

Week 6

AP Environmental Science

Homework bundle for this week

本周作业合集

exercises.lol

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AP Environmental Science

Name: _____ Score: _____

1. A species' **niche** is...

- ☐ its role and the range of resources it uses
- ☐ the exact spot where it sleeps
- ☐ its number of offspring
- ☐ its colour

2. An **r-selected** species tends to...

- ☐ produce many offspring with little parental care
- ☐ produce few offspring with much care
- ☐ never reproduce
- ☐ live for centuries

3. A **survivorship curve** shows...

- ☐ how many of a group survive to each age
- ☐ the weather over a year
- ☐ the size of an animal
- ☐ the colour of a species

4. The **carrying capacity** of an environment is...

- ☐ the largest population it can support long-term
- ☐ the number of species
- ☐ the total rainfall
- ☐ the size of the area

5. With **unlimited** resources, a population grows...

- ☐ exponentially, faster and faster (a J-curve)
- ☐ in a straight line
- ☐ not at all
- ☐ downward

6. A species with a narrow niche, using very few resources, is a _____.

7. A species that reproduces fast and colonises new areas quickly is usually _____-selected.

8. Frogs and fish, whose young die in huge numbers, show a Type _____ curve.

9. When a population grows past its carrying capacity, it is said to _____ the capacity.

10. Anything that slows population growth, like scarce food, is a _____ factor.

1. its role and the range of resources it uses

A **niche** is a species' role — what it eats, where it lives, and the conditions it needs.

2. produce many offspring with little parental care

r-selected species have many offspring quickly and give little care — most young die, but some survive.

3. how many of a group survive to each age

A **survivorship curve** plots how many individuals of a group are still alive at each age.

4. the largest population it can support long-term

The **carrying capacity** (K) is the maximum population an environment can sustain with its resources.

5. exponentially, faster and faster (a J-curve)

With no limits, growth is **exponential** — a J-shaped curve that gets ever steeper.

6. specialist

A **specialist** uses a narrow set of resources — like a panda that eats almost only bamboo.

7. r

r-selected species reproduce fast and are good at colonising disturbed or new habitats.

8. III

Type III (frogs, fish): very high early death, but a few survive — typical of r-strategists.

9. overshoot

An **overshoot** happens when a population briefly exceeds K; it then crashes back down (dieback).

10. limiting

A **limiting factor** (food, water, space, disease) restricts how large a population can grow.

3.1 Generalist and Specialist Species

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS generalist 广食性 • specialist 狭食性 • niche 生态位

Objective

Build the skills to answer exam questions on **generalist and specialist species**.

You must be able to:

- distinguish a **generalist** 广食性 from a **specialist** 狭食性 species
- link each to a broad or narrow **niche** 生态位
- predict which copes better with change

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.

■ Generalists vs specialists

- A **generalist** has a **broad niche** — eats many foods, lives in many habitats (e.g. raccoon, cockroach).
- A **specialist** has a **narrow niche** — depends on specific foods or conditions (e.g. panda eating bamboo, koala eating eucalyptus).

■ Coping with change

Generalists tolerate environmental change well because they have alternatives. **Specialists** are more vulnerable — if their one resource declines, they cannot switch.

■ Stable vs changing environments

Specialists often thrive in **stable** environments (efficient at their niche); generalists do better in **changing** or disturbed environments.

■ A worked prediction

If a forest is disturbed, a generalist raccoon adapts easily, but a specialist panda struggles because its bamboo may be lost.

2 Practice

Now apply the methods above.

2.1 Does a generalist have a broad or narrow niche? [1]

2.2 Give one example of a specialist species. [1]

2.3 Which type copes better with environmental change? [1]

3 Exam-style questions

3.1 A specialist species is most vulnerable to [1]

- **A** a stable environment
 - **B** loss of its specific resource
 - **C** having many food options
 - **D** abundant resources
-

3.2 A panda eats almost only bamboo, while a raccoon eats many foods.

(a) Classify each as generalist or specialist. [2]

(b) Explain which is more likely to survive habitat disturbance. [2]

3.3 Explain why specialists can outcompete generalists in a stable environment. [2]

Solutions

2.1 Broad.

2.2 Any one: panda (bamboo), koala (eucalyptus).

2.3 Generalists.

3.1 B — loss of its specific resource.

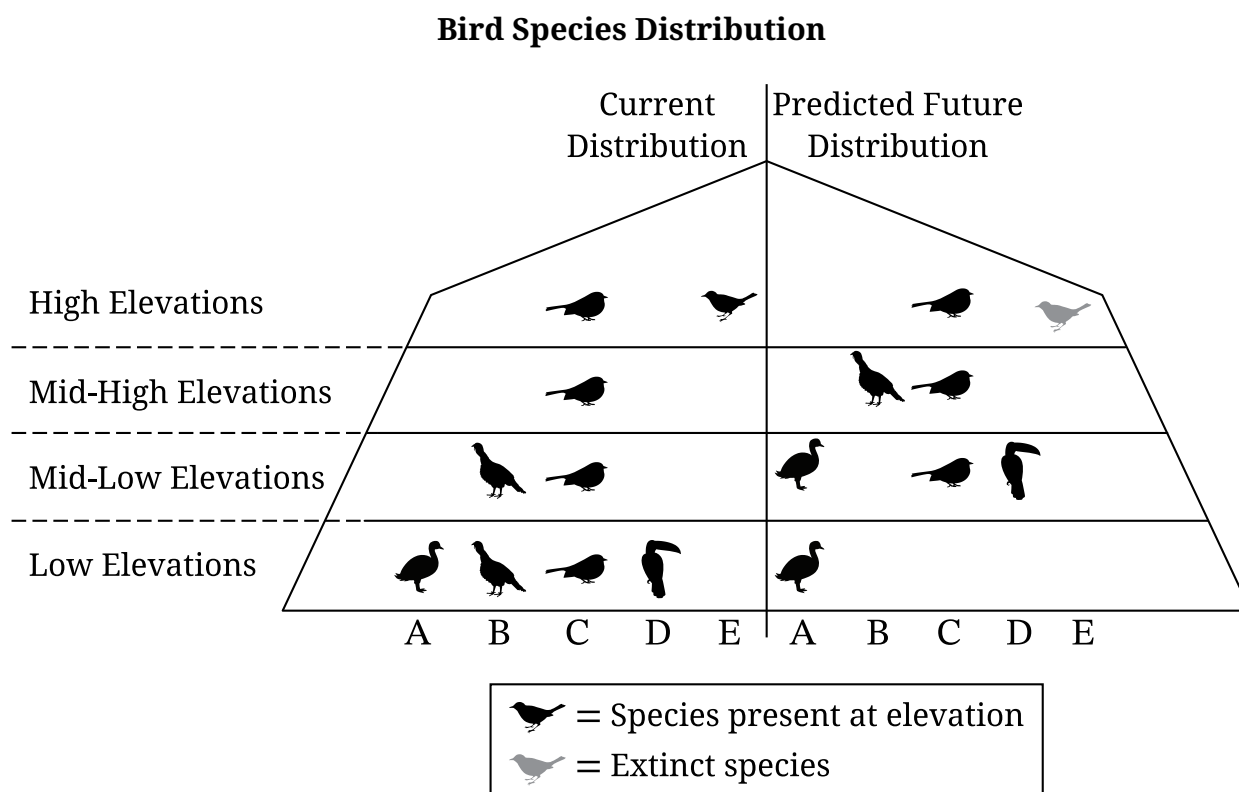
3.2 (a) Panda = specialist; raccoon = generalist. (b) The raccoon (generalist) — it can switch foods/habitats, while the panda depends on bamboo and cannot adapt easily.

3.3 In a stable environment the specialist is highly efficient at using its particular resource, so it outcompetes the less-efficient generalist for that niche.

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

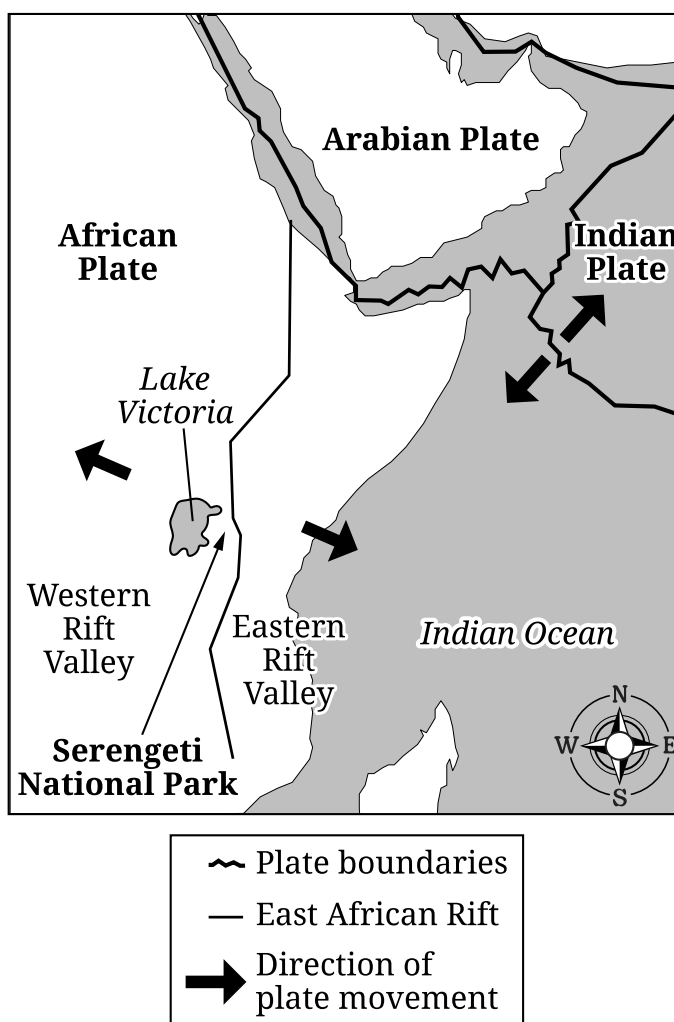
Changes in climate also affect Arctic ecosystems. One impact of climate change is the loss of ice and snow in polar regions. **Describe** a positive feedback loop that results from the loss of ice and snow in polar regions.

