Population Ecology

Ecological interactions affect how organisms evolve, and evolutionary change in turn affects ecological relationships.

Ecology

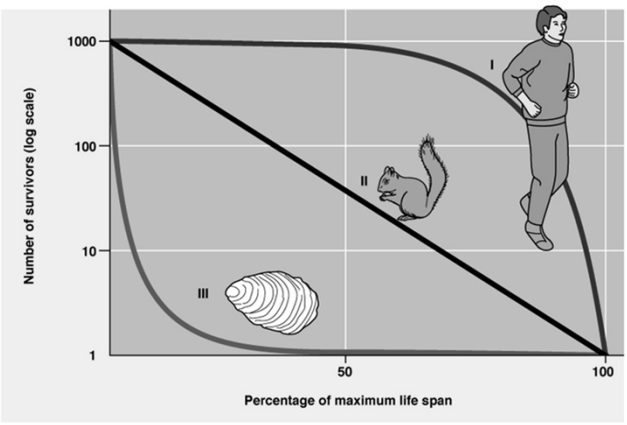
Ecology

- the study of the relationships between organisms and their environment
  + two types of interactions
    - *biotic* (living)
    - *abiotic* (nonliving)
  + levels of study
    - population, community, ecosystem, biosphere

<u>Population Ecology</u>

+ *population*: group of individuals all of the same species living in the same area
  - describing abundance/distribution of populations
    + size (total number of individuals = *N*)
    + density (total number of individuals per area/volume)
    + dispersion (clumped, uniform, random)

Survivorship Curves



Type I: most individuals die old
Type II: length of survivorship is random
Type III: most individuals die young

Factors That Influence Population Size

- There are 3 major factors that influence population size:
  1. the number of births
  2. the number of deaths
  3. the number of individuals that enter or leave a population
     - immigration:
       individuals entering an existing population
     - emigration:
       individuals leaving an existing population

Reproductive Episodes

- Clutch size:
  - Number of offspring produced at each reproductive episode
- Semelparity
  - A life history in which an organism spends most of its energy in growth and development, expend their energy in one large reproductive effort, and then die
  - Many insects, annual plants, salmon, etc.

Reproductive Episodes

- Iteroparity
  - A life history pattern in which organisms produce fewer offspring at a time over a span of many seasons
  - Example: humans, panda bears, etc.

Population Growth

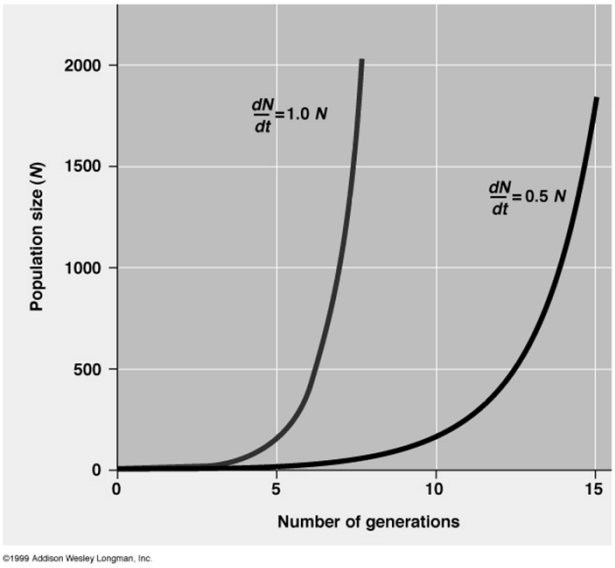
Biotic potential

- maximum growth rate of population under ideal conditions
  - + bacteria divide every 20 minutes
  - + elephants require 2 year gestation period
    - - factors
      - + age at reproductive maturity
      - + clutch size
      - + frequency of reproduction
      - + reproductive lifetime
      - + survivorship of offspring to maturity

Carrying Capacity (*K*)

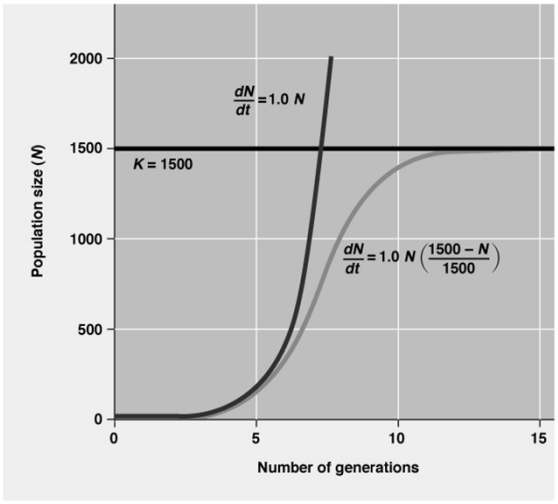
- maximum number of individuals a population can sustain
  - + *limiting factors*
    - - elements that prevent a population from attaining its biotic potential

