Population Biology

POPULATIONS

- Population-all of the individuals of a species that live together in one place at one time.

KEY FEATURES OF POPULATIONS

1. **Population size**
   - is the number of individuals in a population.
   - has an important effect on the ability of the population to survive.
   - A small population is more likely to become extinct:
   - in the case of random events or natural disaster
   - due to inbreeding where the population is more genetically alike. Recessive traits are more likely to appear.
   - with reduced variability it is harder to adapt to changes.

KEY FEATURES OF POPULATIONS

Population density

- the number of individuals in a given area.
- if they are too far apart they may only rarely encounter one another resulting in little reproduction.

KEY FEATURES OF POPULATIONS
Population size is limited by:

density-dependent factors

- Disease
- Competition
- Predators
- Parasites
- Food
- Crowding

- The greater the population, the greater effect these factors have.
- Ex. Black plague in the Middle Ages – more deaths in cities

density-independent factors

- Volcanic eruptions
- Temperature
- Storms
- Floods
- Drought
- Chemical pesticides
- Major habitat disruption (as in the New Orleans flooding)

- Most are abiotic factors

Growth of Populations

- When Populations have nothing to limit their growth they will grow unchecked.

- The maximum size that a population can reach is referred to as Biotic potential

Biotic Potential

- **Population Size is the present number of a certain species**
- **Population growth is the increase of a population size in a certain period of time**
- **Biotic potential is the maximum number of organisms of one species that an environment can maintain**
- **Limiting factors are anything that would keep a population from reaching its biotic potential**

Biotic Potential

- Ability of populations of a given species to increase in size
  - Abiotic Contributing Factors:
    - Favorable light
    - Favorable Temperatures
    - Favorable chemical environment - nutrients
  - Biotic Contributing Factors:
    - Reproductive rate
    - Generalized niche
    - Ability to migrate or disperse
    - Adequate defense mechanisms
    - Ability to cope with adverse conditions

Multiple factors may limit population growth

- declining birth rate or increasing death rate

- The regulation of growth in a natural population is determined by several factors
  - Disease
  - limited food supply
  - the buildup of toxic wastes
  - increased disease
  - predation

Population Growth Curve

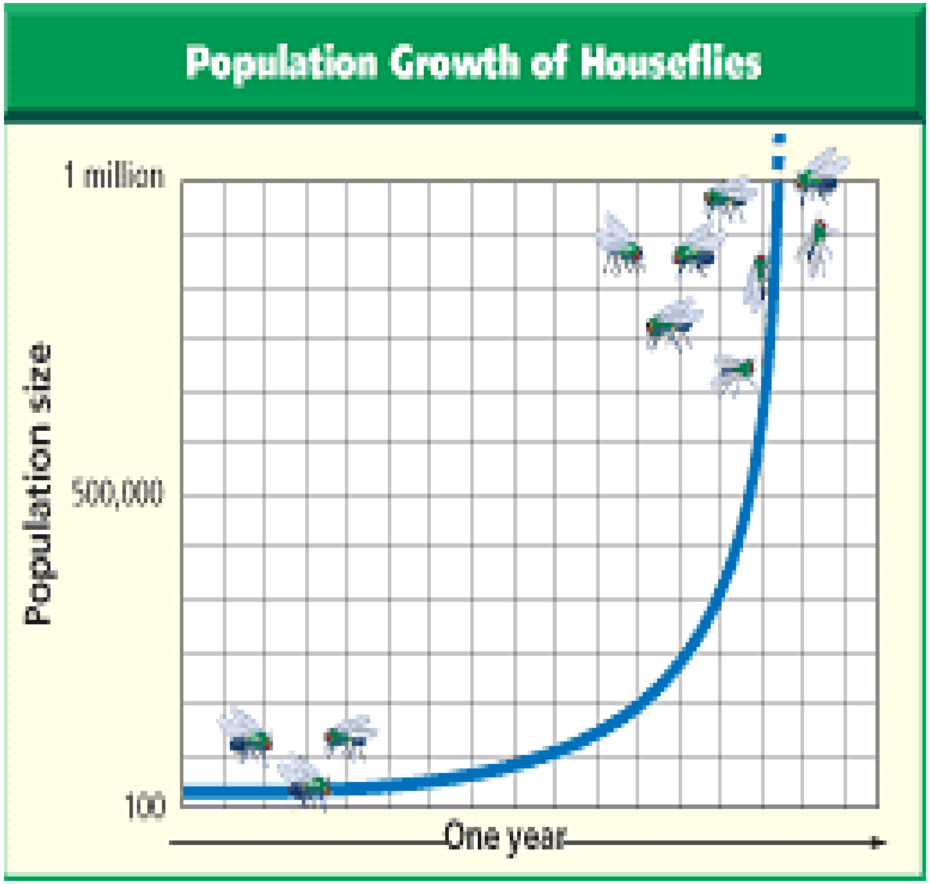
- When you observe a population that has no or few limiting factors the curve is a J curve
- An environment cannot maintain a J curve population growth.
- So in reality the curve has to turn into a S curve

Population Growth

- Populations show two types of growth
  - Exponential
    - J-shaped curve
    - Growth is independent of population density
  - Logistic
    - S-shaped curve
    - Growth is not independent of population density

PREDICTING POPULATION GROWTH

- Exponential growth curve: population growth plotted against time. (J curve)
- As a population gets larger, it also grows at a faster rate.
- This is the maximum population growth under ideal circumstances.
- Includes plenty of room for each member, unlimited resources (food, water) and no hindrances (predators).



FACT: No population exhibits this type of growth for long.

PREDICTING POPULATION GROWTH

- Logistic model: This model accounts for the declining resources available to populations as they grow.
- It assumes the birth and death rates are not constant.
- As the population grows, births decline and death rises.
- Eventually birth=death so the population stops growing.

- Carrying capacity (K): The number of organisms of one species that an environment can support indefinitely.

