Do Now

- In science, how do we define a population?
- What term is given to all the populations inhabiting the same area?
- How do populations affect one another?
DO NOW
EQ: How do populations change?

Population Ecology

Chapter 53
EQ: How do populations change?

Population Ecology

- Population Ecology is concerned with changes in population size & the factors that regulate populations over time.
What is a population?

- A population is a group of organisms of a single species that occupy the same general area.
  - Rely on same resources
  - Influenced by the same environmental factors
  - Likely to interact & breed with one another
Characteristics of Populations

- What characteristics are used to describe a population?
Characteristics of Populations

- Three important characteristics of a population are its:
  - **geographic distribution** (Dispersion)
  - Population density
  - Demographics (including growth rate)
EQ: How do populations change?

Populations are Relative

- Researchers define the boundaries of populations they study.
  - Blue-finned tuna population of the Atlantic Ocean.
    - 1 tuna per 30 miles$^2$
  - Blue-finned tuna population of 1-5 miles off the coast of North Carolina in the Atlantic Ocean.
    - 1 tuna per 5 miles$^2$
Density & Dispersion Patterns

2 Important Variables of a population’s structure:

1. **Population density**
   - Number of individuals per unit area, or volume.
     - Number of oak trees per km$^2$
   - Often uses sampling techniques to estimate actual density

2. **Dispersion Patterns**
   - The way individuals are spaced within their area. 3 types:
     1. Clumping
     2. Uniform
     3. Random
Dispersion Patterns

1.) Clumping dispersion pattern: individuals are grouped in patches (most common in nature).
Dispersion Patterns

2.) Uniform Dispersion Pattern:

- Members of the population are dispersed **evenly**.
- Result of interactions between members of the population.
- Animal territorial behavior
Dispersion Patterns

3.) Random Dispersion Pattern:

- Members of the population are spaced in an unpredictable way. Has no pattern.
  - Windblown seed dispersment, varying habitat conditions, and social interactions.
- Very Rare
What dispersion pattern would you predict in a forest population of termites, which live in damp, rotting wood?

Clumping (in the fallen logs of dead trees)

Why would scientists want to estimate density and dispersion patterns?

To monitor changes in a population and to compare and contrast the growth and stability of populations in different areas.
Life Tables

- **Life Tables** track **survivorship**, the chance of an **individual** in a given population surviving to various ages.
- Used to create **survivorship curves**:
  - **Survivorship curves**: plot survivorship as the proportion of individuals from an initial population that are alive at each age.
Type I Survivorship Curve

- Compared to other organisms, humans have few children and provide them with good care. How do you think the human survivorship curve would appear?
Type II Survivorship Curve

- Type II is intermediate. What would the curve look like if the survivorship is constant over the life span? Individuals are no more vulnerable at one stage than another. Seen in rodents & lizards.
Type III Survivorship Curve

- **How does the chance of survival change with age in organisms with a Type III survivorship curve?**

![Graph showing Type III Survivorship Curve](image)
EQ: How do populations change?
Review

- What is a population?
- Explain the type I, II, & III survivorship curves.
- What 2 Important Variables affect a population’s structure? Explain each.
- Predict factors that could affect population size?
EQ: How do populations change?

Models to Predict Patterns of Population Growth

- **Population sizes fluctuate:**
  - Birthrate vs. Mortality rate
  - Immigration vs. Emigration

- Ecologists use idealized models to predict how the size of a population will change over time under different conditions.
Births and immigration add individuals to a population.

Deaths and emigration remove individuals from a population.
Population Growth

- Population Growth
- Three factors can affect population size:
  - the number of births (birthrate)
  - the number of deaths (mortality rate)
  - the number of individuals that enter or leave the population
- A population can grow when its birthrate is greater than its death rate.

EQ: How do populations change?
EQ: How do populations change?

- You have 4 apples.
- You add 7 apples & take away 3 apples.
- Do you now have more or less apples than you started with?
Population Growth

- **Immigration**, the movement of individuals into an area can cause a population to grow.

- Populations can increase by immigration as animals in search of mates or food arrive from outside.
Population Growth

- Emigration, the movement of individuals out of an area, can cause a population to decrease in size.
  - Emigration can occur when animals leave to find food, mates and establish new territories.
  - A shortage of food in one area may also lead to emigration.

