
## Ecology

- Study of interrelationships between living things and their nonliving environment.
- **Ecosystems** include everything, biotic and abiotic, within a given area.
  - **Biotic** things are living things.
  - **Abiotic** things are nonliving: soil, water, weather, etc.
- The interacting populations of organisms within an ecosystem form a **community**.

## Population Size

- **Populations** are all the organisms of a particular species that live within an ecosystem.
- The size of a population can fluctuate in response to environmental changes.
- The size is regulated by births, deaths, and migration in or out.
  - **Immigration**: migration in to the ecosystem or population
  - **Emigration**: migration out of the population

## Changes in Population Size =

(Births - Deaths) + (Immigrants - Emigrants)

- A stable population has the same number of individuals joining and leaving.
- In most populations, immigrants and emigrants are negligible.

## Changes in Population Size

- The birth and death rates are limited by two opposing forces within an ecosystem:
- **Biotic potential** is the maximum rate at which a population could increase.
  - In ideal conditions, the biotic potential allows the maximum birth rate and minimum death rate.
- **Environmental resistance** limits the population's ultimate size by increasing deaths and decreasing births.
  - Competition, predation, parasitism, and natural events are tools of environmental resistance.

## Population Growth

- The growth rate of a population is a function of the birth rate and death rate.
  - Birth rate is the number of births per individual during a specific length of time.
  - Death rate is the number of deaths per individual during a specific length of time.

Growth Rate = Birth Rate - Death Rate

R = B - D

## Population Growth

Growth Rate = Birth Rate - Death Rate

**R = B - D**

If B is greater than D

the population size increases.

If D is greater than B

the population will decline.

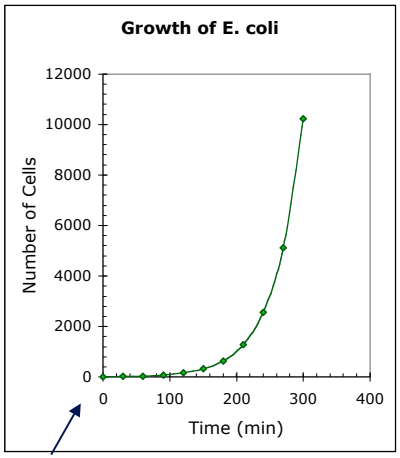
## Exponential Population Growth

- Under optimal conditions, with no environmental resistance, populations will exhibit **exponential growth**.
  - In a given time period, each member of the population will produce an offspring.
  - The population size doubles at fixed intervals, the **doubling time**.

    For example: 2 cells produce 4, 4 become 8, 8 become 16, 16 become 32, 32 become 64, etc.
  - Most bacteria exhibit exponential growth in laboratory settings.

# Exponential Growth

| Time (min) | # Cells |
|---|---|
| 0 | 10 |
| 30 | 20 |
| 60 | 40 |
| 90 | 80 |
| 120 | 160 |
| 150 | 320 |
| 180 | 640 |
| 210 | 1280 |
| 240 | 2560 |
| 270 | 5120 |
| 300 | 10240 |




The typical "J curve" showing exponential growth.

# Exponential Growth

| Time (min) | # Cells |
|---|---|
| 0 | 10 |
| 30 | 20 |
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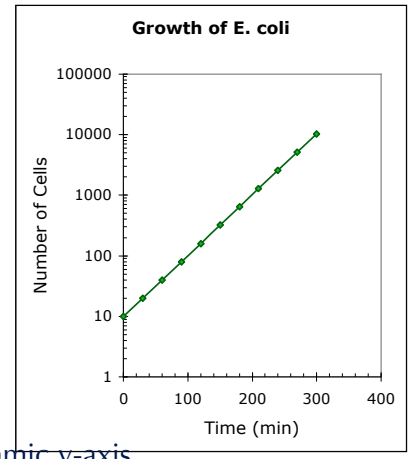



When plotted with an logarithmic y-axis, exponential growth plots as a straight line.

