HUMAN POPULATION DYNAMICS
Chapter Overview Questions

- What is the history of human population growth, and how many people are likely to be here by 2050?
- How is population size affected by birth, death, fertility, and migration rates?
- How is population size affected by percentages of males and females at each age level?
- How can we slow population growth?
Chapter Overview Questions (cont’d)

- What success have India and China had in slowing population growth?
- What are the major impacts of human activities on the world’s natural ecosystems?
Core Case Study: Is the World Overpopulated?

- The world’s population is projected to increase from 6.6 billion to 8.9 billion between 2006 and 2050.
- The debate over interactions among population growth, economic growth, politics, and moral beliefs is one of the most important and controversial issues in environmental science.
Core Case Study: Is the World Overpopulated?

Much of the world’s population growth occurs in developing countries like China and India.

Figure 9-1
Some argue that the planet has too many people.

Some feel that the world can support billions of more people due to technological advances.

There is a constant debate over the need to reduce population growth.

Must consider moral, religious, and personal freedom.
HUMAN POPULATION GROWTH: A BRIEF HISTORY

The human population has grown rapidly because of the expansion of agriculture and industrial production and lower death rates from improvements in hygiene and medicine.

- In 2006, the population of developed countries grew exponentially at 0.1% per year.
- Developing countries grew (15 times faster at 1.5% per year.)
Where Are We Headed?

We do not know how long we can continue increasing the earth’s carrying capacity for humans.

- There are likely to be between 7.2-10.6 billion people on earth by 2050.
- 97% of growth in developing countries living in acute poverty.
- What is the optimum sustainable population of the earth based on the cultural carrying capacity?
Where Are We Headed?

U.N. world population projection based on women having an average of 2.5 (high), 2.0 (medium), or 1.5 (low) children.
Fig. 9-2, p. 173

The graph shows the projected population growth from 1950 to 2050 under three scenarios: High, Medium, and Low. The High scenario is represented by the red line, which shows the population reaching 10.6 billion by 2050. The Medium scenario, represented by the blue line, predicts a population of 8.9 billion by 2050. The Low scenario, depicted by the green line, forecasts a population of 7.2 billion by 2050.
FACTORS AFFECTING HUMAN POPULATION SIZE

Population increases because of births and immigration and decreases through deaths and emigration.

\[
\text{Population change} = (\text{Births} + \text{Immigration}) - (\text{Deaths} + \text{Emigration})
\]

Instead of using raw numbers, crude birth rates and crude death rates are used (based on total number of births or deaths per 1,000 people in a population).
Age Structure: Young Populations Can Grow Fast

How fast a population grows or declines depends on its age structure.

- **Prereproductive age**: not mature enough to reproduce.
- **Reproductive age**: those capable of reproduction.
- **Postreproductive age**: those too old to reproduce.
Limits on Population Growth: Biotic Potential vs. Environmental Resistance

- No population can increase its size indefinitely.
  - The intrinsic rate of increase \((r)\) is the rate at which a population would grow if it had unlimited resources.
  - Carrying capacity \((K)\): the maximum population of a given species that a particular habitat can sustain indefinitely without degrading the habitat.
Populations grow rapidly with ample resources, but as resources become limited, its growth rate slows and levels off.

Figure 8-4
Exponential and Logistic Population Growth: J-Curves and S-Curves

As a population levels off, it often fluctuates slightly above and below the carrying capacity.

Figure 8-4
Exceeding Carrying Capacity: Move, Switch Habits, or Decline in Size

- Over time species may increase their carrying capacity by developing adaptations.
- Some species maintain their carrying capacity by migrating to other areas.
- So far, technological, social, and other cultural changes have extended the earth’s carrying capacity for humans.
Population Density and Population Change: Effects of Crowding

Population density: the number of individuals in a population found in a particular area or volume.

