Introduction

- Individual emperor penguins face the rigors of the Antarctic climate and have special adaptations, including a
  - downy underlayer of feathers for insulation and
  - thick layer of fat for energy storage and insulation.
- The entire population of emperor penguins reflects group characteristics, including the
  - survivorship of chicks and
  - growth rate of the population.

Introduction

- Population ecologists study natural population
  - structure and
  - dynamics.
36.1 Population ecology is the study of how and why populations change

- A population is a group of individuals of a single species that occupy the same general area.
- Individuals in a population
  - rely on the same resources,
  - are influenced by the same environmental factors, and
  - are likely to interact and breed with one another.
- A population can be described by the number and distribution of individuals.
- Population dynamics, the interactions between biotic and abiotic factors, cause variations in population sizes.

36.2 Density and dispersion patterns are important population variables

- Population ecology is concerned with
  - the changes in population size and
  - factors that regulate populations over time.
- Populations
  - increase through birth and immigration to an area and
  - decrease through death and emigration out of an area.
- Population density is the number of individuals of a species per unit area or volume.
- Examples of population density include the
  - number of oak trees per square kilometer in a forest or
  - number of earthworms per cubic meter in forest soil.
- Ecologists use a variety of sampling techniques to estimate population densities.

Within a population’s geographic range, local densities may vary greatly.

The dispersion pattern of a population refers to the way individuals are spaced within their area.
36.2 Density and dispersion patterns are important population variables

- Dispersion patterns can be clumped, uniform, or random.
  - In a clumped pattern
    - resources are often unequally distributed and
    - individuals are grouped in patches.

- In a uniform pattern, individuals are
  - most likely interacting and
  - equally spaced in the environment.
36.2 Density and dispersion patterns are important population variables

- In a random pattern of dispersion, the individuals in a population are spaced in an unpredictable way.

36.3 Life tables track survivorship in populations

- Life tables track survivorship, the chance of an individual in a given population surviving to various ages.
- Survivorship curves plot survivorship as the proportion of individuals from an initial population that are alive at each age.
- There are three main types of survivorship curves.
  - Type I
  - Type II
  - Type III
36.4 Idealized models predict patterns of population growth

- The rate of population increase under ideal conditions is called exponential growth. It can be calculated using the exponential growth model equation, \( G = rN \), in which
  - \( G \) is the growth rate of the population,
  - \( N \) is the population size, and
  - \( r \) is the per capita rate of increase (the average contribution of each individual to population growth).

- Eventually, one or more limiting factors will restrict population growth.
The logistic growth model is a description of idealized population growth that is slowed by limiting factors as the population size increases.

To model logistic growth, the formula for exponential growth, \( rN \), is multiplied by an expression that describes the effect of limiting factors on an increasing population size.

\[ G = rN \left( \frac{K}{N} \right) \]

\( K \) stands for carrying capacity, the maximum population size a particular environment can sustain.
Table 36.4B

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<th>((K - N)/K)</th>
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<td>100</td>
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36.5 Multiple factors may limit population growth

- The logistic growth model predicts that population growth will slow and eventually stop as population density increases.
- At increasing population densities, density-dependent rates result in
  - declining births and
  - increases in deaths.

Intraspecific competition is
- competition between individuals of the same species for limited resources and
- is a density-dependent factor that limits growth in natural populations.

Limiting factors may include
- food,
- nutrients,
- retreats for safety, or
- nesting sites.
36.5 Multiple factors may limit population growth

- In many natural populations, abiotic factors such as weather may affect population size well before density-dependent factors become important.
- **Density-independent factors** are unrelated to population density. These may include
  - fires,
  - storms,
  - habitat destruction by human activity, or
  - seasonal changes in weather (for example, in aphids).

36.6 Some populations have “boom-and-bust” cycles

- Some populations fluctuate in density with regularity.
- Boom-and-bust cycles may be due to
  - food shortages or
  - predator-prey interactions.
36.7 EVOLUTION CONNECTION: Evolution shapes life histories

- The traits that affect an organism’s schedule of reproduction and death make up its life history.