EQ: How do populations change?
The Irish

- The 1845 Potato Famine of Ireland:
  - Invasive fungus (possibly from S. America)
  - Over 1 million Irish starved
  - Over $\frac{1}{2}$ million Irish emigrated out of Ireland and to the US.
  - Constituted $\frac{1}{2}$ the immigrants to America in the 1840s.
EQ: How do populations change?
EQ: How do populations change?
Population growth rate \((dN/dt)\) is the change in population size in a given amount of time.

**IF** (that’s a big if), we ignore immigration and emigration, then the only factors that should affect growth rate should be **birth rate** \((B)\) and **death rate** \((D)\).

- \(N\) = population size
- \(t\) = time
- \(dN\) = change in population size
- \(dt\) = change in time
- \(dN/dt\) = growth rate
  - \(B\) = birth rate
  - \(D\) = death rate
- \(dN/dt = B - D\)

Population growth rate is equal to the rate of births.
2 TYPES OF GROWTH CURVES

- What are exponential growth and logistic growth?
Exponential Growth

- Exponential Growth
  - Under **ideal conditions with unlimited resources**, a population will grow exponentially.
  - Exponential growth occurs when the **individuals in a population reproduce at a constant rate**.
  - The population becomes **larger and larger until it approaches an infinitely large size**.

EQ: How do populations change?
Exponential Growth (J) curve
Exponential Growth Model EQN
\[ \frac{dn}{dt} = rN \]

- \( \frac{dn}{dt} = \) growth rate of the population
- \( N = \) the population size
- \( r = \text{per capita (per person) rate of increase} \)

You have a population of 100 rabbits. In this population there are 50 births but 20 deaths in one month.

What is the net increase?

The \textit{per capita} increase is the net increase/initial population (\( N \))

\[ r = \frac{30}{100} = 0.3 \]
So, if initial population (N) is 100, & per capita growth (r) = .3, we should see an change of + 30 individuals in the first month (\( \frac{dn}{dt} \)). If r remains constant, what will the growth (\( \frac{dn}{dt} \)) equal the next month? & Then the next month?
### Population size ($N$)

**TABLE 36.4A** EXPONENTIAL GROWTH OF RABBITS, $r = 0.3$

<table>
<thead>
<tr>
<th>Time (months)</th>
<th>$N$</th>
<th>$G = rN$</th>
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<tr>
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<td>108</td>
</tr>
<tr>
<td>12</td>
<td>467</td>
<td>140</td>
</tr>
</tbody>
</table>
• The J-shaped curve of exponential growth characterizes some rebounding populations

• For example, the elephant population in Kruger National Park, South Africa, grew exponentially after hunting was banned
EQ: How do populations change?

Logistic Growth

- Logistic Growth
  - In nature, exponential growth does not last long.
Logistic Growth

- As resources become less available, the **growth** of a **population** slows or stops.
- **Logistic growth** occurs when a **population's growth slows** or stops following a period of exponential growth.
  - characterized by an **S-shaped** curve.
Logistic Growth

- **Carrying Capacity**
  - The largest number of individuals of a population that a given environment can support is called its **carrying capacity**.
  - When a population reaches the carrying capacity of its environment, its growth levels off. The average growth rate is zero.

EQ: How do populations change?
Logistic Growth

- **S-shaped** curve.

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

G = Growth Rate  
\( r = \) Per Capita Increase  
N = Initial population  
K = Carrying capacity

EQ: How do populations change?
What could cause a population to reach its carrying capacity?
Limiting Factors

• In the context of populations, a limiting factor is a factor that causes population growth to decrease.

• An example of a limiting factor is a limiting nutrient (limited amount of a certain food source).
Density-Dependent Factors

A limiting factor that depends on population size

Includes:
- competition
- predation
- parasitism
- disease
Density-Dependent Factors

- Density-dependent limiting factors operate only when the population density reaches a certain level.

- If the living space remains constant, as a population's numbers increase, so will the population's density.

- They do not affect small, scattered populations as greatly.

EQ: How do populations change?
EQ: How do populations change?