PREDICTING POPULATION GROWTH

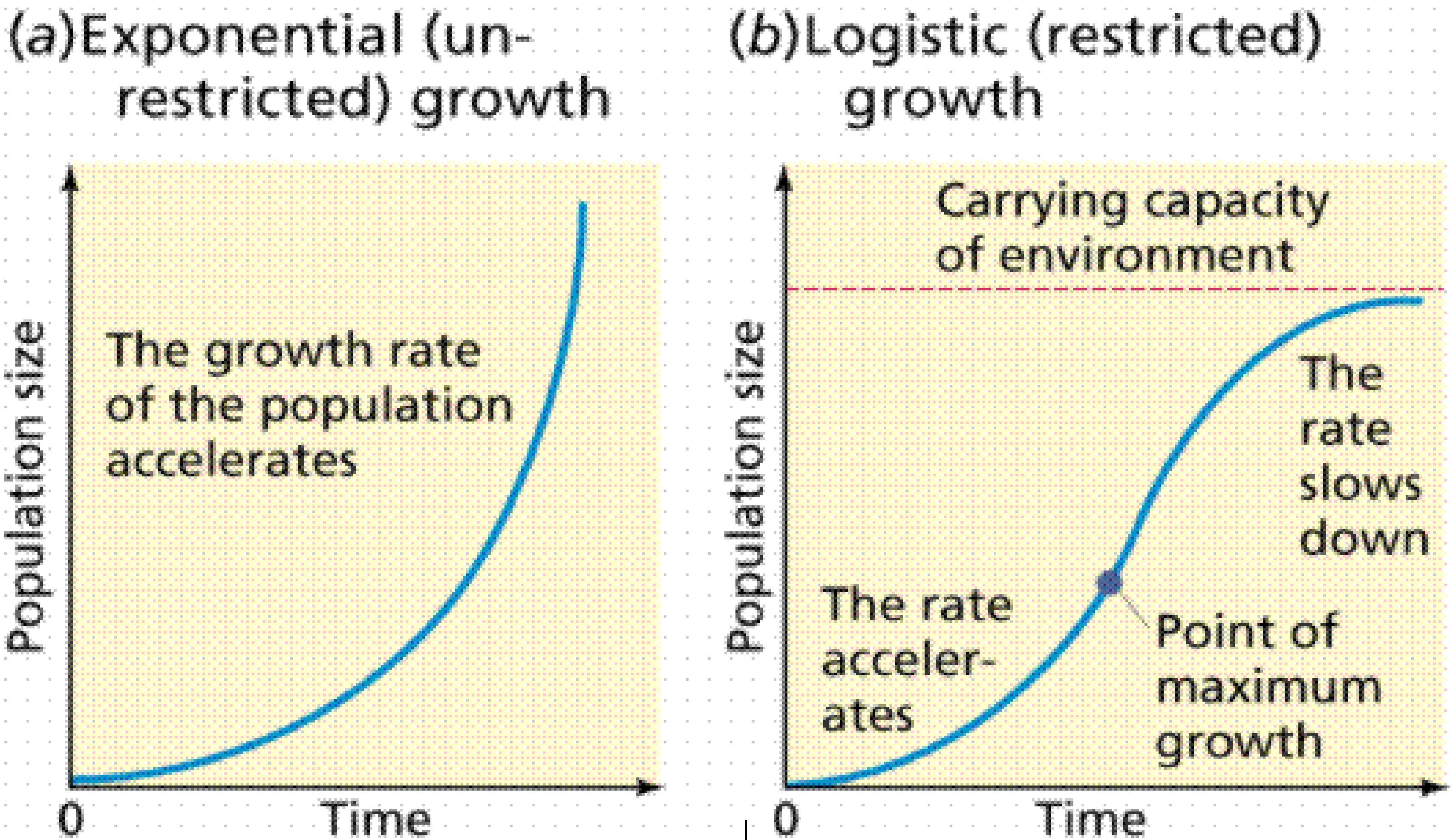
- Nearly all populations will tend to grow exponentially as long as there are resources available.
- Two of the most basic factors that affect the rate of population growth are the birth rate, and the death rate.
- r(rate of growth)=birth rate – death rate

Exponential Growth

- In elephants, one female will produce 6 young over her 100 year life span. In a population, this amounts to a growth rate of 2%
- How many elephants could result from one male and one female in 750 years?

19,000,000 elephants!!!

PREDICTING POPULATION GROWTH, Two modes of population growth.



The Exponential curve (also known as a J-curve) occurs when there is no limit to population size.

The Logistic curve (also known as an S-curve) shows the effect of a limiting factor (in this case the carrying capacity of the environment).

Reproductive Strategies

- Goal of every species is to produce as many offspring as possible
- Each individual has a limited amount of energy to put towards life and reproduction
- This leads to a trade-off of <u>long life</u> or <u>high reproductive rate</u>

POPULATION GROWTH
Strategists

There are 2 ways a population can prosper:

1. Depends on the rate of growth (r)
2. Influenced by the carrying capacity (K)

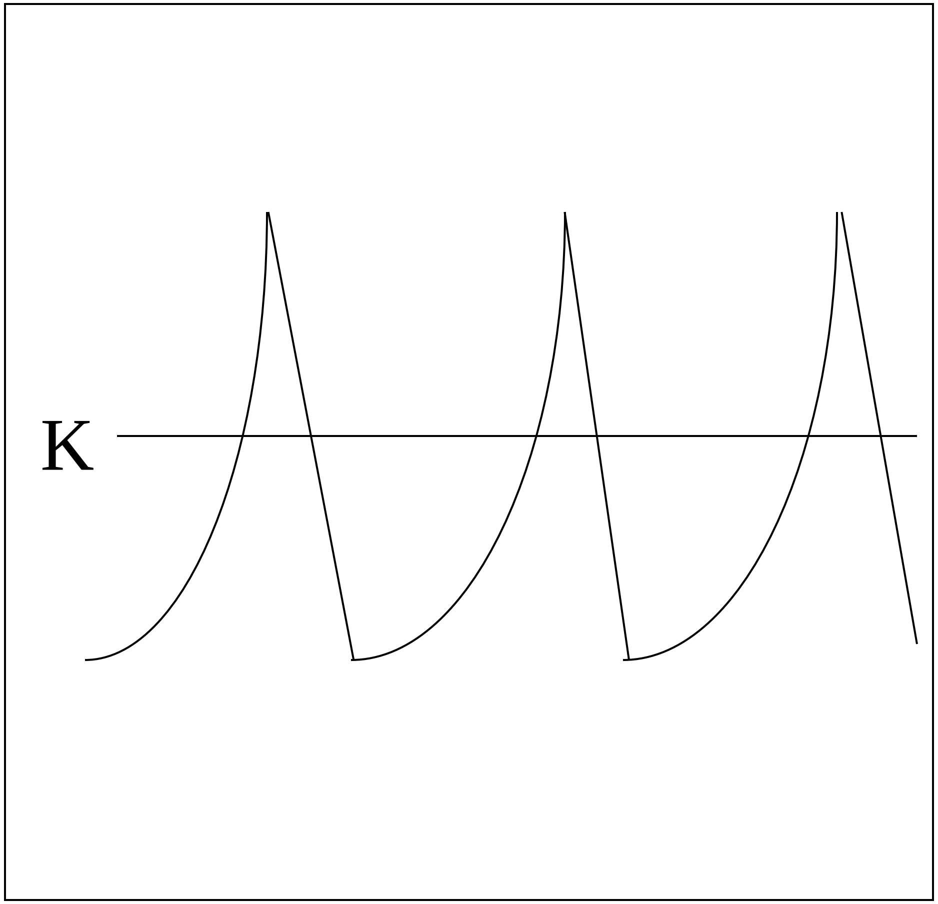
POPULATION GROWTH STRATEGIES

-Growth **Strategists** #1 (r strategy) characterized by exponential growth, which results in temporarily large populations, followed by sudden crashes in population size. Ex. Insects, bacteria, some plants

