasive species. [2]

Solutions

- 2.1 A non-native species that spreads and harms the new ecosystem.
- 2.2 They have no natural predators there and reproduce fast, outcompeting natives.
- 2.3 Any one: prevention, mechanical removal, biological control, chemicals.
- 3.1 B — lack natural predators in the new area.
- 3.2 (a) Any two: outcompetes/crowds out natives, disrupts the food web, reduces biodiversity. (b) Prevention (stopping introductions).
- 3.3 The introduced control organism could itself become invasive, attacking native species and creating a new problem.

Chickadees are a K-selected species of bird that eat insects and spiders. Spiders consume insects, and many insects consume plants as shown in the following food chain.

Plants → Insects → Spiders

Chickadee habitat includes forests and residential yards. Residential yards often contain nonnative plants, which do not naturally exist in an area, but were introduced by humans.

Scientists measured the average number of insects and spiders as related to the percentage of nonnative plants (Figure 1). The scientists also measured the chickadees' average population growth rate (Figure 2) to determine the impact of nonnative plants on chickadee populations.

Figure 1. Percentage of Nonnative Plants and Average Number of Individual Spiders and Insects

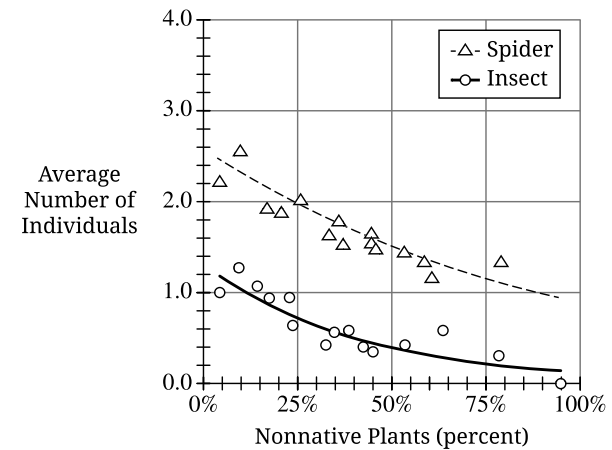
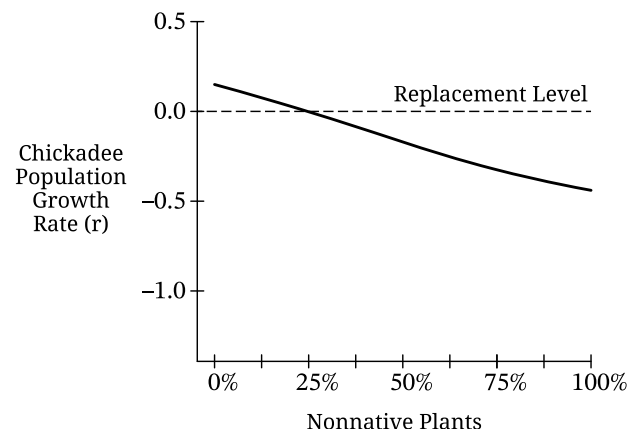


Figure 2. Chickadee Population Average Growth Rate and Percentage of Nonnative

1. Respond to parts A, B, C, D, E, F, G, and H, and all subparts.

- A. Describe** one reproductive strategy used by a K-selected species such as the chickadee.
- B.** Based on the information provided, **explain** how a decrease in spider populations could affect a lower trophic level.
- C.** Based on the data in Figure 1, **identify** the number of spiders per sample at 25% nonnative plants.
- D.** Based on the data in Figure 1, **describe** the trend in the number of insects per sample in relation to the percentage of nonnative plants.
- E.** Scientists hypothesized that the population of chickadees would be stable or growing with fewer than 25% nonnative plants. **Describe** one way that the data in Figure 2 support this hypothesis.
- F.** Insect biodiversity is important to maintain ecosystem health. A group of students was interested in learning about factors that affect ant biodiversity. They located two study sites near their school: a frequently mowed urban park and an unmowed grassland. The students used traps designed to collect ants. They loaded 10 of these traps with the same food and placed them randomly at different locations within each site. Students collected the traps after 24 hours and counted the number of different ant species in each trap to determine species richness.
- Identify** a likely scientific question for the students' investigation of ant diversity.
 - Identify** the dependent variable in the students' investigation.
- G.** The data from the student investigation of ant diversity are shown in the following table. An "X" in the table indicates that the species was present at that site.

Ant Species Present in an Urban Park and Unmowed Grassland

Site	Species A	Species B	Species C	Species D	Species E	Species F
Urban park	X			X	X	
Grassland	X	X	X	X		X

- Explain** why the ant community of the unmowed grassland would be more likely to recover from a disturbance, such as a flood or fire, than the ant community in the mowed urban park would.
 - Explain** how the results of the investigation could have been altered if students had measured ant biodiversity at a paved playground rather than in the grassland.
- H.** Habitat fragmentation has impacts on a variety of species. Paved roads can lead to habitat fragmentation.
- Describe** one effect that a paved road in a forest can have on animal species such as deer or bears.