A population’s density can affect how rapidly it can grow or decline.
  - e.g. biotic factors like disease

Some population control factors are not affected by population density.
  - e.g. abiotic factors like weather
Reproductive Patterns: Opportunists and Competitors

- Large number of smaller offspring with little parental care (r-selected species).
- Fewer, larger offspring with higher invested parental care (K-selected species).

Figure 8-9
### Reproductive Patterns

<table>
<thead>
<tr>
<th>r-Selected Species</th>
<th>K-Selected Species</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cockroach</strong></td>
<td><strong>Elephant</strong></td>
</tr>
<tr>
<td><strong>Dandelion</strong></td>
<td><strong>Saguaro</strong></td>
</tr>
</tbody>
</table>

- **r-selected species** tend to be opportunists while **K-selected species** tend to be competitors.

- Many small offspring
- Early reproductive age
- Most offspring die before reaching reproductive age
- Adapted to unstable climate and environmental conditions
- High population growth rate ($r$)
- Population size fluctuates wildly above and below carrying capacity ($K$)
- Generalist niche
- Low ability to compete
- Early successional species

- Fewer, larger offspring
- High parental care and protection of offspring
- Later reproductive age
- Most offspring survive to reproductive age
- Larger adults
- Adapted to stable climate and environmental conditions
- Lower population growth rate ($r$)
- Population size fairly stable and usually close to carrying capacity ($K$)
- Specialist niche
- High ability to compete
- Late successional species

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Figure 8-10
Many small offspring
Little or no parental care and protection of offspring
Early reproductive age
Most offspring die before reaching reproductive age
Small adults
Adapted to unstable climate and environmental conditions
High population growth rate \((r)\)
Population size fluctuates wildly above and below carrying capacity \((K)\)
Generalist niche
Low ability to compete
Early successional species

Cockroach

Dandelion

r-Selected Species
K-Selected Species

Elephant

Saguaro

Fewer, larger offspring

High parental care and protection of offspring

Later reproductive age

Most offspring survive to reproductive age

Larger adults

Adapted to stable climate and environmental conditions

Lower population growth rate \((r)\)

Population size fairly stable and usually close to carrying capacity \((K)\)

Specialist niche

High ability to compete

Late successional species

Fig. 8-10b, p. 168
Survivorship Curves: Short to Long Lives

- The populations of different species vary in how long individual members typically live.
Early loss

Late loss

Constant loss

Percentage surviving (log scale)

Age

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Fig. 8-11, p. 169
FACTORS AFFECTING HUMAN POPULATION SIZE

Average crude and birth rates for various groupings of countries in 2006.

Figure 9-3
Average crude death rate

- **World**: 21
- **All developed countries**: 11
- **All developing countries**: 23
- **Developing countries (w/o China)**: 27

Average crude birth rate

- **World**: 9
- **All developed countries**: 10
- **All developing countries**: 8
- **Developing countries (w/o China)**: 9
FACTORS AFFECTING HUMAN POPULATION SIZE

The world’s 10 most populous countries in 2006 with projections in 2025.
<table>
<thead>
<tr>
<th>Country</th>
<th>2006</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1.3 billion</td>
<td>1.5 billion</td>
</tr>
<tr>
<td>India</td>
<td>1.1 billion</td>
<td>1.4 billion</td>
</tr>
<tr>
<td>USA</td>
<td>300 million</td>
<td>349 million</td>
</tr>
<tr>
<td>Indonesia</td>
<td>225 million</td>
<td>264 million</td>
</tr>
<tr>
<td>Brazil</td>
<td>187 million</td>
<td>229 million</td>
</tr>
<tr>
<td>Pakistan</td>
<td>166 million</td>
<td>229 million</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>147 million</td>
<td>190 million</td>
</tr>
<tr>
<td>Russia</td>
<td>142 million</td>
<td>130 million</td>
</tr>
<tr>
<td>Nigeria</td>
<td>135 million</td>
<td>199 million</td>
</tr>
<tr>
<td>Japan</td>
<td>128 million</td>
<td>121 million</td>
</tr>
</tbody>
</table>
Declining Fertility Rates: Fewer Babies per Women

The average number of children that a woman bears has dropped sharply.

