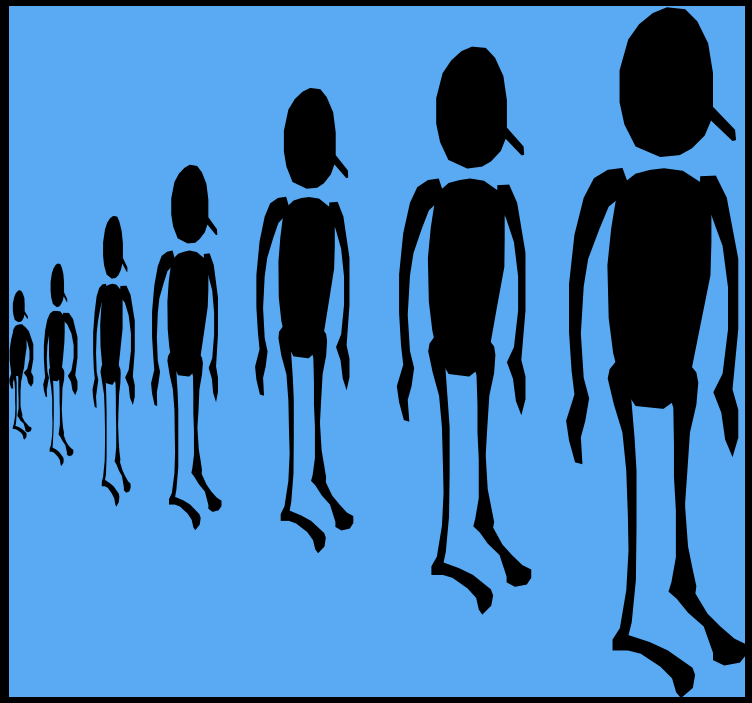


Population Ecology

If it helps, follow along with Chapter 52

- *asterisk means less important

What is a population?

- **A group of individuals of a single species that live in the same area**
- No population can grow indefinitely, not even humans
  - Why not?

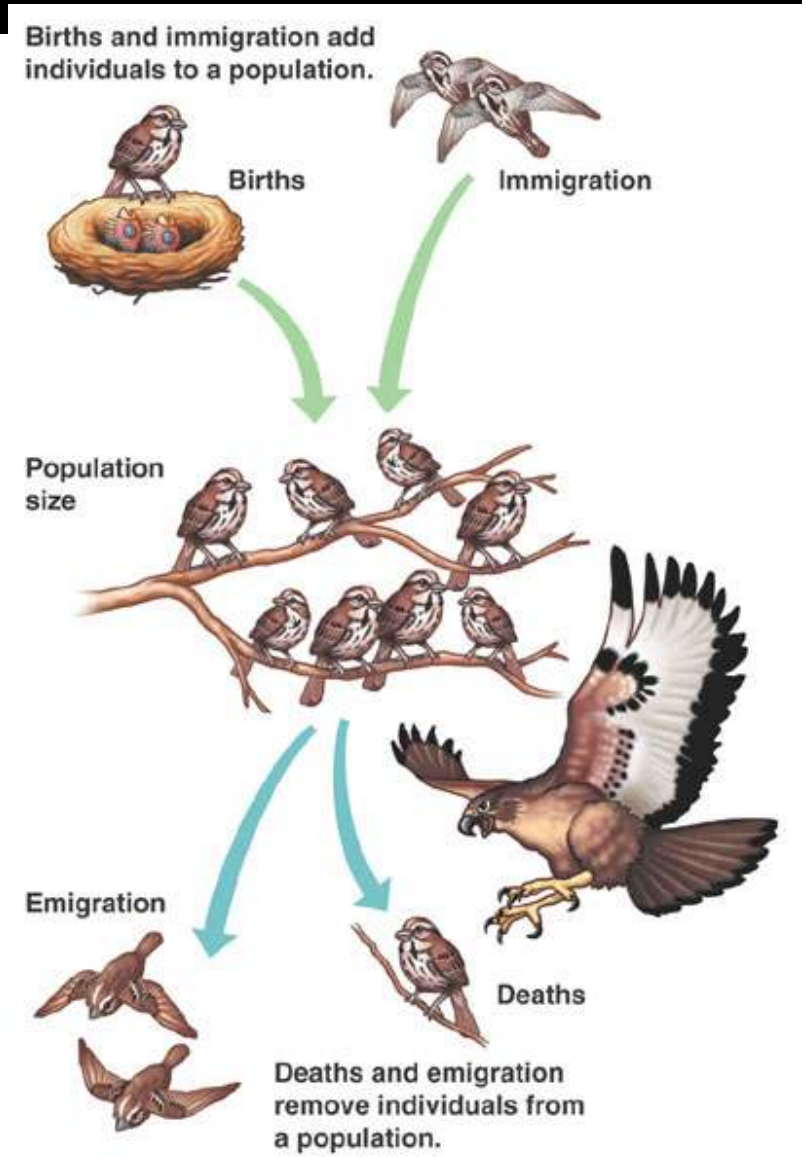
Density and dispersion

- Density- number of individuals per unit area
  - EX: 100 box elder bugs/m^3
  - Number can be estimated from sample plots

