Chapter 14
POPULATION ECOLOGY: PLANET AT CAPACITY—PATTERNS OF POPULATION GROWTH

Learning Objectives

- Understand the fundamentals of ecology
- Identify the key perspective needed in population ecology
- Identify and explain the important factors that impact population growth
- Outline types of population growth
- Understand the variations of life histories
- Understand trade-offs between growth and lifespan
- Define survivorship curves and the relationship between growth, reproduction, and survival
- Understand aging and why some organisms age faster than others
- Outline experiments that demonstrate how longevity can be extended
- Understand the information provided in an age pyramid
- Define an ecological footprint
- Describe the current state of human population growth

Chapter Outline

I. Population Ecology Is the Study of How Populations Interact with Their Environments

A. What Is Ecology?

- **Ecology** can be defined as the study of:

- This involves different or varying levels from individuals to ecosystems. Define the following levels and give an example.
    - Individuals

    - Populations

- Communities

- Ecosystem

- How populations interact with their environment—including the influence of other species, the environment, and their growth—can be referred to as a subfield of ecology called _____.

    - The important processes in population ecology include adaptations, birth rates, death rates, immigration, and emigration. Can any of these processes be studied at the individual level? Explain.

B. Population Growth

- How does a population remain stable (neither growing nor shrinking)? Explain.

- Define the **growth rate** of a population.

- If ***r*** stands for growth rate, give the equation necessary to calculate the growth of a population in a year.

- Define **exponential growth**.

    - Can this type of growth occur for long periods of time? Explain.

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C. Population's Growth Is Limited by Its Environment

- A population's growth is impacted by the number of individual organisms in a specific area, or the **population density**.

- List four **density-dependent factors** that can impact growth.

  1.

  2.

  3.

  4.

    - Can you come up with another factor of your own?

- ***K*** represents _____ _____ of the environment.
    - List two related consequences that could occur if a population size approached its "***K***."

      1.

      2.

- Explain what occurs during **logistic growth**. How is this different than exponential growth?

- Explain how **density-independent factors** impact a population, and give an example of one such factor.

D. Some Populations Cycle between Large and Small

- The _____ growth pattern is the best model to outline the expected growth of populations; however, it is important to understand how certain growth patterns can deviate from the expected.

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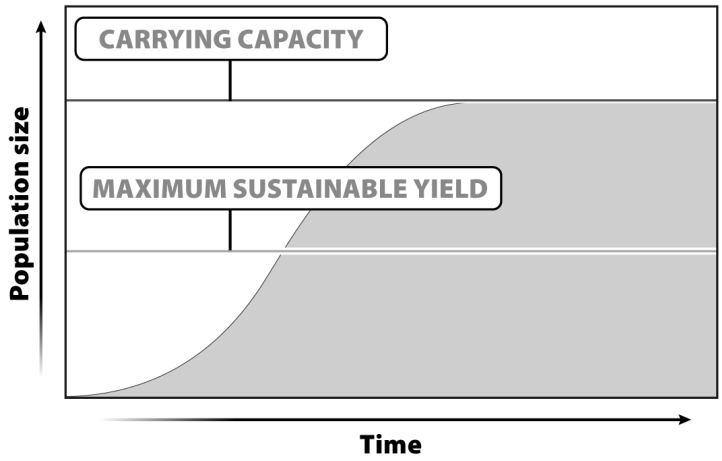
- There are some important examples that illustrate instances when populations do not follow the expected patterns of growth. Explain the pattern of growth for each of the following populations and explain how this cycle occurred.
    - Desert locust population in northwest Africa

    - Lynx and snowshoe hare populations in Canada

- What population growth cycle is a bold urban legend?

E. "Maximum Sustainable Yield" Is Useful but Nearly Impossible to Implement



- An important concept when studying the management of natural resources is the **maximum sustainable yield**. Give a brief definition of this term.

    - While this concept is intended as a positive long-term management solution, it relies on knowing the population's _____.
    - Why is it difficult to estimate or calculate this value?

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II. A Life History Is Like a Species Summary

A. Life Histories Are Shaped by Natural Selection

- The executive summary of an organism, or its **life history,** includes important statistics such as:
    -
    -
    -
    -

- We can observe variations in the life histories of different organisms. One aspect that can vary is the organism's **reproductive investment**. Describe, in general terms, an organism's reproductive investment.

- Explain the two factors to consider when evaluating the costs and benefits of one reproductive strategy over another.

  1.

  2.

    - As an example, explain how humans and rodents differ in life histories.

B. There Are Trade-offs between Growth, Reproduction, and Longevity

- An organism's fitness can be impacted by areas of its life history such as *growth*, *reproduction*, and *survival*.

- There are three major trade-offs in the investments of an organism's life history. Indicate and explain each of these trade-offs.

  1.

  2.

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3.