Exponential Growth



J-shaped curve

Logistic Growth



S-shaped/sigmoid curve

Logistic Growth

- occurs when limiting factors restrict the size of the population to the carrying capacity (K)

$$\frac{\Delta N}{\Delta t} = r \bullet N \frac{(K - N)}{K}$$

- as population increases, r decreases until N = K, and r = 0

Life-history Strategies

(k selected species)

<u>k selected</u> (prudent or equilibrial populations)

+ LOW biotic potential (produce small numbers of young);
  - late reproductive age
  - lots of parental care
  - long life expectancy strategy
+ consequences
  - increased probability of long term survival
  - slow to recuperate numbers when population is reduced

Life-history Strategies

(r selected species)

- r selected (prodigal or opportunistic populations)
  - + high biotic potential (produce many young);
    - early reproductive age
    - very little parental care
    - short life expectancy strategy
  - + consequences
    - can recuperate numbers quickly following population crash
    - lead risky lives

Growth Curves

Exponential growth

- Lag Phase

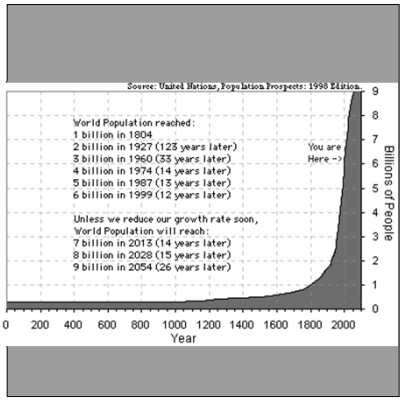
  $b=d$

- Exponential phase

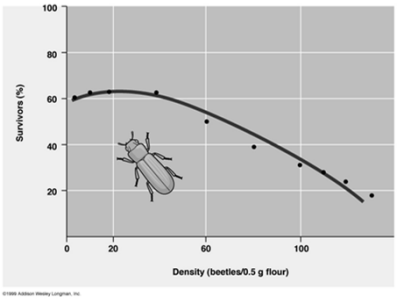
  $b>d$

- Equilibrium phase

  $b=d$

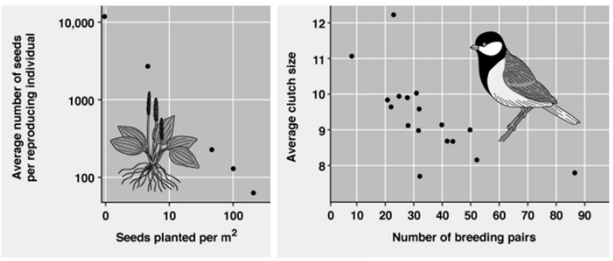


Density-dependent Factors



Density-dependent factor

- intensifies as population increases
  + reduce the population growth by *decreasing reproduction* or by *increasing mortality*
    - parasites/disease, competition, predation, stress

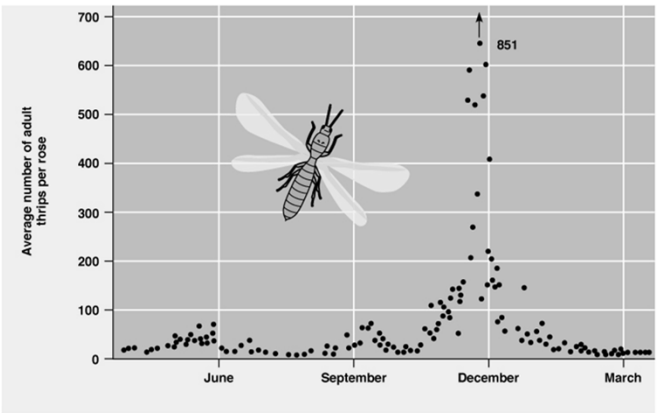


(a) Plantain (b) Great tit

Density-independent Factors

Density-independent factor

- occurs independently of population; unrelated to population size
  + natural disasters and extremes of climate