- Density is not static- it changes

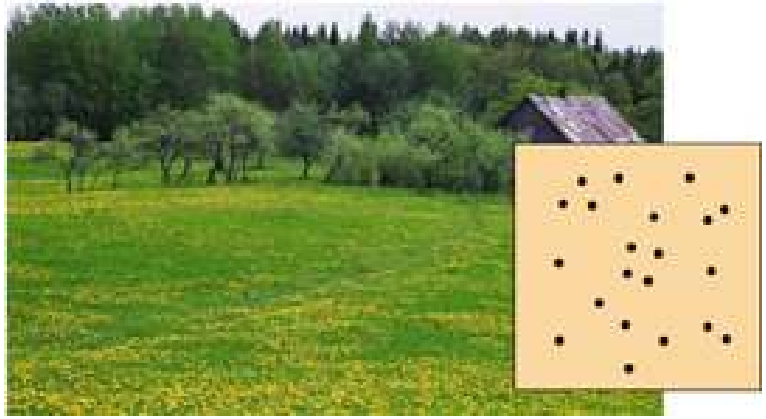
Factors that affect population density

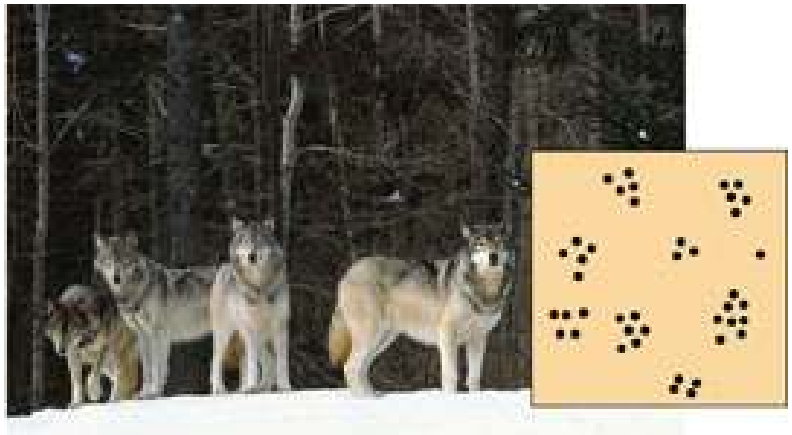
- Immigration- new individuals arrive
- Emigration- some individuals leave
- Birth
- Death

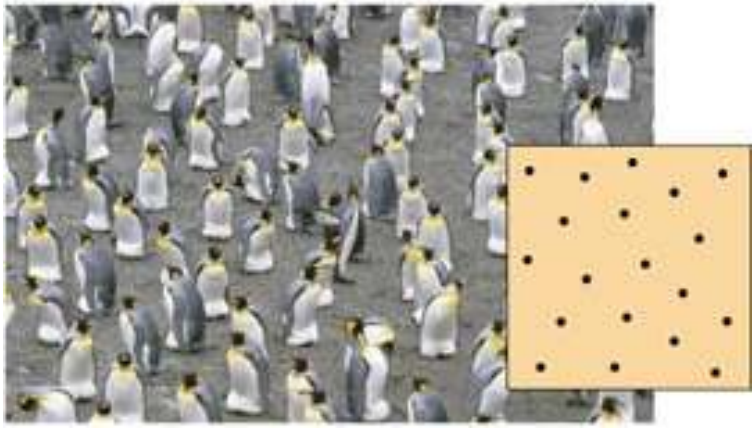


*Density and dispersion

- Dispersion – the spacing patterns of individuals in the area
  - Clumped
  - Uniform
  - Random