This decline is not low enough to stabilize the world’s population in the near future.

- **Replacement-level fertility**: the number of children a couple must bear to replace themselves.

- **Total fertility rate (TFR)**: the average number of children a woman has during her reproductive years.
Case Study: Fertility and Birth Rates in the United States

Nearly 2.9 million people were added to the U.S. in 2006:

- 59% occurred because of births outnumbering deaths.
- 41% came from illegal and legal immigration.
In 2006, the total fertility rate in the United States was slightly > 2.0
Case Study: Fertility and Birth Rates in the United States

The **baby bust** that followed the **baby boom** was largely due to delayed marriage, contraception, and abortion.
Fig. 9-6, p. 175

Demographic transition

End of World War II

Births per thousand population

Year

Demographic transition

Depression

Baby boom

Baby bust

Echo baby boom

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**Life expectancy**
- 47 years (1900)
- 77 years (2000)

**Married women working outside the home**
- 8% (1900)
- 81% (2000)

**High school graduates**
- 15% (1900)
- 83% (2000)

**Homes with flush toilets**
- 10% (1900)
- 98% (2000)

**Homes with electricity**
- 2% (1900)
- 99% (2000)

**Living in suburbs**
- 10% (1900)
- 52% (2000)

**Hourly manufacturing job wage (adjusted for inflation)**
- $3 (1900)

**Homicides per 100,000 people**
- 1.2 (1900)
- 5.8 (2000)
Factors Affecting Birth Rates and Fertility Rates

The number of children women have is affected by:

- The cost of raising and educating them.
- Availability of pensions.
- Urbanization.
- Education and employment opportunities.
- Infant deaths.
- Marriage age.
- Availability of contraception and abortion.
Factors Affecting Death Rates

- Death rates have declined because of:
  - Increased food supplies, better nutrition.
  - Advances in medicine.
  - Improved sanitation and personal hygiene.
  - Safer water supplies.

- U.S. infant mortality is higher than it could be (ranked 46th world-wide) due to:
  - Inadequate pre- and post-natal care for poor.
  - Drug addiction.
  - High teenage birth rate.
Case Study: U.S. Immigration

Since 1820, the U.S. has admitted almost twice as many immigrants and refugees as all other countries combined.

Figure 9-8
The number of people in young, middle, and older age groups determines how fast populations grow or decline. The number of people younger than age 15 is the major factor determining a country’s population growth. Changes in the distribution of a country’s age groups have long-lasting economic and social impacts.
HISTOGRAMS (MILLER PG 179)
Populations with a large proportion of its people in the preproductive ages 1-14 have a large potential for rapid population growth.
Expanding Rapidly
Guatemala
Nigeria
Saudi Arabia

Expanding Slowly
United States
Australia
Canada

Stable
Spain
Portugal
Greece

Declining
Germany
Bulgaria
Italy

Prereproductive ages 0–14
Reproductive ages 15–44
Postreproductive ages 45–85+

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32% of the people in developing countries were under 15 years old in 2006 versus only 17% in developed countries.
Today, baby boomers make up nearly half of all adult Americans and dominate the populations demand for goods and services.
PARTS

Broken down by age. You can see the birth rate, maturity rate and death rate of an entire population. Usually broken down by country.
Expansive/rapid growth

Birth rate exceeds the death rate. Population is getting larger. Pyramid shaped histogram.

Ex’s. Kenya, Nigeria and Saudi Arabia.
Bangladesh: 1999

Population (in millions)

Source: U.S. Census Bureau, International Data Base.
Stable/Slow Growth (Zero Growth)

Birth rate almost equals death rate. The population is not getting any larger or is growing very slowly. Histogram shape is straighter and more box-like until about age 45-85.

