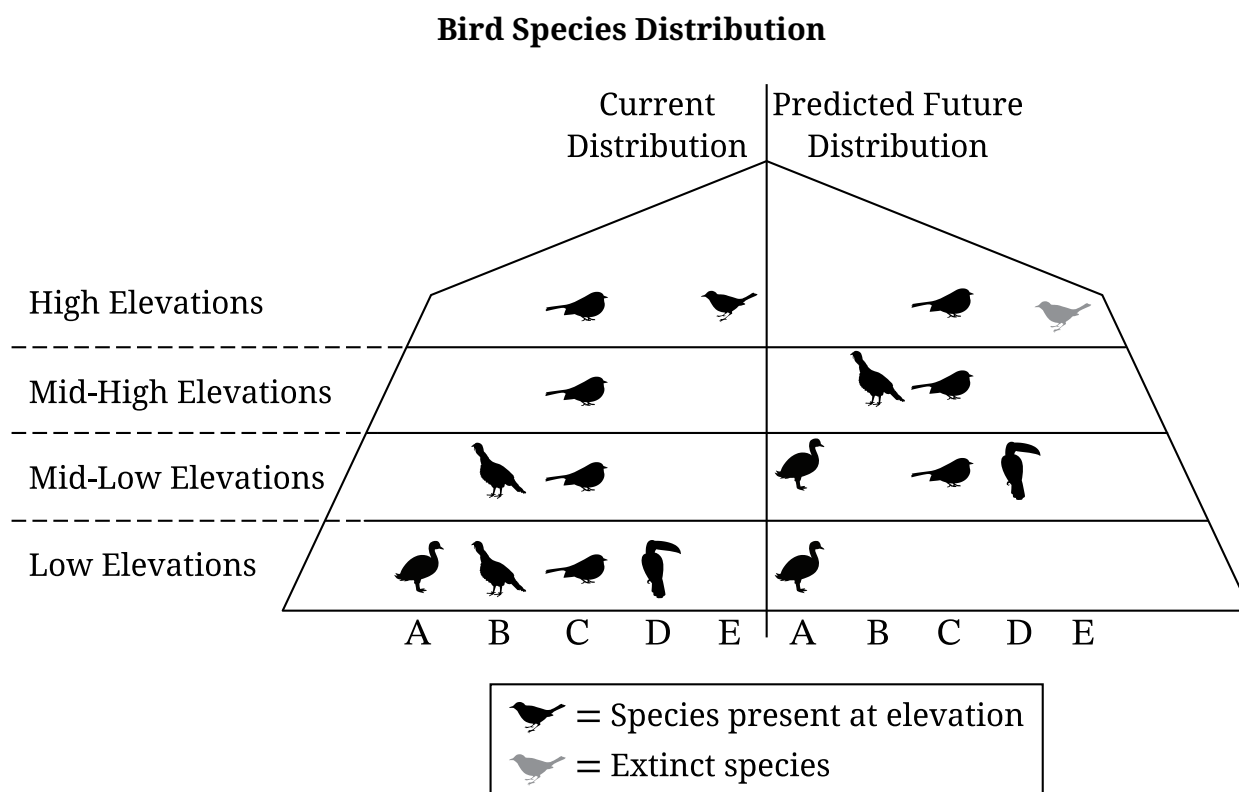


The following information applies to parts A, B, C, D, and E.

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.

- A. Based on the data in the graph, **identify** the number of Common Tern breeding pairs in 1995.
- B. Based on the data in the graph, **describe** the trend in the number of Common Tern breeding pairs from 1995 to 2008.
- C. 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.
- D. **Explain** how climate change can lead to sea level rise.
- E. 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.