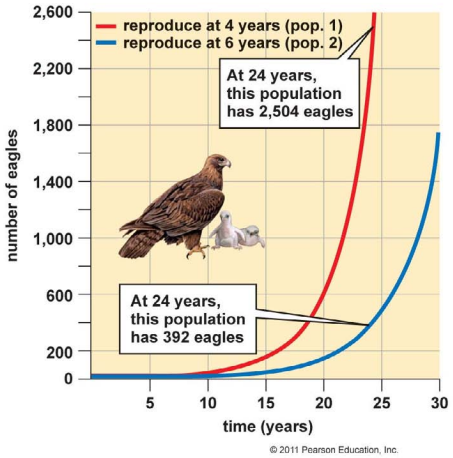
# Exponential Growth

Several factors affect the exponential growth curve:

- The age at which the organism first reproduces
- The frequency of reproduction
- The average number of offspring per reproduction
- The length of an organism's reproductive life span
- The death rate of individuals in the population

# Exponential Growth

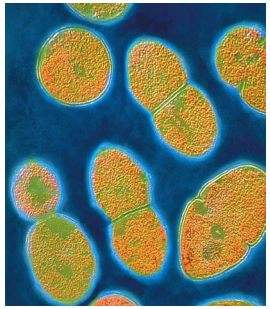
The age at which the organism first reproduces affects population dynamics.

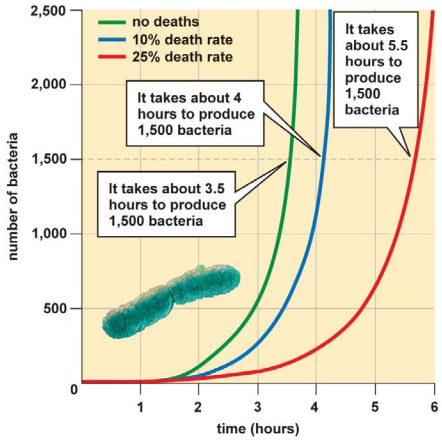



| Time (years) | Number of eagles (pop. 1) | Number of eagles (pop. 2) |
|---|---|---|
| 0 | 2 | 2 |
| 6 | 8 | 4 |
| 12 | 52 | 18 |
| 18 | 362 | 86 |
| 24 | 2,504 | 392 |
| 30 | 17,314 | 1,764 |

# Exponential Growth

The death rate of individuals in the population affects population size.



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# Exponential Growth

- In nature, exponential growth only occurs under special circumstances and only for a limited time.
- **Boom-and-Bust cycles** occur, where populations undergo rapid growth when nutrients are available and rapid die-off when they're used up.

# Boom-and-Bust Cycles

When specific conditions occur (temperature, moisture, nutrient availability, etc.), populations can thrive for short periods of time.

*Karenia brevis*: one cause of red tides.

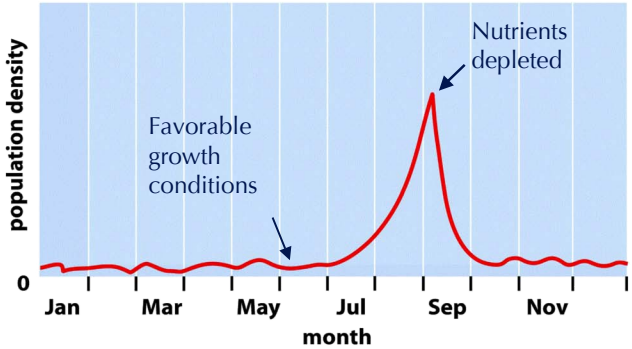


Figure 26-3 Biology: Life on Earth, 8/e
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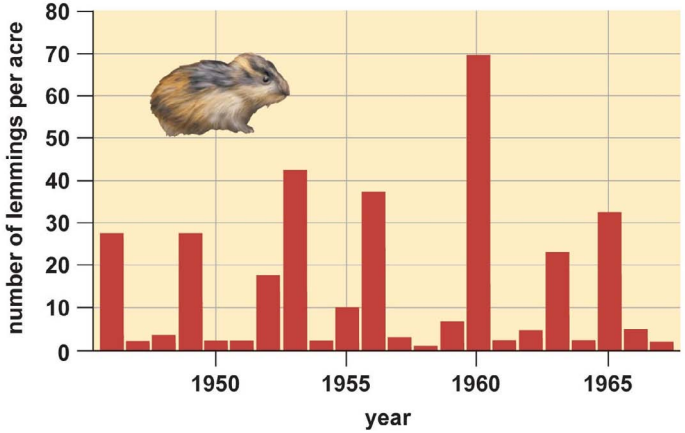
# Boom-and-Bust Cycles




**(b) Boom-and-bust cycles in a lemming population in Alaska**

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# Predator-Prey Population Dynamics

- Populations of snowshoe hares and their lynx predators exhibit boom-and-bust cycles.

