Week 1

AP Environmental Science

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

1. The Living World: Ecosystems

Starter Quiz · 课前小测

AP Environmental Science Name: _____ Score: _____

1. An **ecosystem** is…
   - ☐ all the living things in an area plus their non-living surroundings
   - ☐ only the animals in an area
   - ☐ a single species
   - ☐ a type of rock
2. A **biome** is…
   - ☐ a large region defined by its climate and characteristic life
   - ☐ a single ecosystem
   - ☐ one species
   - ☐ a type of soil
3. Aquatic biomes are mainly divided by their **salinity**, which means…
   - ☐ how much salt is dissolved in the water
   - ☐ how deep the water is
   - ☐ how warm the water is
   - ☐ how fast the water flows
4. Which process **removes** carbon dioxide from the air?
   - ☐ photosynthesis
   - ☐ respiration
   - ☐ combustion
   - ☐ decomposition
5. Why can most living things not use the nitrogen gas in the air directly?
   - ☐ the N2 molecule is very stable and hard to break apart
   - ☐ there is too little of it
   - ☐ it is too cold
   - ☐ it is poisonous
6. Non-living parts of an ecosystem, like sunlight and water, are the _____ factors.

   _____
7. The cold, treeless biome with frozen ground for much of the year is the _____.

   _____
8. The brackish place where a river meets the sea is called an _____.

   _____
9. Carbon locked away for millions of years in coal, oil, and gas is stored as _____ fuels.

   _____
10. Plants use fixed nitrogen to build _____, and animals get it by eating plants.

    _____

AP Environmental Science

1. **all the living things in an area plus their non-living surroundings**

   An **ecosystem** is a community of living things interacting with each other and their non-living environment.

2. **a large region defined by its climate and characteristic life**

   A **biome** is a large area with a distinctive climate and the plants and animals adapted to it.

3. **how much salt is dissolved in the water**

   Salinity is the amount of dissolved salt; it separates freshwater from marine biomes.

4. **photosynthesis**

   Photosynthesis takes CO2 out of the air and stores the carbon in plants.

5. **the N2 molecule is very stable and hard to break apart**

   N2 has a very strong triple bond, so it must first be **fixed** into usable forms.

6. **abiotic**

   Abiotic factors are the non-living conditions and resources an ecosystem depends on.

7. **tundra**

   The **tundra** is cold and treeless, with permanently frozen ground (permafrost) below the surface.

8. **estuary**

   An **estuary** is where fresh and salt water mix; it is very rich in life.

9. **fossil**

   Coal, oil and gas are **fossil fuels** — ancient carbon that combustion releases as CO2.

10. **proteins**

    Nitrogen is essential for **proteins** and DNA; animals get theirs by eating plants.

AP ENVIRONMENTAL SCIENCE • EXERCISE SHEET

1.1 Introduction to Ecosystems

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

KEY WORDS biotic 生物 • abiotic 非生物 • ecosystem 生态系统 • predation 捕食 • competition 竞争

Objective

Build the skills to answer exam questions on **ecosystems** — living and non-living components and their interactions.

You must be able to:

- define an **ecosystem** 生态系统 (biotic + abiotic)
- distinguish **biotic** 生物 and **abiotic** 非生物 factors
- describe interactions (predation, competition, symbiosis)

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 an ecosystem is

An **ecosystem** is all the **living** (biotic) and **non-living** (abiotic) things in an area, interacting together.

Biotic vs abiotic

- **Biotic** — living or once-living: plants, animals, bacteria.
- **Abiotic** — non-living: sunlight, water, temperature, soil, nutrients.

Interactions

Organisms interact through **predation** (one eats another), **competition** (for shared resources), and **symbiosis** (mutualism, commensalism, parasitism).

A worked classification

In a pond: fish and algae are **biotic**; water temperature and dissolved oxygen are **abiotic**. A heron eating a fish is **predation**.

2 Practice

Now apply the methods above.

2.1 Define an ecosystem. [1]

2.2 Classify each as biotic or abiotic: (a) sunlight, (b) a frog, (c) soil, (d) bacteria. [2]

2.3 Name one type of interaction between organisms. [1]

3 Exam-style questions

3.1 Which is an abiotic factor? [1]

- **A** a fish
- **B** water temperature
- **C** algae
- **D** a bacterium

3.2 A student studies a grassland ecosystem.

(a) Give two biotic and two abiotic factors. [2]

(b) Describe one interaction between two organisms in it. [2]

3.3 Explain why both biotic and abiotic factors must be considered when studying an ecosystem. [2]

Solutions

2.1 All the living (biotic) and non-living (abiotic) things in an area, interacting.

2.2 (a) abiotic; (b) biotic; (c) abiotic; (d) biotic.

2.3 Any one: predation, competition, symbiosis.

3.1 B — water temperature.

3.2 (a) Biotic: e.g. grass, grasshopper; abiotic: e.g. sunlight, soil. (b) Any valid interaction, e.g. a grasshopper eats grass (predation/herbivory).

3.3 Organisms depend on abiotic conditions (light, water, nutrients) and on each other; both together determine what can live and how the ecosystem functions.

AP ENVIRONMENTAL SCIENCE • EXERCISE SHEET

1.2 Terrestrial Biomes

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

KEY WORDS biome 生物群系 • desert 沙漠 • temperature and precipitation 温度和降水 • tropical rainforest 热带雨林

Objective

Build the skills to answer exam questions on **terrestrial biomes**.

You must be able to:

- explain that **biomes** 生物群系 are determined mainly by **temperature and precipitation** 温度和降水
- match a biome to its climate
- name key terrestrial biomes

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 sets a biome

A **biome** is a large region with a characteristic climate and community. **Terrestrial biomes** are determined mainly by **temperature** and **precipitation**.

The main terrestrial biomes

- **Desert** — very low precipitation.
- **Tropical rainforest** — hot and very wet.
- **Grassland** — moderate rainfall, seasonal.
- **Temperate forest** — moderate temperature and rainfall.
- **Taiga (boreal forest)** — cold, coniferous.
- **Tundra** — very cold, low precipitation, frozen soil (permafrost).

Reading a climate

Given a climate (e.g. hot, very wet), identify the biome (tropical rainforest). Given the biome, describe its climate.

A worked match

A region with high temperature and high rainfall all year → **tropical rainforest**, with high biodiversity.

2 Practice

Now apply the methods above.

2.1 What two climate factors mainly determine a terrestrial biome? [2]

2.2 Which biome has very low precipitation? [1]

2.3 Which biome has frozen soil (permafrost)? [1]

3 Exam-style questions

3.1 Terrestrial biomes are determined mainly by temperature and [1]

- **A** soil color
- **B** precipitation
- **C** altitude only
- **D** wind speed

3.2 A region is hot with heavy rainfall year-round.

(a) Name the biome. [1]

(b) State one feature you would expect there. [1]

3.3 Explain why deserts and tropical rainforests differ so greatly despite both being warm. [2]

Solutions

2.1 Temperature and precipitation.

2.2 Desert.

2.3 Tundra.

3.1 B — precipitation.

3.2 (a) Tropical rainforest. (b) Any one: high biodiversity, tall dense trees, high productivity.

3.3 They differ mainly in **precipitation** — a desert is very dry while a rainforest is very wet — which controls the plants and animals that can live there.

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

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

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

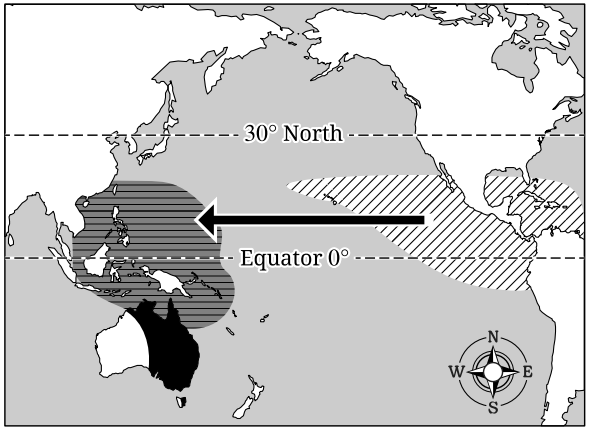
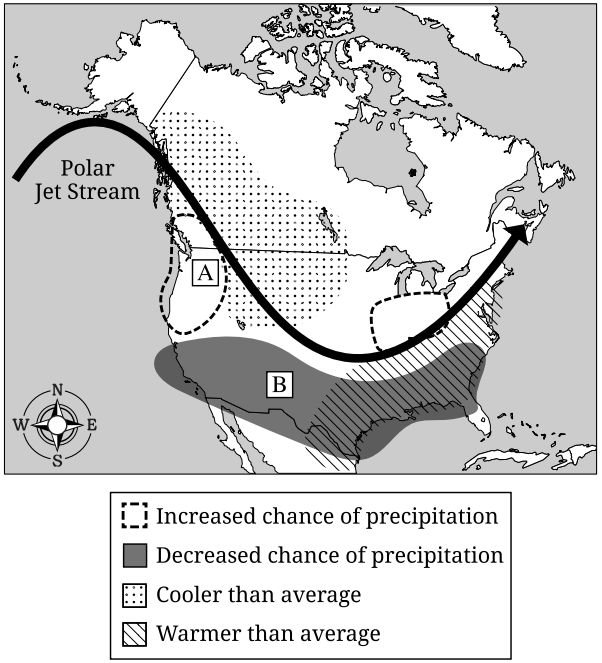


Figure 2. Polar Jet Stream and Climate Conditions in North America



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

A. **Identify** the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1.

B. Based on the information in Figure 1, **identify** the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean.

C. Based on the information in Figure 2, **describe** a difference in climate patterns between the regions A and B.

D. Increases in regional precipitation can lead to increased flooding in certain locations. **Describe** one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation.