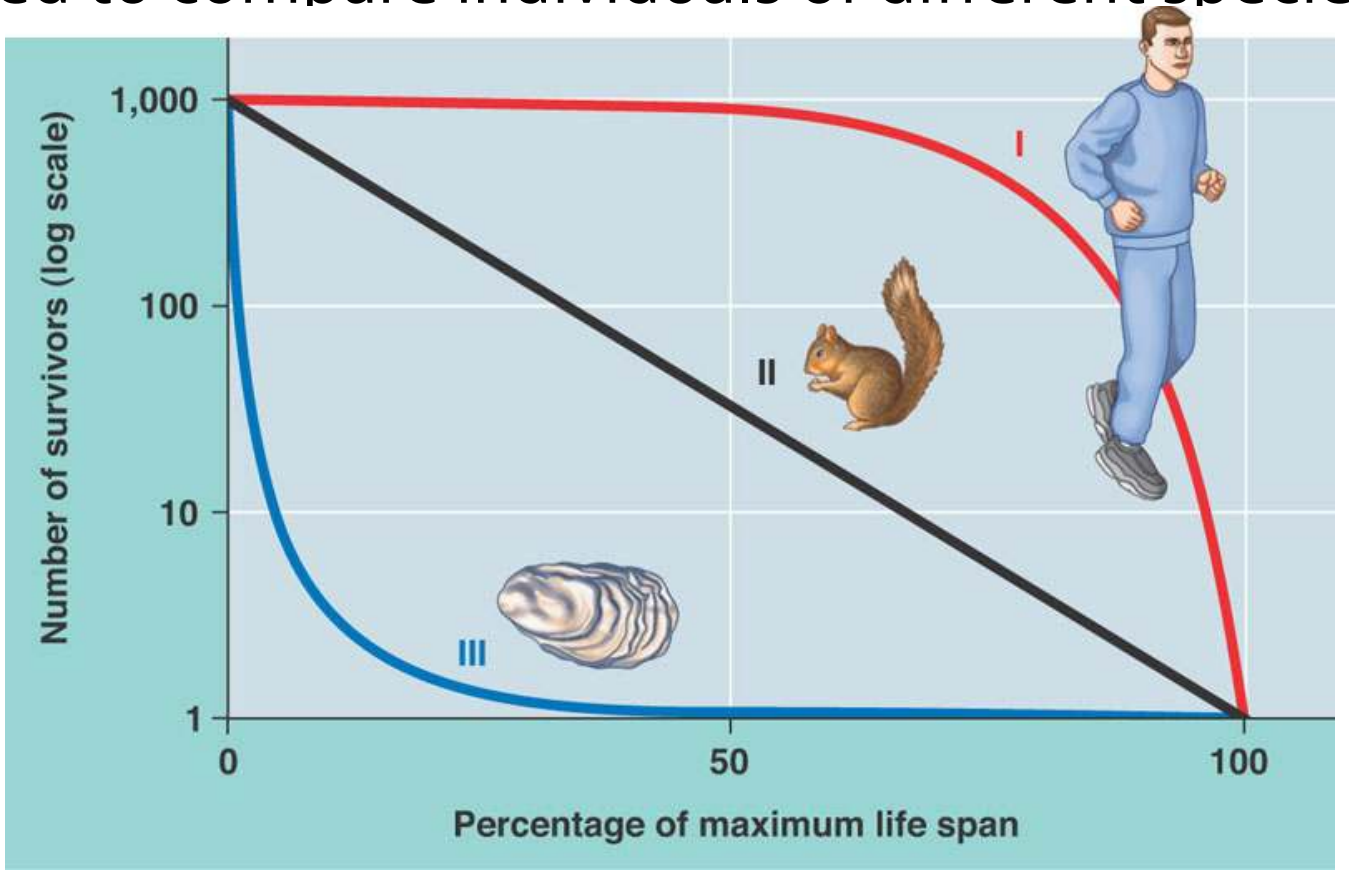
*Demography- study of the population vital statistics how they change over time

- Life tables are used to show this information

Age	number alive at start of the year	Proportion alive at start of the year	Number of deaths during the year	Death rate
0-1	337	1.000	207	0.61
1-2	252	0.386	125	0.50
2-3	127	0.197	60	0.47
3-4	67	0.106	32	0.48
4-5	35	0.054	16	0.46
5-6	19	0.029	10	0.53
6-7	9	0.014	4	0.44
7-8	5	0.008	1	0.20
8-9	4	0.006	3	0.75
9-10	1	0.002	1	1.00

*Demography

- Survivorship curves- the graph of a life table
  - Shows numbers of a group still alive at each age
  - Used to compare individuals of different species