Human Population Growth

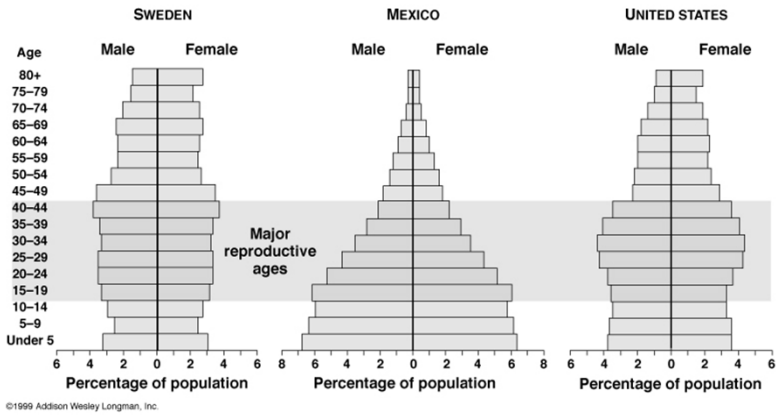
- The human population has been increasing exponentially since approximately 1650
- http://www.pbs.org/wgbh/nova/worldbalance/numbers.html

Human Population Growth

- **Implications of exponential human population growth:**
  - Lack of food supplies
  - Lack of space
  - Lack of natural resources (metals, fossil fuels, etc)
  - Lack of sites for waste disposal
- **Ecologists cannot agree on a carrying capacity for Earth**
  - Are we going to reach carrying capacity through individual choices and/or government programs?

    OR
  - Is Earth's population going to "level off" as a result of mass deaths?

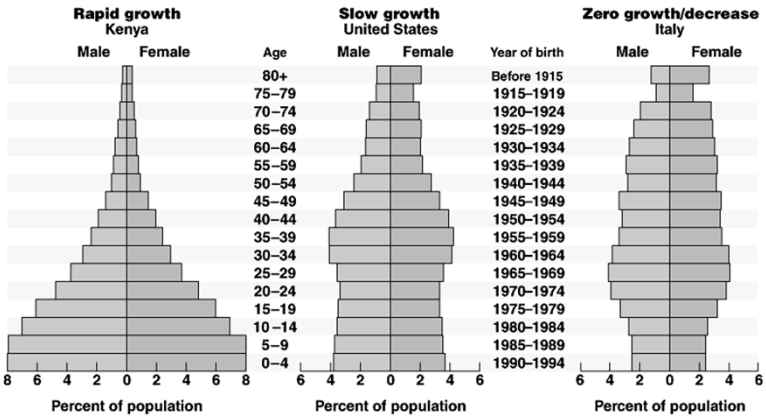
Age Structure



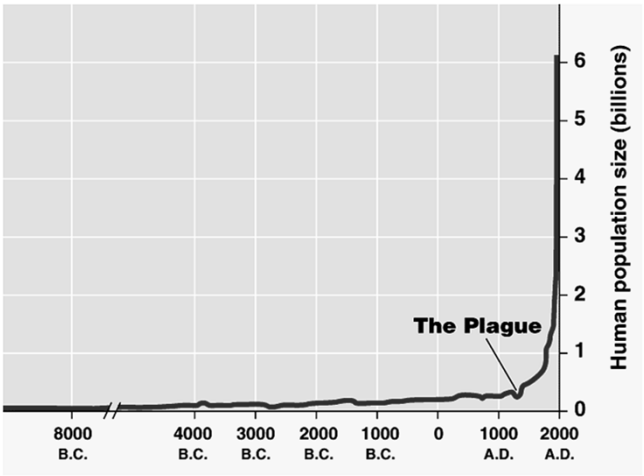
Sweden- relatively stable population growth
Mexico- rapidly growing population
United States- relatively stable population growth

Age-Structure Diagrams

(the relative # of people of each age in the population)



Human Population Growth



Calculating Growth Rate

$$r = \frac{\text{births - deaths}}{N}$$

r = reproductive/growth rate
births - deaths = net increase of individuals

$$N \bullet r = \text{births - deaths}$$

$$\frac{\Delta N}{\Delta t} = r \bullet N$$

represents the change in the number of individuals over a given time

When r is…

- positive (r_{max} = *intrinsic rate*) population size will increase
- negative, population size will decrease
- zero, population size remains constant (**ZPG**)