E. **Propose** a realistic solution a city could implement to decrease the risk of flooding in urban areas.

F. **Justify** the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding.

G. Terrestrial biomes are primarily determined by temperature and precipitation patterns. **Describe** one difference between the climate of a temperate seasonal forest and that of a savanna.

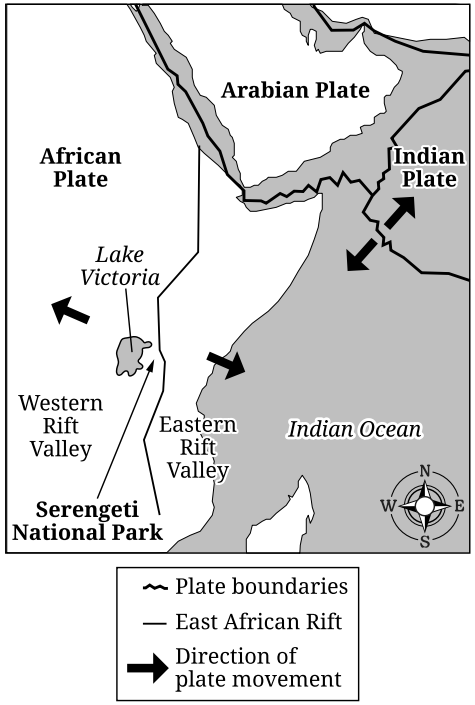
H. Droughts are one environmental problem that can affect the frequency and severity of forest fires. **Identify** the ecological process that occurs following a forest fire that leaves the soil intact.

I. **Describe** one way burning forests contribute to atmospheric pollution.

J. **Describe** one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires.

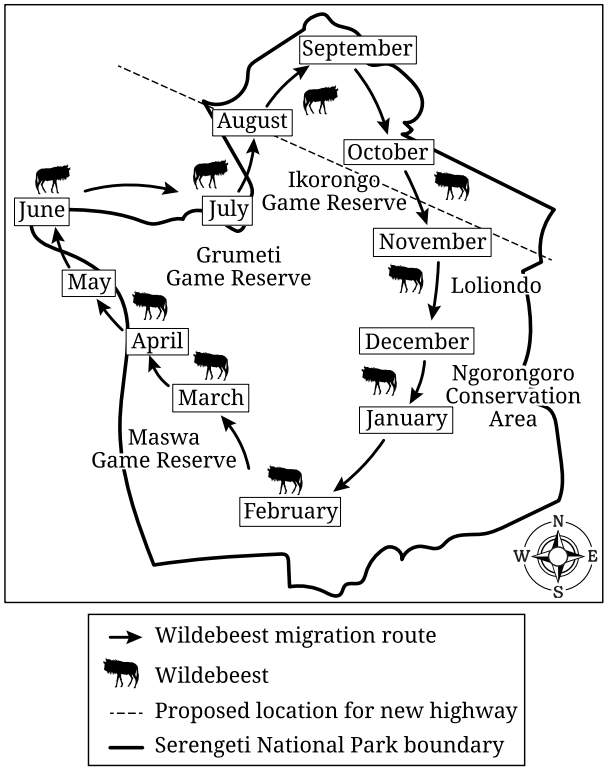
Serengeti National Park is located in Tanzania, Africa. The park is located in a valley along a tectonic plate boundary called the East African Rift. Figure 1 shows the East African Rift and other plate boundaries near the east coast of Africa.

Figure 1. Tectonic Plate Movement near East Coast of Africa



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

Figure 2. Annual Migration of Wildebeest in Serengeti National Park



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

A. Based on the information in Figure 1, **identify** the type of plate boundary that runs beneath Serengeti National Park.

B. Based on the information provided, **identify** the dominant biome within the Serengeti.

C. Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, **identify** the location in the Serengeti where wildebeest are most likely to give birth.

D. The Serengeti has two primary types of grasses: long and short. The two grass types provide similar levels of nutrition for animals. Wildebeest primarily consume long grasses, while other herbivores such as gazelle consume the short grasses. These two similar species coexist in Serengeti National Park.

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

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

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

F. **Propose** a solution to the negative effect created by the planned highway described in part E.

G. Many organisms live in grasslands. One weed species, the spotted knapweed, was introduced at one location in North America in the 1890s and is currently found throughout the rangelands of the western United States. The spotted knapweed poses several environmental problems in North America. Farmers often use crop rotation to control populations of pests like the spotted knapweed. A more traditional method of controlling pests involves spraying pesticides.

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

H. **Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations.

I. **Describe** an environmental problem associated with controlling pest populations with large amounts of pesticide.

J. **Propose** a solution to controlling pests, other than pesticides or crop rotation.

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

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

   (a) **Identify** a typical type of plant that would be used in desert-tolerant landscaping.

   (b) **Justify** the removal of landscaping and lawns that use grasses not native to the local area by describing an additional advantage, other than reducing the amount of water needed for irrigation.

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

   (c) **Describe** how a prescribed burn would reduce the severity and spread of forest fires.

   (d) **Describe** a disadvantage of a prescribed burn in a forested ecosystem.

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

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

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

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

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

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

STOP

END OF EXAM

ENVIRONMENTAL SCIENCE

SECTION II

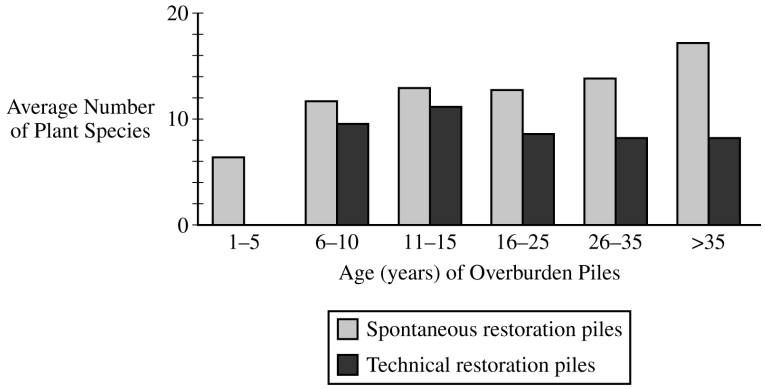
Time—1 hour and 10 minutes

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

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



(a) Based on the data in the graph, **identify** the average number of species found in technically restored piles 16–25 years after restoration started.

(b) Based on the data in the graph, **describe** the relationship between the average number of species and the age of the spontaneous restoration piles.

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

(c) Using the data in the graph, **make a claim** that supports or refutes the hypothesis that the number of animal species in the spontaneously restored piles would be higher than the number of animal species in the technically restored piles.

(d) **Describe** a characteristic of a plant species that would have been present in the spontaneous restoration piles from years 1 to 5.

(e) **Explain** how the return of plant life would have been altered in the spontaneous piles if the mining had taken place in the tundra rather than in temperate forests.

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

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

(f) **Identify** the scientific question for the investigation.

(g) **Identify** a dependent variable in the experiment.

(h) **Explain** how the results of the experiment would likely have been altered if the soil had contained a higher percentage of sand, which has the largest particle size of the components of loam.