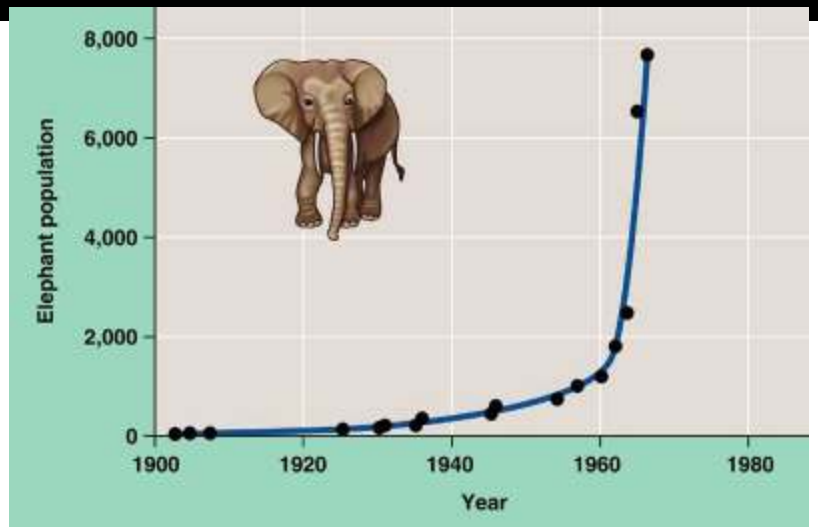
*Demography

- Reproductive tables- summarize reproductive rates of a population

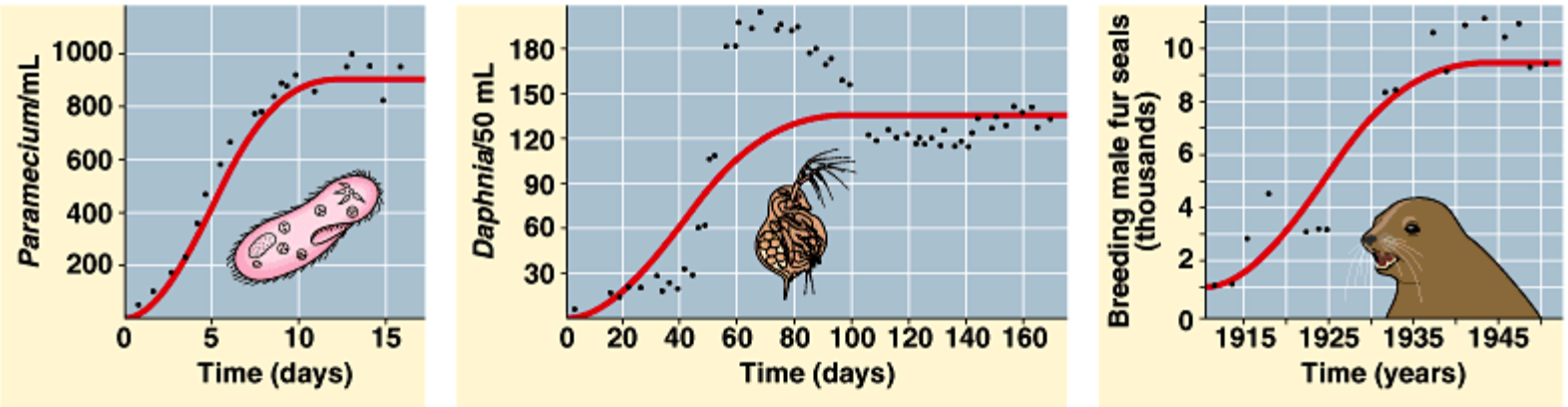
Elapsed Time in Hours	Number of Bacteria A 30 Minutes to Duplicate	Number of Bacteria B 60 Minutes to Duplicate
0	1	1
0.5	2	1
1.0	4	2
1.5	8	2
2.0	16	4
2.5	32	4
3.0	64	8
3.5	128	8
4.0	256	16
4.5	512	16
5.0	1024	32

Types of population growth

- Exponential



- Logistic



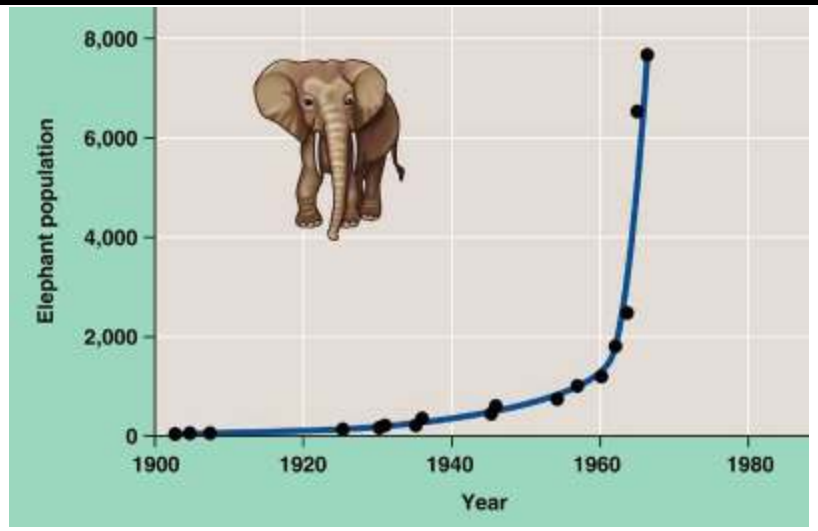
(a) A *Paramecium* population in laboratory culture

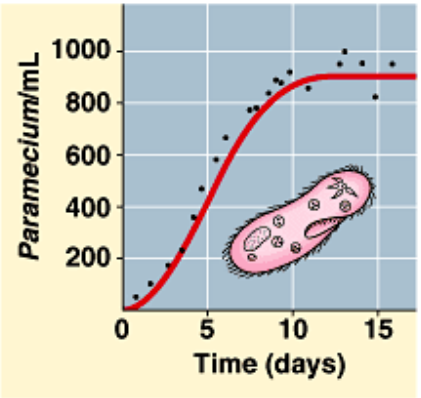
(b) A *Daphnia* population in laboratory culture

(c) A fur seal (*Callorhinus ursinus*) population on St. Paul Island, Alaska

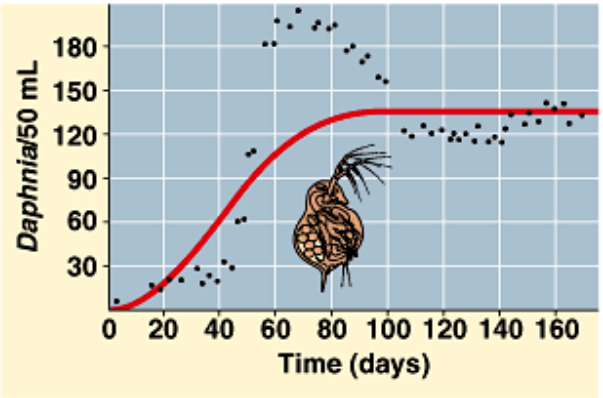
Types of population growth

- Make mental notes about how exponential growth is different than logistic growth