C. *This Is How We Do It.* Life History Trade-Offs: Rapid Growth Comes at a Cost

- Describe the experimental design that allowed researchers to determine the existence of a growth–life span trade-off in the groups of stickleback fish.

- The life-span differences observed were independent of what?

- What did the experimental design *not* allow the researchers to determine?

D. Populations Can Be Described Quantitatively in Life Tables and Survivorship Curves

- Although life tables are used when an individual is purchasing life insurance, biologists can use the information in an organism's **life table** to create an important graph called a **survivorship curve**. The information from a life table includes:
    - Longevity, or how long the organism is expected to live
    -
    -

- What, specifically, is plotted on a **survivorship curve**?

- The information plotted can be broken down into three specific areas or types. Explain what each type means.

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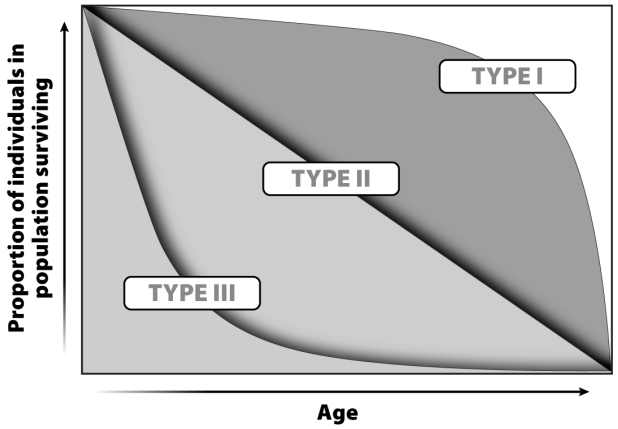
1. Type I

2. Type II

3. Type III



III. Ecology Influences the Evolution of Aging in a Population

A. Things Fall Apart: What is Aging and Why Does It Occur?

- If you asked different individuals to define aging, you would hear different definitions. Therefore, we need to define **aging** based on a population. Provide this information below.

    - While the average lifespan in the United States is _____ years, the oldest human ever documented lived to be at least _____ years old.

- Explain the relationship between natural selection and why we age.

- Briefly define reproductive output.

- If a person is carrying a mutation that will cause disease or death at a very young age, is it possible for him or her to pass the mutation on to future offspring? Explain.

- If a person is carrying a mutation that will cause disease or death later in life, is it possible for him or her to pass the mutation on to future offspring? Explain.

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- Even though there are many causes of death, the accumulation of "bad" alleles is responsible for the physical breakdown of an individual.

B. What Determines the Longevity of Different Species?

- A key factor in understanding why some organisms age more rapidly than others is the age at which the organism reproduces. Explain why.

- The world can often be a scary place, and some organisms live in a much riskier environment than others. Describe **hazard factors** and give an example.

- Explain the connection between an organism's hazard factor and reproduction.

C. Can We Slow Down the Process of Aging?

- Outline the experimental steps researchers took that resulted in doubling the lifespan of fruit flies.

- Explain the impact of delaying the fruit fly egg collection in the process of starting a new generation of flies.

IV. The Human Population Is Growing Rapidly

A. Age Pyramids Reveal Much about a Population

- How does a "baby boom" impact society?

- Describe an "age pyramid" and its use.

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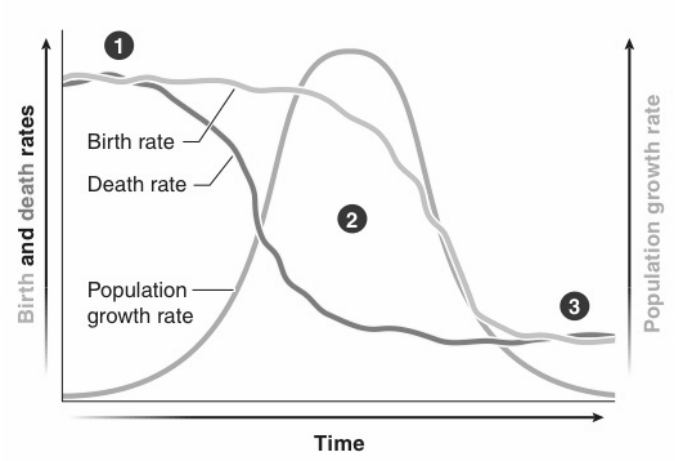
- What is the shape of the age pyramid in the United States?

    - What is the concern over the shape of this pyramid?

B. As Less-Developed Countries Become More Developed, a Demographic Transition Often Occurs

- Population growth is important to measure and track as it impacts public health, food production, social services, and other facets of our society.

- Define **demographic transition.**



- Describe all the possible combinations of birth and death rates when the population growth rate is slow. Describe the possible combinations when the population growth rate is fast.

- Give an example of a country or area where the demographic transition has been completed.

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- Give an example of an area that is currently going through this transition.

C. Human Population Growth: How High Can It Go?

- Can the carrying capacity of humans be accurately established? Explain why or why not.