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

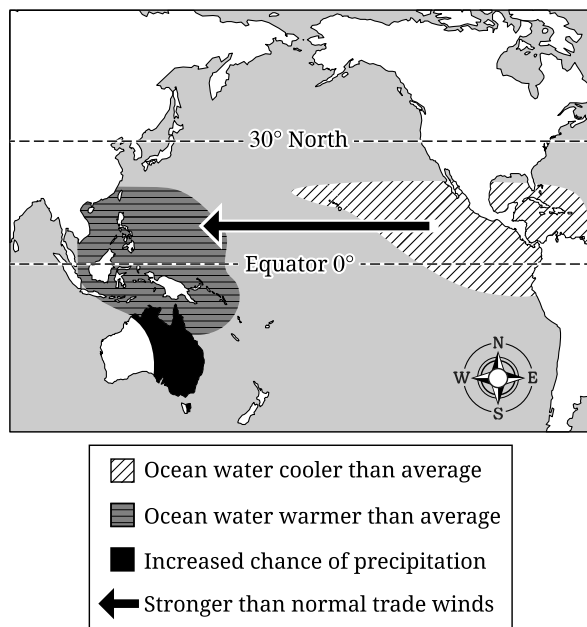
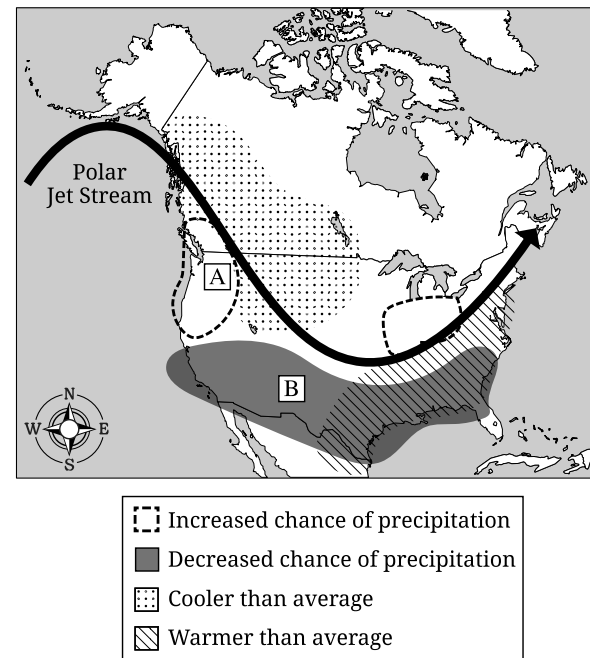
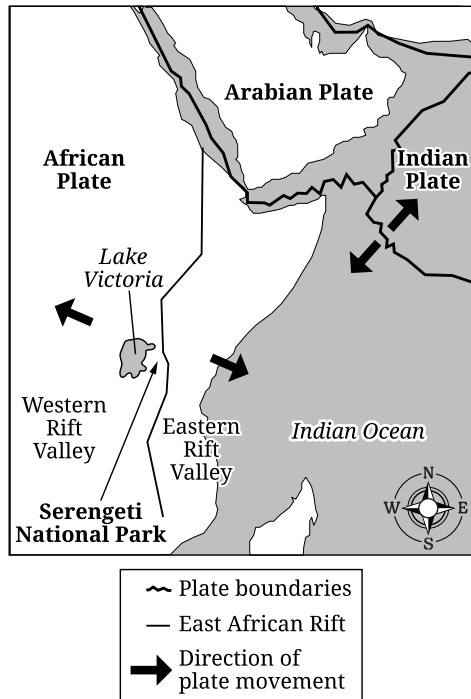


Figure 2. Polar Jet Stream and Climate Conditions in North America



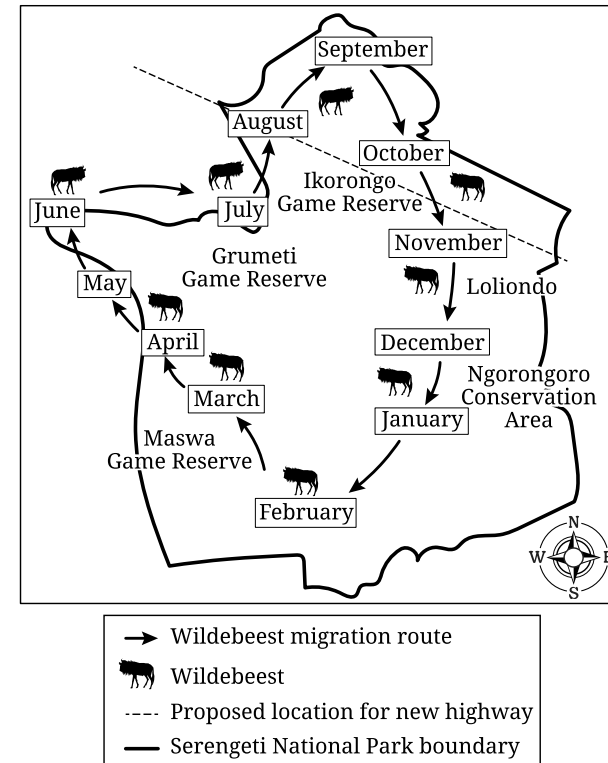
Serengeti National Park is located in Tanzania, Africa. The park is located in a valley along a tectonic plate boundary called the East African Rift. Figure 1 shows the East African Rift and other plate boundaries near the east coast of Africa.

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.



STOP

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. 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.

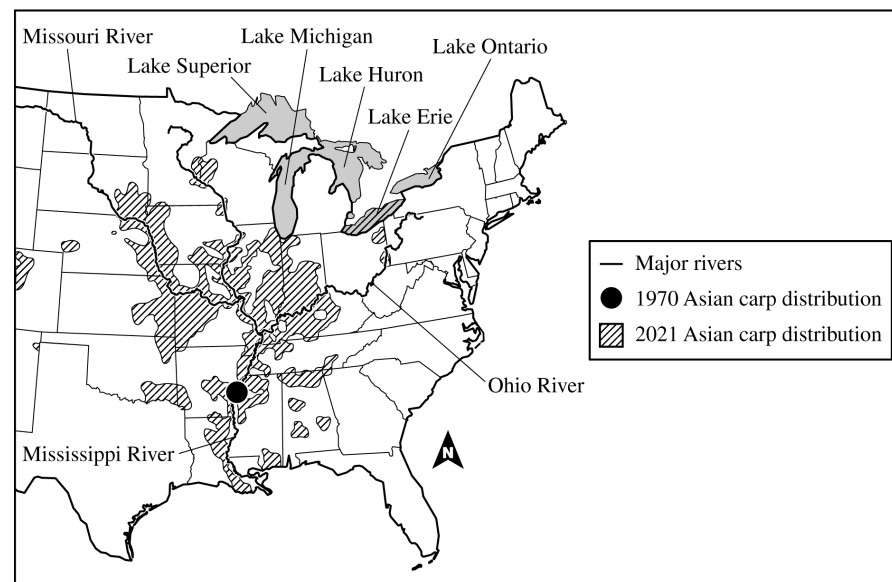
A survey indicated that one of the plots had twice the plant diversity that the other plots had. Over the next five years, the river occasionally flooded the plots, killing off many of the species that inhabited the plots.