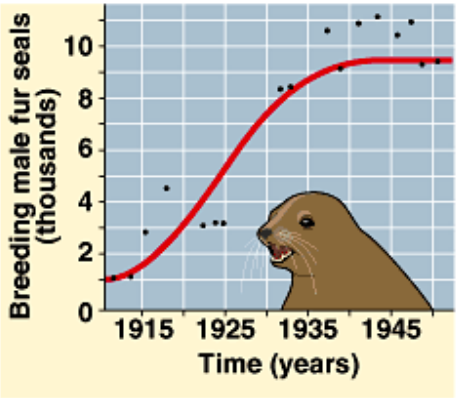




(a) A *Paramecium* population in laboratory culture



(b) A *Daphnia* population in laboratory culture



(c) A fur seal (*Callorhinus ursinus*) population on St. Paul Island, Alaska

Exponential growth

- This is how a population would grow in a environment with unlimited resources
  - If one bacteria divides every 20 min, in10 hours there would be…..
  - In 36 hours?
  - Elephants take 2 years to reproduce. In 2000 years, their weight would be more than that of the earth
- What are some real limits to population growth?

Population growth can be modeled mathematically

- $\Delta N/\Delta t = rN$
  - ΔN is the change in the total population number
  - Δt is the change in time
  - r = per capita rate of increase
  - N= number of individuals in the population

  - How do we calculate the per capita rate of increase?
  - $r = b - m$
    - b = per capita birth rate
    - m = per capita death rate
  - In general these rules apply
    - $r > 0$ = Population Growth
    - $r < 0$ = Population Reduction
    - Zero population growth: # of births = # of deaths

Best part: We can convert our equation so we can use calculus!!

- $dN/dt = rN$

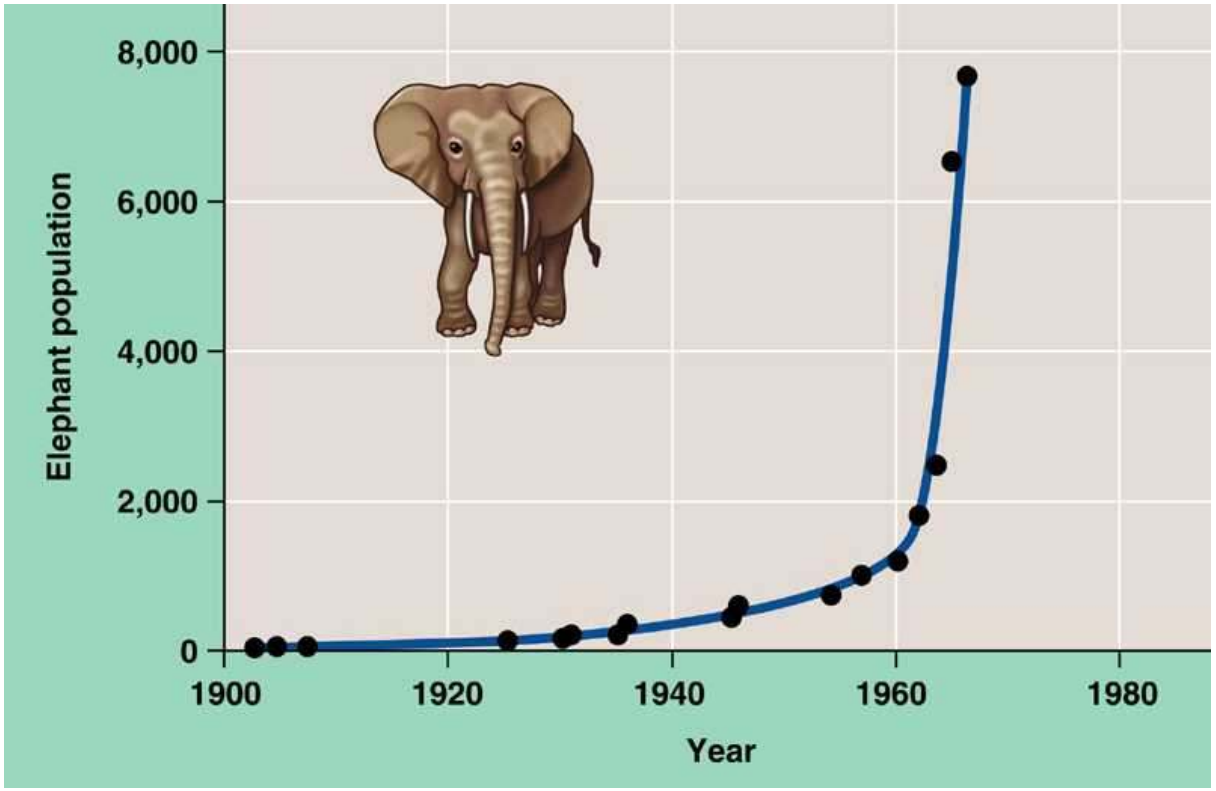
- But, don't worry, we won't ☺
- Think of dN/dt as just another variable or measurement to solve for