Part J

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

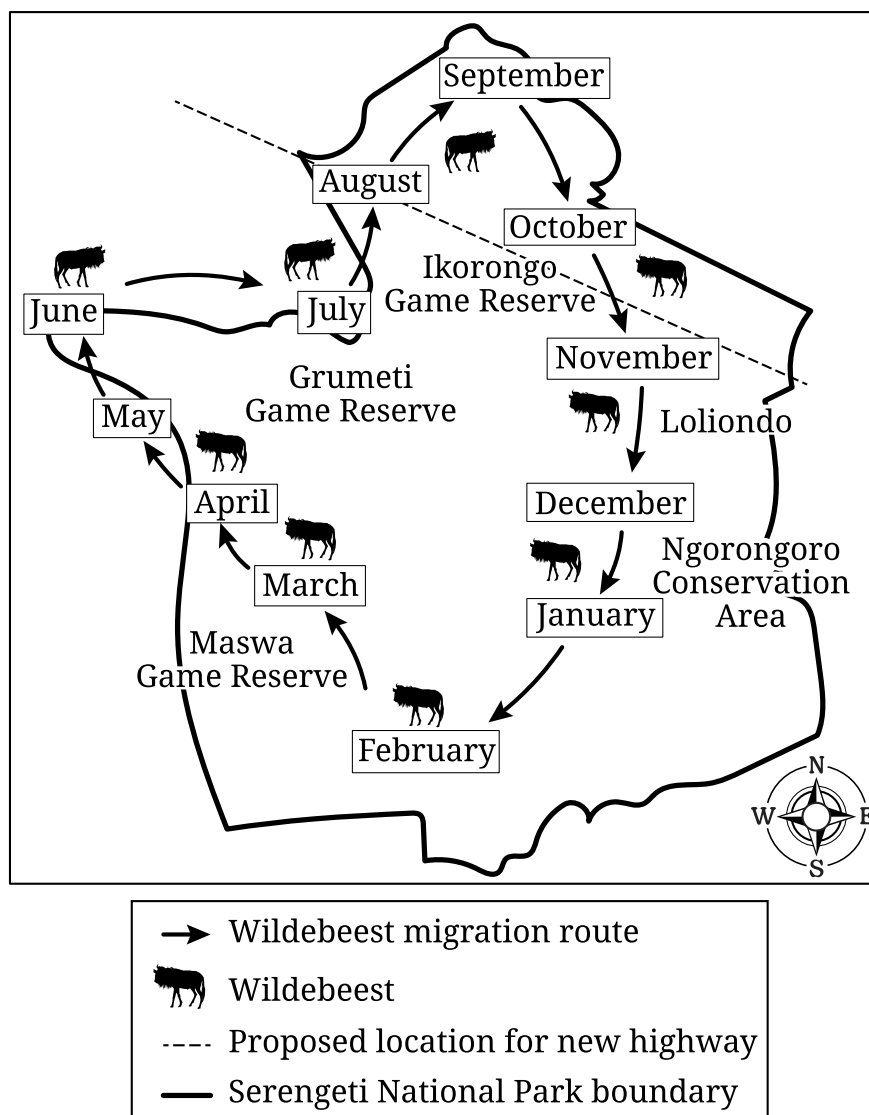
Serengeti National Park is located in Tanzania, Africa. The park is located in a valley along a tectonic plate boundary called the East African Rift. Figure 1 shows the East African Rift and other plate boundaries near the east coast of Africa.

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. Habitat destruction and fragmentation can have many different effects on species.

- (a) **Describe** a characteristic of a specialist species that would make the specialist species more likely to be negatively affected by habitat fragmentation than a generalist species.

A rapidly growing suburban municipality purchases nearby forested land and proposes a newly planned housing development, which would involve clear-cutting much of the area for the construction of single-family homes. While evaluating the land, the development committee discovers that development will encroach upon the habitat of a wood thrush population. The wood thrush is a solitary, territorial bird whose preferred habitat consists of large, intact densely forested areas. Wood thrush populations are also threatened by cowbirds. A cowbird lays her egg in an existing nest of a wood thrush. After the cowbird egg hatches, the cowbird pushes the unhatched wood thrush eggs out. The wood thrush parents raise the cowbird hatchling as their own.

- (b) **Identify** the symbiotic relationship between the wood thrush and the cowbird.
- (c) **Describe** one ecological advantage of leaving areas of undeveloped forest in the development plan as compared to clear-cutting the property.
- (d) **Propose** a solution that will minimize the effect of development on the resident population of wood thrush while still meeting the municipality's need for a housing development.
- (e) A male wood thrush needs a minimum of 800 m^2 of territory for reproduction. The municipal development committee has set a biodiversity preservation target of 275 male wood thrush territories. **Calculate** the area that must be set aside to support the goal of 275 male thrush territories. **Show** your work.
- (f) A real estate developer wants to build houses on the property. The plan will support 1,000 lots with a lot size of $1,100 \text{ m}^2$. The developer has proposed setting aside land equal to 10% of the size of each lot it sells. **Calculate** the maximum number of male wood thrush territories that could be created under this proposal. **Show** your work.
- (g) **Calculate** the percentage of each of the 1,000 lots that would need to be set aside in order to support the goal of 275 male wood thrush territories. **Show** your work.

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

STOP

END OF EXAM

3.2 K-Selected and r-Selected Species

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS k-selected 策略 • carrying capacity 环境容纳量

Objective

Build the skills to answer exam questions on **K-selected** and **r-selected** species.

You must be able to:

- distinguish **r-selected** and **K-selected** 策略 species
- link each to a reproductive strategy
- predict which recovers faster from disturbance

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.

■ Two reproductive strategies

- **r-selected** — many small offspring, little parental care, fast maturity, short life (insects, weeds). Population grows fast (high r).
- **K-selected** — few large offspring, much parental care, slow maturity, long life (elephants, humans). Population stays near carrying capacity (K).

■ Recovery from disturbance

r-selected species reproduce rapidly and recolonize quickly after a disturbance. **K-selected** species recover slowly, so they are more vulnerable to overharvesting or habitat loss.

■ A worked classification

A mouse (many young, short life) is **r-selected**; a whale (few young, long life, much care) is **K-selected**.

■ Extinction risk

K-selected species with low reproduction are at **higher extinction risk** when their populations fall, because they cannot rebuild quickly.

2 Practice

Now apply the methods above.

2.1 Do r-selected species have many or few offspring? [1]

2.2 Give one example of a K-selected species. [1]

2.3 Which type recovers faster after a disturbance? [1]

3 Exam-style questions

3.1 A K-selected species typically has [1]

- **A** many offspring and little care
 - **B** few offspring and much parental care
 - **C** a very short life
 - **D** rapid population growth
-

3.2 An insect species and an elephant species live in the same area.

(a) Classify each as r- or K-selected. [2]

(b) Explain which is more vulnerable to overharvesting. [2]

3.3 Explain why r-selected species are often the first to recolonize a disturbed area. [2]

Solutions

2.1 Many.

2.2 Any one: elephant, whale, human.

2.3 r-selected.

3.1 B — few offspring and much parental care.

3.2 (a) Insect = r-selected; elephant = K-selected. (b) The elephant (K-selected) — it reproduces slowly, so its population cannot recover quickly from overharvesting.

3.3 They mature fast and produce many offspring, so they multiply and spread rapidly to fill the empty, disturbed habitat.