- live in unpredictable and rapidly changing environments
- Reproduce quickly when conditions are favorable
- Many offspring: small, mature rapidly, no parental care
- r = rate of growth

r - Strategists

- Spend most of their time in exponential growth
- Maximize reproductive life
- Minimum life



r Strategists

- Many offspring
- Small
- 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

J Curve

Time	Number of Cells	
0 minutes	1	$= 2^0$
20	2	$= 2^1$
40	4	$= 2^2$
60	8	$= 2^3$
80	16	$= 2^4$
100	32	$= 2^5$
120 (= 2 hours)	64	$= 2^6$
3 hours	512	$= 2^9$
4 hours	4,096	$= 2^{12}$
8 hours	16,777,216	$= 2^{24}$
12 hours	68,719,476,736	$= 2^{36}$

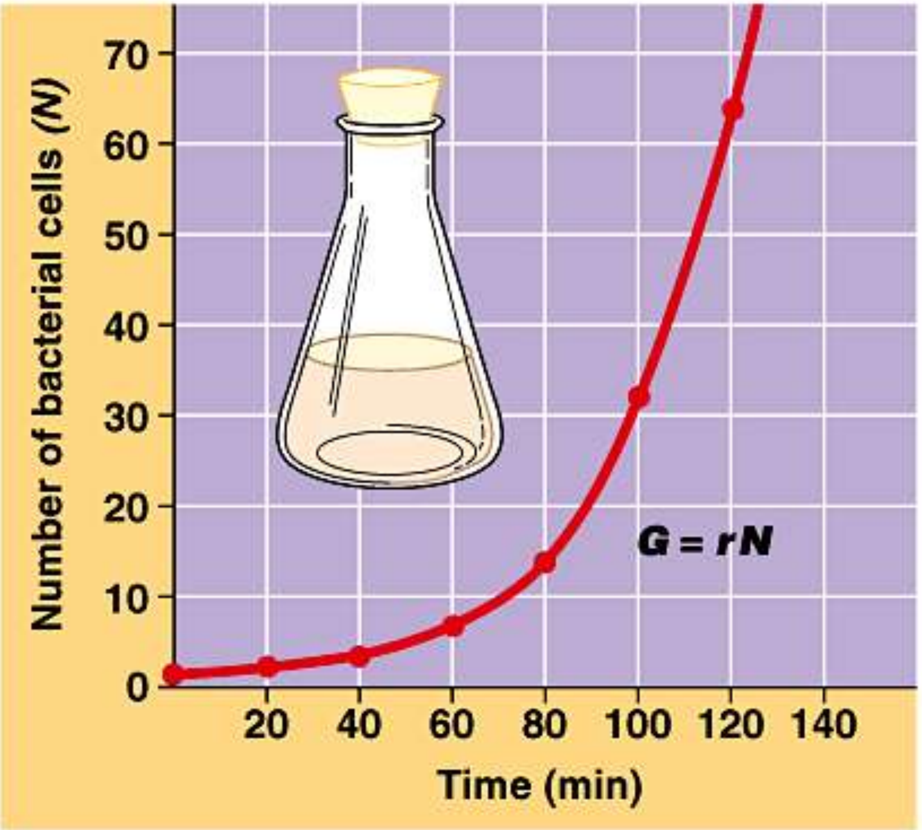


Figure 35.3A

POPULATION GROWTH
Strategists

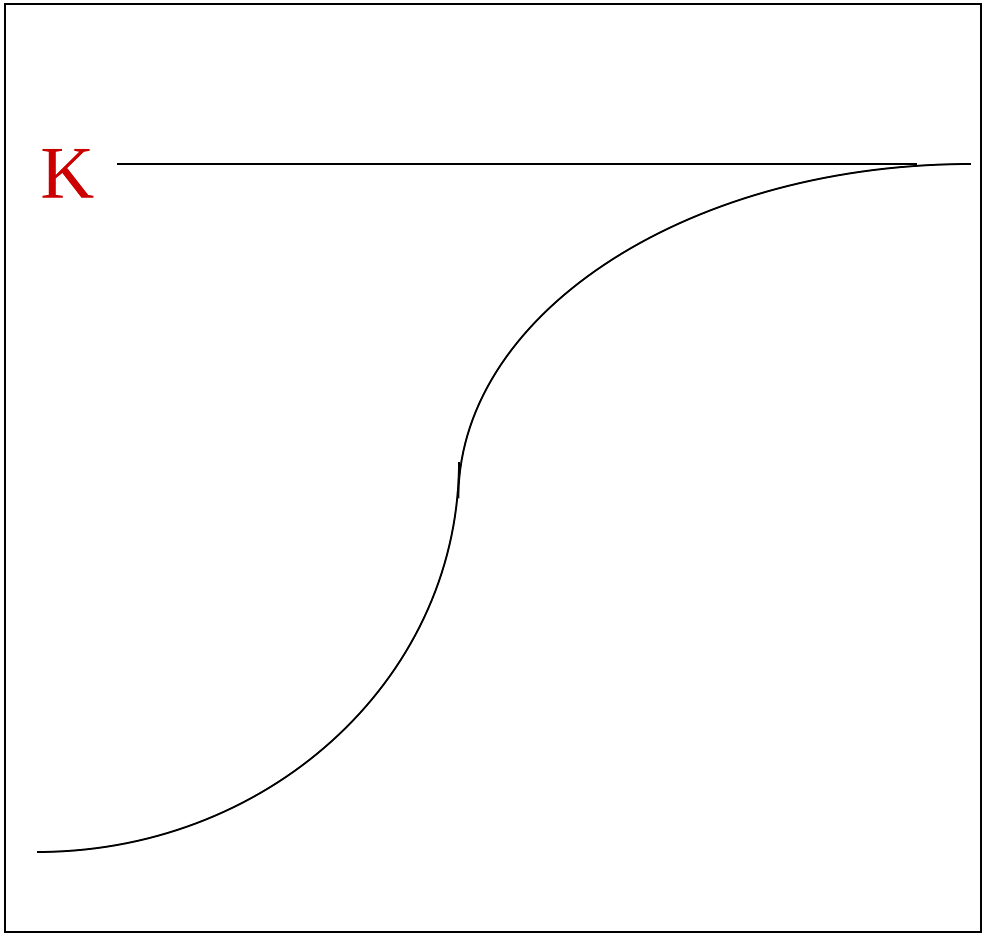
-*Growth Strategy #2 (K*-strategy): characterized by a high degree of specialization. Ex. Trees, whales, tigers, etc.