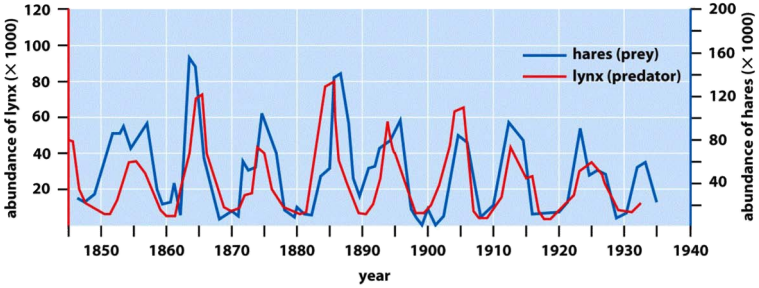



Figure E26-1 Biology: Life on Earth, 8/e


# Exponential Growth

- Exponential growth can occur when environmental resistance is removed.
  - Removal of a predator
  - Introduction into a new ecosystem
- **Invasive species**: organisms with a high biotic potential that are introduced into ecosystems where they encounter little environmental resistance.

# Exponential Growth

In 1940, the whooping crane population had dropped to 20 individuals and was declared protected, removing human predators.

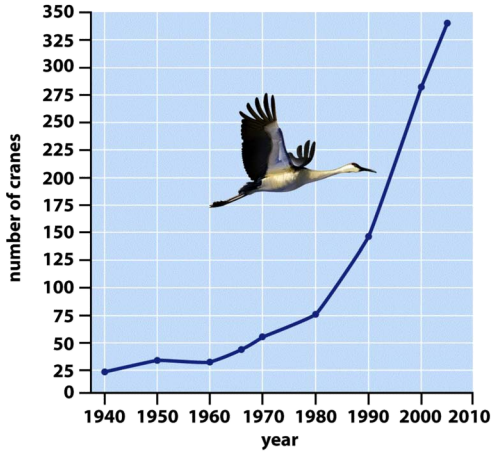



Figure 26-5 Biology: Life on Earth, 8/e



# Exponential Growth

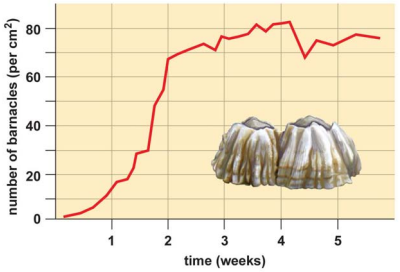
The cane toad was introduced to Australia in 1935 to control cane beetle populations.

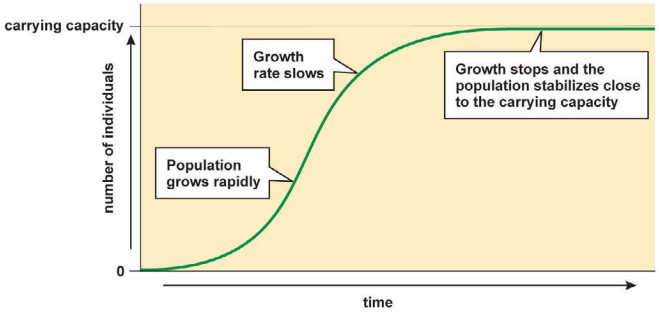
With no predators, the cane toad population has increased exponentially.

# Stabilizing Populations

- Most populations experience **logistic population growth**.
  - Exponential growth up to the maximum number their environment can sustain, then they stabilize.
- The **carrying capacity (K)** is the maximum population size that can be sustained for an extended period of time without damage to the ecosystem.

# Stabilizing Populations



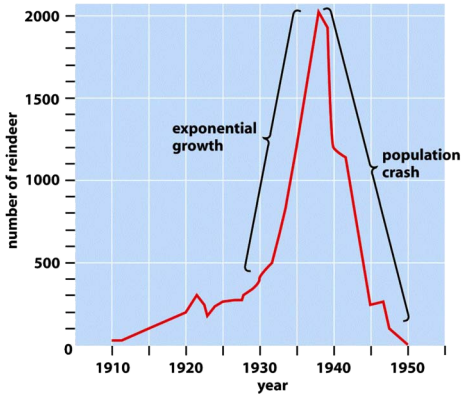




(a) An S-shaped growth curve stabilizes at carrying capacity



When a population exceeds the carrying capacity of the ecosystem, the population usually crashes.