Ex. US, Australia & Canada has slow growth. Denmark, Austria and Italy has stable growth.
Iceland: 1989

Source: U.S. Census Bureau, International Data Base.
Declining (negative growth)

When the birth rate is smaller than the death rate. The pyramid bulges near the top or is inverted.

Ex. Germany, Bulgaria & Hungary.
Demography

Definition: The study of human populations, their characteristics and changes.
Population Explosion

Anything that causes the population to grow uncontrollably. (Read Miller’s pg 175 & 180)

Ex. Baby boom. 78 Million person increase between 1946-1964. Look at the histogram on pg 180.

(Men came home from the war. These people all had children and so this increase will continue to move up through the country’s age structure as members of this group grow older)
Exponential Growth -

Growth of a population that increases by a fixed percentage of the whole in a given time.

When plotted it looks like the letter J.
Biotic Potential

- Maximum reproductive rate of an organism.
- Of course there are limiting factors for a population.
- For example the common housefly can lay 120 eggs in each generation. If nothing hurt the eggs or the flies, in 7 generations there would be 6,182,442,727,320 flies.
Human predictions

- If there was a continued growth and not death, food would run short and available space would run out.
- But, humans can’t reproduce as fast as other animals.
- This helps to stop the growth.
Demographic Measures

Statistics about people, such as births, deaths, and where they live as well as total population size.
Density - number of people in a certain space.

Birth rate (natality) - the number of births in a year per 1,000 people.

Death Rate (mortality) - the number of deaths in a year per 1,000 people.
What factors affect death rates?

1. Increased food supplies and distribution
2. Better nutrition
3. Improvements in medical & public health technology (ex. immunizations and antibiotics)
4. Improvements in sanitation & personal hygiene
5. Safer water supplies to stop spread of infectious disease
Growth Rate - includes birth rate, death rate, immigration and emigration

Doubling time - The time it takes for the population to double the number of people

Gross National Product - The most commonly used measure of the economic growth of a country.
**Immigration** - People coming into the population

**Emigration** - The movement of people out of the population.

**Net Migration** - Total number of people moving into or out of the population.
Infant mortality rate - Number of child/infant deaths.

If a mother lives in an area with a high infant mortality rate she will tend to have a lot of children to ensure some will make it to adulthood.
Zero Population Growth - When the number of births, equals the number of deaths. No growth in the population.

Total Fertility Rate - an estimate of the average number of children a woman will have during her childbearing years.
Replacement-level fertility - the number of children a couple must bear to replace themselves. It is slightly higher than two children per couple. (2.2 in developed countries and as high as 2.5 in some developing countries)

It is greater in countries with high infant mortality rates than in countries with low infant mortality rates.
Age structure - Percentage of the population at each age level in a population

Generation time - the time it takes for 1 generation to pass.
**Growth rate**

\[(\text{Birth rate-death rate}) + (\text{immigration} - \text{emigration}) / 10\]

If a population of 10,000 experiences 100 births, 40 deaths, 10 immigrants and 30 emigrants in a year, what is the net annual percentage growth rate?
Figure 11-5  The world’s 10 most populous countries in 2000, with projections of their population size in 2025. In 2000, more people lived in China than in all of Europe, Russia, North America, Japan, and Australia combined. (Data from World Bank and Population Reference Bureau)
Rule of 70’s

Doubling Time = 70/growth rate
Demographics of Countries
Developing Countries-

- China is the largest but has taken drastic population control methods.
- By 2050, India is predicted to pass it. Pakistan is projected to become 3rd with Iran and Ethiopia following.
- However, Russia is losing 600,000 people a year, after being the 4th largest country in 1950. This is because of environmental pollution, hyperinflation, crime, corruption, disease and despair.
For more than five decades, India has tried to control its population growth with only modest success.