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

Plants → Insects → Spiders

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

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

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

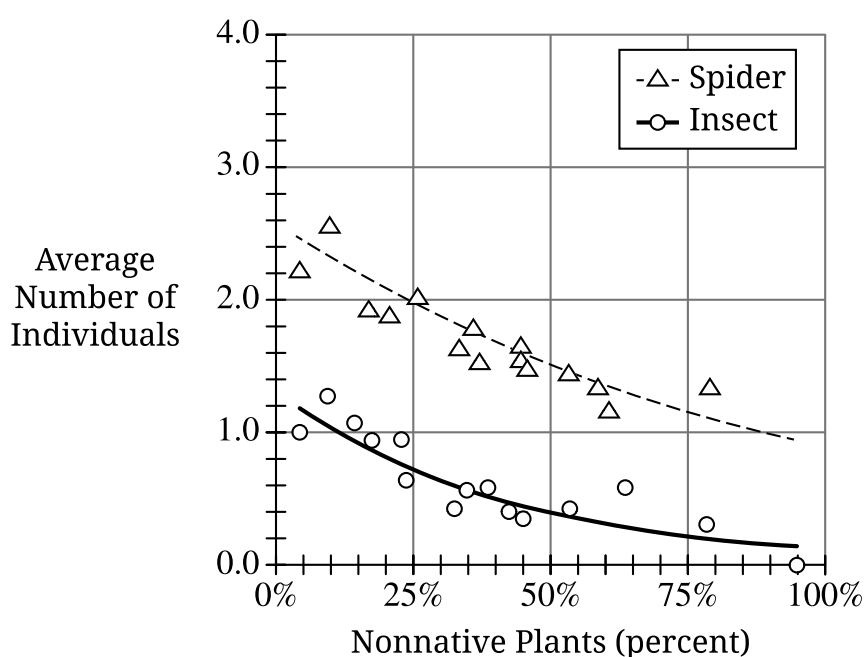
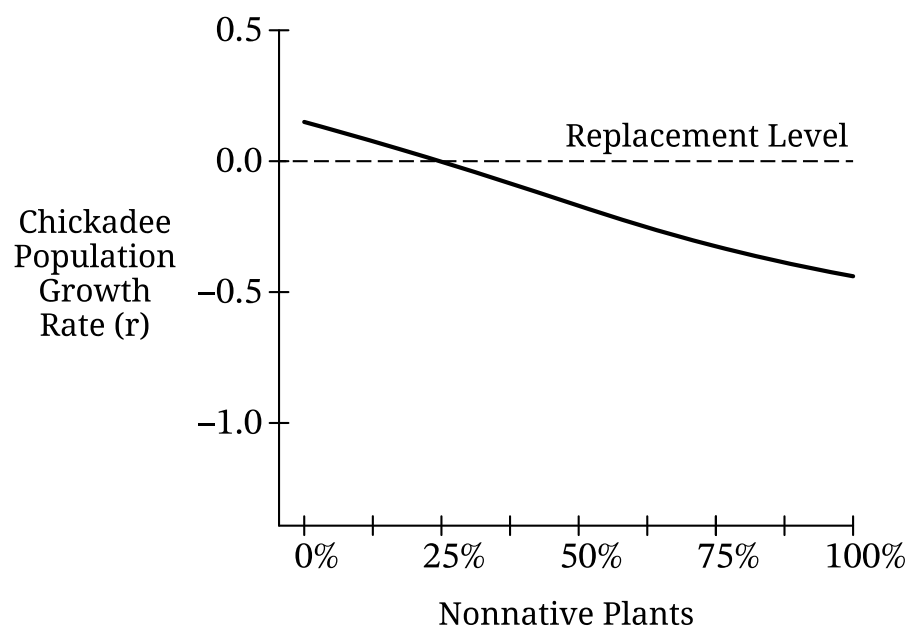


Figure 2. Chickadee Population Average Growth Rate and Percentage of Nonnative



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

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

Ant Species Present in an Urban Park and Unmowed Grassland

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

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

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

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

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

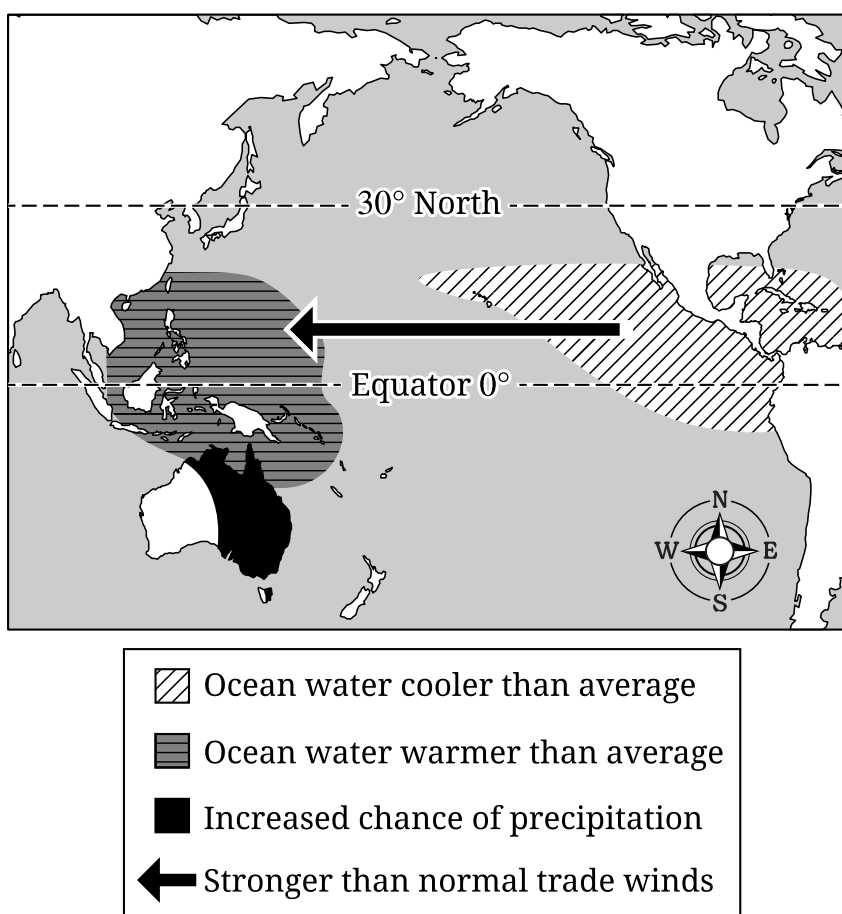
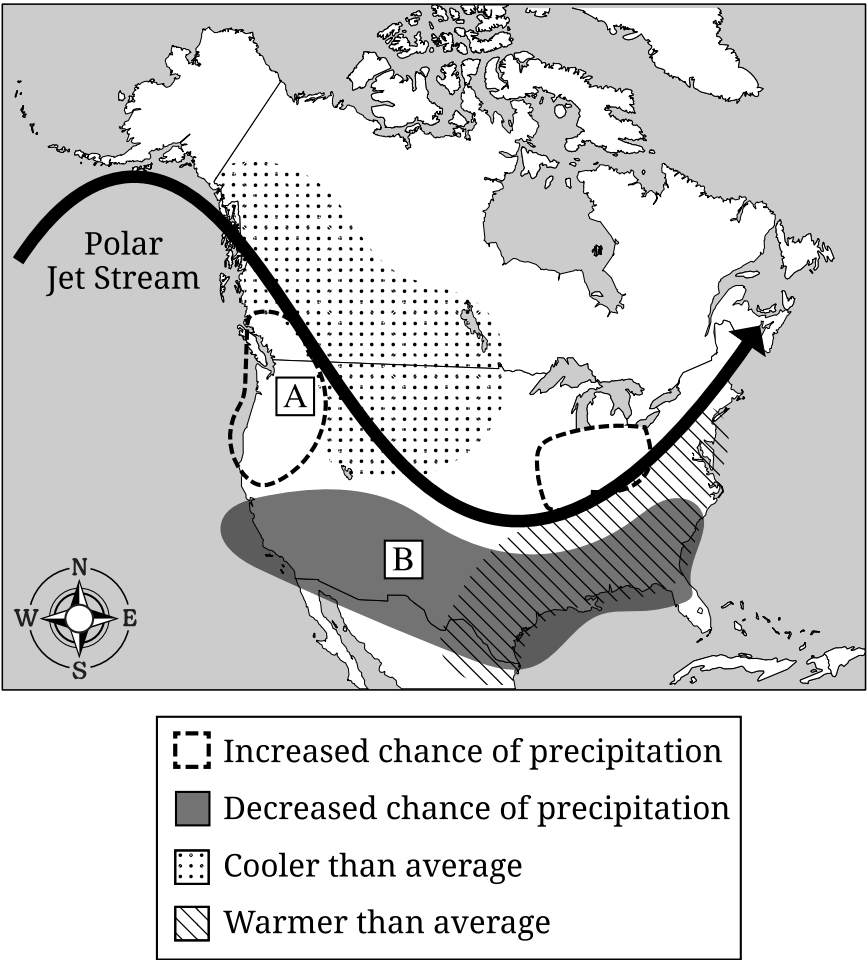
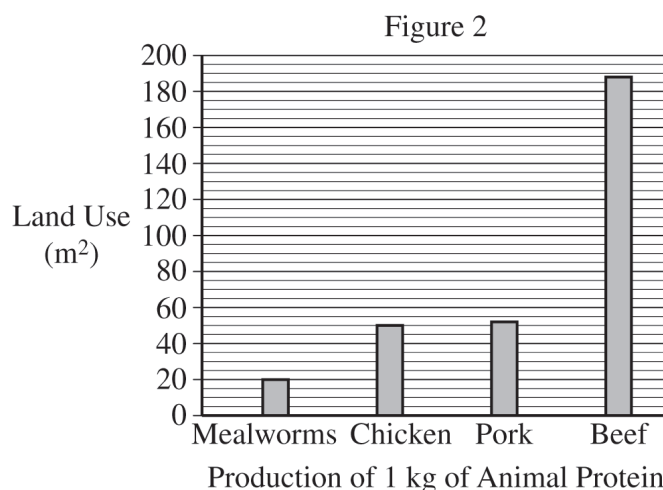
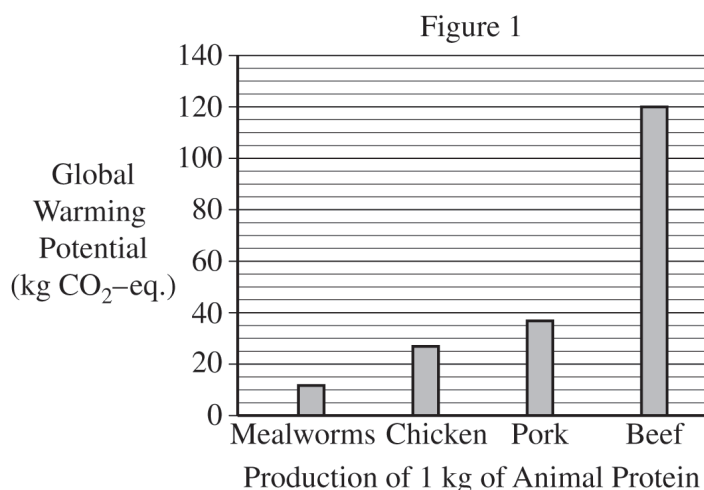


