Interdependence in Nature

Q: What factors contribute to changes in populations?

**WHAT I KNOW**

5.1 How do populations grow?

SAMPLE ANSWER: Populations can increase or decrease in size.

5.2 What factors limit a population's growth?

SAMPLE ANSWER: Predation, disease, and other factors slow or stop population growth.

5.3 How is the human population growing?

SAMPLE ANSWER: The human population has been growing for thousands of years.

**WHAT I LEARNED**

SAMPLE ANSWER: Populations vary in their geographic range, density, distribution, growth rate, and age structure. Exponential or logistic growth patterns result from births, deaths, immigration, and emigration.

SAMPLE ANSWER: Density-dependent factors that limit population growth include competition, predation, herbivory, parasitism, disease, and overcrowding. Density-independent factors include unusual weather and introduced species.

SAMPLE ANSWER: Some countries have higher growth rates than others because of differences in birthrates, death rates, and the age structure of their populations.
5.1 How Populations Grow

Lesson Objectives

- List the characteristics used to describe a population.
- Identify factors that affect population growth.
- Describe exponential growth.
- Describe logistic growth.

Lesson Summary

Describing Populations Researchers study five important characteristics of a population:

- **Geographic range** is the area in which a population lives.
- **Population density** is the number of individuals per unit area.
- Population distribution is how individuals are spaced out in their range.
- Growth rate determines whether a population grows, shrinks, or stays the same size.
- **Age structure** is the number of males and females of each age in a population.

Population Growth Populations can grow, shrink, or stay the same size.

- Factors that increase population size include births and **immigration**, which is the movement of individuals into an area.
- Factors that decrease population size include deaths and **emigration**, which is the movement of individuals out of an area.

Exponential Growth When conditions are ideal, the larger a population gets, the faster it grows. When a population’s numbers grow larger with each generation, **exponential growth** is occurring. Ideal conditions include unlimited resources and absence of predation and disease.

Logistic Growth Resources become less available as a population grows.

- **Logistic growth** occurs when population growth slows and then stops after a period of exponential growth has occurred.
- Population size stabilizes at the **carrying capacity**, the maximum number of individuals of a given species that an environment can support.

Describing Populations

For Questions 1–5, complete each statement by writing the correct word or words.

1. The **geographic range** is the area in which a population lives.
2. Population density is the **number** of individuals per unit area.
3. How the individuals are spaced in their range is a population’s **distribution**.
4. Growth rate is how quickly a population **increases or decreases** in size.
5. To find the **age structure** of a population, count the number of males and females of each age.
Population Growth

For Questions 6–10, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

6. If the death rate is less than the birthrate, the population is likely to shrink. **greater**

7. Immigration increases population size. **True**

8. Young animals may immigrate from the place where they were born to establish new territories. **emigrate**

9. A high birthrate and immigration decrease population size. **increase**

10. Populations grow if more individuals are born than die in a period of time. **True**

11. The dots in the box represent individuals in a population with a random pattern of distribution. Use arrows and dots to show what will happen to this population if emigration is greater than immigration. (Assume birthrate and death rate are equal.) On the lines below, explain your drawing.

Sample answer: When emigration is greater than immigration, there are more dots leaving the population (arrows out) than entering it (arrows in). The result will be a decrease in population size.

Exponential Growth

12. Describe the conditions in which exponential growth occurs.

Exponential growth occurs under ideal conditions with no limits on food, water, or space and no predation or disease.

13. Can exponential growth occur in a population of organisms that take a long time to reproduce? Why or why not?

Yes, it can. If population size grows larger and the growth rate increases with each generation, exponential growth occurs.
14. Complete the graph by drawing the characteristic shape of exponential population growth.

### Exponential Growth of Bacterial Population

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Number of Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>100,000</td>
</tr>
<tr>
<td>2</td>
<td>200,000</td>
</tr>
<tr>
<td>4</td>
<td>300,000</td>
</tr>
</tbody>
</table>

15. What letter is used to refer to the characteristic shape of an exponential growth curve?

*An exponential growth curve is shaped like the letter J.*

### Logistic Growth

16. Complete the graph by drawing the characteristic shape of logistic population growth.

### Logistic Growth of a Population

- Carrying capacity

17. What letter is used to refer to the characteristic shape of the logistic growth curve?

*The logistic growth curve is shaped like an S.*
18. When real-world populations of plants and animals are analyzed, why do they most often have the logistic growth curve?