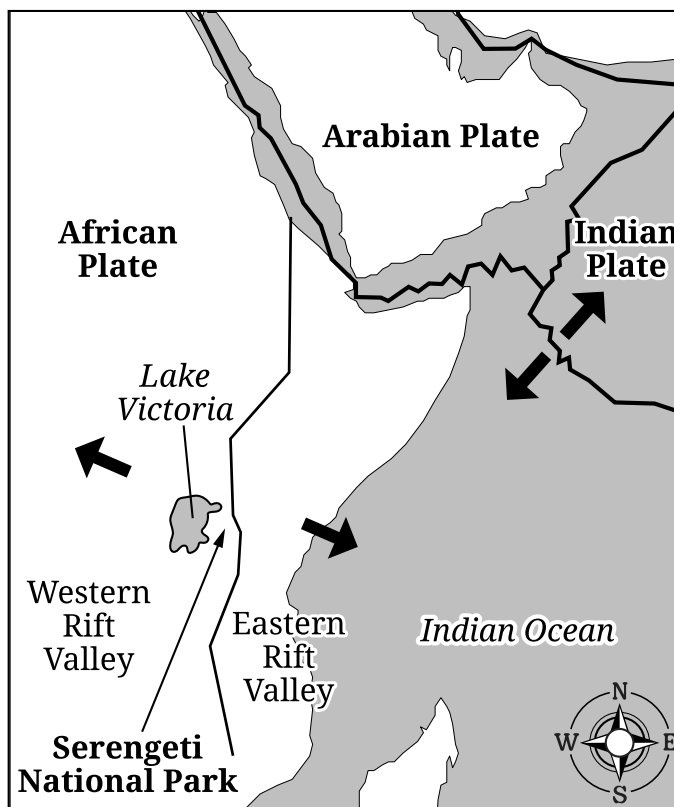
Sea Level Rise and Number of Wading Bird Species at Four Coastal Locations

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

- i. **Identify** a hypothesis that researchers are likely investigating in the wading bird study.
- ii. **Identify** the dependent variable in this study.
- F. 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.
- G. **Describe** a regulating ecosystem service that can be provided by wetlands.
- H. 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.
- I. **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.

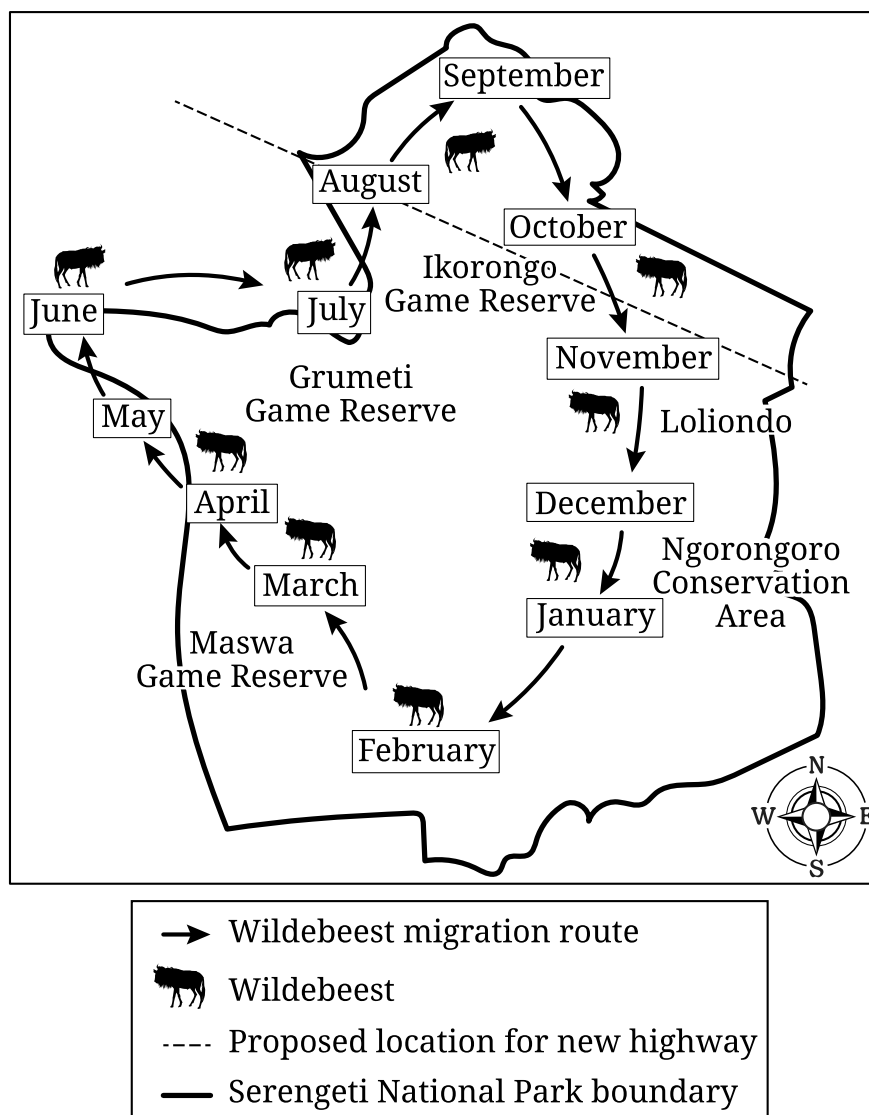
Figure 1. Tectonic Plate Movement near East Coast of Africa