# Exceeding Carrying Capacity




# Limiting Population Size

- Environmental resistance ultimately limits the maximum population size.
- **Density independent factors** limit population size regardless of density.
  - **Density** is the number of individuals per given area.
- **Density dependent factors** are more effective means of limiting population size.

## Density-Dependent Factors

- **Predators**, organisms that feed on other organisms usually by hunting.
  - Prey are those organisms being hunted.
- Predators tend to keep their prey at well below the carrying capacity of the ecosystem.
- Removing or introducing a new predator can alter an entire community.

## Density-Dependent Factors

- **Parasites**, organisms that live on larger organisms feeding off of its host without killing it.
  - The host is the organism targeted by the parasite.
- Parasites spread more rapidly among dense populations.

## Competition for Resources

- **Competition**, interaction among individuals who attempt to use the same limited resource.
  - **Interspecific competition**, among individuals of different species.
  - **Intraspecific competition**, among individuals of the same species.
  - **Contest competition**, use of social or chemical interactions to limit access to important resources, like marking and defending territory.

## How is the Human Population Changing?

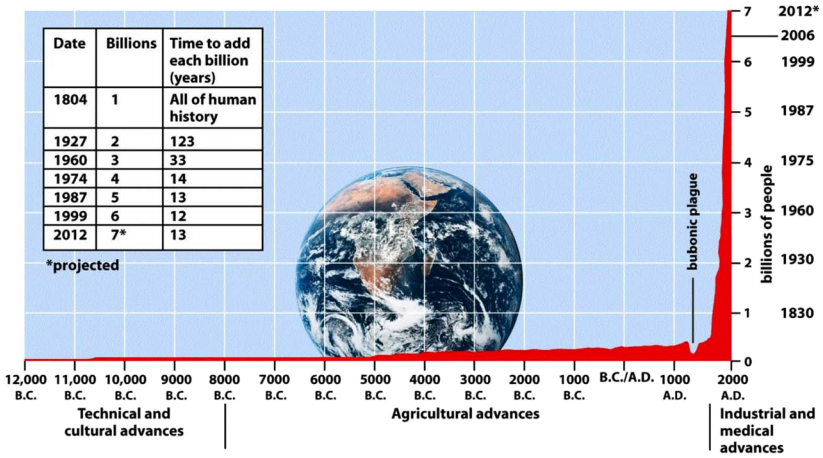



Figure 26-15 Biology: Life on Earth, 8/e

# How is the Human Population Changing?

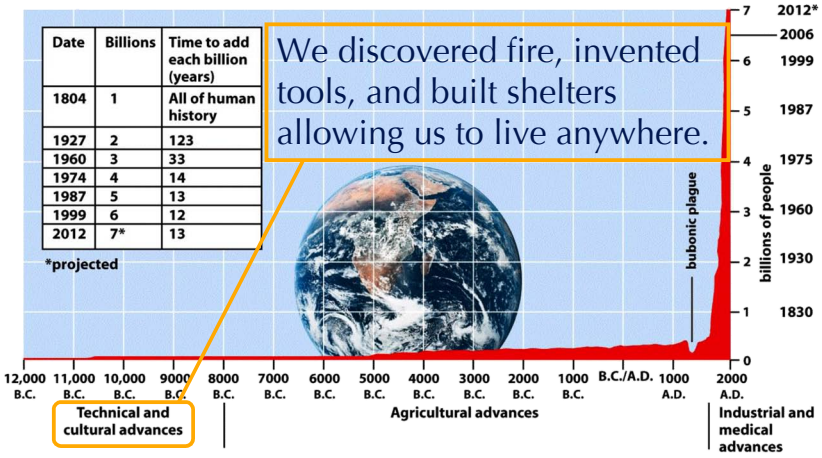



Figure 26-15 Biology: Life on Earth, 8/e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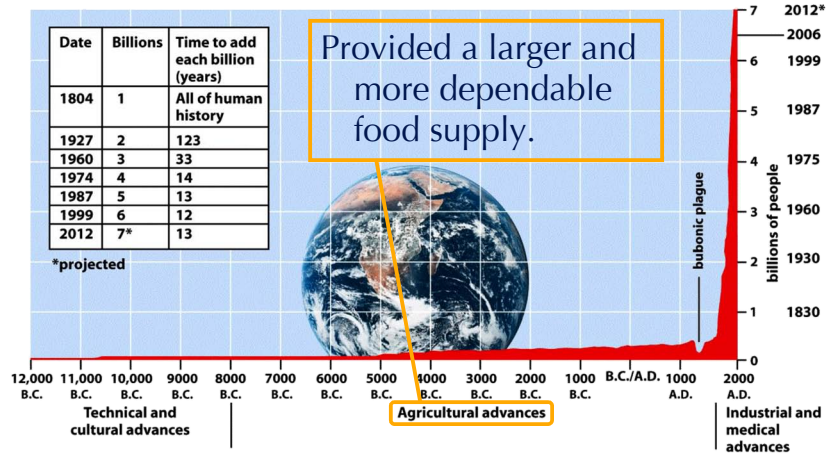


Figure 26-15 Biology: Life on Earth, 8/e


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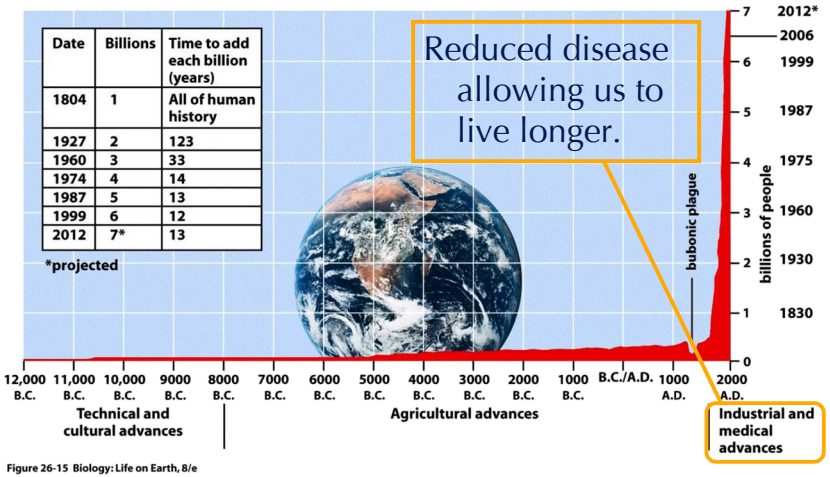



Figure 26-15 Biology: Life on Earth, 8/e


# Population Growth is Unevenly Distributed

In developing countries, medical advances increased life span while maintaining high birth rates.

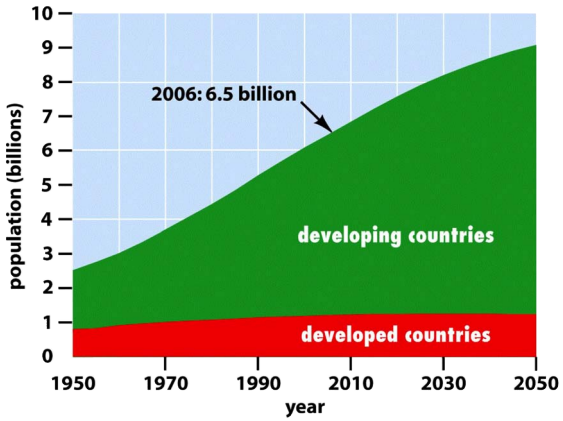
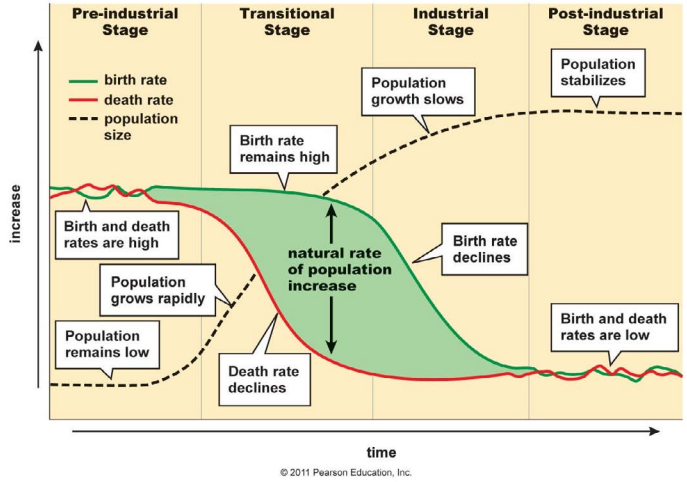