- (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.

2. Asian carp were first introduced in the southern United States in the 1970s by fish farmers wanting to control algal growth in fish ponds. Asian carp can eat up to 40% of their body weight in algae each day, and a female carp can produce up to 1 million eggs every year.

Distribution of the Asian Carp in the United States



- (a) Based on the information given, **identify** a body of water invaded by Asian carp that is labeled on the map.
- (b) Based on the information shown in the map, **describe** the change in the distribution of Asian carp since their introduction in the 1970s.

The Great Lakes are a group of five major freshwater inland lakes that all share the same watershed.

- (c) **Describe** one impact the introduction of Asian carp could have on the ecosystem services provided by the Great Lakes region.
- (d) **Propose** a realistic solution to help reduce the spread of the Asian carp from their current distribution.
- (e) **Justify** the solution proposed in part (d) by providing an additional advantage.

The following is an example of a simple food chain in the Great Lakes.

Algae → Zooplankton → Macroinvertebrates → Yellow perch → Rainbow trout

- (f) **Identify** the primary consumer in the Great Lakes food chain.
- (g) **Describe** what the arrows in the aquatic food chain represent.

(h) **Describe** one possible effect of the introduction of the Asian carp on the Great Lakes food chain.

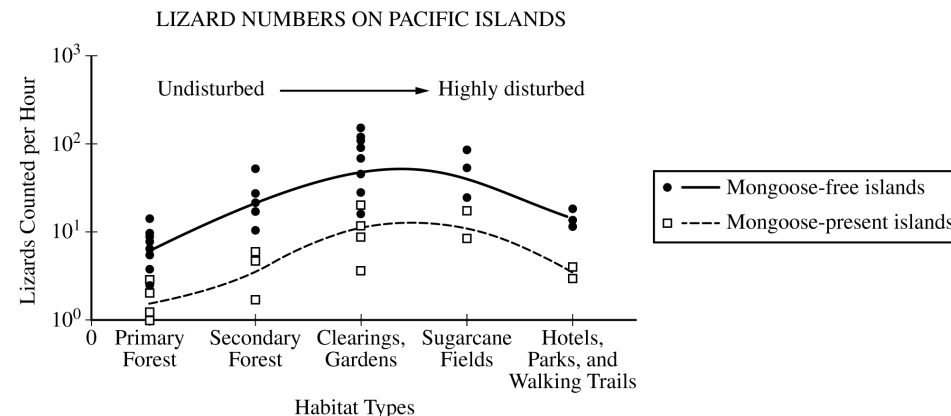
The blue pike, a fish that was endemic to the Great Lakes, was commercially fished from the late 1800s until their population crashed in 1958. In 1970, the species was declared to be extinct.

(i) **Describe** one way that overfishing of blue pike illustrates the tragedy of the commons.

(j) One potential solution to reduce overfishing is to use aquaculture. **Describe** one disadvantage of this solution.

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.

ENVIRONMENTAL SCIENCE

SECTION II

Time—1 hour and 30 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 following article from the *Fremont Daily Times* and answer the questions that follow.

Fremont Daily Times

May 1, 2018

GREEN IS THE NEW SCHOOL COLOR AT FREMONT HIGH SCHOOL!

A group of students from Fremont High School addressed the city council last night and proposed that one of the existing buildings at Fremont High School, which was built in 1970, be renovated to take advantage of recent advances in green technology. Currently the heat for the school is provided by fossil fuel combustion. The students said that the redesigned building would reduce the school's carbon footprint, which is a measure of the amount of carbon dioxide and other carbon compounds released by various human activities. Incorporating specific features that conserve energy and utilize

renewable energy sources can help reduce the carbon footprint.

Councilperson Gail Fassler praised the idea, saying that the project could conserve local water resources, reduce the need for consuming new resources, and act as a “shining beacon” of sustainability for the greater Fremont community. Fassler suggested the project could even incorporate a living green roof as an additional sustainable feature. The council approved the initial site planning request and urged students to report back when the project was under way.

- (a) The students want to reduce the school's carbon footprint.
- (i) **Define** carbon footprint.
 - (ii) **Identify** one way the school's heating system is likely adding to the school's carbon footprint.
 - (iii) **Describe** one realistic way to reduce the contribution of the heating system to the school's carbon footprint.
- (b) **Identify** TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.
- (c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.
- (d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.
- (e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

9.9 Endangered Species

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS endangered species 濒危物种**Objective**Build the skills to answer exam questions on **endangered species**.

You must be able to:

- describe causes of endangerment (**HIPPO**)
- explain conservation strategies
- link small populations to extinction risk

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.

■ Causes of endangerment (HIPPO)

- **Habitat loss** (biggest cause).
- **Invasive species**.
- **Pollution**.
- **Population (human) growth**.
- **Overexploitation** (hunting, fishing).

■ Small populations are at risk

A small population has **low genetic diversity** and is vulnerable to disease, inbreeding, and random events, raising **extinction risk**.

■ Conservation strategies

- **Protected areas** and habitat restoration.
- **Laws** (e.g. Endangered Species Act, CITES banning trade).
- **Captive breeding** and reintroduction.
- **Wildlife corridors**.

■ A worked link

A species losing its habitat to farmland has fewer, smaller, isolated populations, which lose genetic diversity and become more likely to go extinct.

2 Practice

Now apply the methods above.