- Our population is estimated at over _____ billion people. The United Nations estimates that our carrying capacity is between _____ and _____ billion.

- List three ways that humans, with the aid of technology, can increase our carrying capacity.

  1.

  2.

  3.

- What information does an **ecological footprint** provide?

    - Is the ecological footprint the same from country to country? Explain.

- Provide some of your own thoughts of what impact humans may feel if the world population reaches our carrying capacity on earth.

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Testing and Applying Your Understanding

Multiple Choice (For more multiple choice questions, visit www.prep-u.com.)

1. The demographic transition:
   a) is not influenced by the quality of health care available to a population.
   b) occurs in predator-prey pairs, such as the lynx and hare, whose population sizes cycle regularly.
   c) includes a decrease in the birth rate followed by a decrease in the death rate as a population becomes industrialized.
   d) is characterized by an increase in a population's growth rate.
   e) includes a decrease in the death rate followed by a decrease in the birth rate as a population becomes industrialized.

2. How does exponential growth differ from logistic growth?
   a) With logistic growth generally comes infinite expansion.
   b) Exponential growth models include consideration of a population's carrying capacity.
   c) Long-term exponential growth is more commonly observed than long-term logistic growth in nature.
   d) The logistic model of growth incorporates environmental limitations on population size.
   e) Logistic growth models take the population's age-structure into account.

3. A primary difference in the age pyramids of industrialized versus third-world countries is:
   a) mean longevity is significantly greater among third-world countries.
   b) third-world countries show a characteristic "bulge," which indicates a baby boom.
   c) third-world countries have significantly more individuals than industrialized countries.
   d) third-world countries have much larger proportions of their population in the youngest age group.
   e) in third-world countries females live significantly longer than men, whereas in industrial countries the reverse is true.

4. A Type-III survivorship curve would be expected in a species in which:
   a) biparental care is necessary.
   b) mortality occurs at a constant rate over the lifespan.
   c) parental care is extensive.
   d) mortality rate is quite low for the young.
   e) a large number of offspring are produced but parental care is minimal.

5. A population is:
   a) a group of individuals of the same species that live in the same general location and have the potential to interbreed.
   b) a group of individuals of related species that live in the same general location and have the potential to interbreed.
   c) a group of individuals of the same species that live in the same general location and

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have the same genotypes.
d) a group of individuals of the same species that have the potential to interbreed.
e) a group of species that share the same habitat.

6. Which of the following is NOT an example of a density-dependent limiting factor that will influence carrying capacity?
a) food supply
b) predation
c) disease
d) flooding
e) territory availability

7. In years when beech trees produce a large crop of nuts, growth rings are narrow. This is best explained by:
a) the trade-off between the number and size of offspring an organism can produce.
b) their decreased reproductive value.
c) the Type-I life history of beech trees.
d) density-dependent regulation affects.
e) the trade-off that exists between growth and reproduction.

8. In a population, as *N* approaches *K*, the logistic growth equation predicts that:
a) the carrying capacity of the environment will increase.
b) the growth rate will approach zero.
c) the carrying capacity of the environment will decrease.
d) the population size will decrease.
e) the population size will increase exponentially.

9. The number of individuals that can be supported in a given habitat is the:
a) density-independent effect.
b) innate capacity for increase.
c) density-dependent effect.
d) biotic potential.
e) carrying capacity.

10. In 1900, the world had a human population of approximately _____, and, in 2000, the world had a human population of approximately _____.
a) 1.6 billion; 6.7 billion
b) 6.7 million; 7.6 billion
c) 1.6 billion; 5.2 billion
d) 4.3 billion; 6.7 billion
e) 1.6 billion; 6.1 billion

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Short Answer

1. Compare and contrast how density-dependent factors and density-independent factors impact populations.

2. Explain how technology can increase carrying capacity in some environments as well as potentially decrease the carrying capacity in others.

3. Many populations cycle between periods of growth. What is the biggest difference between the growth cycles of the desert locust and the lynx/snowshoe hare populations?

4. What are some of the important characteristics an organism must possess if they fall into the Type I group on the survivorship curve?

5. As humans, we often look back toward our parents, grandparents, and even great-grandparents to see how long we might live. Why do we age, and what is the familial, or genetic, connection to aging?

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6. Indicate and explain the potential differences in hazard factors between a population of box turtles that can live up to 100 years of age and a population of bullfrogs that live an average of eight years.

7. The ecological footprints of individuals living in different countries will vary greatly depending on the country. As the text indicated, the ecological footprint of people living in India is much smaller than that of people living in Australia or Norway. How does the ecological footprint impact the earth's carrying capacity?

8. In your opinion, what should be done about the exploding population—increase the carrying capacity via technology, reduce the ecological footprint of wealthier nations, impose a mandatory population control policy, or something else? Back up your argument with information from the text and outside resources.

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