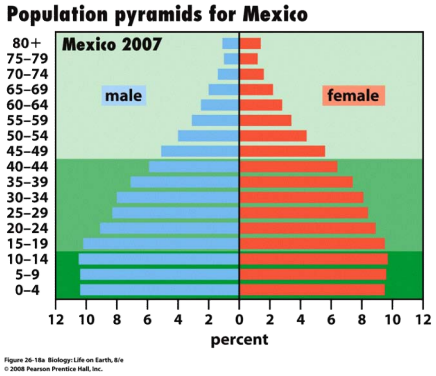

Figure 26-17 Biology: Life on Earth, 8/e

# Demographic Transitions in Population Growth of Nations



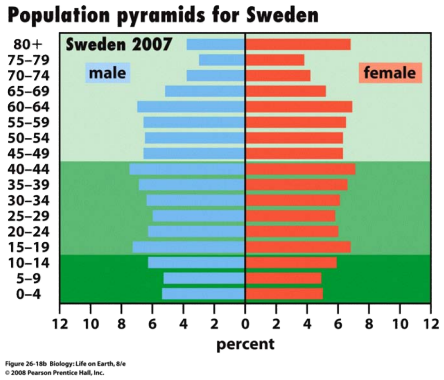

# Population Growth is Unevenly Distributed

- Mexico's population is growing rapidly.




# Population Growth is Unevenly Distributed

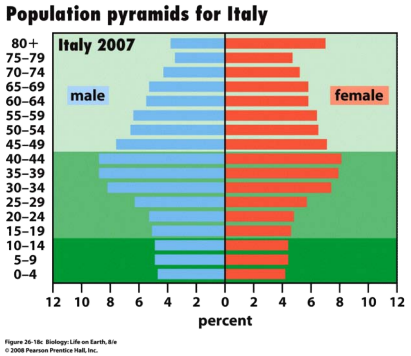
- Sweden's population has stabilized.




Sweden's population has reached **replacement level fertility**: the number of births equals the number of deaths.

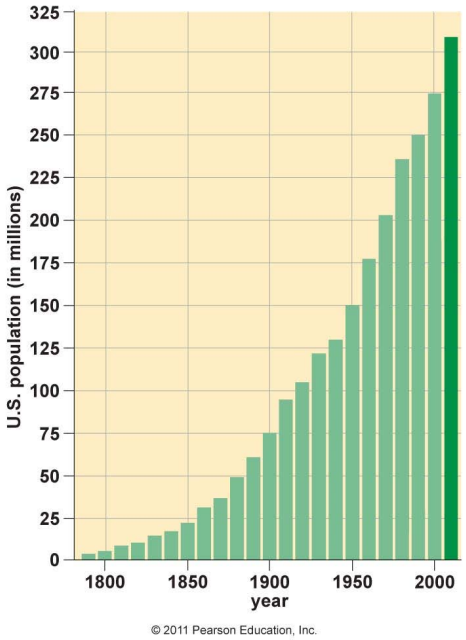
# Population Growth is Unevenly Distributed

- Italy's population, along with most of Europe, is shrinking.



# United States Population Growth

The U.S. is growing at a rate of 1% per year, more than any other developed country!




# Are We Exceeding Earth's Capacity?

- Amount of space and resources we need for all 6.5 billion of us is already 25% over the earth's limits.
  - This does not taking account any space for other species!
- 850 million people are chronically undernourished.
- 1.1 billion people lack clean water.
- 2.6 billion have no sanitation.
- $^{2}/_{3}$ of the world's agricultural land is suffering from erosion.

# Easter Island

- Island off the coast of Chile
- Geologic pollen records suggest a dense covering of forest.
- Humans populated the island for over 2000 years.
- Now, the island has no trees, and no knowledge of the ancient civilization.
- How did these humans exceed the carrying capacity of their island?

# Ecological "Footprints"

- An **ecological footprint** is a measure of a person's environmental impact.
  - Energy Usage
  - Type of home you live in
  - Type of food you eat

**www.myfootprint.org**

- US average = 609 acres each
- Global average = 58 acres each
- Earth's carrying capacity = 43 acres per person

# Homework

- Thinking Through the Concepts, Review Question #9.
- Applying the Concepts #5
- Calculate your ecological footprint at www.myfootprint.org. Name one thing (from the questions they ask) that you could realistically do to decrease your ecological footprint.