- Live in stable and predictable environments
- Can compete effectively
- Reproduce late in life
- Few offspring: large, mature slowly, often much parental care
- *K* = carrying capacity

K - Strategists

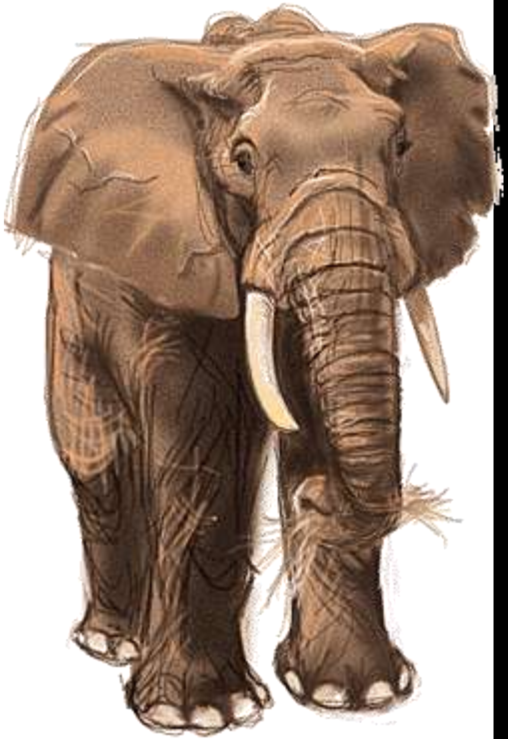
- Maintain population at carrying capacity (K)

- Maximize lifespan



K- Strategist

- **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**



2. <u>Logistic growth</u> is slowed by population-limiting factors that result in an s curve because and reach carring capacity

- Carrying capacity is the maximum population size that an environment can support

S curve

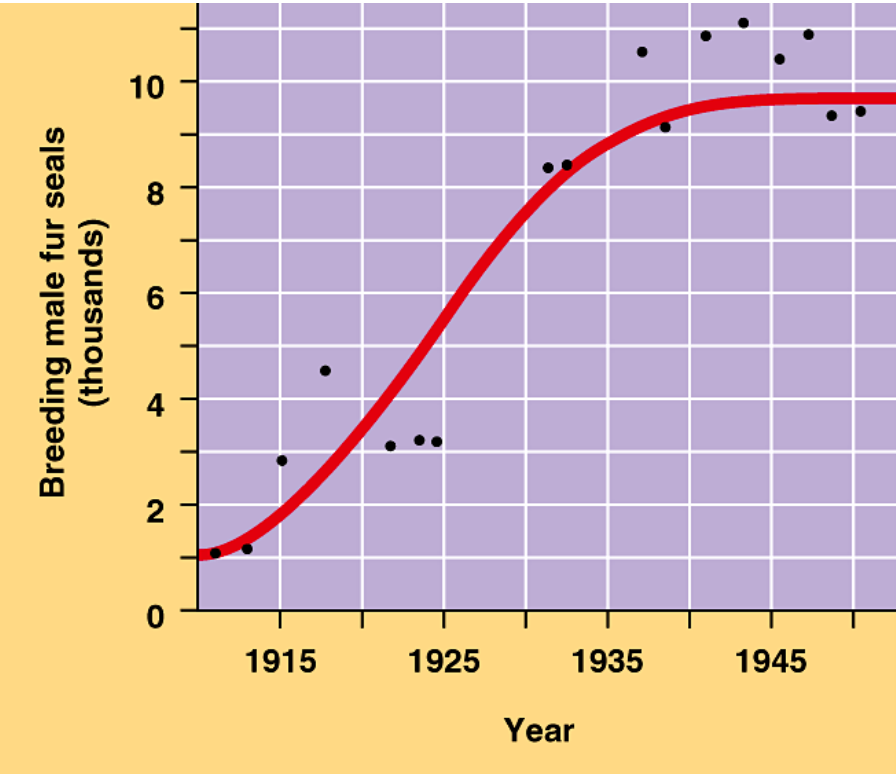


Figure 35.3B

Emigration vs immigration

- Emigration - When an area becomes unsuitable organisms will move out of the area to find a better area.
- Immigration – When organism moves into an area to find a better environment.

Population Size

- Natality
  - Number of individuals added through reproduction
  - Total Fertility Rate – Average number of children born alive per female in her lifetime

- Mortality
  - Number of individuals removed through death

– About every 10 years, both hare and lynx populations have a rapid increase (a "boom") followed by a sharp decline (a "bust")