Figure 2. Polar Jet Stream and Climate Conditions in North America



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.

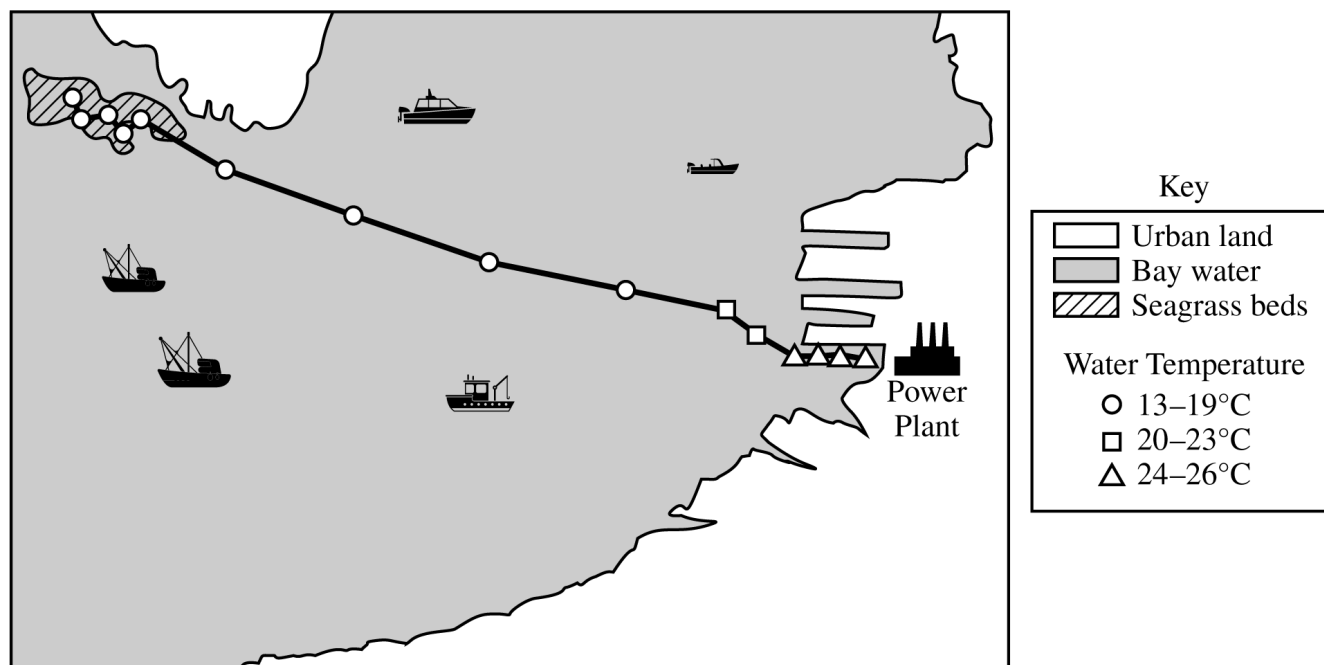
Agricultural practices can have negative impacts on rivers and streams.

- (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.

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

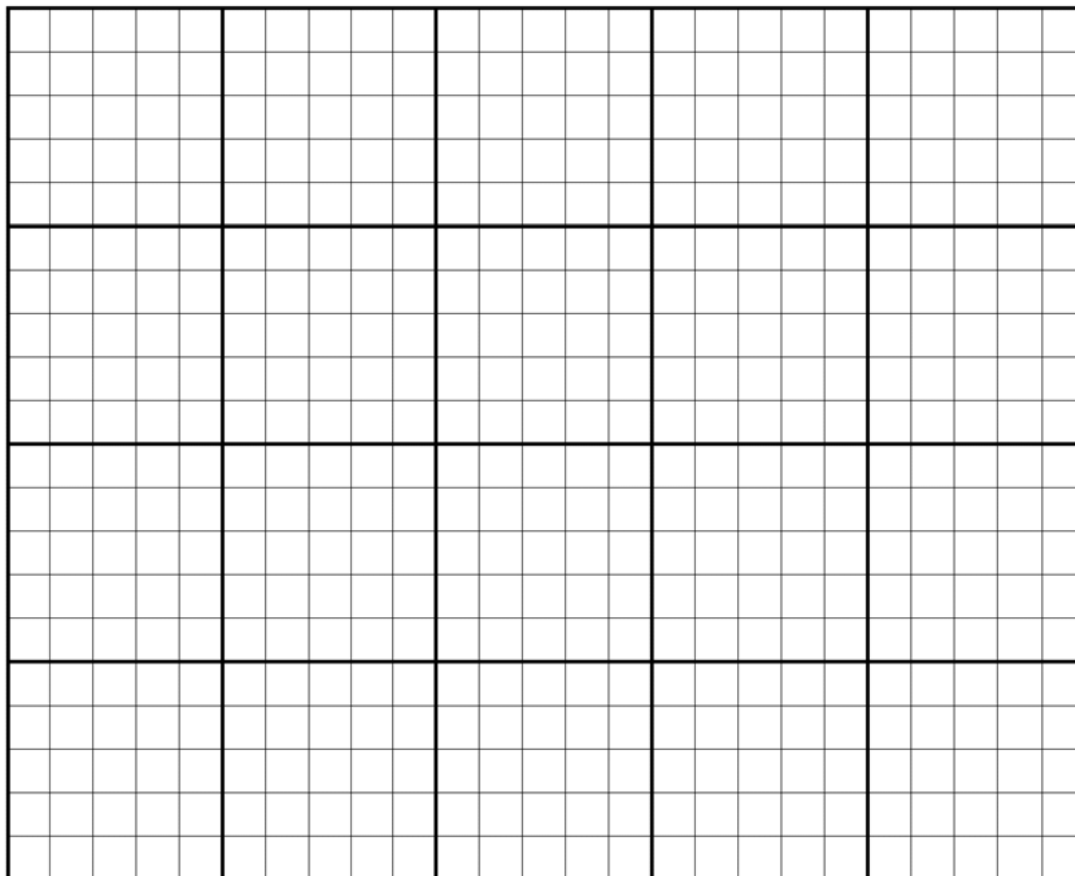
Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

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

ESTIMATED AFRICAN
ELEPHANT POPULATION
ON THE AFRICAN
CONTINENT

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

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



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

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.

3.3 Survivorship Curves

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS survivorship curve 存活曲线

Objective

Build the skills to answer exam questions on **survivorship curves**.

You must be able to:

- describe **Type I, II, and III** 存活曲线 survivorship curves
- match each to a reproductive strategy
- read a survivorship curve

1 Worked examples

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

■ The three curves

A **survivorship curve** plots the fraction surviving against age:

- **Type I** — high survival when young, most deaths in **old age** (large mammals, humans). K-selected.
- **Type II** — a **constant** death rate at all ages (many birds, rodents) — a straight diagonal line.
- **Type III** — very high death rate when young, few survive to adulthood (fish, insects, plants). r-selected.

■ Matching to strategy

Type III goes with **r-selected** species (many offspring, little care); **Type I** with **K-selected** species (few offspring, much care).

■ Reading a curve

A curve that stays high then drops steeply at the end is **Type I**; one that drops steeply at the start is **Type III**; a straight line is **Type II**.

■ A worked match

A sea turtle laying hundreds of eggs, most eaten young, shows a **Type III** curve.

2 Practice

Now apply the methods above.