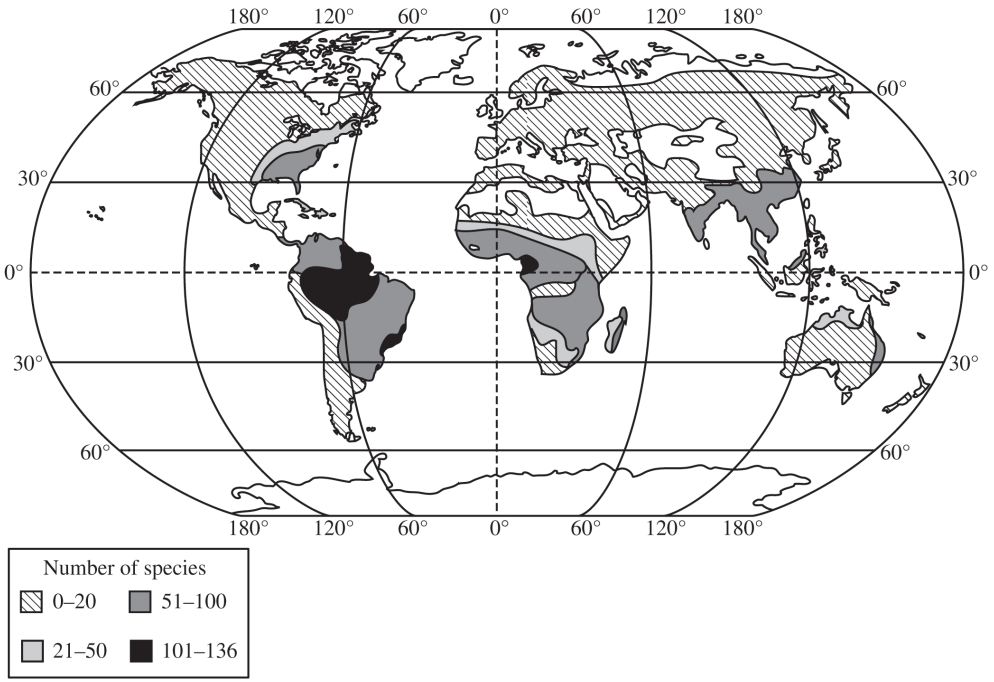
Runoff from mining waste can also affect water quality.

(i) **Describe** one ecological impact that could result from the drainage from mine waste into nearby waterways.

(j) **Describe** one strategy to reduce the drainage from mine waste into waterways downstream from mines.

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

GLOBAL AMPHIBIAN SPECIES RICHNESS



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

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

(i) **Identify** the latitudinal range with the greatest amphibian species richness.

(ii) **Identify** what biome this range most likely represents.

(iii) **Describe** one reason amphibian species richness would tend to be highest in this region.

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

(c) Many factors influence biodiversity.

(i) **Explain** how the species richness of an ecosystem influences its response to environmental stressors.

(ii) **Explain** why amphibian biodiversity is declining globally, other than from deforestation.

(d) Currently, wildlife species are going extinct at an alarming rate. To combat this threat, governments around the world have enacted legislation and signed treaties to protect species threatened by extinction.

(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.

AP ENVIRONMENTAL SCIENCE • EXERCISE SHEET

1.3 Aquatic Biomes

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS marine 海洋 • estuaries 河口 • freshwater 淡水 • salinity 盐度 • coral reef 珊瑚礁

Objective

Build the skills to answer exam questions on **aquatic biomes**.

You must be able to:

- distinguish **freshwater** 淡水 and **marine** 海洋 systems
- describe productive zones (**estuaries** 河口, coral reefs)
- state the factors that shape aquatic biomes (salinity, sunlight, nutrients)

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.

■ Freshwater and marine

Aquatic biomes cover most of Earth. **Freshwater** (streams, lakes, wetlands) has low salt; **marine** (open ocean, reefs, estuaries) is salty. They differ in **salinity**, **sunlight**, and **nutrients**.

■ Highly productive zones

- **Estuaries** — where rivers meet the sea; nutrient-rich and highly productive nurseries.
- **Coral reefs** — high biodiversity, need warm, clear, shallow water.

■ Factors that shape them

Sunlight (limits photosynthesis with depth), temperature, **salinity**, dissolved oxygen, and nutrient levels all determine what lives where.

■ A worked reasoning

An estuary is highly productive because rivers deliver nutrients and it is shallow enough for sunlight to reach the producers.

2 Practice

Now apply the methods above.

2.1 State the main difference between freshwater and marine biomes. [1]

2.2 Where is an estuary found? [1]

2.3 Name one factor that shapes an aquatic biome. [1]

3 Exam-style questions

3.1 Estuaries are highly productive because they [1]

- **A** have no sunlight
- **B** are nutrient-rich where rivers meet the sea
- **C** are very deep
- **D** have no life

3.2 A coral reef is a highly biodiverse marine biome.

(a) State two conditions coral reefs require. [2]

(b) Explain why sunlight limits life in deep ocean water. [2]

3.3 Explain why estuaries are described as important “nurseries” for marine life. [2]

Solutions

2.1 Salinity — freshwater has low salt, marine is salty.

2.2 Where a river meets the sea.

2.3 Any one: salinity, sunlight, temperature, nutrients, dissolved oxygen.

3.1 B — nutrient-rich where rivers meet the sea.

3.2 (a) Warm, clear, shallow water (any two). (b) Sunlight cannot penetrate deep water, so photosynthesis (and the producers it supports) is limited near the surface.

3.3 They are nutrient-rich and sheltered, so many marine species breed and their young grow there before moving to the open sea.

1.4 The Carbon Cycle

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS reservoirs 碳库 • fossil fuels 化石燃料 • carbon cycle 碳循环

Objective

Build the skills to answer exam questions on the **carbon cycle**.

You must be able to:

- name the processes that move carbon (**photosynthesis, respiration, decomposition, combustion**)
- identify carbon **reservoirs** 碳库
- explain how humans disturb the 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.

Moving carbon

The **carbon cycle** moves carbon between the atmosphere, organisms, oceans, and rocks:

- **Photosynthesis** removes CO_2 from the air.
- **Respiration** and **decomposition** return CO_2.
- **Combustion** (burning fossil fuels) releases stored carbon.

Reservoirs

Carbon is stored in **reservoirs**: the atmosphere (CO_2), organisms, the ocean (dissolved), soil, and rocks/fossil fuels (the largest, slowest store).

Human disturbance

Burning **fossil fuels** adds CO_2 far faster than natural processes remove it, raising atmospheric CO_2 and driving climate change. Deforestation also reduces CO_2 uptake.

A worked link

A tree takes in CO_2 (photosynthesis); when it burns or decays, that carbon returns to the atmosphere.

2 Practice

Now apply the methods above.

2.1 Which process removes CO_2 from the atmosphere? [1]

2.2 Name two processes that return CO_2 to the atmosphere. [2]

2.3 Name the largest, slowest carbon reservoir. [1]

3 Exam-style questions

3.1 The process that removes carbon dioxide from the air is [1]

- **A** respiration
- **B** combustion
- **C** photosynthesis
- **D** decomposition

3.2 Humans burn large amounts of fossil fuels.

(a) Explain how this disturbs the carbon cycle. [2]

(b) State one other human activity that affects the cycle. [1]

3.3 Explain why atmospheric CO_2 is rising even though photosynthesis removes CO_2. [2]

Solutions

2.1 Photosynthesis.

2.2 Any two: respiration, decomposition, combustion.

2.3 Rocks / fossil fuels (sediments).

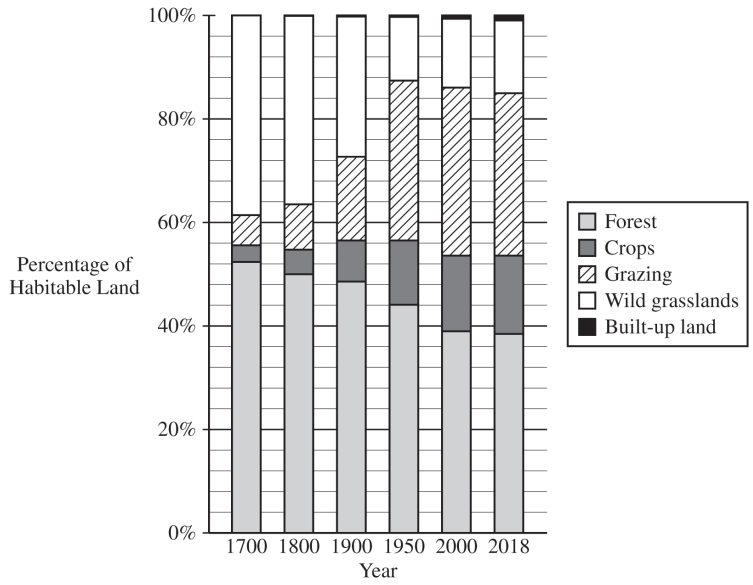
3.1 **C** — photosynthesis.

