Concept 5-2  No population can grow indefinitely because of limitations on resources and because of competition among species for those resources.

Most Populations Live in Clumps

- A **population** is a group of interbreeding individuals of the same species.
- **Populations** are dispersed, or distributed, in 3 different ways: **clumped**, **uniform**, or **random**.
- Most populations live in **clumps**.
- Why **clumps**?
  1. The resources a species needs vary greatly in availability from place to place, so the species tends to cluster where the resources are available.
  2. Individuals moving in groups have a better chance of encountering patches or clumps of resources than they would searching on their own.
  3. Living in groups can help to protect some individuals from predators.
  4. Living in packs gives some predator species a better chance of getting a meal.

Populations Can Grow, Shrink, or Remain Stable

- 4 **variables** govern changes in population size: **births**, **deaths**, **immigration**, and **emigration**.
- **Population Change** = (Births + Immigration) − (Deaths + Emigration)
- A population’s **age structure** (its distribution of individuals among various age groups) can have a strong effect on how rapidly it increases or decreases in size.
- **Age groups** are usually described in terms of:
  - Organisms not mature enough to reproduce (**pre-reproductive age**)
  - Organisms capable of reproduction (**reproductive age**)
  - Organisms too old to reproduce (**post-reproductive age**).
- Populations will **increase** if it is made up of mostly individuals in or about to be in reproductive age.
- Populations will **decrease** in size if made up mostly of individuals past reproductive age.
- When there is a relatively even distribution, populations usually remain **stable**.

Some Factors Can Limit Population Size

- Each population in an ecosystem has a **range of tolerance** to variations in its physical and chemical environment.
- Individuals within a population may have slightly different tolerance levels due to **genetic variation**.
- Populations have an **optimum level or range** where they are most successful.
A number of physical or chemical factors can help determine the number of individuals in a population.

Sometimes, one or more factors, known as limiting factors, are more important than other factors in regulating population growth.

Limiting Factor Principle: Too much or too little of any physical or chemical factor can limit or prevent growth of a population, even if all of the other factors are at or near the optimal range of tolerance.

Terrestrial Limiting Factors include:
- Precipitation
- Soil Nutrients
- Too Much Water or Fertilizer
- Temperature

Aquatic Limiting Factors include:
- Temperature
- Sunlight
- Nutrient Availability
- Dissolved Oxygen Content
- Salinity

No Population Can Grow Indefinitely: J-Curves and S-Curves

- Some species have an incredible ability to increase numbers.
- These populations usually reproduce at an early age, have many offspring each time they reproduce, and reproduce many times, with short intervals between generations. Ex: bacteria
- However, no population can grow indefinitely because of limiting factors and competition for resources.
- In nature, a rapidly growing population reached some size limit imposed by availability of one or more limiting factors.
- There are always limits to population growth in nature.
- Environmental resistance is the combination of all factors that act to limit the growth of a population.
• **Environmental resistance** determines an area’s **carrying capacity**: the maximum population of a given species that a particular habitat can sustain indefinitely.

• The growth rate of a population decreases as its size nears the **carrying capacity**.

• A population with few, if any, limitations on resource supplies can grow **exponentially** at a fixed rates such as 1% or 2% per year.

• **Exponential growth** starts slowly but then accelerates as the population increases because the base size of the population is increasing.

• **Exponential growth** is depicted by a J-shaped curve.

• Eventually **exponential growth** has to stop (due to carrying capacity) and **logistic growth** occurs, depicted by an S-curve.

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**Why Do California’s Sea Otters Face an Uncertain Future?**

- Read the Science Focus on textbook page 114.
- What factors are affecting sea otter populations in California?
- As a keystone species, how do fluctuations in sea otter populations affect other species?
- How does resulting reduced biodiversity upset the food web?

**Case Study: Exploding White-Tailed Deer Populations in the United States**

- Read the Case Study on textbook pages 115-116.
- What factors have contributed to the explosion in white tailed deer populations?
- How have populations of humans and deer affected one another?
- Should humans artificially control deer populations?
- Should hunting rules be changed?
When a Population Exceeds Its Carrying Capacity It Can Crash

- Some species do not make a smooth transition from exponential growth to logistic growth.
- Such populations use up resources and temporarily overshoot, or exceed, the carrying capacity of the environment.
- This occurs because of reproductive lag time: the period needed for birth rate to fall and death rate to rise in response to resource overconsumption.
- In these cases, the population suffers a sharp decline, called dieback, or population crash.

Species Have Different Reproductive Patterns

- Species use different reproductive patterns to help ensure long-term survival.
- Some species have many, usually small, offspring and give them little to no parental care. This is called overproduction.
- Other species tend to reproduce later in life, have a small number of offspring with long life spans, and parents care for offspring. Long generation times make these species vulnerable to extinction.
- Most organisms are between these 2 extremes.


- Population density is the number of individuals in a population found in a particular area or volume.
- Limiting factors can be density-dependent or density-independent.
- Density-Dependent Limiting Factors include:
• Parasitism
• Infectious Disease
• Competition for Resources

• **Density-Independent Limiting Factors** include:
  • Natural Disasters: freezes, floods, hurricanes, fires, etc.
  • Habitat Destruction and Pollution

• **Higher population densities** may help sexually reproducing organisms...easier to find mates.
• But, can also lead to increased competition for mates, food, space, sunlight, water, etc.
• High populations can shield some members from predators (herds or schools), however, large groups are vulnerable to human harvesting.

• **Density-dependent factors** tend to regulate population size, keeping it fairly constant and near carrying capacity.

**Several Different Types of Population Change Occur in Nature**

• In nature, we find 4 general patterns of variation in population size:
  • Stable
  • Irruptive
  • Cyclic
  • Irregular

**Stable Population Size Pattern**

• Population size fluctuates slightly above and below its carrying capacity.
• Characteristic of species found in undisturbed tropical rain forests, where average temperature and rainfall vary little from year to year.

**Irruptive Population Size Pattern**

• Population growth may occasionally surge to a high peak and then crash to a more stable level or, in some cases, to a very low, unstable level.
• Short-lived, rapidly reproducing species such as algae have irruptive population cycles depending on seasons and nutrient availability.

Cyclic Population Size Patterns

• Cyclic or boom-and-bust cycles can happen in populations over a period of time.
• Ex: Lynx and hare populations generally rise and fall in 10 year cycles.
• Top-Down Population Regulation through predation.
• Bottom-Up Population Regulation through scarcity of one or more resources.

Irregular Population Size Patterns

• No recurring patterns in population size.
• This irregular pattern is contributed to some sort of chaos or response to catastrophic population crashes.
Humans are NOT exempt from population crashes.

Ireland experienced a crash after a fungus destroyed its potato crop in 1845. About 1 million people died from hunger or diseases related to malnutrition.

Some people say we can keep expanding our ecological footprint indefinitely because we have technologies. Others say we will reach the limits that nature always imposes on all populations.