2.1 Which survivorship type has most deaths in old age? [1]

2.2 Which type has a constant death rate at all ages? [1]

2.3 Which type matches r-selected species? [1]

3 Exam-style questions

3.1 A Type III survivorship curve shows [1]

- **A** most deaths in old age
 - **B** a constant death rate
 - **C** very high death rates when young
 - **D** no deaths
-

3.2 A fish species lays thousands of eggs, and very few survive to adulthood.

(a) State the survivorship curve type. [1]

(b) Explain how this matches its reproductive strategy. [2]

3.3 Explain why humans show a Type I survivorship curve. [2]

Solutions

2.1 Type I.

2.2 Type II.

2.3 Type III.

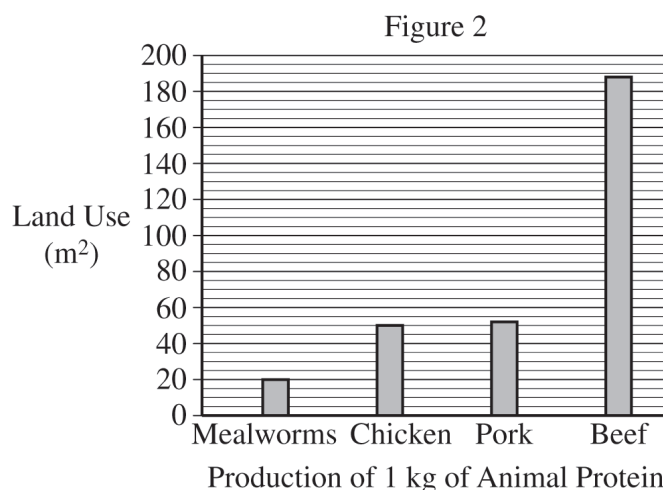
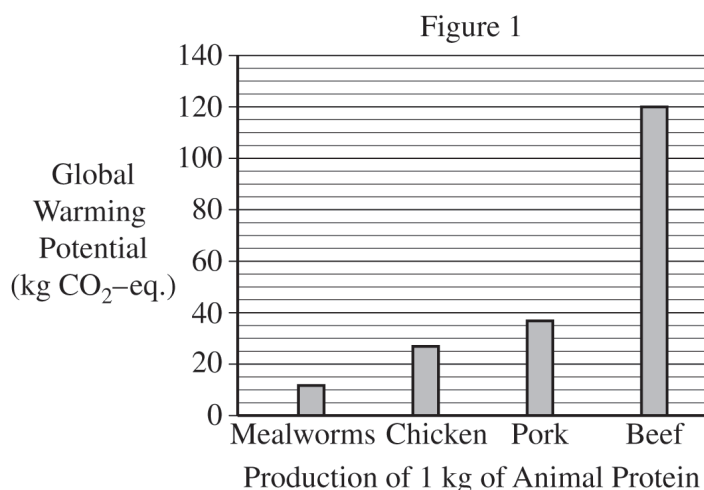
3.1 C — very high death rates when young.

3.2 (a) Type III. (b) It is r-selected — producing many offspring with little care, so most die young, giving a steep early drop.

3.3 Humans (K-selected) produce few offspring with much care, so most survive to old age and deaths cluster late in life, giving a Type I curve.

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

Global Warming Potential and Land Use from Animal Protein Production



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

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

- (b) Based on the information provided, **identify** the type of survivorship curve exhibited by the darkling beetle.
- (c) **Explain** why the reproductive strategy of the darkling beetle is an advantage for using mealworms as an alternative protein source for the rapidly growing human population.

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

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

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

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

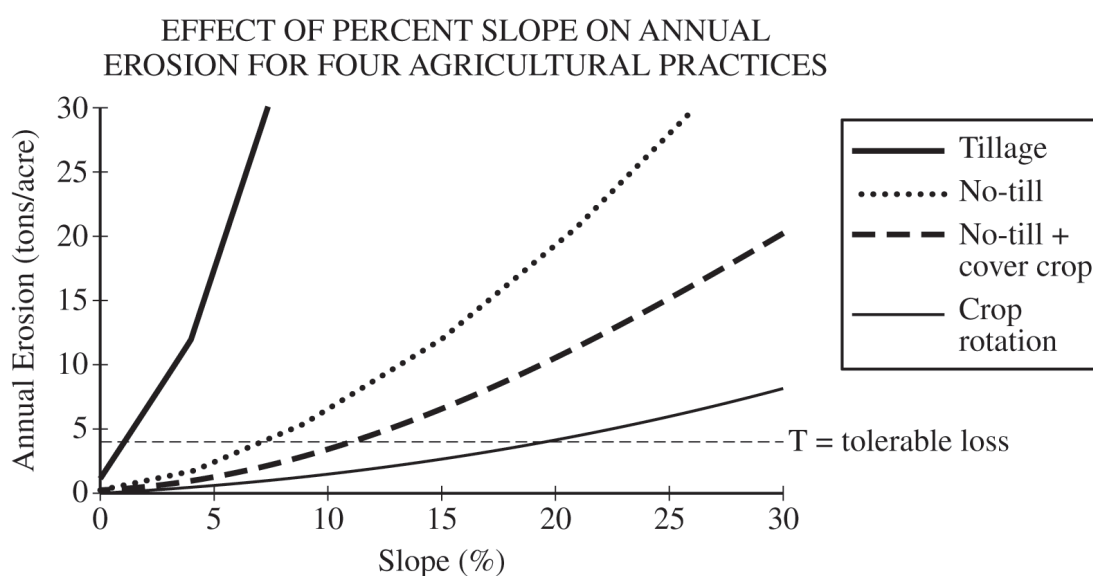
Agricultural practices can have negative impacts on rivers and streams.

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

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

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

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.4 Carrying Capacity

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS carrying capacity 环境容纳量 • die-off 骤减 • overshoot 超载 • limiting factors 限制因素

Objective

Build the skills to answer exam questions on **carrying capacity**.

You must be able to:

- define **carrying capacity** 环境容纳量 K
- explain **overshoot** 超载 and **die-off** 骤减
- describe **limiting factors** 限制因素

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.

■ Carrying capacity

Carrying capacity (K) is the maximum population an environment can support long-term, set by **limiting factors** (food, water, space, disease).

■ Overshoot and die-off

If a population grows **past** K (an **overshoot**), resources are used up faster than they renew, causing a **die-off** (crash) back below K .

■ Limiting factors

Density-dependent factors (competition, disease) intensify as the population grows and pull it toward K . **Density-independent** factors (weather) can also cap it.

■ A worked scenario

Deer multiply past the food supply (overshoot); winter food runs out and many starve (die-off), dropping the population below carrying capacity.

2 Practice

Now apply the methods above.

2.1 Define carrying capacity. [1]

2.2 What is an overshoot? [1]

2.3 Name one limiting factor. [1]

3 Exam-style questions

3.1 When a population exceeds carrying capacity, the likely result is a [1]

- **A** continued rise
 - **B** die-off (crash)
 - **C** stable population
 - **D** new carrying capacity
-

3.2 A deer population grows rapidly and exceeds the food supply.

(a) Name what happens to the population next, and why. [2]

(b) State one density-dependent limiting factor. [1]

3.3 Explain how density-dependent factors keep a population near its carrying capacity. [2]

Solutions

2.1 The maximum population an environment can support long-term.

2.2 When a population grows past its carrying capacity.

2.3 Any one: food, water, space, disease.

3.1 B — a die-off (crash).

3.2 (a) A die-off (crash) — resources are used faster than they renew, so many individuals die. (b) Any one: competition, disease.

3.3 As density rises, competition and disease increase, raising deaths and lowering births; this pushes the population back down toward K .