2.1 What is the biggest cause of species endangerment? [1]

2.2 State one conservation strategy. [1]

2.3 Why is a small population at higher extinction risk? [1]

3 Exam-style questions

3.1 In the HIPPO acronym, the first “P” stands for [1]

- **A** predators
- **B** pollution
- **C** photosynthesis
- **D** phosphorus

3.2 A species is endangered by habitat loss and hunting.

(a) Name two conservation strategies that could help. [2]

(b) Explain why its small remaining population is vulnerable. [2]

3.3 Explain how international agreements like CITES help protect endangered species.[2]

Solutions

2.1 Habitat loss.

2.2 Any one: protected areas, laws, captive breeding, corridors.

2.3 It has low genetic diversity and is vulnerable to disease, inbreeding, and chance events.

3.1 B — pollution.

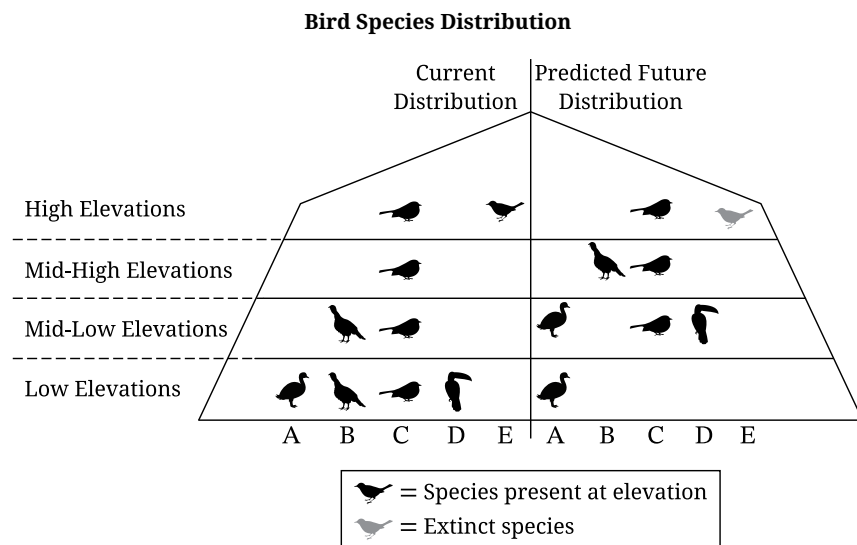
3.2 (a) Any two: protected areas/habitat restoration, laws banning hunting/trade, captive breeding. (b) A small population has low genetic diversity, so it is vulnerable to disease, inbreeding, and random events that could wipe it out.

3.3 CITES restricts or bans international trade in threatened species, reducing the demand that drives overexploitation, so fewer are hunted or collected.

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.

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

Ocelots are small wildcats that were previously found in 25 counties in Texas where shrubland is prevalent. As a result of land use changes, only 74 ocelots remain in 4 counties in Texas today. Rodents such as pocket mice are the main source of food for ocelots, but ocelots also prey on other small animals such as snakes and lizards.

3. Respond to parts A, B, C, D, E, and F, and all subparts.**Part A**

Identify one environmental consequence that could result from having a smaller population of ocelots.

Part B

Calculate the percent change in the number of Texas counties where ocelots have been found historically as compared to today. **Show** your work.

Part C

Researchers expect the ocelot population to grow at a constant rate of 2.8% per year. **Calculate** the number of years it will take for the ocelot population to double based on a constant rate of growth. **Show** your work.

Part D

Pocket mice eat plants in the shrubland, while snakes are carnivores. **Explain** why the amount of primary production energy available to ocelots would change if ocelots ate only carnivores such as snakes and not pocket mice.

Part E

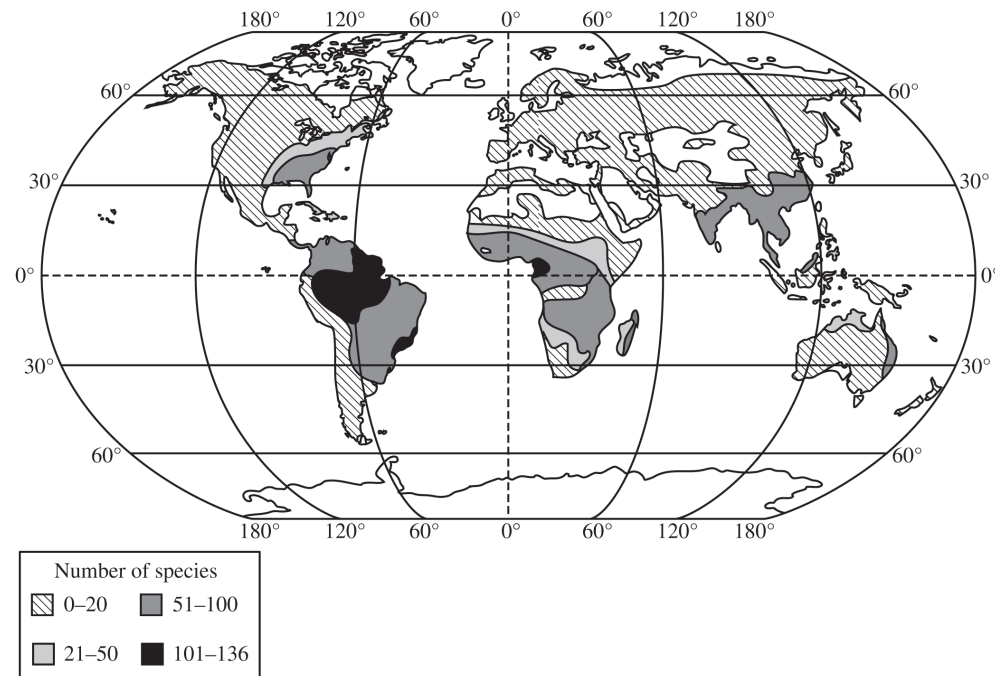
Ocelots need 720 grams of food per day. Pocket mice weigh an average of 43 grams each. If the ocelot diet consists of 46% pocket mice by weight, **calculate** how many pocket mice an ocelot would need to consume in one day, assuming each mouse weighs the average amount. **Show** your work.