1st Generation
EQ: How do populations change?

2\textsuperscript{nd} Generation
EQ: How do populations change?

3rd Generation
EQ: How do populations change?

4th Generation
EQ: How do populations change?
EQ: How do populations change?

6th Generation
Density-Dependent Factors

- Competition
- When populations become crowded, organisms compete for food, water space, sunlight, and other essentials.

EQ: How do populations change?
Density-Dependent Factors

- **Competition** can also occur between members of different species.
- This type of competition can lead to evolutionary change.
- Over time, the species may evolve to occupy different niches.
Density-Dependent Factors

• Predation
  • Populations in nature are often controlled by predation.
  • The regulation of a population by predation takes place within a predator-prey relationship, one of the best-known mechanisms of population control.
Density-Dependent Factors

Wolf and Moose Populations on Isle Royale

EQ: How do populations change?
Density-Dependent Factors

- Parasitism and Disease
  - Parasites can limit the growth of a population.
  - A parasite lives in or on another organism (the host) and consequently harms it.
Density-Independent Factors

Density-Independent Factors

Density-independent limiting factors affect all populations in similar ways, regardless of the population size.
Density-Independent Factors

Examples of density-independent limiting factors include:

- unusual weather
- natural disasters
- seasonal cycles
- certain human activities—such as damming rivers and clear-cutting forests
Try on your own

- Draw an exponential population growth curve.
  - Think of an example of an appropriate population and time scale.
  - What is another, one letter, name for this type of curve?
  - Explain situations where this type of population growth could occur.
- What will likely happen to this population if the graph were allowed to continue for an infinite amount of time? Why would the growth rate change?
More questions

- On the same graph you just created, show (using a dotted line) logistic growth.
  - What letter represents this growth curve?
- What are limiting factors?
  - Name a few density dependent limiting factors.
  - Name a few density independent limiting factors.
More review

• What are the three most important characteristics used to describe or define a population?

1.) geographic distribution (Dispersion)

2.) Population density

3.) growth rate
Even More review

- What is a population?
- Explain the type I, II, & III survivorship curves.
- What 2 Important Variables affect a population’s present structure? Explain each.

Population density & dispersion patterns

Give the 3 types of dispersion patterns and an example of organisms that fits each
• Explain how predator-prey relationships can cause both the predator and the prey’s population to ‘boom’ (grow) and ‘bust’ (crash).
EQ: How do populations change?

Boom-and-Bust Cycle

The graph shows the population changes of moose and wolves from 1955 to 1995. The population of moose and wolves exhibit a boom-and-bust cycle, with peaks and valleys that suggest interactions between the two species.
EQ: How do populations change?

Evolution Shapes Life Histories

- **Life History**: Series of events from birth, through reproduction, to death.
- Natural selection shapes a species' life history.
  - **R-selected Life History Traits**:
  - **K-selected Life History Traits**:
Evolution Shapes Life Histories

**R-selected Life History Traits:**
- Many offspring.
- Grow rapidly in unpredictable environments.

**K-selected traits:**
- Few offspring.
- Stable populations.
- Most species fall between these two extremes.

EQ: How do populations change?
Human Populations

EQ: How do populations change?
**Human Populations**

- Human population is expected to continue increasing for several decades
- 95% of the increase is in developing nations

EQ: How do populations change?
EQ: How do populations change?

<table>
<thead>
<tr>
<th>Population</th>
<th>Birth Rate per 1,000</th>
<th>Death Rate per 1,000</th>
<th>Per Capita Rate of Increase (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>20.3</td>
<td>8.5</td>
<td>11.8</td>
</tr>
<tr>
<td>More developed nations</td>
<td>11.1</td>
<td>10.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Less developed nations</td>
<td>22.4</td>
<td>8.0</td>
<td>14.4</td>
</tr>
</tbody>
</table>
EQ: How do populations change?
Human Populations: Momentum

**Population Momentum**: When on average, a woman of a given population exceeds the replacement rate of 2 children/couple.

- **Causes future increase in women of childbearing age**. So population continues to expand.

EQ: How do populations change?
Human Populations: Age Structure

- Age structure diagram
  - Reveals a population’s growth trends
EQ: How do populations change?
EQ: How do populations change?