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

Plants → Insects → Spiders

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

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

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

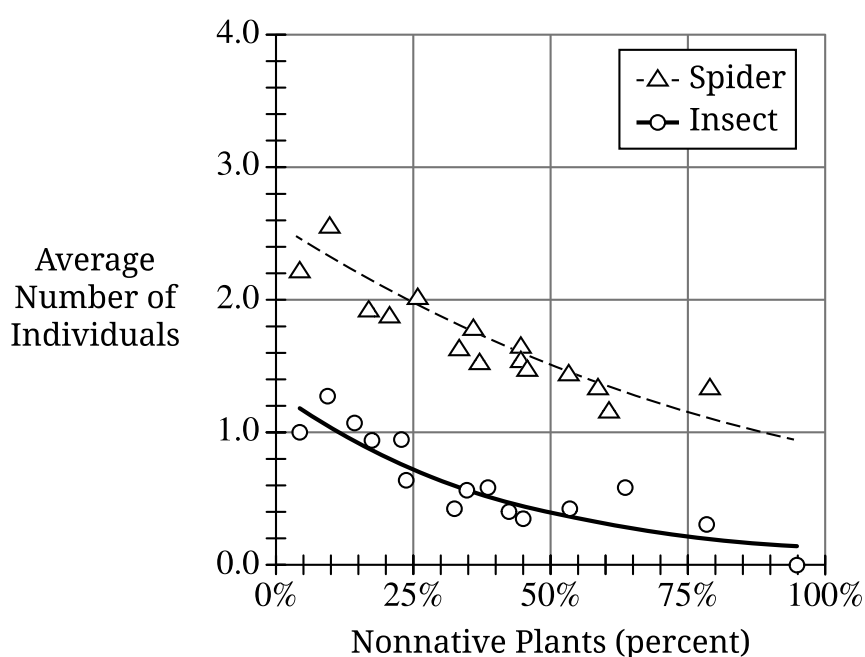
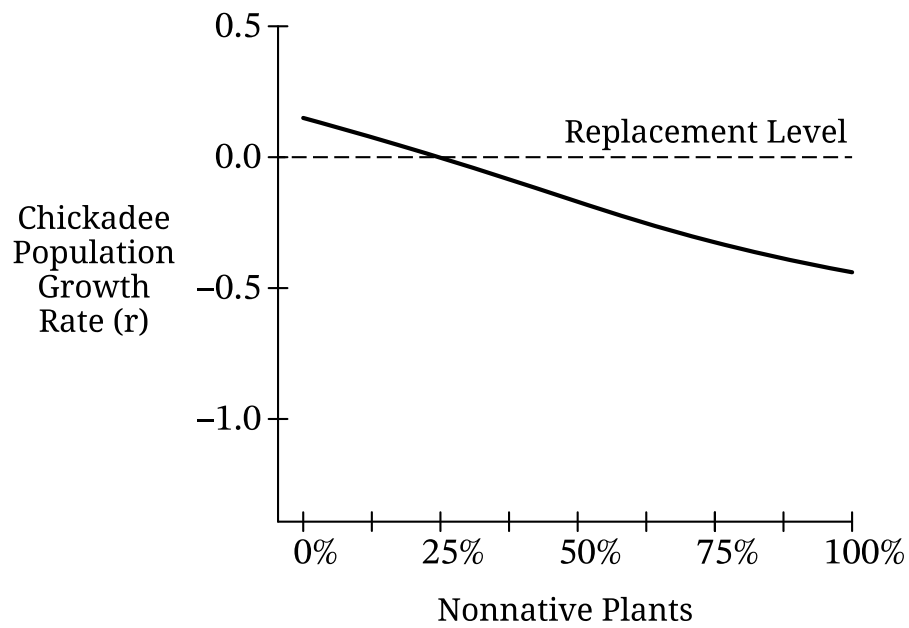


Figure 2. Chickadee Population Average Growth Rate and Percentage of Nonnative

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

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

Ant Species Present in an Urban Park and Unmowed Grassland

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

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

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

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

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

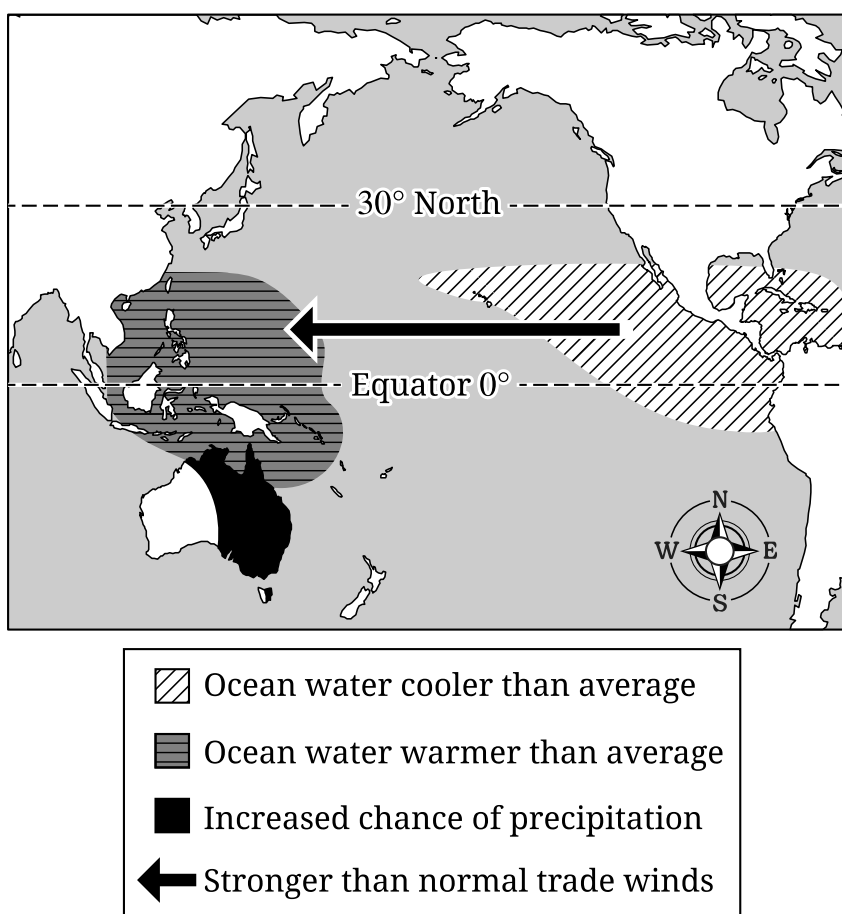
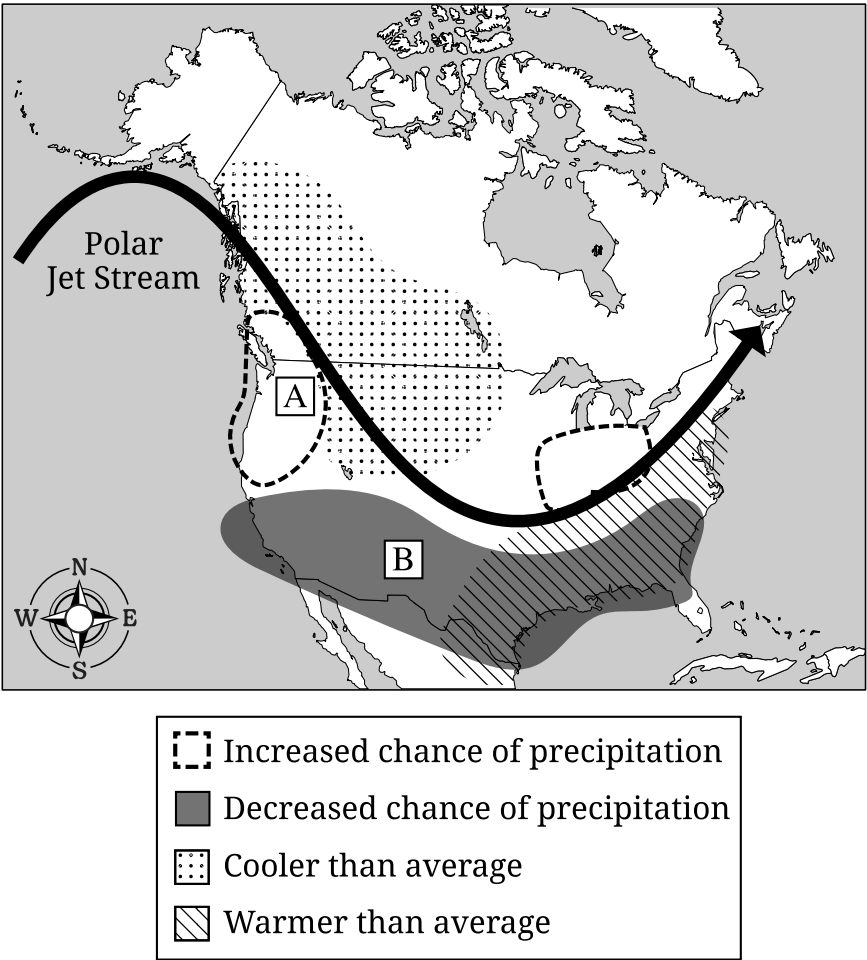


Figure 2. Polar Jet Stream and Climate Conditions in North America



3. Habitat destruction and fragmentation can have many different effects on species.

- (a) **Describe** a characteristic of a specialist species that would make the specialist species more likely to be negatively affected by habitat fragmentation than a generalist species.

A rapidly growing suburban municipality purchases nearby forested land and proposes a newly planned housing development, which would involve clear-cutting much of the area for the construction of single-family homes. While evaluating the land, the development committee discovers that development will encroach upon the habitat of a wood thrush population. The wood thrush is a solitary, territorial bird whose preferred habitat consists of large, intact densely forested areas. Wood thrush populations are also threatened by cowbirds. A cowbird lays her egg in an existing nest of a wood thrush. After the cowbird egg hatches, the cowbird pushes the unhatched wood thrush eggs out. The wood thrush parents raise the cowbird hatchling as their own.

- (b) **Identify** the symbiotic relationship between the wood thrush and the cowbird.
- (c) **Describe** one ecological advantage of leaving areas of undeveloped forest in the development plan as compared to clear-cutting the property.
- (d) **Propose** a solution that will minimize the effect of development on the resident population of wood thrush while still meeting the municipality's need for a housing development.
- (e) A male wood thrush needs a minimum of 800 m^2 of territory for reproduction. The municipal development committee has set a biodiversity preservation target of 275 male wood thrush territories. **Calculate** the area that must be set aside to support the goal of 275 male thrush territories. **Show** your work.
- (f) A real estate developer wants to build houses on the property. The plan will support 1,000 lots with a lot size of $1,100 \text{ m}^2$. The developer has proposed setting aside land equal to 10% of the size of each lot it sells. **Calculate** the maximum number of male wood thrush territories that could be created under this proposal. **Show** your work.
- (g) **Calculate** the percentage of each of the 1,000 lots that would need to be set aside in order to support the goal of 275 male wood thrush territories. **Show** your work.