Part F

As urbanization has increased in southern Texas, motor vehicle collisions have become the main cause of death in ocelots, which poses an added threat to the remaining ocelots.

- Propose** a realistic solution to reduce the number of ocelots killed by vehicles.
- Justify** the solution proposed in part F (i) by explaining an additional advantage, other than reducing the number of ocelots killed by vehicles.

STOP
END OF EXAM

**GLOBAL AMPHIBIAN SPECIES RICHNESS****2. Biodiversity around the world is changing as a result of anthropogenic influences.**

- 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.
- There are many environmental threats facing amphibians today, such as deforestation. **Describe** one possible anthropogenic reason for deforestation.
- 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.
- 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.



- (i) **Identify** one specific piece of legislation that has been designed to protect species threatened by extinction.
- (ii) **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.
- (i) **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.
- (ii) **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.

ENVIRONMENTAL SCIENCE

SECTION II

Time—1 hour and 30 minutes

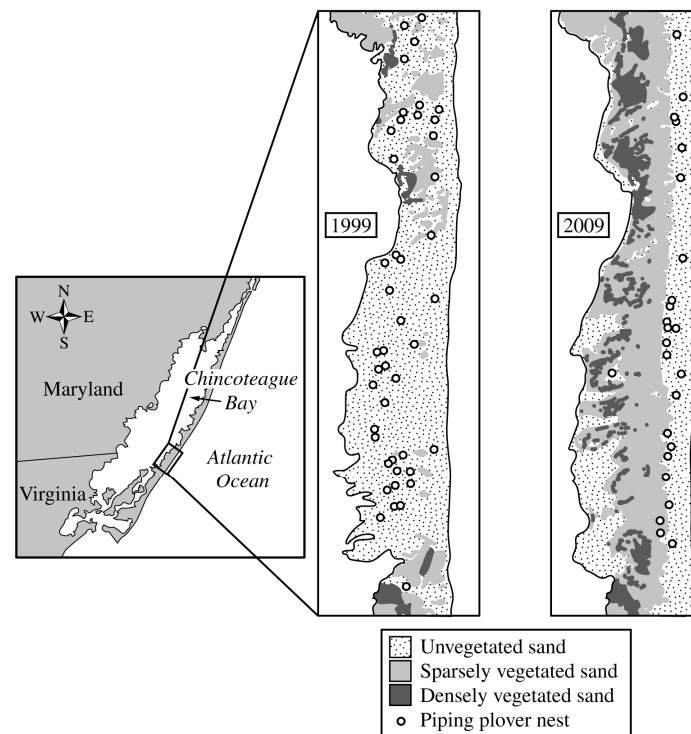
4 Questions

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. The piping plover is a globally threatened species, with perhaps as few as 2,000 nesting pairs remaining in the Atlantic population of these migratory shorebirds. Plovers were nearly hunted to extinction in the nineteenth century.

Plovers prefer to nest and search for food on open sandy beaches between sparsely vegetated sand dunes. Washovers, where sand is washed up from the beach and buries vegetated areas during big storms, are also important to plovers because they provide moist and undisturbed habitat for plover adults and their chicks. Ecologists with the Elliott Oceanographic Institute mapped the distribution of plover nests during two seasonal surveys of nesting sites over a ten-year period on Assateague Island. This is a barrier island, a long, narrow island running parallel to the Atlantic coast of Virginia.

SPRING PIPING PLOVER NESTING SITES
ON ASSATEAGUE ISLAND, VIRGINIA

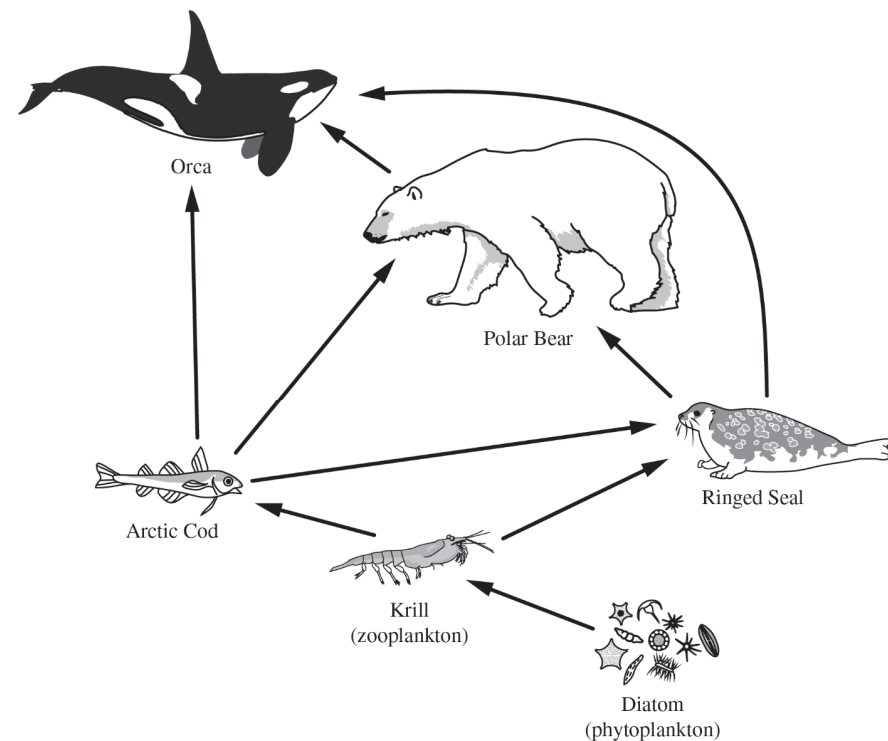


- (a) Use the maps provided to answer the following questions.
- Identify** the preferred nesting habitat for piping plovers.
 - Describe** the change in the number of piping plover nests on Assateague Island between 1999 and 2009.
 - Describe** one likely reason for the change in the number of piping plover nests between 1999 and 2009.
- (b) Coastal species are affected by more than just natural events.
- Special beach restrictions can help piping plovers during nesting season. **Describe** one restriction that could reasonably be implemented to help prevent the destruction of plover nests by human actions.
 - In addition to providing habitat for piping plovers, barrier islands (and closely related landforms) are important for other reasons. **Explain** one way that these features help to preserve and protect the environment in coastal regions.
 - Identify** one human action that directly threatens coastal habitats and **describe** one impact on species, other than the piping plover, that use the habitat.