Calculating exponential growth

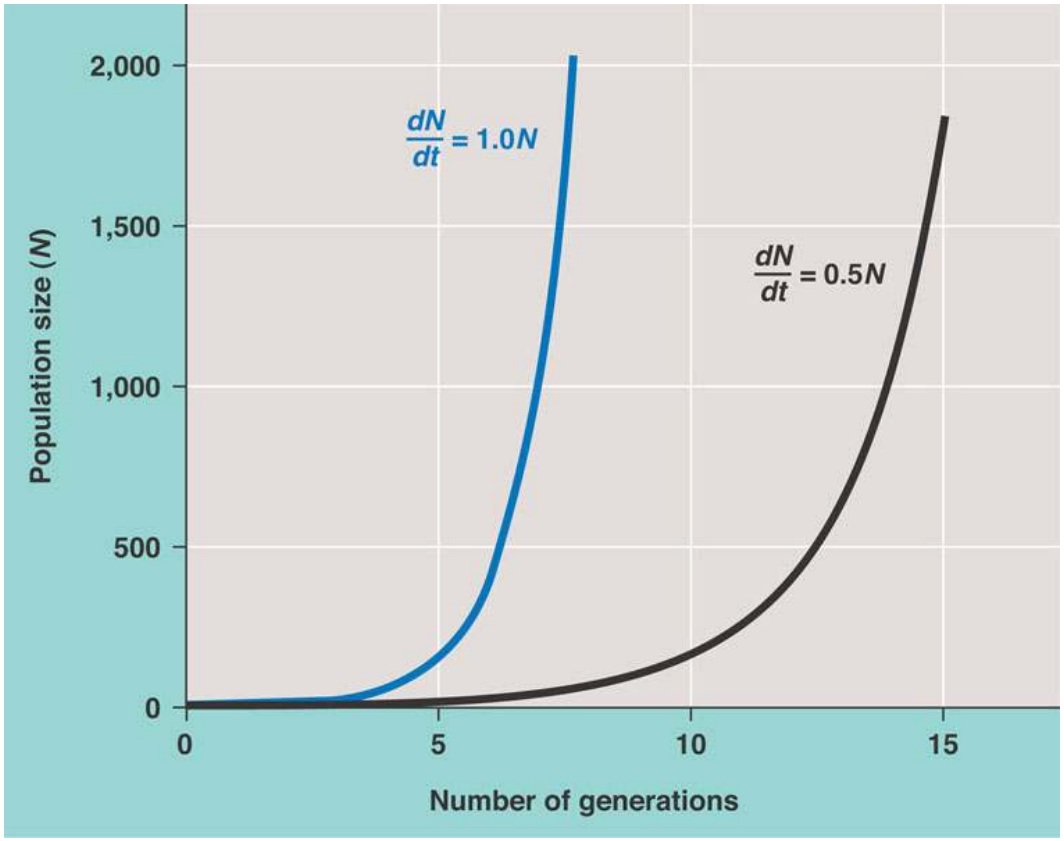
- Exponential growth is characterized by unlimited resources and individuals reproducing at their maximum capacity
  - Use the intrinsic rate of increase r_{max} which shows this
  - What is r_{max}? The maximum per capita rate of increase

- $dN/dt = r_{max}N$

Why does the curve get steeper?



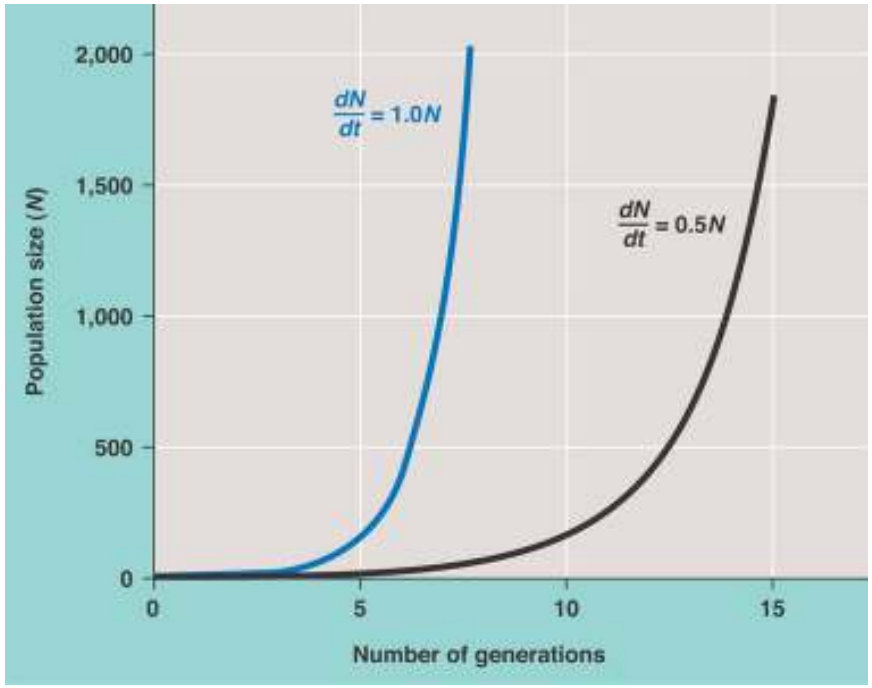
How does the growth of a population with an intrinsic rate of $dN/dt = 1.0N$ compare to a population with a rate of $dN/dt = 0.5N$?