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

STOP

END OF EXAM

3.5 Population Growth and Resource Availability

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS logistic 逻辑斯蒂增长 • carrying capacity 环境容纳量

Objective

Build the skills to answer exam questions on **population growth and resource availability**.

You must be able to:

- use the **growth-rate** formula (births – deaths, plus migration)
- calculate a percent growth rate
- link resources to exponential vs logistic growth

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.

■ Growth rate

A population's growth depends on births, deaths, and migration:

$$\text{growth rate} = (\text{births} + \text{immigration}) - (\text{deaths} + \text{emigration}).$$

■ Percent growth rate

As a percentage of the population:

$$\% \text{ growth} = \frac{\text{births} - \text{deaths}}{\text{population}} \times 100.$$

(For humans, often expressed per 1000 people.)

■ A worked calculation

A country of 1000 has 30 births and 10 deaths in a year: $\text{growth} = 30 - 10 = 20$;
 $\text{percent} = \frac{20}{1000} \times 100 = 2\%.$

■ Resources shape the curve

With abundant resources, growth is **exponential** (J-curve); as resources become limited, growth slows to **logistic** (S-curve), leveling at carrying capacity.

2 Practice

Now apply the methods above.

2.1 Write the percent growth-rate formula (births and deaths). [1]

2.2 A population of 2000 has 60 births and 20 deaths. Find the percent growth rate. [2]

2.3 What shape is growth with unlimited resources? [1]

3 Exam-style questions

3.1 With limited resources, population growth follows a [1]

- **A** J-shaped (exponential) curve
 - **B** S-shaped (logistic) curve
 - **C** straight line
 - **D** decreasing curve
-

3.2 A town of 5000 has 100 births, 40 deaths, 30 immigrants, and 10 emigrants in a year.

(a) Find the net population change. [2]

(b) Find the percent growth rate. [2]

3.3 Explain why a population's growth slows as it approaches its carrying capacity. [2]

Solutions

2.1 $\% = \frac{\text{births} - \text{deaths}}{\text{population}} \times 100.$

2.2 $\frac{60 - 20}{2000} \times 100 = 2\%.$

2.3 J-shaped (exponential).

3.1 B — an S-shaped (logistic) curve.

3.2 (a) $(100 + 30) - (40 + 10) = 80.$ (b) $\frac{80}{5000} \times 100 = 1.6\%.$

3.3 As the population nears carrying capacity, resources become limited and competition rises, so births fall and deaths rise, slowing growth.

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

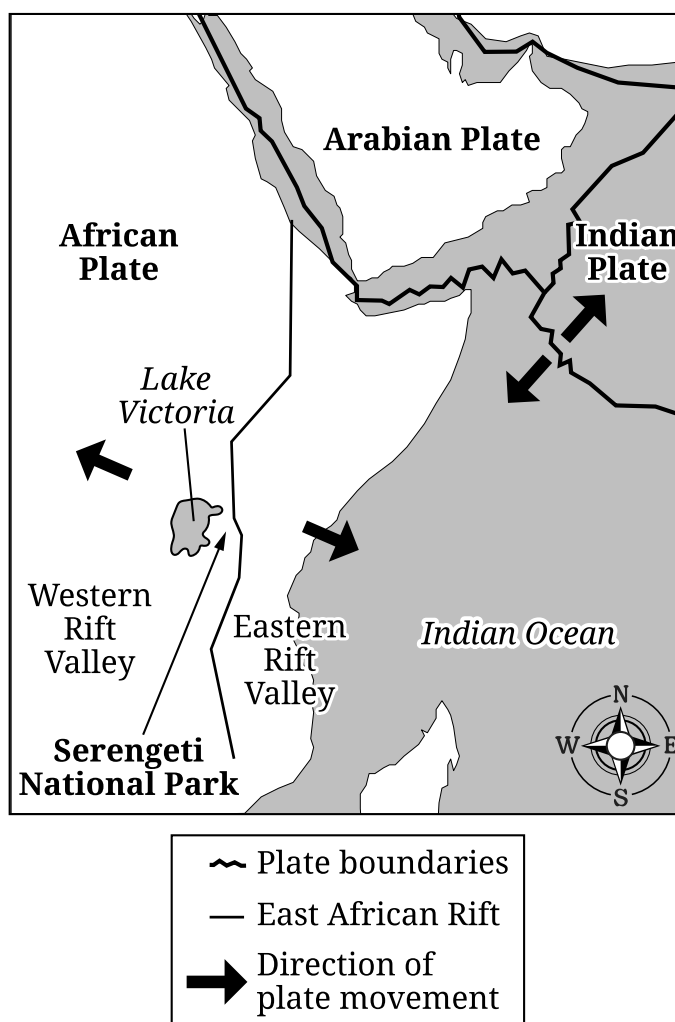
As urbanization has increased in southern Texas, motor vehicle collisions have become the main cause of death in ocelots, which poses an added threat to the remaining ocelots.

- 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

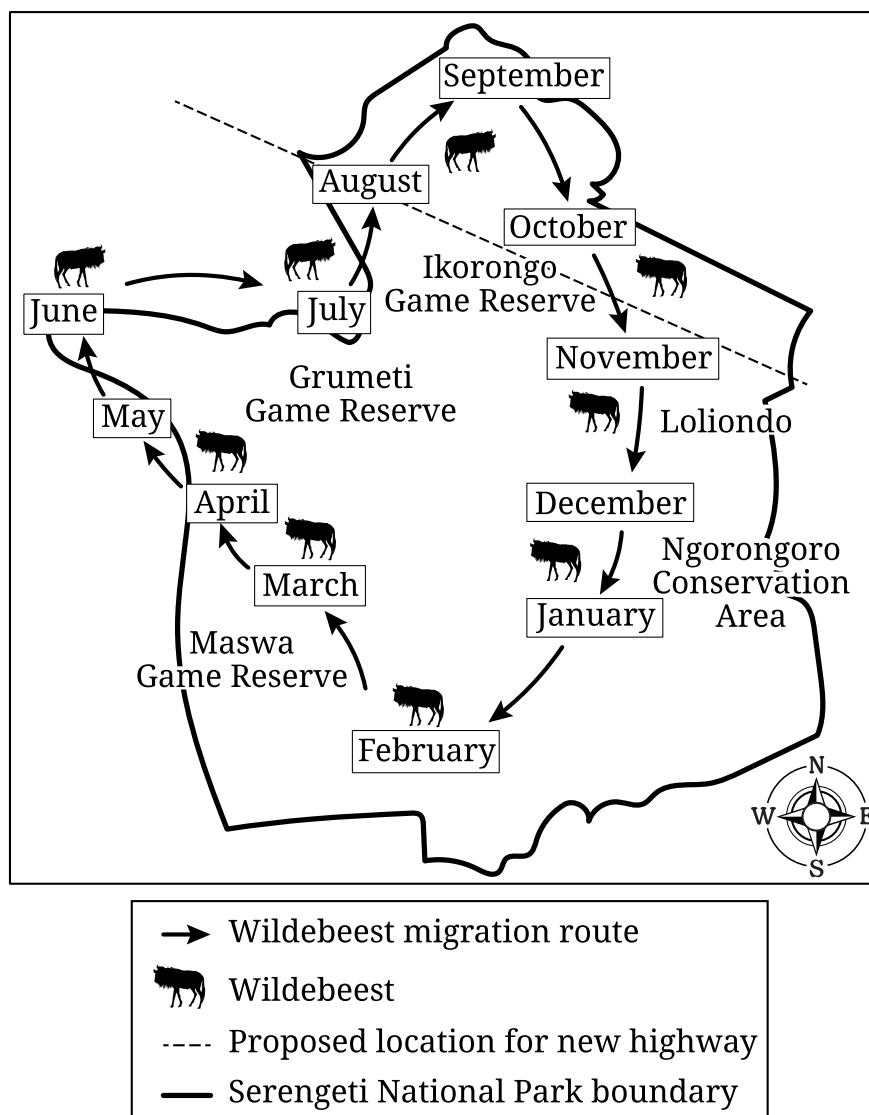
Serengeti National Park is located in Tanzania, Africa. The park is located in a valley along a tectonic plate boundary called the East African Rift. Figure 1 shows the East African Rift and other plate boundaries near the east coast of Africa.

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.

3.6 Age Structure Diagrams

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS age structure diagram 年龄结构图

Objective

Build the skills to answer exam questions on **age structure diagrams**.

You must be able to:

- read an **age structure diagram** 年龄结构图 (population pyramid)
- predict future growth from its shape
- link a wide base to rapid growth

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 the diagram shows

An **age structure diagram** shows the number of people in each age group by sex, stacked youngest at the bottom. Its **shape** predicts future growth.

■ Shapes and growth

- **Wide base** (many young) → **rapid growth** (many future parents).
- **Even/straight sides** → **stable** population.
- **Narrow base** (few young) → **declining** population.