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

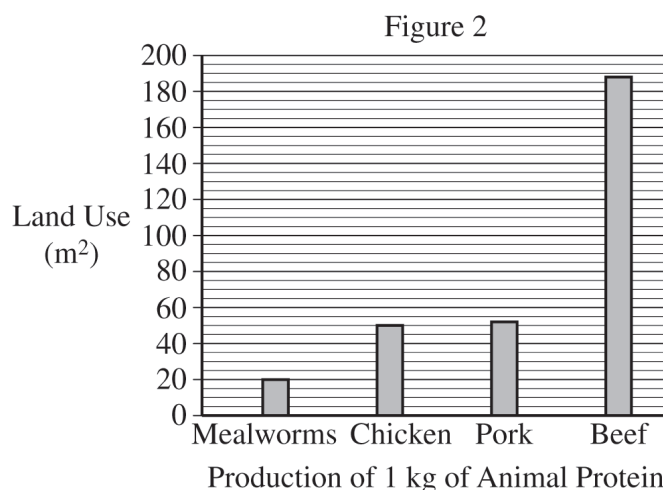
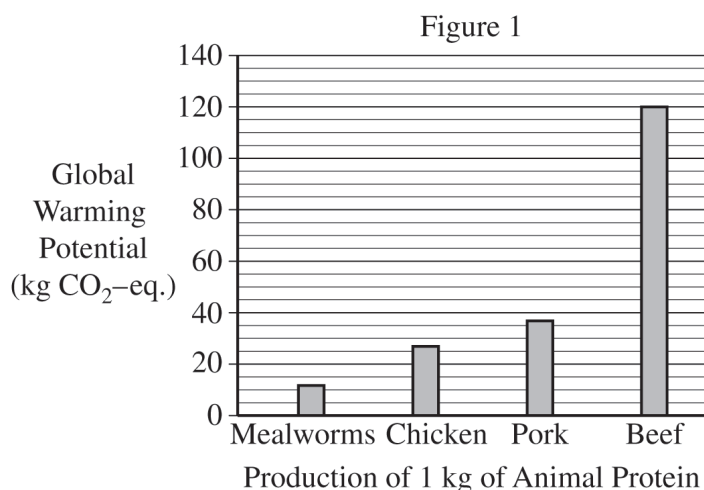
Serengeti National Park contains a variety of tropical habitats but is dominated by wideopen lands that include a variety of grass species with scattered trees and shrubs. Most grass growth occurs after the March through May rainy season. Many of the park's herbivores, such as wildebeest and zebra, migrate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

Figure 2. Annual Migration of Wildebeest in Serengeti National Park



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

Global Warming Potential and Land Use from Animal Protein Production



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

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

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

- (c) **Explain** why the reproductive strategy of the darkling beetle is an advantage for using mealworms as an alternative protein source for the rapidly growing human population.

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

- (d) Based on the data in the graphs, **explain** whether producing 1 kilogram of chicken protein or 1 kilogram of pork protein would cause less environmental damage.

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

- (e) Based on the data in the graphs, **explain** why the production of 1 kilogram of beef protein has a different impact on global warming than the production of 1 kilogram of protein from any of the other animals studied would have.

Agricultural practices can have negative impacts on rivers and streams.