3.2 (a) Burning fossil fuels releases stored carbon as CO_2 far faster than natural processes remove it, raising atmospheric CO_2. (b) Deforestation (reduces CO_2 uptake).

3.3 Humans release CO_2 (burning fossil fuels, deforestation) faster than photosynthesis and the oceans can absorb it, so the net amount in the atmosphere increases.

2. The following graph shows how global uses of habitable land have changed since 1700.

Land Use Changes on Earth, 1700–2018



(a) Based on the data in the graph, **identify** the year with the highest percentage of forest.

(b) Based on the data in the graph, **describe** the relationship between the land use changes in the wild grasslands and grazing from 1700 to 1950.

(c) **Identify** an environmental problem associated with overgrazing by livestock.

(d) A student hypothesized that the change in the percentage of forest from 1700 to 2018 has decreased atmospheric carbon dioxide concentrations. **Explain** whether the hypothesis is supported or refuted based on the data in the graph.

Urban environments have accounted for an increasing percentage of land use within the last few decades.

(e) **Describe** a water-related environmental problem associated with urbanization.

(f) **Describe** a potential response to mitigate the environmental problem identified in part (e).

Farmers who own large sections of cropland notice that bobcats, a medium-sized predatory forest cat, were present many years ago but are now virtually absent in the area. Instead, smaller mammal species now inhabit the area. Over time, the farmers have cleared nearly all of the forest on their property and converted it to farmland.

(g) **Explain** why there are fewer bobcats present on the farmland now compared to several decades ago.

The small mammal species are considered pests by the farmers. The farmers partner with a conservation group to increase the number of bobcats in the area. As a solution, the conservation group will introduce bobcats onto the few isolated patches of the original forested habitat left in the area. They can introduce only a small number of bobcats in each patch.

(h) **Describe** a disadvantage of introducing only a small population of bobcats.

(i) **Propose** a solution to improve the chances that the bobcat reintroductions will be successful in reestablishing wild populations.

(j) **Justify** the solution proposed in part (i) by describing an additional advantage, other than reestablishing the bobcat population near the farms.

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

4. 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

1.5 The Nitrogen Cycle

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS nitrogen fixation 固氮 • denitrification 反硝化 • nitrogen cycle 氮循环

Objective

Build the skills to answer exam questions on the **nitrogen cycle**.

You must be able to:

- describe **nitrogen fixation** 固氮, nitrification, assimilation, and **denitrification** 反硝化
- explain why nitrogen must be "fixed" to be usable
- explain how fertilizer disturbs the 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.

Why nitrogen must be fixed

The air is ~78% N_2, but most organisms **cannot use** N_2 directly. It must be **fixed** into usable forms (ammonia, nitrates), mostly by **bacteria**.

The steps

- **Nitrogen fixation** — bacteria convert N_2 to ammonia.
- **Nitrification** — bacteria convert ammonia to nitrates.
- **Assimilation** — plants take up nitrates to build proteins/DNA.
- **Denitrification** — bacteria return nitrogen to the air as N_2.

Human disturbance

Fertilizers add large amounts of reactive nitrogen. Runoff carries it to water, causing **eutrophication** (algal blooms).

A worked link

Legume plants host nitrogen-fixing bacteria in their roots, enriching the soil naturally — which is why farmers rotate legumes into fields.

2 Practice

Now apply the methods above.

2.1 Why can't most organisms use atmospheric N_2 directly? [1]

2.2 What converts N_2 into a usable form? [1]

2.3 What does denitrification do? [1]

3 Exam-style questions

3.1 Nitrogen fixation converts N_2 into [1]

- **A** nitrates directly usable by all animals
- **B** ammonia (a usable form)
- **C** carbon dioxide
- **D** oxygen

3.2 A farmer applies nitrogen fertilizer to a field near a river.

(a) Explain how this can disturb the nitrogen cycle and harm the river. [3]

(b) State one natural way to add nitrogen to soil. [1]

3.3 Explain the role of bacteria in making nitrogen available to plants. [2]

Solutions

2.1 N_2 is very stable/unreactive, so most organisms cannot use it directly.

2.2 Nitrogen-fixing bacteria.

2.3 Returns nitrogen to the air as N_2.

3.1 B — ammonia (a usable form).

3.2 (a) Excess reactive nitrogen runs off into the river; it fertilizes algae, causing an algal bloom (eutrophication); decomposition then depletes oxygen, harming aquatic life. (b) Planting legumes (nitrogen-fixing bacteria).

3.3 Nitrogen-fixing bacteria convert unusable N_2 into ammonia, and nitrifying bacteria convert it to nitrates that plants can absorb.

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

AP ENVIRONMENTAL SCIENCE • EXERCISE SHEET

1.6 The Phosphorus Cycle

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

KEY WORDS phosphorus cycle 磷循环 • limiting nutrient 限制性营养 • carbon cycle 碳循环 • food chain 食物链

Objective

Build the skills to answer exam questions on the **phosphorus cycle**.

You must be able to:

- explain that the phosphorus cycle has **no atmospheric (gas) stage**
- describe it as slow (rock → soil → organisms → sediment)
- explain why phosphorus is often the **limiting nutrient** 限制性营养

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.

No gas phase

Unlike carbon and nitrogen, the **phosphorus cycle has no atmospheric stage** — phosphorus does not form a common gas. It moves through **rock, soil, water, and organisms** only.

A slow cycle

Phosphorus is released slowly by **weathering** of rock into soil, taken up by plants, passed through food chains, and returned to soil/sediment by decomposition. It is a **slow** cycle.

The limiting nutrient

Because usable phosphorus is scarce and released slowly, it is often the **limiting nutrient** — the one in shortest supply that limits growth.

Human disturbance

Adding phosphorus (fertilizer, detergents) to water can trigger **algal blooms** and **eutrophication**, because the normally-limiting nutrient is suddenly abundant.

2 Practice

Now apply the methods above.

2.1 What stage does the phosphorus cycle lack (unlike carbon and nitrogen)? [1]

2.2 How is phosphorus released from rock? [1]

2.3 Why is phosphorus often the limiting nutrient? [1]

3 Exam-style questions

3.1 The phosphorus cycle differs from the carbon cycle because it has no [1]

- **A** rock reservoir
- **B** atmospheric (gas) stage
- **C** role in organisms
- **D** water movement

3.2 Phosphate detergents enter a lake.

(a) Explain why this can cause an algal bloom. [2]

(b) State why phosphorus normally limits growth. [1]

3.3 Explain why the phosphorus cycle is slower than the carbon cycle. [2]

Solutions

2.1 An atmospheric (gas) stage.

2.2 By weathering of rock.

2.3 It is scarce and released slowly, so it runs out first and limits growth.

3.1 B — an atmospheric (gas) stage.

3.2 (a) Phosphorus is normally limiting; adding it lets algae grow rapidly (a bloom), which then decomposes and depletes oxygen. (b) It is the nutrient in shortest supply, so growth stops when it runs out.

3.3 It has no fast atmospheric stage and relies on the slow weathering of rock, so phosphorus moves through the environment much more slowly than carbon.

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

AP ENVIRONMENTAL SCIENCE • EXERCISE SHEET

1.7 The Hydrologic (Water) Cycle

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

KEY WORDS transpiration 蒸腾 • evaporation 蒸发 • precipitation 降水 • water cycle 水循环

Objective

Build the skills to answer exam questions on the **hydrologic (water) cycle**.

You must be able to:

- name the processes (**evaporation** 蒸发, **transpiration** 蒸腾, condensation, **precipitation** 降水, runoff, infiltration)
- describe how water moves between reservoirs
- explain how humans alter the 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.

The processes

The **water cycle** moves water by:

- **Evaporation** — liquid water becomes vapor.
- **Transpiration** — water evaporates from plant leaves.
- **Condensation** — vapor forms clouds.
- **Precipitation** — rain/snow falls.
- **Runoff** — water flows over land to rivers/oceans.
- **Infiltration** — water soaks into the ground (groundwater).

Reservoirs

Water is stored in oceans (most), ice caps, groundwater, lakes/rivers, and the atmosphere.

Human disturbance

Paving land increases runoff and reduces infiltration; **deforestation** reduces transpiration; **withdrawing groundwater** faster than it recharges depletes aquifers.

A worked link

Cutting a forest reduces transpiration and infiltration, so more water runs off quickly, raising flood risk and lowering groundwater recharge.

2 Practice

Now apply the methods above.