Since 1970, China has used a government-enforced program to cut its birth rate in half and sharply reduce its fertility rate.
Total fertility rate

- India: 2.9 children per woman (down from 5.3 in 1970)
- China: 1.6 children per woman (down from 5.7 in 1972)

Illiteracy (% of adults)

- India: 17%
- China: 47%

Population under age 15 (%)

- India: 20%
- China: 36%

Population growth rate (%)

- India: 1.6%
- China: 0.6%

GDP PPP per capita

- India: $3,120
- China: $5,890

Fig. 9-15, p. 186
India’s Failed Family Planning Program

- Poor planning.
- Bureaucratic inefficiency.
- Low status of women.
- Extreme poverty.
- Lack of administrative financial support.
- Disagreement over the best ways to slow population growth.
China’s Family Planning Program

Currently, China’s TFR is 1.6 children per women.

China has moved 300 million people out of poverty.

Problems:

- Strong male preference leads to gender imbalance.
- Average population age is increasing.
- Not enough resource to support population.
India’s Failed Family Planning Program

- Poor planning.
- Bureaucratic inefficiency.
- Low status of women.
- Extreme poverty.
- Lack of administrative financial support.
- Disagreement over the best ways to slow population growth.
Developed countries

Usually don’t have such population problems. It can be linked to poverty level even in developed countries.
Demographic Transition: As countries become economically developed, their birth and death rates tend to decline.

- Preindustrial stage: little population growth due to high infant mortality.

- Transitional stage: industrialization begins, death rates drops and birth rates remain high.

- Industrial stage: birth rate drops and approaches death rate.
Generalized model of demographic transition.

Some developing countries may have difficulty making the demographic transition.
Birth rate
Death rate
Total population

Stage 1
Preindustrial

Stage 2
Transitional

Stage 3
Industrial

Stage 4
Postindustrial

Growth rate over time
Birth rate and death rate (number per 1,000 per year)

Low
Increasing
Very high
Decreasing
Low
Zero
Negative

High
Low

Fig. 9-14, p. 183
Demographic stages in countries-

As countries becomes industrialized their birth rates decline.
Pre-industrial

Harsh living conditions lead to a high birth rate and high death rate. Thus, there is little population growth.
Transitional

- As industrialization begins, food production rises and health care improves.
- Death rates drop and birth rates remain high.
- The population grows rapidly.
Industrialization is wide spread. The birth rate drops and eventually approaches the death rate. This is because of:

- better access to birth control
- decline in the infant mortality rate
- increased job opportunities for women
- the high cost of raising children who don’t enter the work force until after high school or college.
Postindustrial

- The birth rate declines even further, equaling the death rate and thus reaching zero population growth.
- Then, the birth rate falls below the death rate and the total population size slowly decreases.

(Cont....)
37 countries have reached this stage. (mainly in W. Europe)
To most population experts, the challenge is to help the remaining 88% of the world to get to this stage.
U.S. Statistics

Because of the ‘Baby Boom’ the US has a bulge in the pyramid with people in their 50’s-60’s.

There are also more women than men in the older age group because of differences in longevity between the sexes.

(Cont...)
The US has a high % of retired people because of long life expectancy. This makes us realize the importance of social security, etc.

The US is considered a slow growth population.
Environmental Impact
Environmental Impact Equation  
*(Paul Ehrlich Formula)*

Population X affluence X technology = Environmental impact
Developed Countries

- High rates of resource use
- Result in high levels of pollution and environmental degradation per person
- These are believed to be the key factors determining overall environmental impact.

(Cont....)
It is estimated that a US citizen consumes 35 X’s as much as the average citizen of India and 100 X’s as much as the average person in the world’s poorest countries. (Cont...)
Thus, poor parents in a developing country would need 70-200 kids to have the same lifetime environmental impact as 2 typical US kids.
Urbanization

What happens? Slums, fecal snow, disease

This problem doesn’t exist too much in the US because of better working & housing conditions & air and water quality being improved.

(Cont....)
Urban areas must import most of its food, water, energy, minerals, & other resources.

They produce enormous quantities of wastes that can pollute the air, water & land.