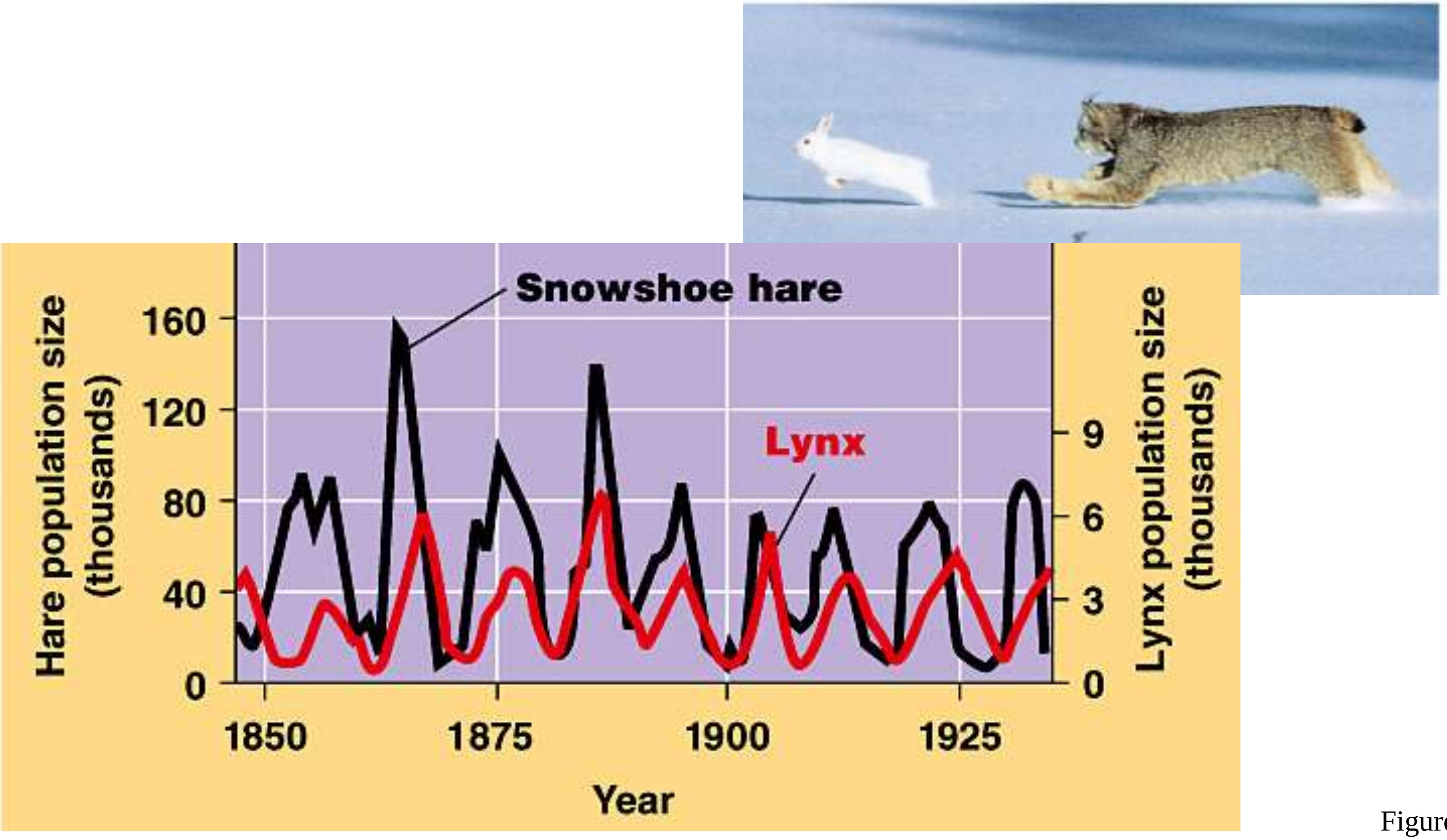
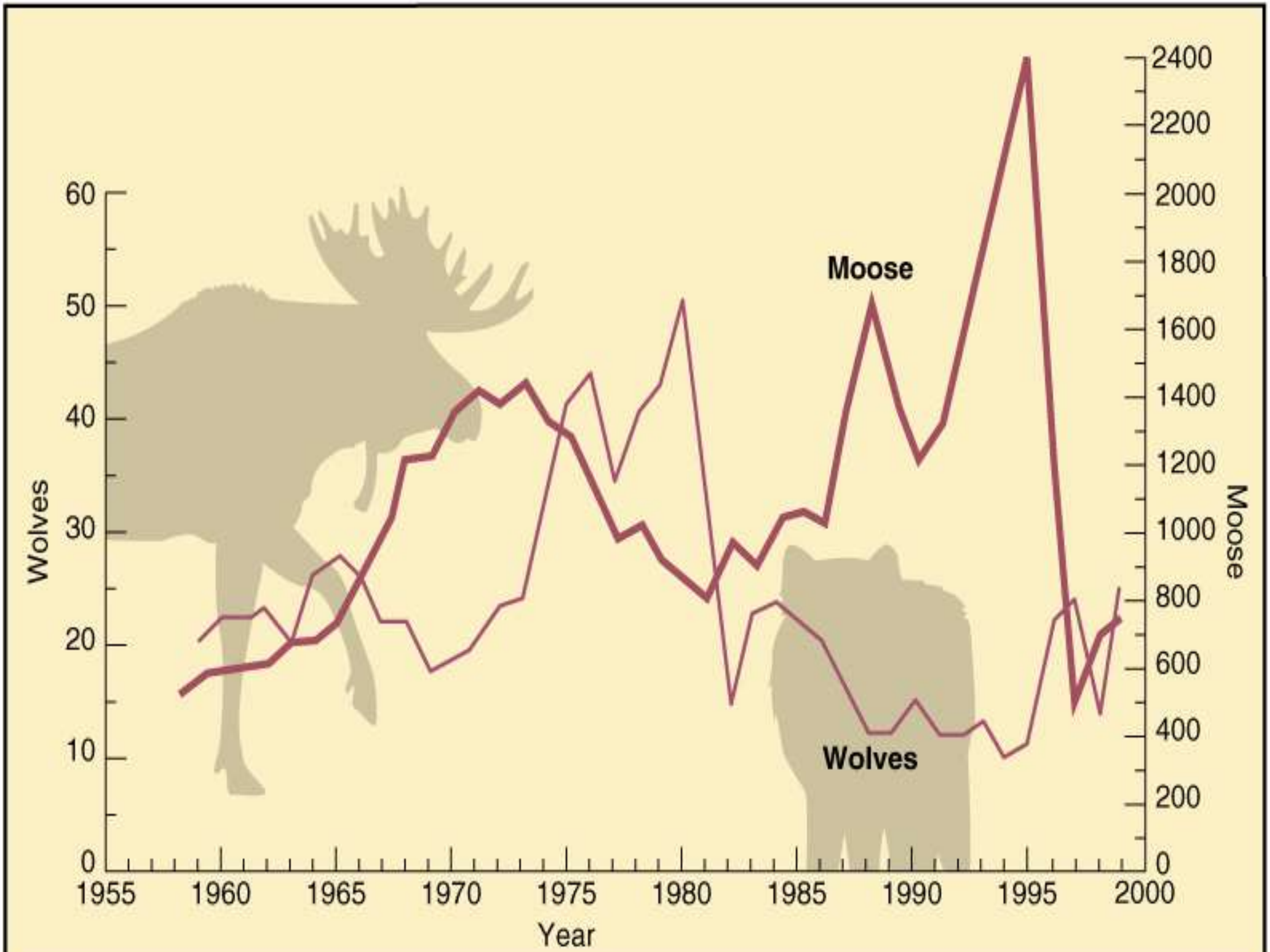
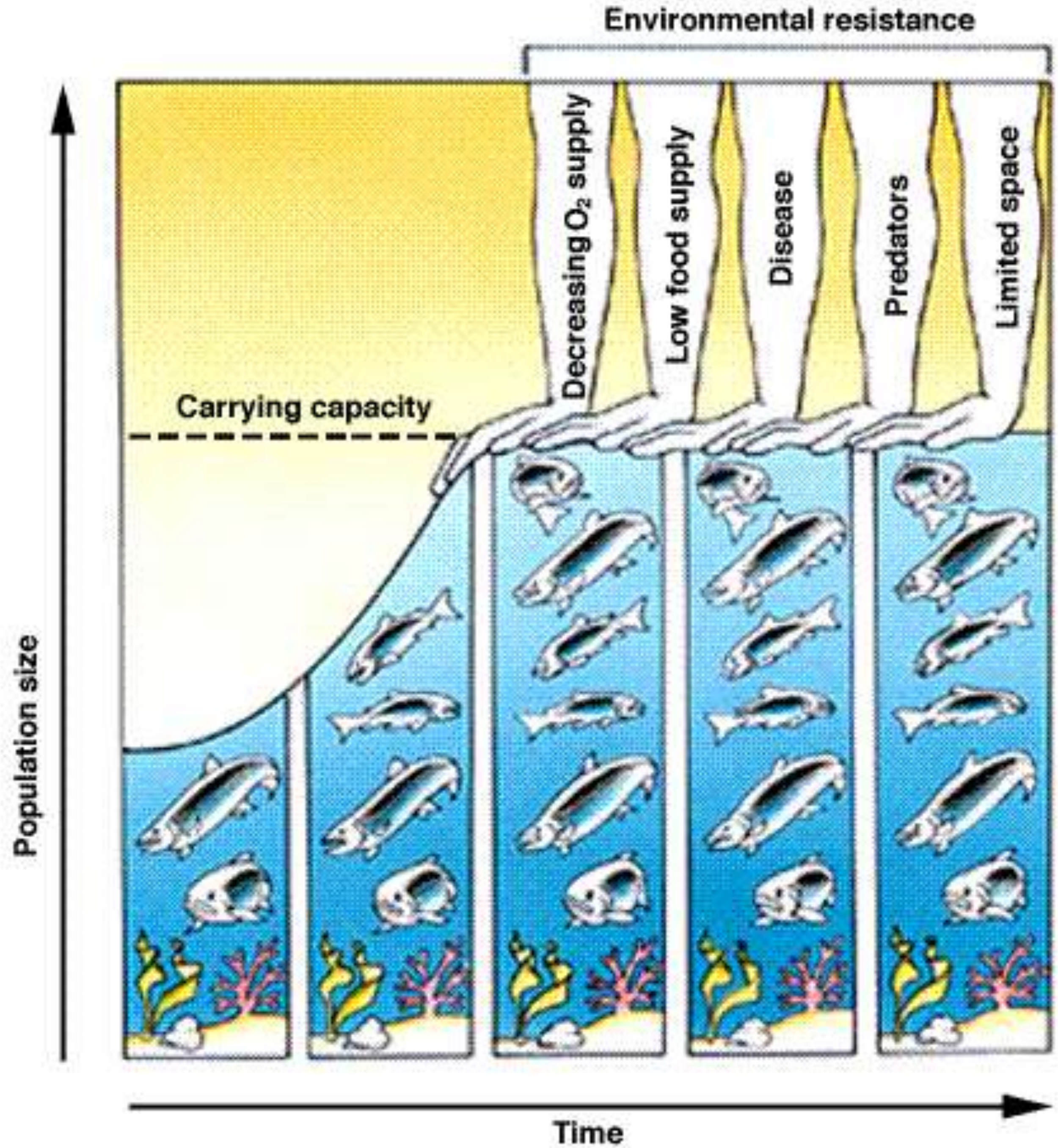