2.1 What is transpiration? [1]

2.2 What process soaks water into the ground? [1]

2.3 Name the largest reservoir of water. [1]

3 Exam-style questions

3.1 Water evaporating from plant leaves is called [1]

- **A** precipitation
- **B** infiltration
- **C** transpiration
- **D** runoff

3.2 A city paves over a large grassy area.

(a) Explain the effect on runoff and infiltration. [2]

(b) State one consequence of increased runoff. [1]

3.3 Explain how deforestation changes the local water cycle. [2]

Solutions

2.1 Evaporation of water from plant leaves.

2.2 Infiltration.

2.3 The oceans.

3.1 C — transpiration.

3.2 (a) Paving increases runoff (water flows over the hard surface) and reduces infiltration (less soaks in). (b) Any one: flooding, less groundwater recharge, more erosion/pollution carried to rivers.

3.3 Fewer trees means less transpiration and less infiltration (roots no longer hold water), so more water runs off quickly and groundwater recharge falls.

AP ENVIRONMENTAL SCIENCE • EXERCISE SHEET

1.8 Primary Productivity

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS primary productivity 初级生产力 • net primary productivity 净初级生产力 • producers 生产者 • gross 总 • ecosystem 生态系统

Objective

Build the skills to answer exam questions on **primary productivity**.

You must be able to:

- define **gross** 总 and **net primary productivity** 净初级生产力 (GPP, NPP)
- use NPP = GPP − respiration
- identify the most productive ecosystems

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.

■ Productivity

Primary productivity is the rate at which producers capture energy (usually by photosynthesis).

- **Gross primary productivity (GPP)** — the **total** energy captured.
- **Net primary productivity (NPP)** — what's **left** after the producers' own respiration.

■ The equation

$$\text{NPP} = \text{GPP} - \text{respiration}.$$

NPP is the energy actually **available** to consumers.

■ A worked calculation

If GPP = 1000 kcal/m^2/yr and respiration = 400, then NPP = 1000 − 400 = 600 kcal/m^2/yr.

■ Most productive ecosystems

Warm, wet, sunlit systems are most productive: **tropical rainforests**, **estuaries**, and **coral reefs** have high NPP; deserts and open ocean have low NPP.

2 Practice

Now apply the methods above.

2.1 Write the equation relating NPP, GPP, and respiration. [1]

2.2 For GPP = 800 and respiration = 300, find NPP. [2]

2.3 Name one highly productive ecosystem. [1]

3 Exam-style questions

3.1 Net primary productivity is the energy [1]

- **A** captured before respiration
- **B** available to consumers after producer respiration
- **C** lost as heat only
- **D** stored in rocks

3.2 A grassland has GPP = 1200 kcal/m^2/yr and respiration = 500.

(a) Calculate the NPP. [2]

(b) Explain what NPP represents for the ecosystem. [1]

3.3 Explain why a tropical rainforest has higher NPP than a desert. [2]

Solutions

2.1 NPP = GPP − respiration.

2.2 NPP = 800 − 300 = 500.

2.3 Any one: tropical rainforest, estuary, coral reef, wetland.

3.1 B — available to consumers after producer respiration.

3.2 (a) NPP = 1200 − 500 = 700 kcal/m^2/yr. (b) The energy available to the consumers (the rest of the food web).

3.3 A rainforest has abundant warmth, water, and sunlight, so producers photosynthesize much more than in a dry, resource-poor desert, giving higher NPP.

1.9 Trophic Levels

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

KEY WORDS decomposers 分解者 • producers 生产者 • consumers 消费者 • trophic levels 营养级

Objective

Build the skills to answer exam questions on **trophic levels**.

You must be able to:

- name the trophic levels (**producers** 生产者, **consumers** 消费者, **decomposers** 分解者)
- classify an organism by its level
- explain the role of decomposers

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 trophic levels

- **Producers** (autotrophs) — make their own food (plants, algae).
- **Primary consumers** — herbivores that eat producers.
- **Secondary/tertiary consumers** — carnivores that eat other consumers.
- **Decomposers** — break down dead matter, recycling nutrients.

Classifying an organism

Ask what it eats: a rabbit eats plants (primary consumer); a fox eats the rabbit (secondary consumer); a mushroom breaks down dead matter (decomposer).

Decomposers recycle nutrients

Decomposers (bacteria, fungi) release nutrients from dead organisms back into the soil/water, making them available to producers again — essential for nutrient cycles.

A worked chain

grass (producer) → grasshopper (primary consumer) → frog (secondary consumer) → snake (tertiary consumer).

2 Practice

Now apply the methods above.

2.1 What is a producer? [1]

2.2 Classify a rabbit that eats grass. [1]

2.3 What is the role of decomposers? [1]

3 Exam-style questions

3.1 An organism that breaks down dead matter and recycles nutrients is a [1]

- **A** producer
- **B** primary consumer
- **C** decomposer
- **D** tertiary consumer

3.2 In the chain grass → grasshopper → frog → snake:

(a) Identify the producer and the secondary consumer. [2]

(b) State the trophic level of the snake. [1]

3.3 Explain why decomposers are essential for nutrient cycling. [2]

Solutions

2.1 An organism that makes its own food (e.g. by photosynthesis).

2.2 Primary consumer (herbivore).

2.3 They break down dead matter and recycle nutrients back to the environment.

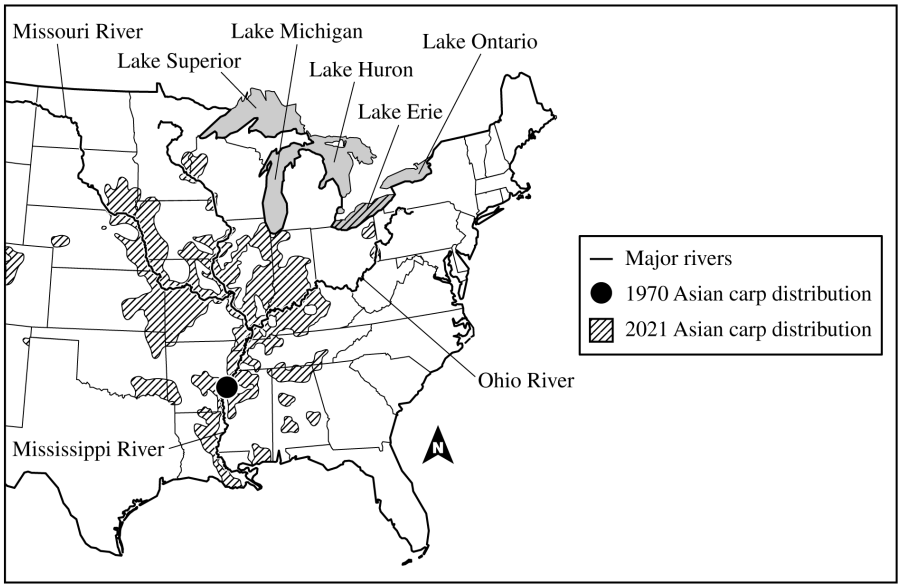
3.1 C — decomposer.

3.2 (a) Producer: grass; secondary consumer: frog. (b) Tertiary consumer.

3.3 They release the nutrients locked in dead organisms back into the soil/water, making them available to producers again, so the cycle continues.

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.

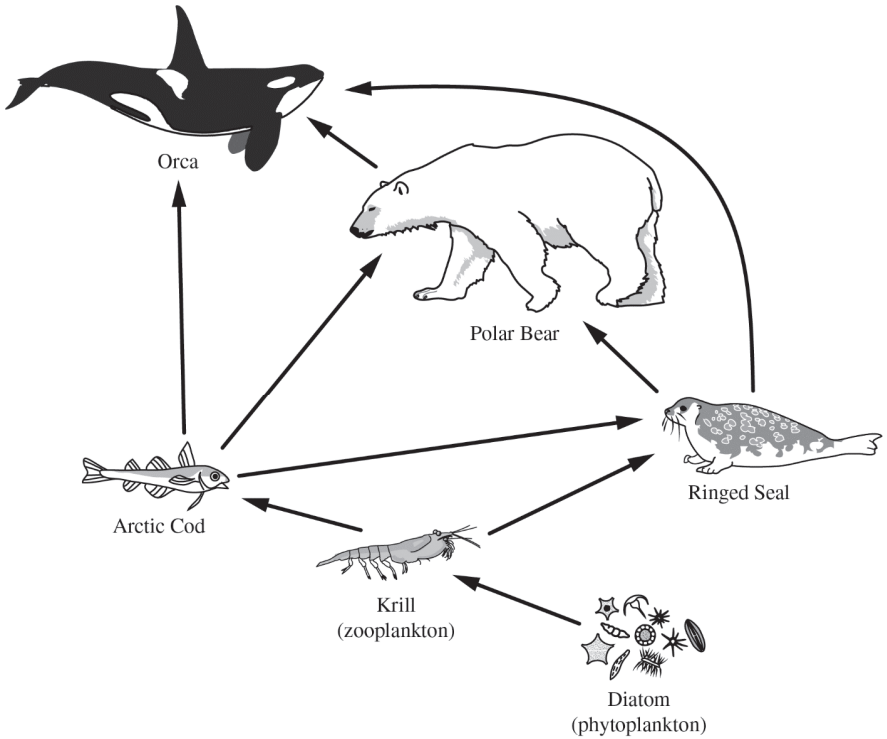
The blue pike, a fish that was endemic to the Great Lakes, was commercially fished from the late 1800s until their population crashed in 1958. In 1970, the species was declared to be extinct.