*Exponential growth cannot continue indefinitely. Resources become limited, which slows birthrate and may increase death rate. Eventually, a population's growth slows or stops and the population size becomes more or less stable.*

19. What does the term carrying capacity refer to?

*It refers to the largest number of individuals of a species (population) that can be supported by a particular environment.*

20. Complete the table to name and explain three phases of logistic growth. Use the terms growth rate, population size, and carrying capacity in your explanations.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Phase name</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exponential growth</td>
<td>Individuals reproduce rapidly and few die. Both the population size and the growth rate increase rapidly.</td>
</tr>
<tr>
<td>3</td>
<td>Growth stops.</td>
<td>The growth rate drops to zero, and the population size stabilizes at the carrying capacity.</td>
</tr>
</tbody>
</table>

21. What is an example of a limiting factor that humans use to control the carrying capacity of an environment for a particular type of organism? Explain your answer.

*Sample answer: Agriculture and gardening are ways humans control the carrying capacity of an area that includes farms or gardens. Adding fertilizer, for example, promotes plant growth and increases the environment's carrying capacity for plants. Growing only one kind of crop can leave some animal populations without a food source, and the carrying capacity for those animals would decrease.*
5.2 Limits to Growth

Lesson Objectives

Identify factors that determine carrying capacity.
Identify the limiting factors that depend on population density.
Identify the limiting factors that do not depend on population density.

Lesson Summary

Limiting Factors  A limiting factor is a factor that controls the growth of a population.

- Some factors depend on the density of the population. Others do not.
- Acting separately or together, limiting factors determine an environment’s carrying capacity.
- Limiting factors produce the pressures of natural selection.

Density-Dependent Limiting Factors

- Density-dependent limiting factors operate strongly when the number of individuals per unit area reaches a certain point.
- Examples include:
  - competition
  - predation and herbivory
  - parasitism and disease
  - stress from overcrowding

Density-Independent Limiting Factors

- Some limiting factors do not necessarily depend on population size.
- Density-independent limiting factors depend on population density, or the number of organisms per unit area.
- Examples include severe weather, natural disasters, and human activities.
- Some of these factors may have more severe effects when population density is high.

Limiting Factors

For Questions 1–6, write True if the statement is true. If the statement is false, change the underlined word to make the statement true.

1. Limiting factors determine the immigration capacity of a population.
   True 2. A limiting factor controls the growth of a population.
   True 3. Limiting factors operate when growth is exponential.
   True 4. Populations grow too large in the absence of limiting factors.
   True 5. Competition is an example of a limiting factor.
   True 6. Population size can be limited by factors such as predation.
Density-Dependent Limiting Factors

7. What is a density-dependent limiting factor?
   It is a limiting factor that depends on the number of organisms per unit area.

8. When do density-dependent factors operate most strongly?
   They operate most strongly when a population is large and dense.

9. What are four density-dependent limiting factors?
   Possible answers include: competition, predation, herbivory, parasitism, disease, and stress from overcrowding

Use the graph to answer Questions 10–13.

10. What happened to the number of wolves on Isle Royale between 1975 and 1985?
    It dropped by about half, from about 40 to about 20.

11. What happened to the moose population when the number of wolves was low?
    It grew large rapidly.

12. What is the relationship between the moose and the wolves on Isle Royale?
    The wolf is the predator. The moose is the prey.

13. Is the number of moose on the island a density-dependent or density-independent limiting factor for the wolf? Explain your answer.
    It is density-dependent because when the wolf population is small, there may be enough moose for food; when the wolf population is large, food may be scarce for the wolf if the moose population is small.
Density-Independent Limiting Factors

14. What term describes a limiting factor that affects all populations in similar ways, regardless of population size?

*It is a density-independent limiting factor.*

15. What is the usual response in the population size of many species to a density-independent limiting factor?

*The population size decreases.*

16. Complete the graphic organizer with examples of density-independent limiting factors.

![Diagram of population size limited by density-independent factors]

**SAMPLE ANSWERS:** drought, flood, fire, hurricane, very hot weather, very cold weather, etc.

17. A population continues at a stable size for many years. Suddenly, in a single season, the population size drops by half. Is the cause more likely to be density-dependent, density-independent, or both? Explain your answer.

*It could be either or both. A density-independent factor such as extreme weather or a natural disaster could reduce numbers quickly. A density-dependent factor such as disease, parasitism, human activities, or a newly introduced predator or herbivore could also reduce numbers quickly.*