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

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

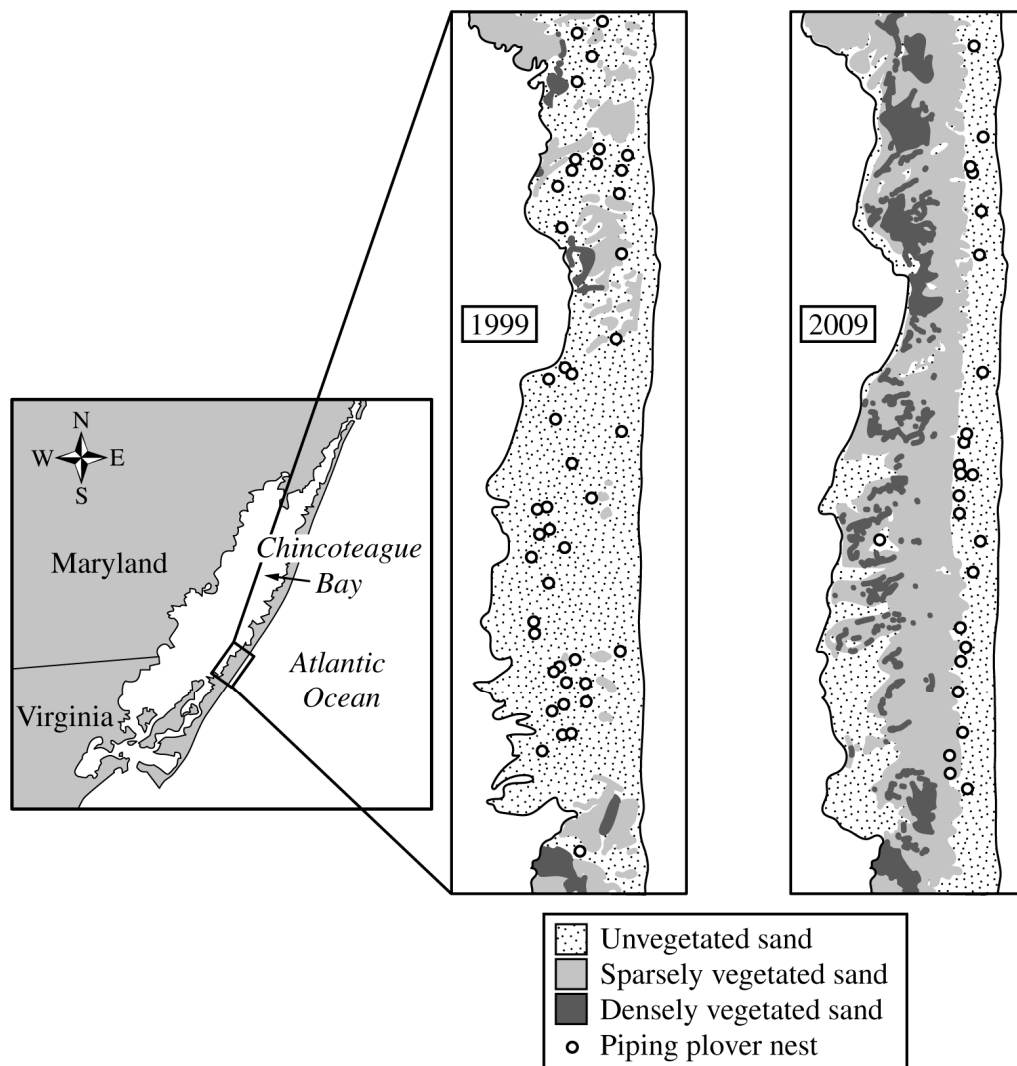
ENVIRONMENTAL SCIENCE**SECTION II****Time—1 hour and 30 minutes****4 Questions**

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.

- (i) **Identify** the preferred nesting habitat for piping plovers.
- (ii) **Describe** the change in the number of piping plover nests on Assateague Island between 1999 and 2009.
- (iii) **Describe** one likely reason for the change in the number of piping plover nests between 1999 and 2009.