<table>
<thead>
<tr>
<th>Age</th>
<th>Birth years</th>
<th>Male</th>
<th>Female</th>
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</thead>
<tbody>
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<td>80+</td>
<td>before 1900</td>
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<td>75-79</td>
<td>1901-1905</td>
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<tr>
<td>70-74</td>
<td>1906-10</td>
<td></td>
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<tr>
<td>65-69</td>
<td>1911-15</td>
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</tr>
<tr>
<td>60-64</td>
<td>1916-20</td>
<td></td>
<td></td>
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<tr>
<td>55-59</td>
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<td>50-54</td>
<td>1926-30</td>
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<td>45-49</td>
<td>1931-35</td>
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<td>40-44</td>
<td>1936-40</td>
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<td>35-39</td>
<td>1941-45</td>
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<tr>
<td>30-34</td>
<td>1946-50</td>
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<td>25-29</td>
<td>1951-55</td>
<td></td>
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<td>20-24</td>
<td>1956-60</td>
<td></td>
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<tr>
<td>15-19</td>
<td>1961-65</td>
<td></td>
<td></td>
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<tr>
<td>10-14</td>
<td>1966-70</td>
<td></td>
<td></td>
</tr>
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<td>5-9</td>
<td>1971-75</td>
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</tr>
<tr>
<td>0-4</td>
<td>1976-80</td>
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Population in millions
Total population size = 227,726,463
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<tr>
<th>Age</th>
<th>Birth years</th>
<th>Male</th>
<th>Female</th>
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<tr>
<td>80+</td>
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<td>2001-2005</td>
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Population in millions
Total population size = 295,734,134
### EQ: How do populations change?

<table>
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<tr>
<th>Age</th>
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<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
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<td>before 1951</td>
<td>12</td>
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</tr>
<tr>
<td>75-79</td>
<td>1951-55</td>
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</tr>
<tr>
<td>70-74</td>
<td>1956-60</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>65-69</td>
<td>1961-65</td>
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**Population in millions**

Total population size = 363,811,435
EQ: How do populations change?
U.S. Baby Boomers

EQ: How do populations change?
An ecological footprint is a measure of resource consumption

- U.S. Census Bureau projection
  - 8 billion people within the next 20 years
  - 9.5 billion by mid-21st century
An ecological footprint is a measure of resource consumption

- Ecological footprint helps understand resource availability and usage
- The United States has a
  - Big ecological footprint
  - Large ecological deficit
Human Populations
You should now be able to

1. Explain the factors that determine the characteristics of a population
2. Describe exponential growth and the factors that produce logistic growth of a population
3. Explain the limiting factors that influence population growth
4. Distinguish between $r$- and $K$-strategies
5. Describe and give examples of the different types of life histories
You should now be able to

6. Explain the factors that determine human population growth
7. Describe the concept of ecological footprint
• What are the 3 characteristics of populations that scientists study?

• What do you have specify when describing density? Why?

• What is the difference between density and dispersion?
• Explain the impact of immigration and emigration on population density. (To avoid any confusion, remember this little trick: immigration is the movement into a population, while emigration is the exiting of individuals from a population).
Label the dispersion pattern shown by each population below. Second, and most important, what do the dispersion patterns tell us about those populations and their interactions?
Survivorship curves show patterns of survival. In general terms, survivorship curves can be classified into three groups. Sketch, label and describe the 3 idealized survivorship patterns.
• What will the per capita birth rates be if a population is demonstrating zero population growth?

• What does it mean for a population to be experiencing exponential population growth? Give an example of a population growing this way?
• What is carrying capacity and what does it mean to the populations living in an ecosystem?

• What are 3 examples of limiting resources that can influence carrying capacity?
• In the *Logistic Growth Model*, the per capita rate of increase approaches zero as the ________________________________ is reached.

• In the graph below, explain why the logistic model is an S-shaped curve when the population density is plotted over time. Hint: The critical part of this answer concerns why growth slows as N approaches K.
• Explain the ideas behind the creation of r-selection and K-selection.

• Compare and contrast Density Dependent Factors & Density Independent Factors