Does exponential growth exist in the real world? Why or why not?

Yes, but it is temporary

- Typically it is characteristic of populations rebounding from loss, introduction of species to a new area, or invasive species populations
  - Why temporary?

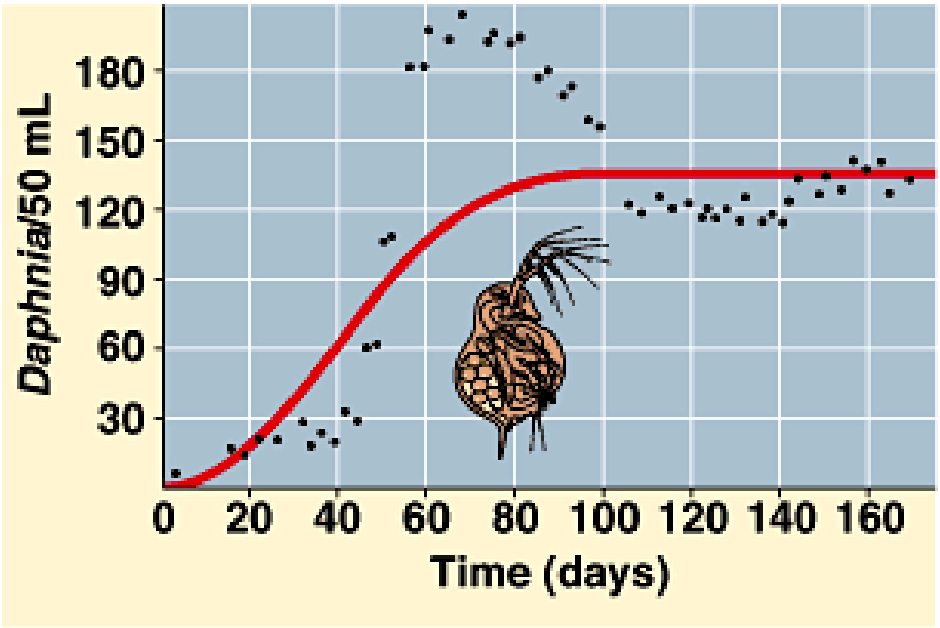


There is a better, more accurate model to show population growth

- Logistic growth

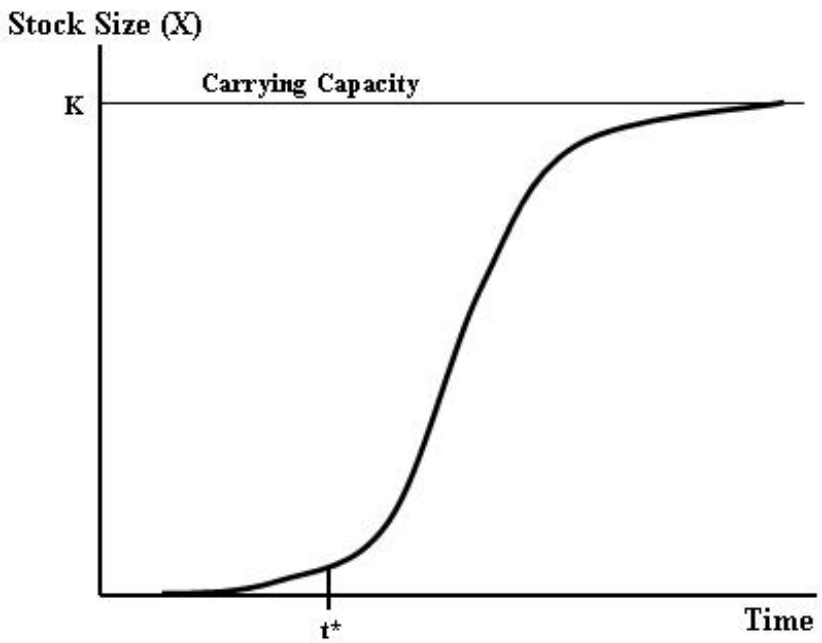
Logistic growth models populations with respect to limits

- As populations grow, each individual has access to fewer resources
- Environments can only support a certain number of individuals due to scarce resources