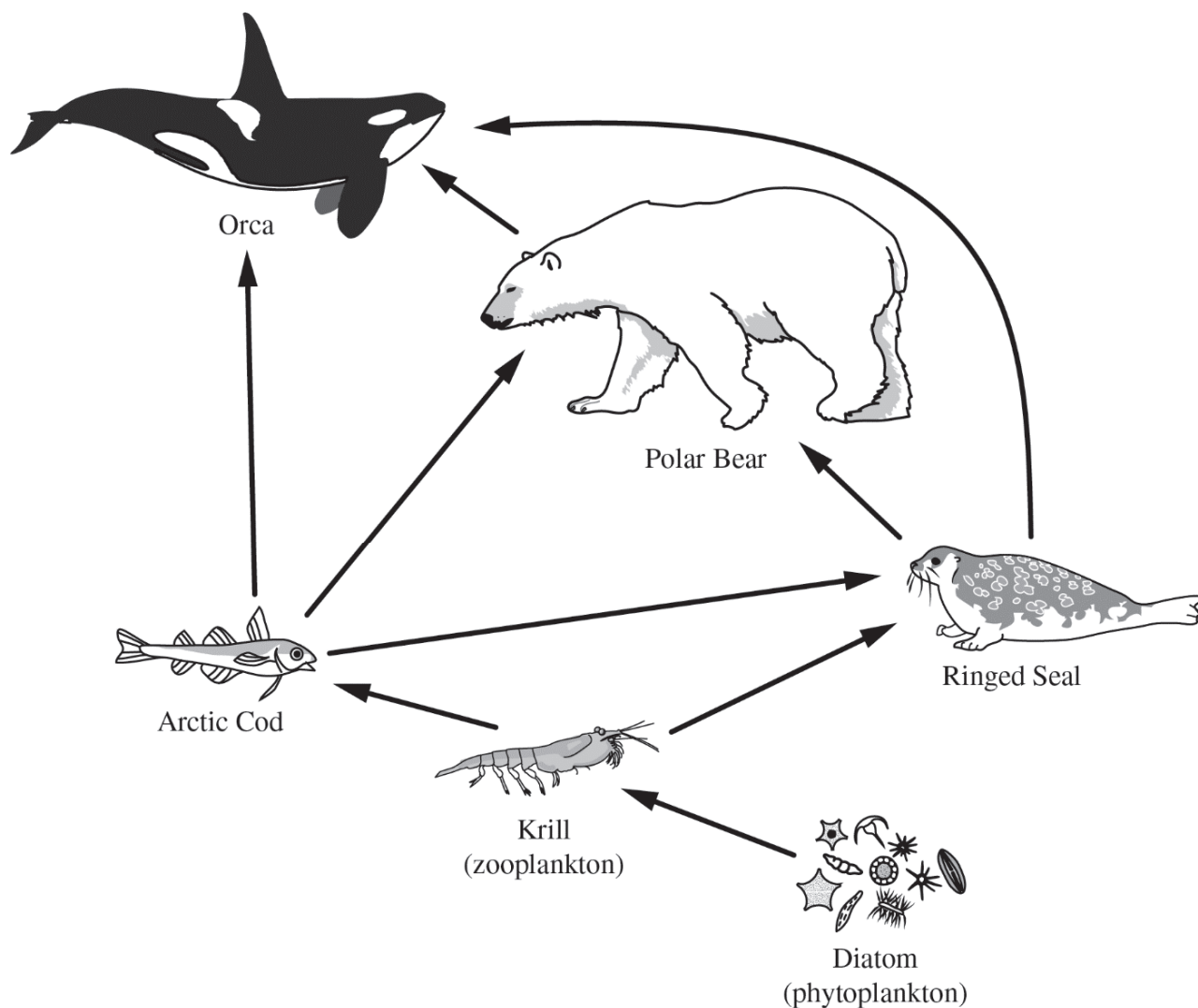
(b) Coastal species are affected by more than just natural events.

- (i) 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.
- (ii) 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.
- (iii) **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.

- (c) **Identify** one economic impact on coastal communities that has resulted from rising sea levels.
- (d) **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).

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

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

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

- (c) Nitrate levels exceeding the United States Environmental Protection Agency's primary drinking water standard have been found in the groundwater of areas with intensive agriculture.
 - (i) **Identify** one agricultural practice that can lead to elevated nitrate levels in groundwater.
 - (ii) **Describe** how the practice you identified in (c)(i) leads to elevated nitrate levels in groundwater.
- (d) Acid deposition has affected soil quality in many parts of the northeastern United States.
 - (i) **Explain** one way acid deposition onto soil can affect plant health.
 - (ii) **Describe** one method for remediating soil affected by acid deposition.
- (e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. **Describe** TWO ways that climate change can degrade soil.

STOP

END OF EXAM

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

Directions: Answer all four questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this book. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

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

The Floridian Daily**May 21, 2013**

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

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

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

4. 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