- Key life history traits include
  - age of first reproduction,
  - frequency of reproduction,
  - number of offspring, and
  - amount of parental care.

- Populations with so-called *r*-selected life history traits
  - produce more offspring and
  - grow rapidly in unpredictable environments.

- Populations with *K*-selected traits
  - raise fewer offspring and
  - maintain relatively stable populations.

- Most species fall between these two extremes.

A long-term project in Trinidad
- studied guppy populations,
- provided direct evidence that life history traits can be shaped by natural selection, and
- demonstrated that questions about evolution can be tested by field experiments.

Hypothesis: Predator feeding preferences caused difference in life history traits of guppy populations.
36.8 CONNECTION: Principles of population ecology have practical applications

- **Sustainable resource management** involves
  - harvesting crops and
  - eliminating damage to the resource.
- The cod fishery off Newfoundland
  - was overfished,
  - collapsed in 1992, and
  - still has not recovered.
- Resource managers use population ecology to determine sustainable yields.

36.9 The human population continues to increase, but the growth rate is slowing

- The human population
  - grew rapidly during the 20th century and
  - currently stands at about 7 billion.
36.9 The human population continues to increase, but the growth rate is slowing

- The **demographic transition**
  - is the shift from high birth and death rates
  - to low birth and death rates, and
  - has lowered the rate of growth in developed countries.

36.9 The human population continues to increase, but the growth rate is slowing

- In the developing nations
  - death rates have dropped,
  - birth rates are still high, and
  - these populations are growing rapidly.

36.9 The human population continues to increase, but the growth rate is slowing

- The **age structure** of a population
  - is the proportion of individuals in different age groups and
  - affects the future growth of the population.
36.9 The human population continues to increase, but the growth rate is slowing

- **Population momentum** is the continued growth that occurs
  - despite reduced fertility and
  - as a result of girls in the 0–14 age group of a previously expanding population reaching their childbearing years.

![Population momentum diagram](image)

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36.10 CONNECTION: Age structures reveal social and economic trends

- Age-structure diagrams reveal
  - a population’s growth trends and
  - social conditions.

![Age structure diagrams](image)

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36.11 CONNECTION: An ecological footprint is a measure of resource consumption

- The U.S. Census Bureau projects a global population of
  - 8 billion people within the next 20 years and
  - 9.5 billion by mid-21st century.
- Do we have sufficient resources to sustain 8 or 9 billion people?
- To accommodate all the people expected to live on our planet by 2025, the world will have to double food production.

An ecological footprint is an estimate of the amount of land required to provide the raw materials an individual or a nation consumes, including
  - food,
  - fuel,
  - water,
  - housing, and
  - waste disposal.
The United States
- has a very large ecological footprint, much greater than its own land, and
- is running on a large ecological deficit.

Some researchers estimate that
- if everyone on Earth had the same standard of living as people living in the United States,
- we would need the resources of 4.5 planet Earths.

You should now be able to
1. Define a population and population ecology.
2. Define population density and describe different types of dispersion patterns.
3. Explain how life tables are used to track mortality and survivorship in populations.
4. Compare Type I, Type II, and Type III survivorship curves.
5. Describe and compare the exponential and logistic population growth models, illustrating both with examples.
You should now be able to

6. Explain the concept of carrying capacity.
7. Describe the factors that regulate growth in natural populations.
8. Define boom-and-bust cycles, explain why they occur, and provide examples.
9. Explain how life history traits vary with environmental conditions and with population density.
10. Compare $r$-selection and $K$-selection and indicate examples of each.

You should now be able to

11. Describe the major challenges inherent in managing populations.
12. Explain how the structure of the world’s human population has changed and continues to change.
13. Explain how the age structure of a population can be used to predict changes in population size and social conditions.
14. Explain the concept of an ecological footprint. Describe the uneven use of natural resources in the world.

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**Figure 36.UN01**
Few large offspring, low mortality until old age
Many small offspring, high mortality

**Figure 36.UN02**

**Figure 36.UN03**

**Figure 36.UN04**

\[ G = rN \frac{(K - N)}{K} \]