■ Reading momentum

A wide base gives **population momentum**: even if fertility drops, the large young group will still have children, so growth continues for a while.

■ A worked prediction

A pyramid with a very wide base and narrow top predicts a **fast-growing** population, typical of a developing country.

2 Practice

Now apply the methods above.

2.1 What does a wide base on an age structure diagram indicate? [1]

2.2 What shape indicates a stable population? [1]

2.3 What does a narrow base indicate? [1]

3 Exam-style questions

3.1 A population pyramid with a very wide base is likely to [1]

- **A** decline rapidly
 - **B** grow rapidly
 - **C** stay perfectly stable
 - **D** have no children
-

3.2 A country's age structure diagram has a wide base and narrows sharply toward the top.

(a) Predict its future population trend. [1]

(b) Explain your prediction. [2]

3.3 Explain what population momentum means and why a wide-based pyramid causes it. [2]

Solutions

2.1 Rapid future growth (many young people).

2.2 Straight/even sides (a column shape).

2.3 A declining population.

3.1 B — grow rapidly.

3.2 (a) Rapid growth. (b) The wide base means many young people who will become parents, so births will stay high for years.

3.3 Population momentum is continued growth even after fertility falls, because the large group of young people already born will still reach reproductive age and have children.

3.7 Total Fertility Rate

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS total fertility rate 总和生育率 • replacement level 更替水平

Objective

Build the skills to answer exam questions on **total fertility rate (TFR)**.

You must be able to:

- define **total fertility rate** 总和生育率
- compare TFR to **replacement level** 更替水平 (~2.1)
- link TFR to population growth or decline

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.

■ Total fertility rate

TFR is the average number of children a woman is expected to have in her lifetime.

■ Replacement level

Replacement-level fertility is about **2.1** (two to replace the parents, plus a bit for child mortality). At replacement, the population is roughly **stable** long-term.

■ TFR and growth

- **TFR** > 2.1 → population grows.
- **TFR** = 2.1 → roughly stable.
- **TFR** < 2.1 → population eventually declines.

■ Factors that lower TFR

TFR falls with **education of women**, **access to family planning**, urbanization, and higher child survival. Developed countries tend to have lower TFRs.

2 Practice

Now apply the methods above.

2.1 Define total fertility rate. [1]

2.2 What is the approximate replacement-level TFR? [1]

2.3 A country has a TFR of 1.5. Will its population grow or decline (long-term)? [1]

3 Exam-style questions

3.1 A TFR above 2.1 leads to a population that [1]

- **A** grows
 - **B** stays exactly constant
 - **C** declines
 - **D** disappears
-

3.2 Country X has a TFR of 4.5; country Y has a TFR of 1.8.

(a) State which population is growing and which is declining. [2]

(b) State one factor that lowers TFR. [1]

3.3 Explain why the replacement-level TFR is slightly above 2, not exactly 2. [2]

Solutions

2.1 The average number of children a woman is expected to have in her lifetime.

2.2 About 2.1.

2.3 Decline.

3.1 A — grows.

3.2 (a) Country X (TFR 4.5) is growing; country Y (TFR 1.8) is declining. (b) Any one: education of women, family planning access, urbanization.

3.3 Two children replace the two parents, but some children die before reproducing, so a little above 2 is needed to keep the population stable.

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

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

DEMOGRAPHIC DATA FOR HAITI

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

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

3.8 Human Population Dynamics

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS doubling time 倍增时间 • crude birth rate 出生率 • crude death rate 死亡率

Objective

Build the skills to answer exam questions on **human population dynamics**.

You must be able to:

- use **crude birth rate** 出生率 and **crude death rate** 死亡率
- calculate a growth rate and the **doubling time** 倍增时间 (rule of 70)
- explain factors affecting human populations

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.

■ Birth and death rates

Crude birth rate (CBR) and **crude death rate (CDR)** are births/deaths per 1000 people per year. The natural growth rate is:

$$\% \text{ growth} = \frac{\text{CBR} - \text{CDR}}{10}.$$

(Dividing by 10 converts “per 1000” to a percentage.)

■ A worked growth rate

$$\text{CBR} = 30, \text{CDR} = 10: \text{growth} = \frac{30 - 10}{10} = 2\% \text{ per year.}$$

■ Doubling time (rule of 70)

The time for a population to double is approximately:

$$\text{doubling time} \approx \frac{70}{\% \text{ growth rate}}.$$

At 2%, doubling time = $70/2 = 35$ years.

■ Factors

Growth is affected by health care (lowers CDR), education, economic development, and family planning (lower CBR).

2 Practice

Now apply the methods above.

2.1 A country has $\text{CBR} = 25$ and $\text{CDR} = 5$. Find the percent growth rate. [2]

2.2 Write the rule-of-70 doubling-time formula. [1]

2.3 Find the doubling time for a 2% growth rate. [1]

3 Exam-style questions

3.1 The doubling time for a population growing at 3.5% is about [1]

- A 10 years
- B 20 years
- C 35 years
- D 70 years

3.2 A country has $\text{CBR} = 40$ and $\text{CDR} = 12$ per 1000.

(a) Find the percent growth rate. [2]

(b) Find the doubling time. [2]

3.3 Explain how improved health care can, at first, increase population growth. [2]

Solutions

2.1 $\frac{25 - 5}{10} = 2\%$.

2.2 doubling time $\approx \frac{70}{\% \text{ growth rate}}$.

2.3 $70/2 = 35$ years.

3.1 B — $70/3.5 = 20$ years.

3.2 (a) $\frac{40 - 12}{10} = 2.8\%$. (b) $70/2.8 = 25$ years.

3.3 Better health care lowers the death rate (fewer people die) while birth rates stay high, so the gap between births and deaths widens, increasing growth.

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

3. Respond to parts A, B, C, D, E, F, and G.

A. **Identify** a type of surface mining the company could use to access the coal.

B. **Describe** an environmental problem associated with surface mining.

C. The town is located downwind of the new coal-burning power plant.

Describe an environmental problem the town could experience as a result of the electricity generation at the coal-burning power plant.

D. The local government is concerned about the environmental consequences of using coal to generate electricity for the town.

Propose a realistic solution the local government could enact that would reduce the negative environmental consequences of using coal to generate electricity.

E. Burning one pound of coal produces an average of 0.88 kilowatt-hours (kWh) of electricity. An average household in the United States uses 1.064×10^4 kWh of electricity each year.

Calculate how many pounds of coal would need to be burned to generate enough electricity to power a town with 11,000 houses for a year. **Show** your work.

F. Researchers are concerned about the impact of noise pollution on songbirds in a forest near the power plant. Since the power plant was installed, bird species richness has declined from 7.5 species per hectare to 6.0 species per hectare.

Calculate the percent change in bird species per hectare since the power plant was installed. **Show** your work.

G. The town has been growing since it was built and had a growth rate of 5.38% in 2022, with a population of 26,250.

Assuming that the growth rate remains constant, **calculate** the year in which the population will reach 52,500. **Show** your work.

STOP

END OF EXAM

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

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

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

Population of Charlotte, North Carolina, 2013–2019

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

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

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

STOP

END OF EXAM



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

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

3.9 Demographic Transition

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS demographic transition 人口转变

Objective

Build the skills to answer exam questions on the **demographic transition**.

You must be able to:

- describe the four stages of the **demographic transition** 人口转变
- link each stage to birth and death rates
- connect the model to development

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 four stages

The **demographic transition** describes how birth and death rates change as a country develops:

1. **Pre-industrial** — high birth **and** high death rates; slow growth.
2. **Transitional** — death rate **falls** (better food, health); high births; **rapid growth**.
3. **Industrial** — birth rate falls (education, family planning); growth slows.
4. **Post-industrial** — low birth and low death rates; population stable or declining.

■ Reading a country's stage

Match the country's birth and death rates to a stage. A country with rapidly falling deaths but high births is in **Stage 2** (fastest growth).

■ The link to development

As countries develop (industrialize, educate, urbanize), they move from Stage 1 toward Stage 4, and growth slows.

■ A worked identification

A wealthy country with low birth and death rates and a stable population is in **Stage 4**.

2 Practice

Now apply the methods above.

2.1 In Stage 1, what are the birth and death rates like? [1]

2.2 In which stage is population growth fastest? [1]

2.3 What happens to the birth rate in Stage 3? [1]

3 Exam-style questions

3.1 A country with low birth and low death rates and a stable population is in [1]

- **A** Stage 1
 - **B** Stage 2
 - **C** Stage 3
 - **D** Stage 4
-

3.2 A developing country's death rate has dropped sharply, but its birth rate is still high.

(a) State the stage. [1]

(b) Explain why its population is growing rapidly. [2]

3.3 Explain how development (education and family planning) moves a country from Stage 2 to Stage 3. [2]

Solutions

2.1 Both high.

2.2 Stage 2 (transitional).

2.3 It falls.

3.1 D — Stage 4.

3.2 (a) Stage 2. (b) Deaths have fallen but births remain high, so the gap between them is large and the population grows rapidly.

3.3 Education (especially of women) and access to family planning lower the birth rate, so the birth–death gap narrows and growth slows, moving the country into Stage 3.