Approximately 40% of the United States population resides in coastal areas, such as areas near Assateague Island, where sea level rise and shoreline erosion is occurring.

- Identify** one economic impact on coastal communities that has resulted from rising sea levels.
- Describe** TWO methods that may be used locally to protect coastal communities from rising sea levels.

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

- (a) Refer to the food web above to complete the following table.

	Organism from Arctic food web
(i) Identify a primary producer	
(ii) Identify a primary consumer	
(iii) Identify a secondary consumer	

- (b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

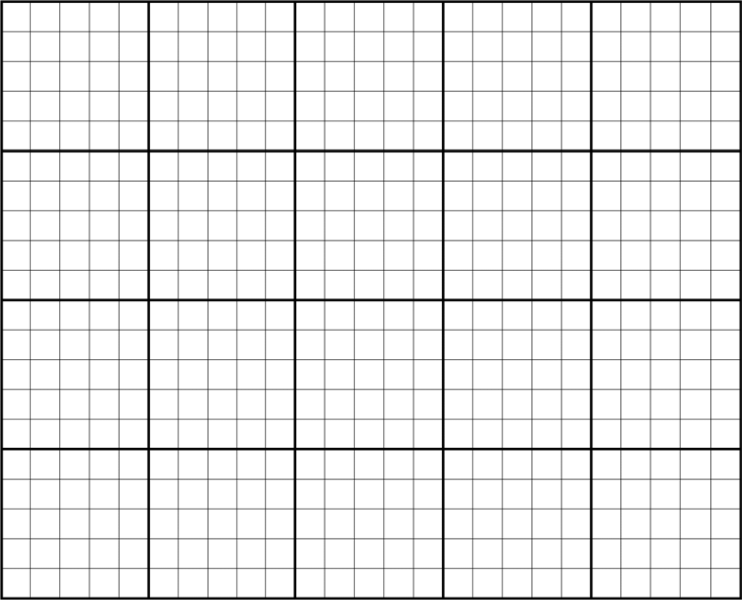
- (c) **Describe** how the change in sea ice habitat is affecting polar bears’ ability to hunt and feed.
- (d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.
- (e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.
- (i) **Provide** one reason a species may migrate a long distance.
- (ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.
- (iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

2. Populations of large terrestrial animals, such as African elephants and snow leopards, are in decline around the world. Many of these large animals are now on the verge of extinction.

ESTIMATED AFRICAN
ELEPHANT POPULATION
ON THE AFRICAN
CONTINENT

Year	Population
1970	2,000,000
1980	1,300,000
1990	600,000
1995	550,000
2000	400,000
2005	550,000
2010	650,000
2015	600,000

- (a) Using the data provided in the table above, **plot** the elephant population data as points on the grid below, placing the independent variable on the *x*-axis. Clearly **label** the axes.



- (b) **Calculate** the percent loss of elephants in Africa from 1970 to 2000. Show all work.
- (c) The International Union for Conservation of Nature (IUCN) estimates that the elephant population will decline by 20 percent between 2015 and 2022. Use this estimate to **calculate** how many elephants will be left in Africa in 2022. Show all work.
- (d) Most large terrestrial mammals are K-strategists. **Identify** one characteristic of a K-strategist and **explain** how the characteristic you identified can make these mammals prone to extinction.
- (e) **Identify** and **discuss** TWO conservation strategies that could be implemented to prevent the extinction of large terrestrial mammals, such as the African elephant or snow leopard.

9.10 Human Impacts on Biodiversity

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS invasive species 入侵物种 • greenhouse gases 温室气体

Objective

Build the skills to answer exam questions on **human impacts on biodiversity**.

You must be able to:

- summarize how human activities reduce biodiversity
- explain why biodiversity loss matters
- describe solutions

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 overall picture

Human activities — **habitat loss, pollution, overexploitation, invasive species, and climate change** — are driving a rapid loss of biodiversity, sometimes called a **sixth mass extinction**.

■ Why it matters

Biodiversity provides **ecosystem services** (food, clean water, pollination, climate regulation, medicine) and makes ecosystems **resilient**. Losing it reduces these benefits and destabilizes ecosystems.

■ Solutions

- **Protect and restore habitat** (reserves, corridors).
- **Reduce pollution** and greenhouse gases.
- **Sustainable resource use** (fishing, forestry, farming).
- **Laws and international cooperation**.

■ A worked reasoning

Protecting a large connected habitat conserves many species at once and maintains the services (like pollination and water filtration) that people depend on.

2 Practice

Now apply the methods above.

2.1 Name two human causes of biodiversity loss. [2]

2.2 State one reason biodiversity matters to humans. [1]

2.3 State one solution to biodiversity loss. [1]

3 Exam-style questions

3.1 The current rapid loss of species is sometimes called the [1]

- **A** first mass extinction
- **B** sixth mass extinction
- **C** ice age
- **D** green revolution

3.2 A government wants to protect its biodiversity.

(a) Suggest two effective strategies. [2]

(b) Explain why protecting biodiversity also protects human well-being. [2]

3.3 Explain why habitat protection is often the most effective single conservation action.^[2]

Solutions

2.1 Any two: habitat loss, pollution, overexploitation, invasive species, climate change.

2.2 Any one: ecosystem services (food, water, pollination, medicine), resilience.

2.3 Any one: protect/restore habitat, reduce pollution, sustainable use, laws.

3.1 B — the sixth mass extinction.

3.2 (a) Any two: protected areas/corridors, pollution reduction, sustainable resource use, laws. (b) Biodiversity provides essential services (food, clean water, pollination, medicine) and resilience, so protecting it safeguards the benefits people depend on.