Figure 35.5



Moose
Wolves
Wolves
Moose
Year
0
10
20
30
40
50
60
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

Carrying Capacity

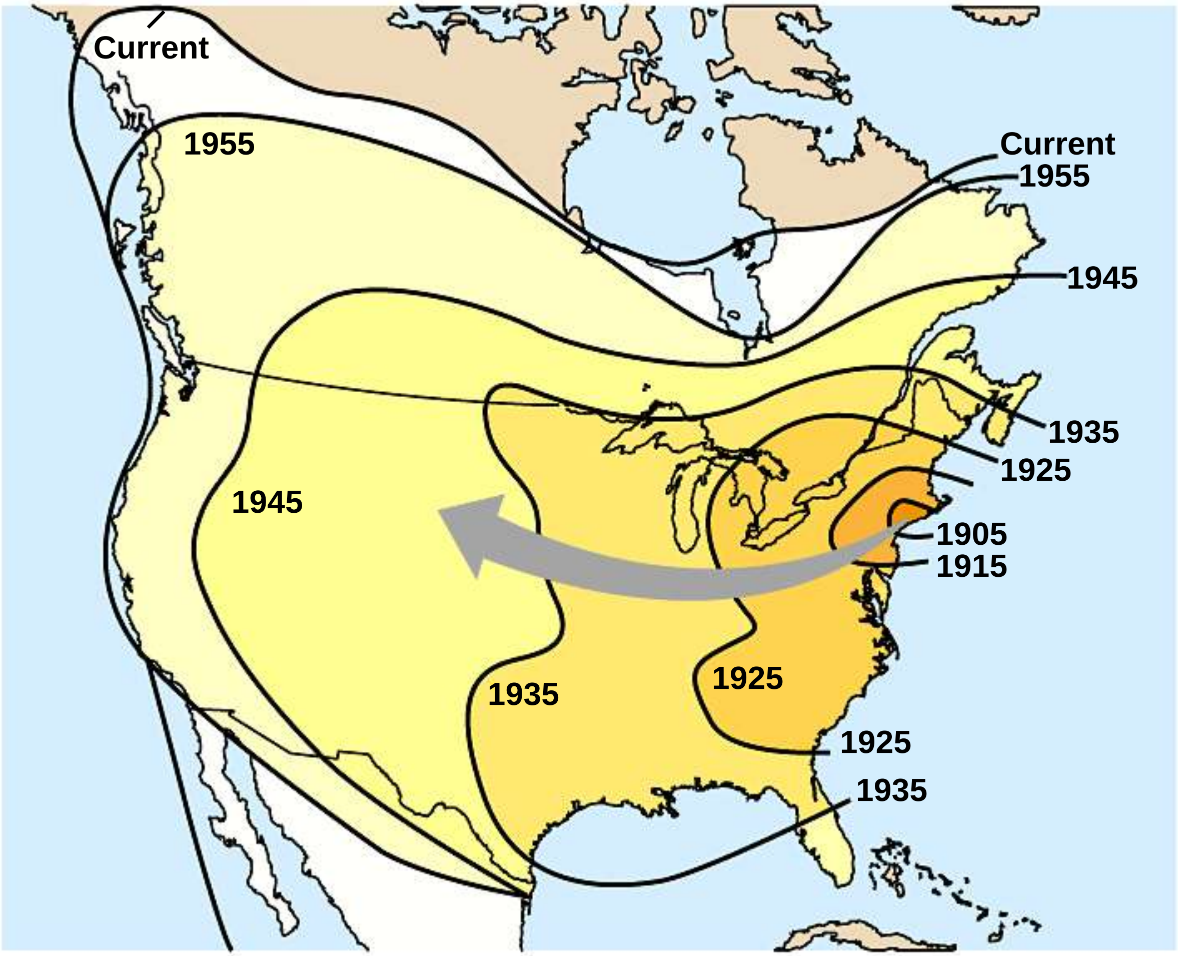


- Principles of population ecology may be used to
  - manage wildlife, fisheries, and forests for sustainable yield
  - reverse the decline of threatened or endangered species
  - reduce pest populations
  - IPM = Integrated Pest Management

The Spread of Shakespeare's Starlings

- In 1890, a group of Shakespeare enthusiasts released about 120 starlings in New York's Central Park

- Today: over 100 million starlings, spread over N. Amer.