(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.

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).

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 following article from the *Fremont New Tribune.*

Fremont New Tribune **May 2, 2016**

As another winter concludes, biologists are alarmed by the continued spread of white nose syndrome (WNS) in bats. WNS is a fungal disease that is decimating bat populations across eastern North American forests, with mortality rates reaching up to 100 percent at many sites. WNS has been found in at least 25 states in the United States and 5 Canadian provinces.

The fungus (*Pseudogymnoascus destructans*) grows well in cool conditions such as those found in caves and has been observed as white patches on the muzzles, noses, ears, and wings of many cave-dwelling bats. WNS has caused significant population declines for several bat species, including once-numerous species such as the little brown bat (*Myotis lucifugus*).

Little brown bats hunt using echolocation by emitting up to 200 high-frequency calls per second when pursuing their prey. When healthy, the little brown bat can live up to ten years and have one or two offspring (called pups) each year.

"Little brown bats provide tremendous value to the United States economy every year by the essential services they provide to farmers and other people. We need to understand how this deadly disease spreads and attempt to help reduce its impact on the little brown bat and other bat species," said Dr. Duke Serach of the Fremont office of the United States Fish and Wildlife Service. Dr. Serach concluded with, "It may yet be possible to save the little brown bats, but the remaining population will be alarmingly small."

(a) Diseases can devastate populations; however, most diseases do not drive their host to extinction. **Provide** one explanation for why diseases seldom cause extinction.

(b) Dr. Serach suggests that even if the impact of WNS on little brown bat populations can be reduced and the extinction of the species avoided, the bat populations are likely to remain alarmingly small.

(i) **Describe** TWO threats (other than WNS) to the survival of the bat species if the total number of bats becomes very small.

(ii) If the little brown bat species does not become extinct and can potentially recover, the rate of recovery is likely to be slow. **Discuss** one aspect of bat biology that might slow the recovery of little brown bat populations to pre-WNS numbers.

(c) Bats are found in ecosystems around the world. **Describe** TWO ways in which other organisms in an ecosystem could be affected by a decline in a bat population.

(d) The Eastern deciduous forest in which the little brown bats live is an important ecosystem. **Identify** TWO ecosystem services that forests provide, and **explain** how each service benefits human society.

WNS is an emerging disease in bats. Humans are also subject to emerging diseases, such as Ebola. A recent study suggests that the number of emerging infectious diseases affecting human populations has been steadily increasing in recent decades.

(e) **Provide** a likely reason for the increase in emerging infectious diseases affecting human populations. Include an explanation for the reason you provided.

AP ENVIRONMENTAL SCIENCE • EXERCISE SHEET

1.10 Energy Flow and the 10% Rule

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS 10% rule 十分之一定律 • trophic levels 营养级 • producers 生产者 • ecosystem 生态系统

Objective

Build the skills to answer exam questions on **energy flow and the 10% rule**.

You must be able to:

- apply the **10% rule** 十分之一定律
- calculate energy at each trophic level
- explain why energy is lost between levels

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 10% rule

Only about **10%** of the energy at one trophic level is passed to the next. The other ~90% is lost as **heat** and used for the organism's own life processes (movement, respiration).

Calculating up the levels

Multiply by 0.1 at each step. Producers with 10 000 units → primary consumers 1000 → secondary 100 → tertiary 10.

Why energy is lost

Energy is used for respiration, movement, and heat, and not all of an organism is eaten or digested — so most energy never reaches the next level.

A worked calculation

If producers store 50 000 kcal, the secondary consumers receive $50\,000 \times 0.1 \times 0.1 = 500$ kcal.

2 Practice

Now apply the methods above.

2.1 What percentage of energy passes to the next trophic level? [1]

2.2 Producers have 8000 kcal. How much reaches the primary consumers? [1]

2.3 Where does the "lost" energy go? [1]

3 Exam-style questions

3.1 By the 10% rule, energy passed from producers to primary consumers is [1]

- **A** 1%
- **B** 10%
- **C** 90%
- **D** 100%

3.2 Producers in an ecosystem store 30 000 kcal/m^2/yr.

(a) Calculate the energy reaching the tertiary consumers. [3]

(b) Explain why so little reaches this level. [1]

3.3 Explain why energy flow limits the number of trophic levels an ecosystem can support. [2]

Solutions

2.1 About 10%.

2.2 800 kcal.

2.3 Lost as heat and used in life processes (respiration, movement).

3.1 B — 10%.

3.2 (a) primary = 3000; secondary = 300; tertiary = 30 kcal/m^2/yr. (b) About 90% of the energy is lost at each of the three transfers.

3.3 Because ~90% of energy is lost at each level, after a few levels there is too little energy left to support another, limiting the number of levels.

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.

i. **Propose** a realistic solution to reduce the number of ocelots killed by vehicles.

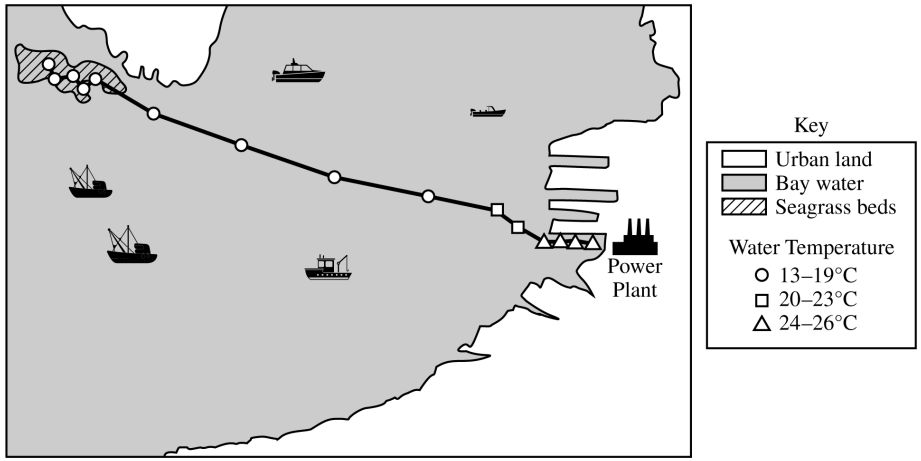
ii. **Justify** the solution proposed in part F (i) by explaining an additional advantage, other than reducing the number of ocelots killed by vehicles.

STOP

END OF EXAM

2. The diagram shows the movement of one adult manatee over a 12-hour period across an active shipping channel during the winter. Manatees are large, aquatic, herbivorous mammals that primarily eat seagrass. Manatees can travel several miles to graze. Manatees mature slowly, have low biotic potential, and inhabit warm coastal waters. They cannot survive in water below 20°C for extended periods of time.

Satellite Track and Water Temperature Log of the Movement of One Adult Manatee Over a 12-Hour Period



(a) Based on the information in the diagram, **identify** the temperature range of the water through which the majority of the adult manatee's daily movement occurs.

(b) Large groups of manatees are often observed in shallow waters near the waste water released by the electrical power plant during the winter. Based on the information in the diagram, **identify** a characteristic of the power plant waste water that would attract the manatees.

(c) Based on the information in the diagram, **describe** a potential negative impact of the waste water released by the power plant on other aquatic species.

(d) Seagrass beds have declined significantly over the last several years. In 2021 manatee mortality was three times higher than the previous five-year average.

(i) **Describe** a characteristic of the manatees that increases their vulnerability to the recent decline of seagrasses.

(ii) **Describe** the change in energy flow through the trophic levels that occurs when there is a significant loss of seagrasses.

(e) Research has shown increased nutrient and sediment runoff can cause seagrass beds to decline.

(i) **Propose** a solution to reduce nutrient or sediment pollution in an estuary that is surrounded by urban development.

(ii) **Justify** the solution proposed in part (e)(i) by providing an additional advantage of reduced nutrients in an estuary, other than one related to manatees.

Urban areas have a heavy dependence on automobiles and often experience photochemical smog.

(f) **Describe** how summertime weather conditions can increase the frequency of photochemical smog.