3.3 Protecting a habitat conserves all the species living in it at once, along with the ecosystem processes and services they support — far more efficient than saving one species at a time.

Chickadees are a K-selected species of bird that eat insects and spiders. Spiders consume insects, and many insects consume plants as shown in the following food chain.

Plants → Insects → Spiders

Chickadee habitat includes forests and residential yards. Residential yards often contain nonnative plants, which do not naturally exist in an area, but were introduced by humans.

Scientists measured the average number of insects and spiders as related to the percentage of nonnative plants (Figure 1). The scientists also measured the chickadees' average population growth rate (Figure 2) to determine the impact of nonnative plants on chickadee populations.

Figure 1. Percentage of Nonnative Plants and Average Number of Individual Spiders and Insects

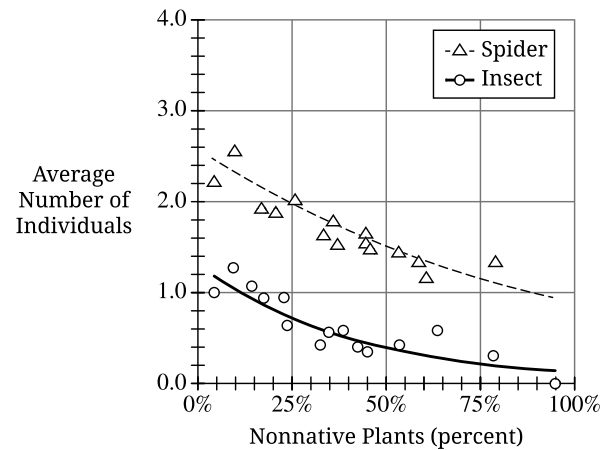
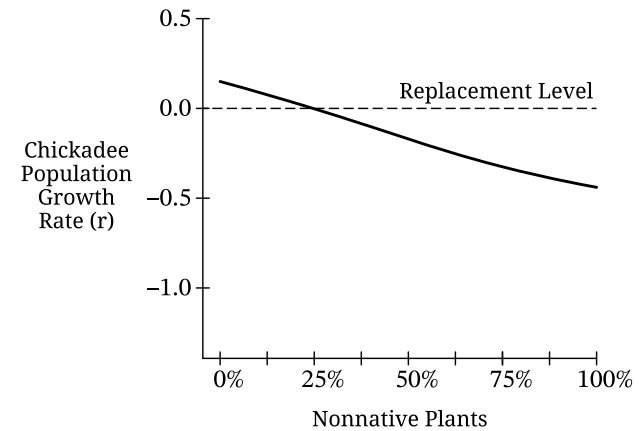


Figure 2. Chickadee Population Average Growth Rate and Percentage of Nonnative



1. Respond to parts A, B, C, D, E, F, G, and H, and all subparts.

- A. **Describe** one reproductive strategy used by a K-selected species such as the chickadee.
- B. Based on the information provided, **explain** how a decrease in spider populations could affect a lower trophic level.
- C. Based on the data in Figure 1, **identify** the number of spiders per sample at 25% nonnative plants.
- D. Based on the data in Figure 1, **describe** the trend in the number of insects per sample in relation to the percentage of nonnative plants.
- E. Scientists hypothesized that the population of chickadees would be stable or growing with fewer than 25% nonnative plants. **Describe** one way that the data in Figure 2 support this hypothesis.
- F. Insect biodiversity is important to maintain ecosystem health. A group of students was interested in learning about factors that affect ant biodiversity. They located two study sites near their school: a frequently mowed urban park and an unmowed grassland. The students used traps designed to collect ants. They loaded 10 of these traps with the same food and placed them randomly at different locations within each site. Students collected the traps after 24 hours and counted the number of different ant species in each trap to determine species richness.
- Identify** a likely scientific question for the students' investigation of ant diversity.
 - Identify** the dependent variable in the students' investigation.
- G. The data from the student investigation of ant diversity are shown in the following table. An "X" in the table indicates that the species was present at that site.

Ant Species Present in an Urban Park and Unmowed Grassland

Site	Species A	Species B	Species C	Species D	Species E	Species F
Urban park	X			X	X	
Grassland	X	X	X	X		X

- Explain** why the ant community of the unmowed grassland would be more likely to recover from a disturbance, such as a flood or fire, than the ant community in the mowed urban park would.
 - Explain** how the results of the investigation could have been altered if students had measured ant biodiversity at a paved playground rather than in the grassland.
- H. Habitat fragmentation has impacts on a variety of species. Paved roads can lead to habitat fragmentation.
- Describe** one effect that a paved road in a forest can have on animal species such as deer or bears.