Population Density

- Population Density (or ecological population density) is the amount of individuals in a population per unit habitat area
  - Some species exist in high densities - Mice
  - Some species exist in low densities - Mountain lions

- Density depends upon
  - social/population structure
  - mating relationships
  - time of year

Population Dispersion

Population dispersion is the spatial pattern of distribution

There are three main classifications

<u>Clumped</u>: individuals are lumped into groups
ex. Flocking birds or herbivore herds due to resources that are clumped or social interactions
most common

http://www.johndarm.clara.net/galleryphots/

Population Dispersion

http://www.calflora.net/bloomingplants/creosotebush2.html

Uniform: Individuals are regularly spaced in the environment - ex. Creosote bush due to antagonism between individuals, or do to regular spacing of resources rare because resources are rarely evenly spaced

Random: Individuals are randomly dispersed in the environment ex. Dandelions due to random distribution of resources in the environment, and neither positive nor negative interaction between individuals rare because these conditions are rarely met

www.agry.purdue.edu/turf/ tips/2002/clover611.htm

Human Impacts

on Populations

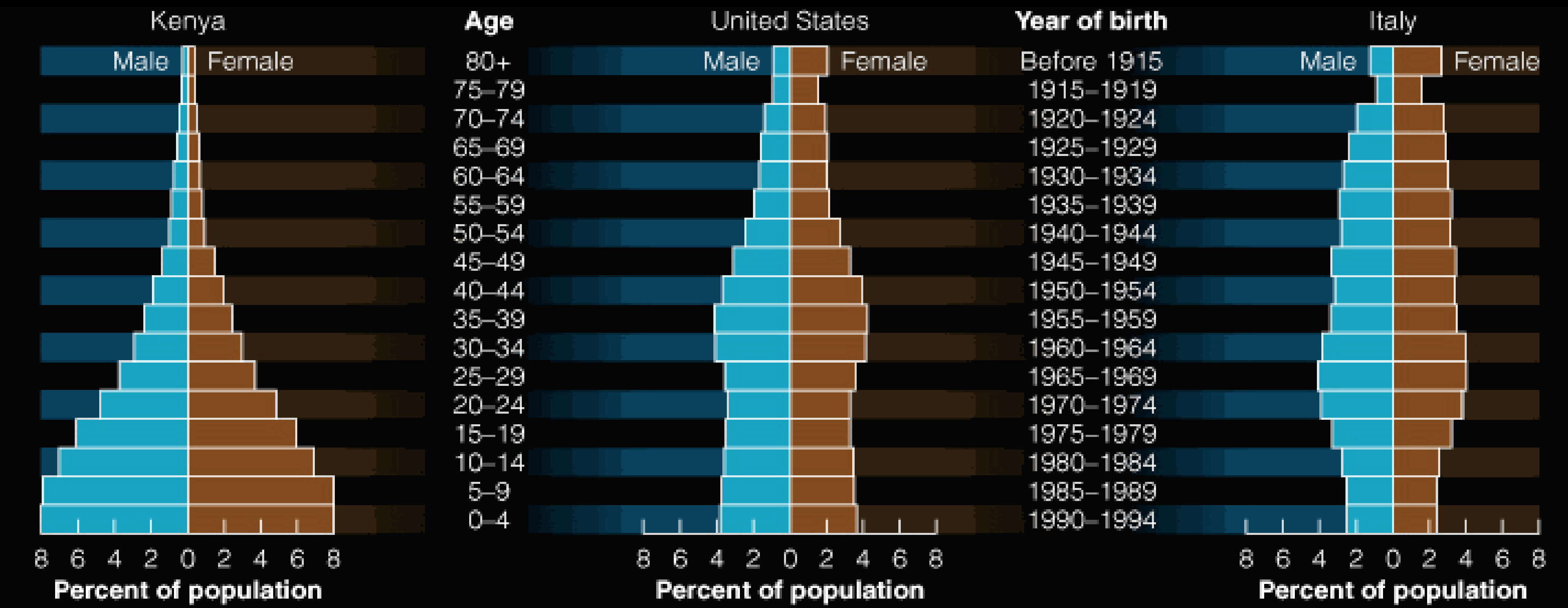
- Deliberately or accidentally introducing new species
- Overharvesting potentially renewable resources
- Interfering with the normal chemical cycling and energy flows in ecosystem

Age Structure

- The age structure of a population is usually shown graphically
- The population is usually divided up into prereproductives, reproductives and postreproductives
- The age structure of a population dictates whether is will grow, shrink, or stay the same size

Age Structure Diagrams

Positive Growth	Zero Growth (ZPG)	Negative Growth
Pyramid Shape	Vertical Edges	Inverted Pyramid



THE HUMAN POPULATION

- doubled three times in the last three centuries
- about 6.1 billion and may reach 9.3 billion by the year 2050
- improved health and technology have lowered death rates