44% of the world’s people live in urban areas that occupy only 5% of the world’s land & they consume 75% of the world’s resources.
Reasons for World Hunger Issues

- Unequal distribution of available food
- Loss of arable land
- Increasing population growth rate
- Increasing poverty in developing countries
Reasons the human population has been so dramatic in the last century

- The Industrial Revolution
- Modern Medicine
Strategies for ensuring adequate nutrition for a growing population:

- Increase the number of new food crops from a diversity of plant species
- Distribute food more equitably
- Increase land area that is dedicated to grain production rather than meat production
- Assist developing countries in efficient crop irrigation systems.
Fertility rates & reduction

- Environmental pressures of urbanization from population growth are reduced because birth rates in urban areas usually are 3-4 X’s lower than in rural areas.

- Cities provide education opportunities.
Some countries, including China, penalize couples who have more than one or two children by:

1. Raising their taxes
2. Charging other fees
3. Eliminating income tax deductions for a couple’s third child
4. Loss of health-care benefits, food allotments and job options
In China couples who pledge to have no more than one child receive

1. Extra food
2. Larger pensions
3. Better housing
4. Free medical care
5. Salary bonuses
6. Free school tuition for their one child
7. Preferential treatment in employment when their child enters the job market.
However, according to some studies, there is a strong preference for male children.

1. Girls are aborted at a higher rate than boys

2. Some infant girls are killed

3. Male children sometimes are fed better than female children.
SOLUTIONS: INFLUENCING POPULATION SIZE

Family planning has been a major factor in reducing the number of births and abortions throughout most of the world.

Women tend to have fewer children if they are:
- Educated.
- Hold a paying job outside the home.
- Do not have their human right suppressed.
SOLUTIONS: INFLUENCING POPULATION SIZE

The best way to slow population growth is a combination of:

- Investing in family planning.
- Reducing poverty.
- Elevating the status of women.
Factors that affect birth & fertility rates

- Importance of kids in labor force
- Urbanization
- Cost of raising & educating kids
- Availability of private & public pensions
- Religious beliefs, traditions & cultural norms
- Educational & employment opportunities
- Infant mortality rate
- Average age at marriage
- Availability of reliable birth control
Figure 11-27 Estimated global use of contraceptive methods in the 1990s by married women, ages 15–49. (Data from United Nations)

- Female sterilization: 17%
- Male sterilization: 5%
- Condom: 5%
- Pill: 8%
- Other methods: 10%
- IUD: 12%
- No method: 43%
Encouraged action to stabilize the world’s population at 7.8 billion by 2050, instead of the projected 11-12.5 billion.
The major goals are to:

- Provide universal access to family-planning services.
- Improve the health care of infants, children & pregnant women.
- Encourage development of national population policies.
- Improving the status of women by expanding education & job opportunities.
Major goals continued:

- Increase access to education for girls
- Increase men’s involvement in child-rearing responsibility & family planning
- Take steps to eradicate poverty
- Reduce & eliminate unsustainable patterns of production & consumption.
Annual Rate of Natural Population Change (\%) =

\[
\frac{\text{Birth rate} - \text{Death rate}}{1,000 \text{ people}} \times 100
\]
Declining Fertility Rates: Fewer Babies per Women

- The replacement level to sustain a population is 2.0 children.
- In 2006, the average global Total Fertility Rate was 2.7 children per woman.
  - 1.6 in developed countries (down from 2.5 in 1950).
  - 3.0 in developing countries (down from 6.5 in 1950).
We have used technology to alter much of the rest of nature in ways that threaten the survival of many other species and could reduce the quality of life for our own species.
Reduction of biodiversity

Increasing use of the earth's net primary productivity

Increasing genetic resistance of pest species and disease-causing bacteria

Elimination of many natural predators

Deliberate or accidental introduction of potentially harmful species into communities

Using some renewable resources faster than they can be replenished

Interfering with the earth's chemical cycling and energy flow processes

Relying mostly on polluting fossil fuels