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

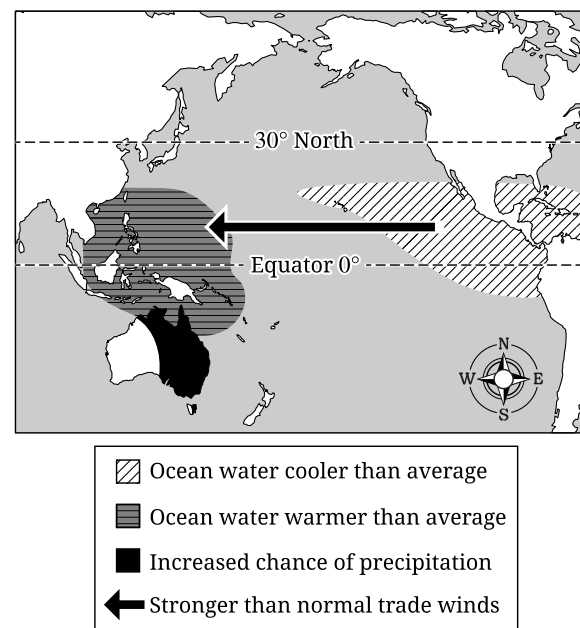
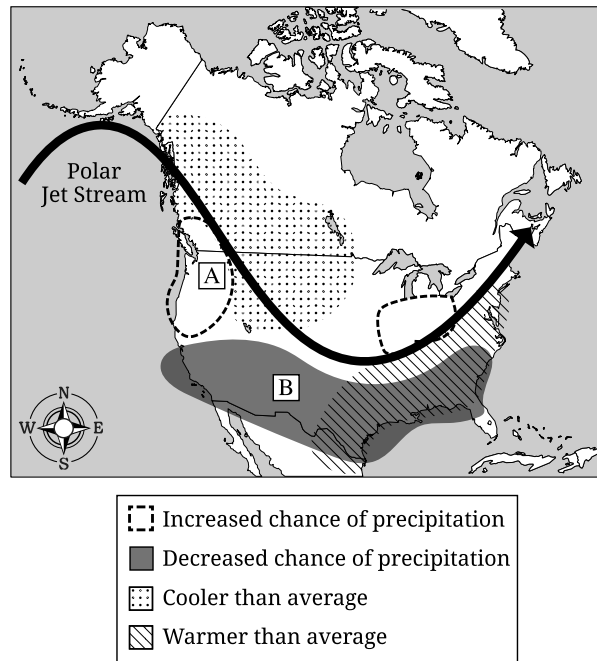
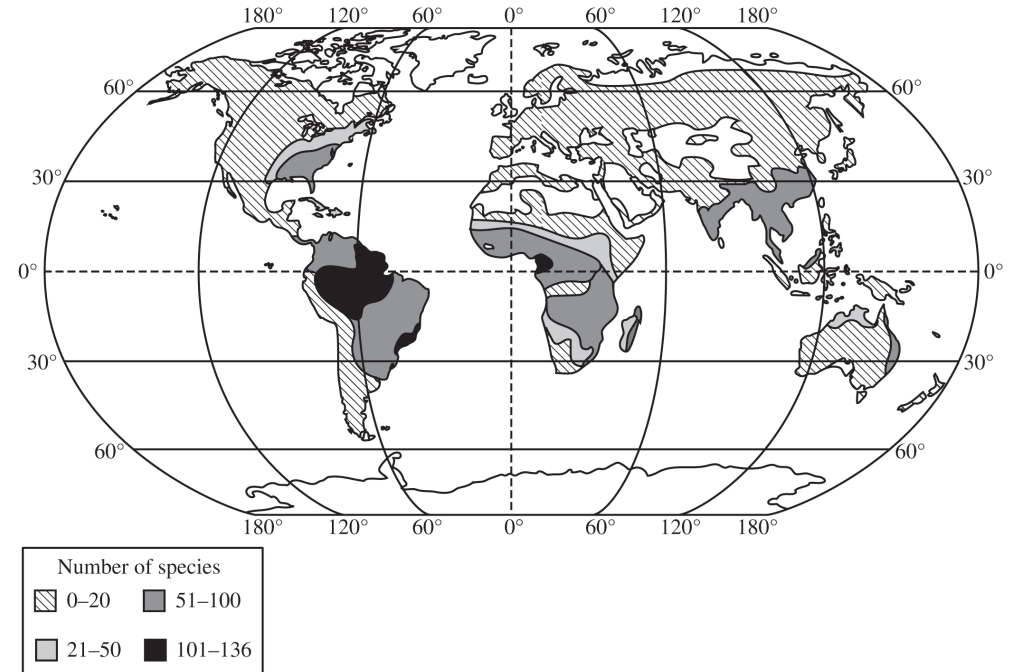


Figure 2. Polar Jet Stream and Climate Conditions in North America**GLOBAL AMPHIBIAN SPECIES RICHNESS**

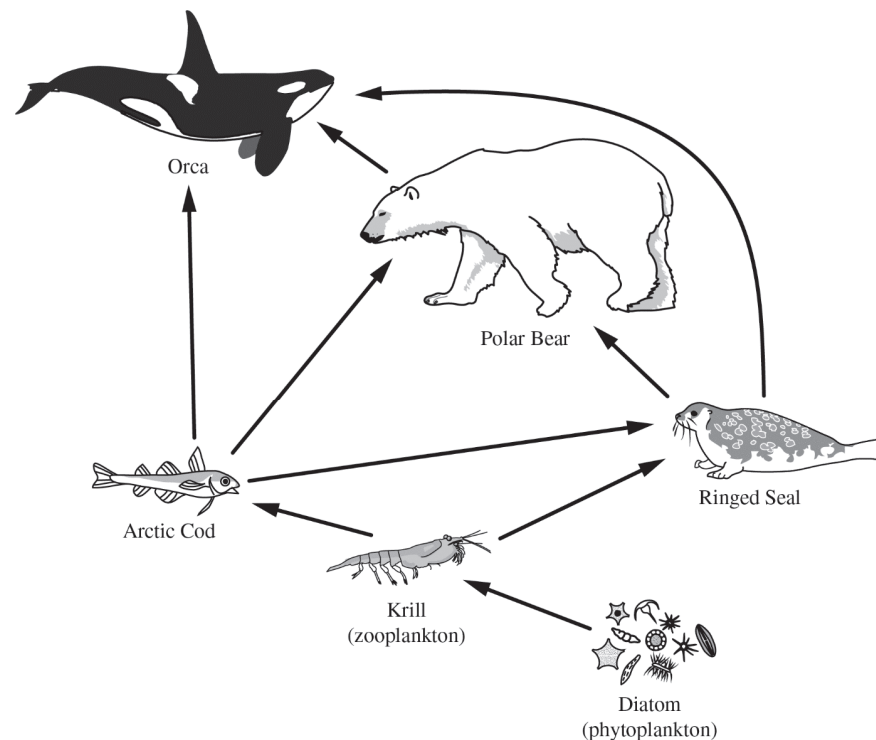
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