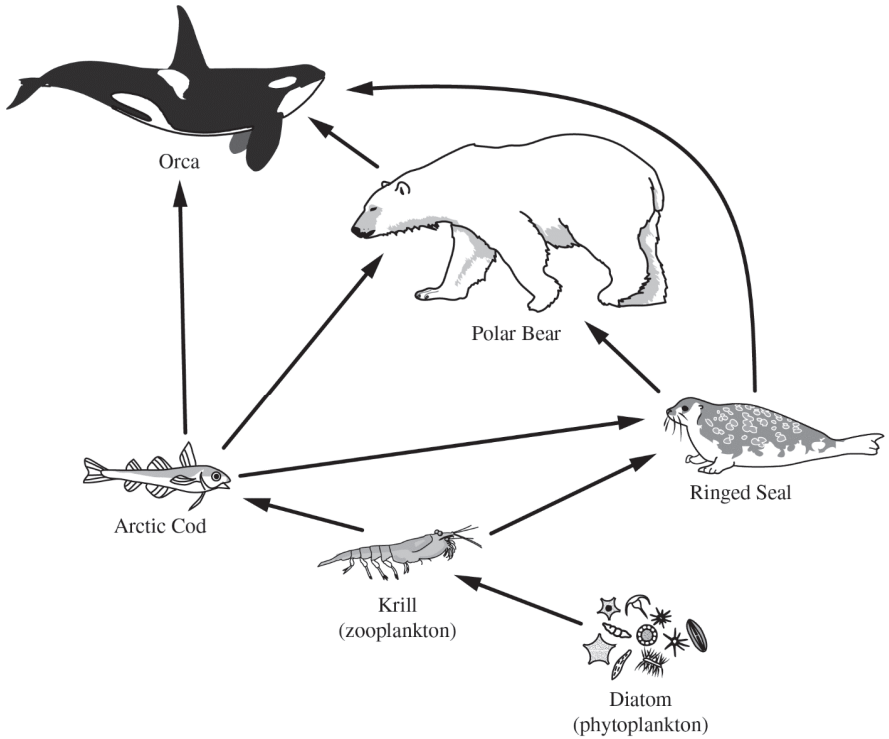
(g) **Identify** one ecological problem that results from exposure to photochemical smog.

A potential solution to reduce photochemical smog in urban areas with high automobile traffic is to replace gasoline-powered cars with cars powered by hydrogen fuel cells.

(h) **Describe** a potential disadvantage of using hydrogen fuel cells to power automobiles.

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. 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).

AP ENVIRONMENTAL SCIENCE • EXERCISE SHEET

1.11 Food Chains and Food Webs

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

KEY WORDS food chain 食物链 • food web 食物网 • keystone species 关键种

Objective

Build the skills to answer exam questions on **food chains and food webs**.

You must be able to:

- distinguish a **food chain** 食物链 from a **food web** 食物网
- trace energy flow and read arrows correctly
- predict the effect of removing a species

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.

Chains vs webs

A **food chain** is a single line of who-eats-whom. A **food web** links **many** chains into a realistic picture of feeding relationships.

Arrows show energy flow

The arrow points **from** the organism eaten **to** the organism that eats it — it shows the direction energy flows (prey → predator).

Removing a species

Because species are connected, **removing** one has knock-on effects: its prey may increase, and its predators lose a food source. A **keystone species** has an outsized effect.

A worked prediction

If foxes are removed from a web, rabbits (their prey) may increase, over-grazing plants; species competing with rabbits may decline.

2 Practice

Now apply the methods above.

2.1 What is the difference between a food chain and a food web? [1]

2.2 In a food chain, which way does the arrow point? [1]

2.3 What is a keystone species? [1]

3 Exam-style questions

3.1 In a food web, an arrow from a rabbit to a fox shows that [1]

- **A** the rabbit eats the fox
- **B** energy flows from the rabbit to the fox
- **C** they do not interact
- **D** the fox is a producer

3.2 In a food web, hawks eat both snakes and mice.

(a) Predict what happens to the mouse population if hawks are removed. [2]

(b) Explain why a food web is more realistic than a single food chain. [1]

3.3 Explain why removing a keystone species can have a large effect on a food web. [2]

Solutions

2.1 A food chain is a single line of feeding; a food web links many chains together.

2.2 From the organism eaten to the one that eats it (prey → predator).

2.3 A species with an outsized role whose removal greatly affects the community.

3.1 B — energy flows from the rabbit to the fox.

3.2 (a) With fewer predators, the mouse population is likely to increase. (b) Most organisms eat and are eaten by several species, which a web shows but a single chain does not.

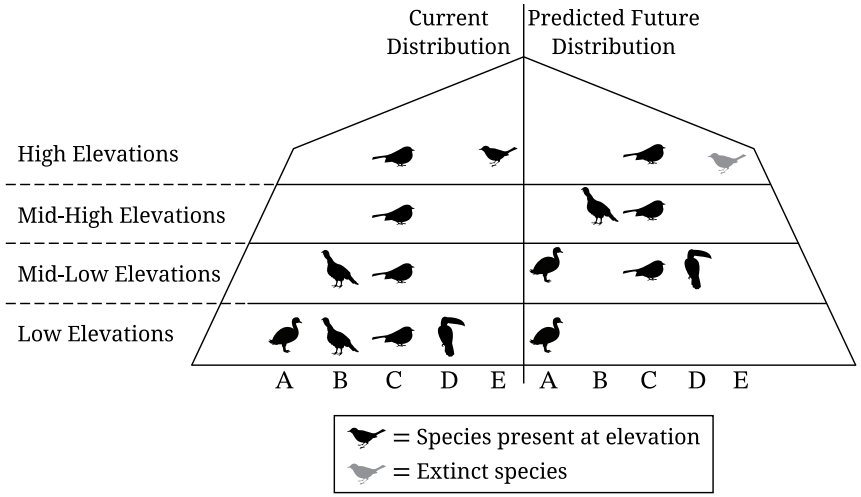
3.3 A keystone species affects many others (e.g. by controlling prey numbers); removing it lets some populations grow and others shrink, changing the whole web.

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.

Bird Species Distribution



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

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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.

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

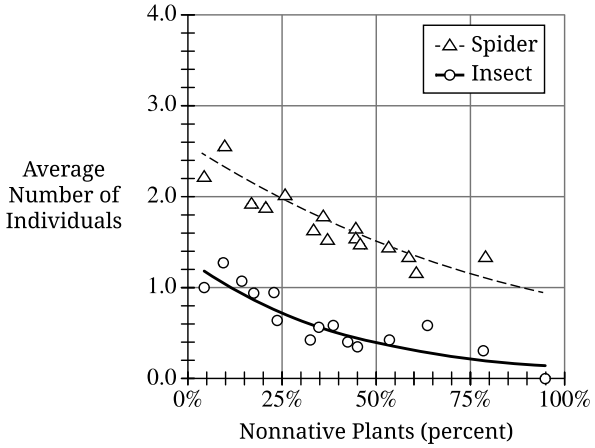
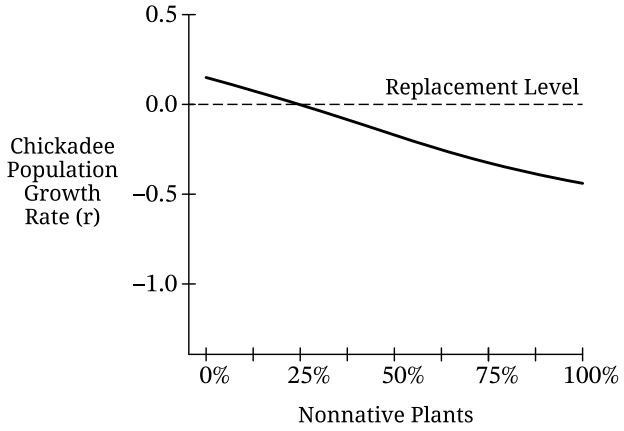


Figure 2. Chickadee Population Average Growth Rate and Percentage of Nonnative



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.

i. **Identify** a likely scientific question for the students' investigation of ant diversity.

ii. **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

i. **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.