- The history of human population growth

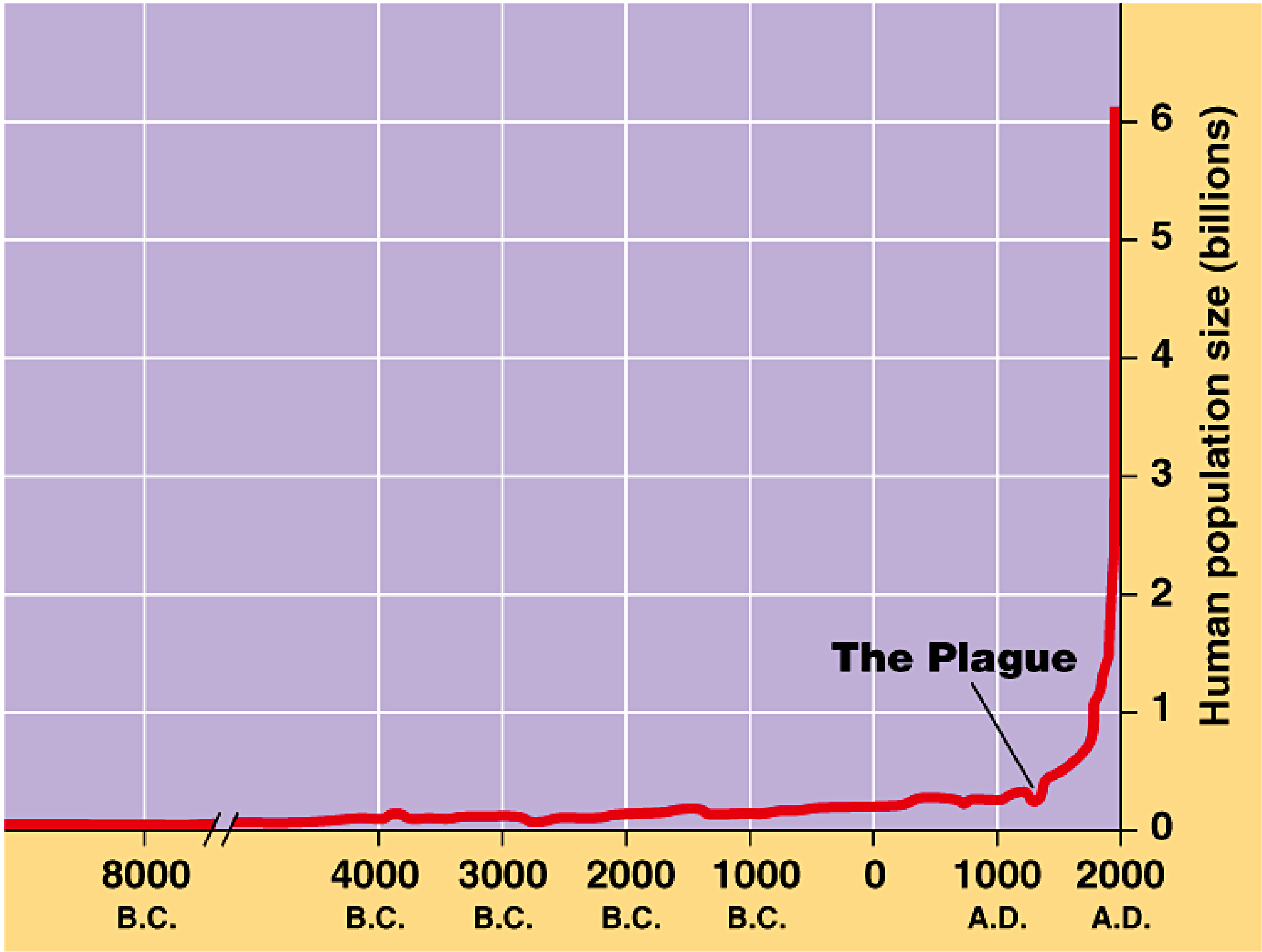
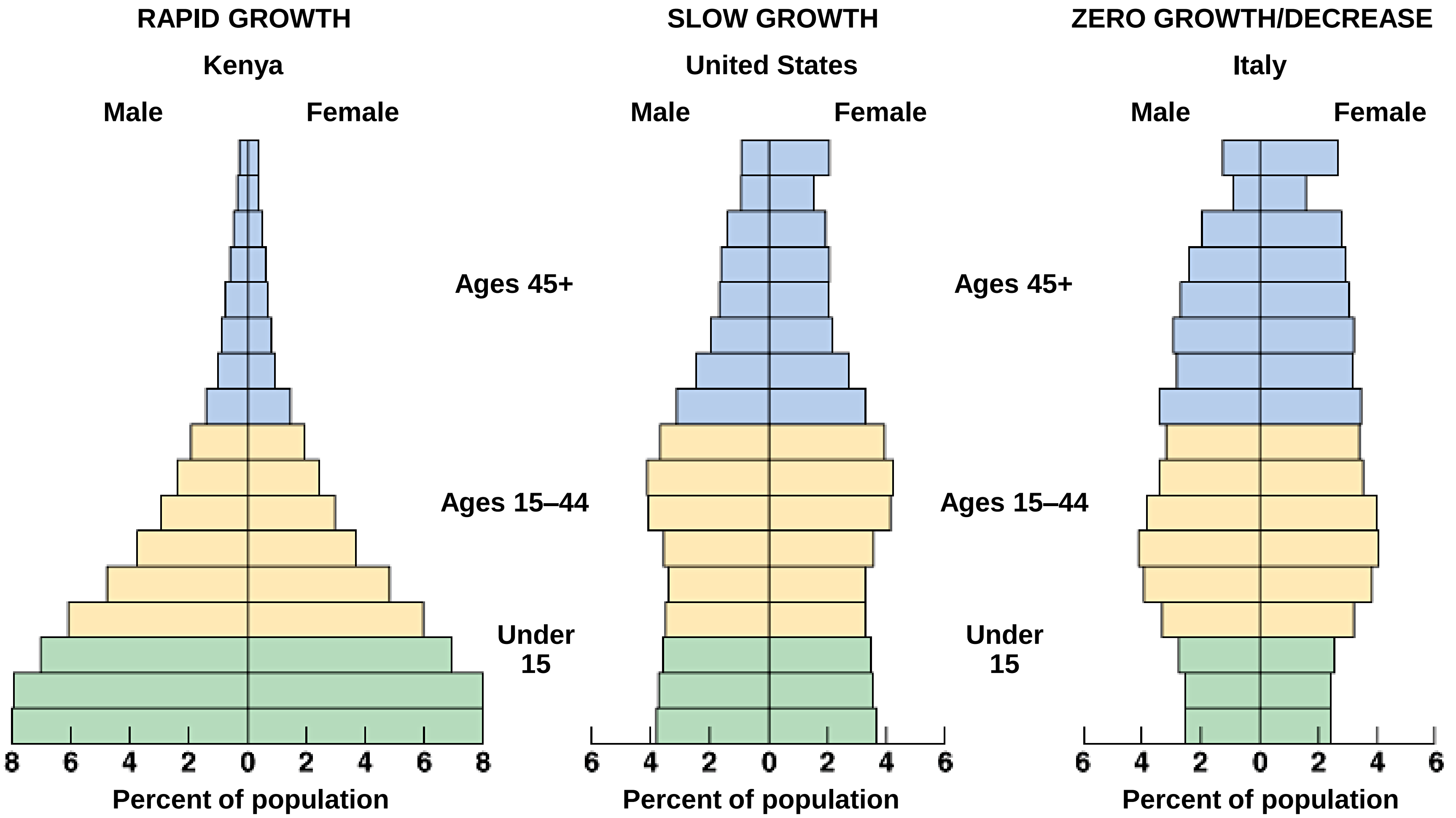


Figure 35.8A

- The age structure of a population is the proportion of individuals in different age-groups



Human conservation

- Careful and sensible use of natural resources by humans is important to maintain our world
- Protect ecosystems and find practical ways to prevent premature extinctions of species

Conservation of the Environment

- **Three Principles**
  1. Biodiversity and ecological integrity are useful and necessary to all life on earth and should not be reduced by human actions
  2. Humans should not cause or hasten the premature extinction of populations and species or disrupt vital ecological processes
  3. Best way to preserve earth's biodiversity and ecological integrity is to protect intact ecosystems that provide sufficient habitat

Working with Nature

- Learn six features of living systems
  - Interdependence
  - Diversity
  - Resilience
  - Adaptability
  - Unpredictability
  - Limits

Basic Ecological Lessons

1. Sunlight is primary source of energy
2. Nutrients are replenished and wastes are disposed of by recycling materials
3. Soil, water, air, plants and animals are renewed through natural processes
4. Energy is always required to produce or maintain an energy flow or to recycle chemicals

Four Principles for Sustainable

1. *We are part of, not apart from, the earth's dynamic web of life.*
2. *Our lives, lifestyles, and economies are dependent on the sun and the earth.*
3. *Everything is connected to everything else; we are all in it together.*