ii. **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

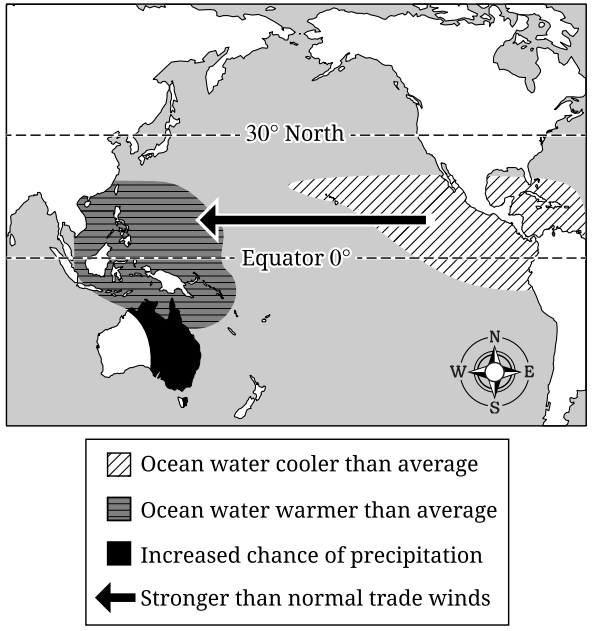
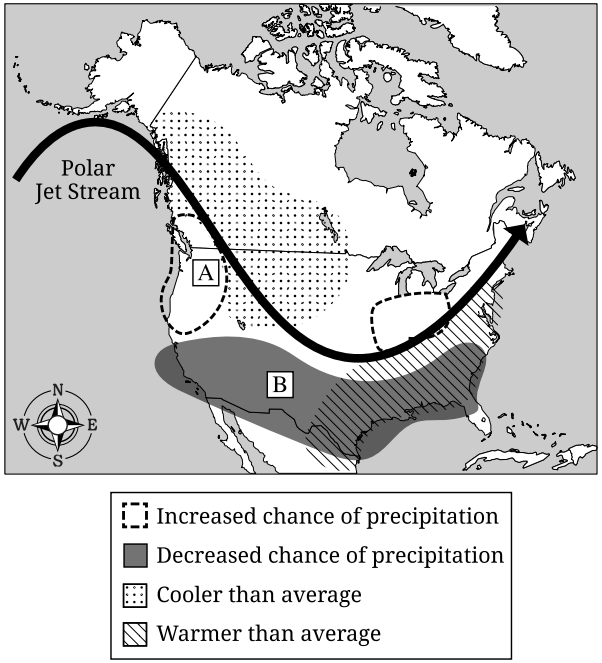
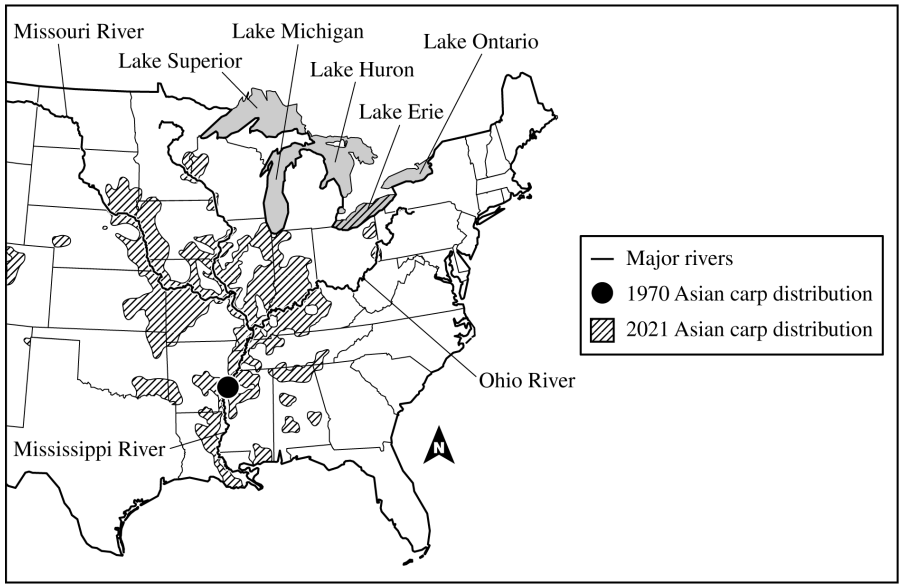


Figure 2. Polar Jet Stream and Climate Conditions in North America



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.

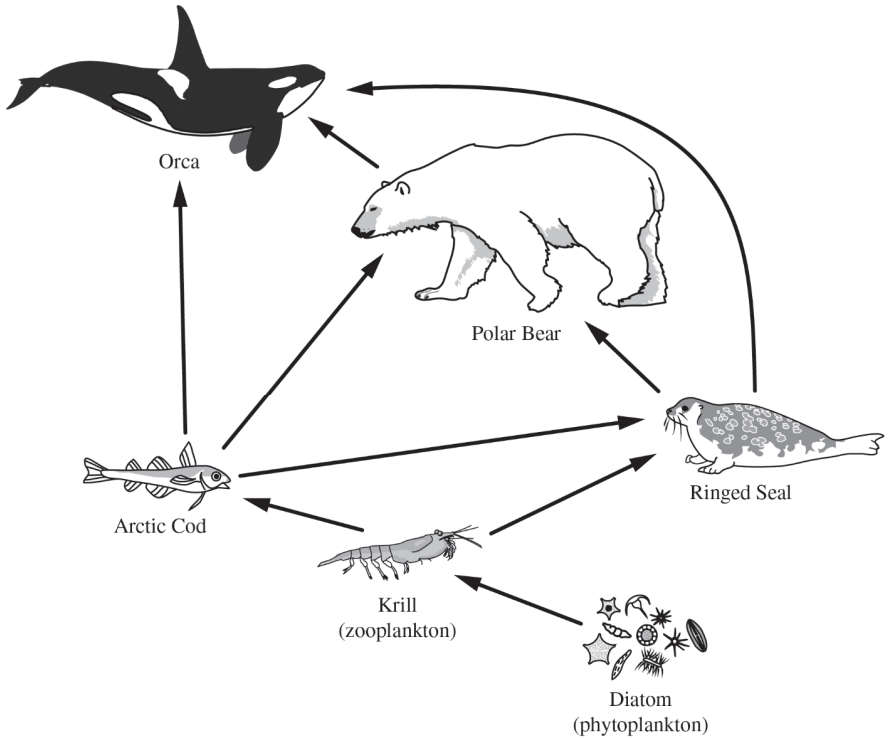
The blue pike, a fish that was endemic to the Great Lakes, was commercially fished from the late 1800s until their population crashed in 1958. In 1970, the species was declared to be extinct.

(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.

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).

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 following article from the *Fremont New Tribune.*

Fremont New Tribune **May 2, 2016**

As another winter concludes, biologists are alarmed by the continued spread of white nose syndrome (WNS) in bats. WNS is a fungal disease that is decimating bat populations across eastern North American forests, with mortality rates reaching up to 100 percent at many sites. WNS has been found in at least 25 states in the United States and 5 Canadian provinces.

The fungus (*Pseudogymnoascus destructans*) grows well in cool conditions such as those found in caves and has been observed as white patches on the muzzles, noses, ears, and wings of many cave-dwelling bats. WNS has caused significant population declines for several bat species, including once-numerous species such as the little brown bat (*Myotis lucifugus*).

Little brown bats hunt using echolocation by emitting up to 200 high-frequency calls per second when pursuing their prey. When healthy, the little brown bat can live up to ten years and have one or two offspring (called pups) each year.

"Little brown bats provide tremendous value to the United States economy every year by the essential services they provide to farmers and other people. We need to understand how this deadly disease spreads and attempt to help reduce its impact on the little brown bat and other bat species," said Dr. Duke Serach of the Fremont office of the United States Fish and Wildlife Service. Dr. Serach concluded with, "It may yet be possible to save the little brown bats, but the remaining population will be alarmingly small."

(a) Diseases can devastate populations; however, most diseases do not drive their host to extinction. **Provide** one explanation for why diseases seldom cause extinction.

(b) Dr. Serach suggests that even if the impact of WNS on little brown bat populations can be reduced and the extinction of the species avoided, the bat populations are likely to remain alarmingly small.

(i) **Describe** TWO threats (other than WNS) to the survival of the bat species if the total number of bats becomes very small.

(ii) If the little brown bat species does not become extinct and can potentially recover, the rate of recovery is likely to be slow. **Discuss** one aspect of bat biology that might slow the recovery of little brown bat populations to pre-WNS numbers.

(c) Bats are found in ecosystems around the world. **Describe** TWO ways in which other organisms in an ecosystem could be affected by a decline in a bat population.

(d) The Eastern deciduous forest in which the little brown bats live is an important ecosystem. **Identify** TWO ecosystem services that forests provide, and **explain** how each service benefits human society.

WNS is an emerging disease in bats. Humans are also subject to emerging diseases, such as Ebola. A recent study suggests that the number of emerging infectious diseases affecting human populations has been steadily increasing in recent decades.

(e) **Provide** a likely reason for the increase in emerging infectious diseases affecting human populations. Include an explanation for the reason you provided.