Carrying Capacity

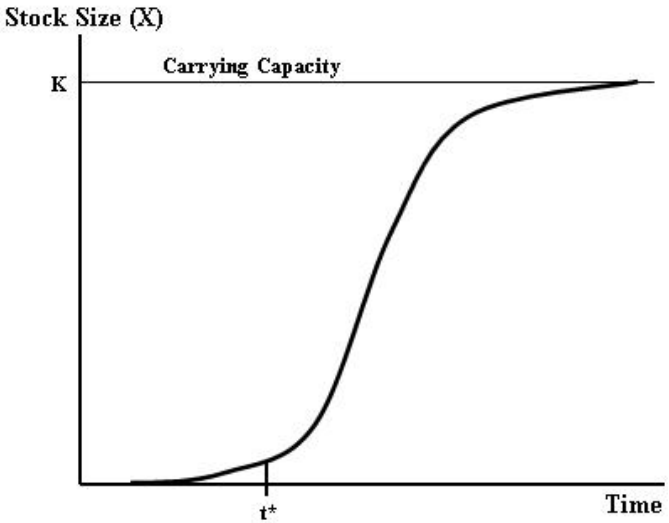
- The maximum population size that a particular environment can support
- K= carrying capacity
- K is not fixed but varies over time



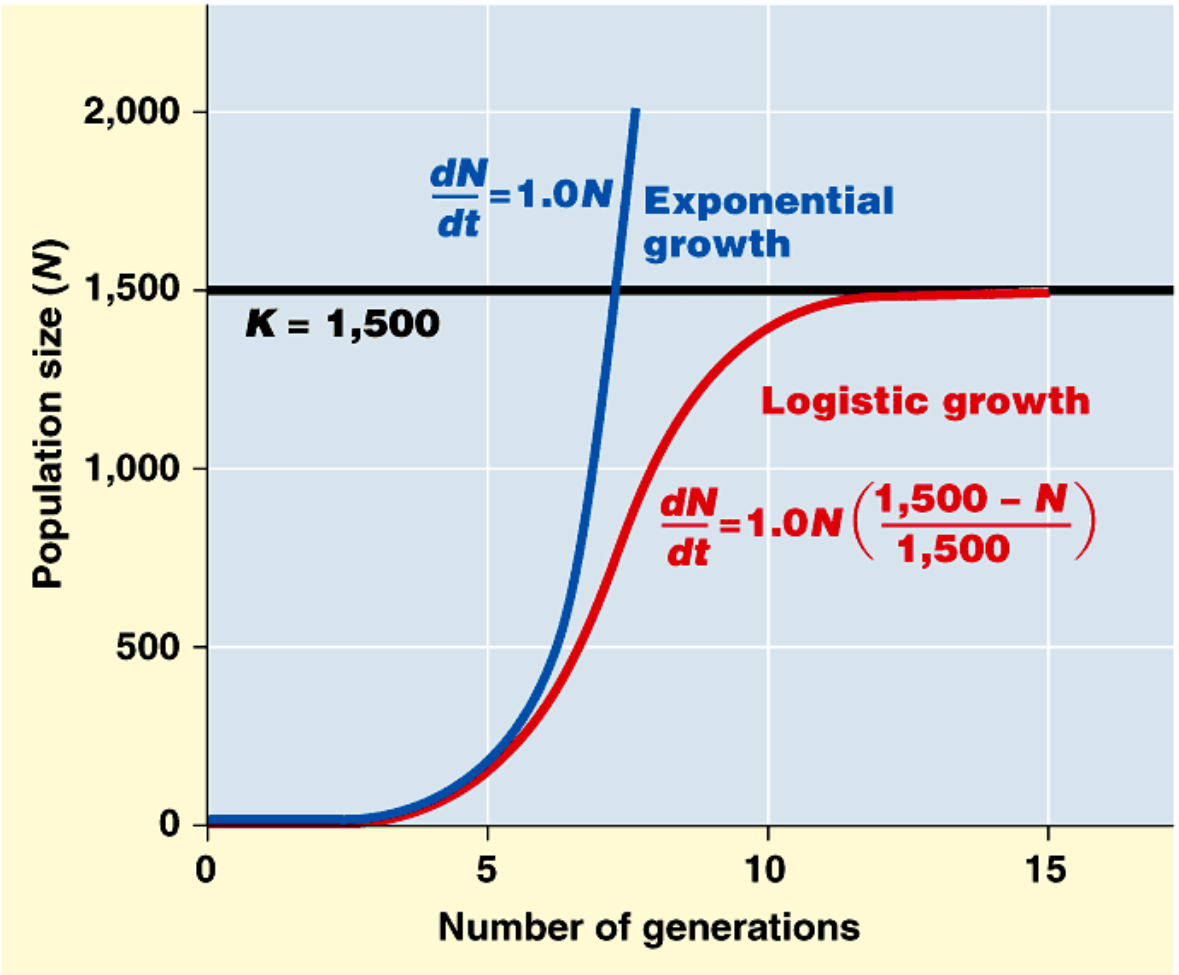
Modeling logistic growth

- $dN/dt = r_{max}N(K-N/K)$

- Populations stop growing when K = N
- Why does population growth slow down at the end?
  - Birth decrease, death increase
- Is the logistic model seen in real life?

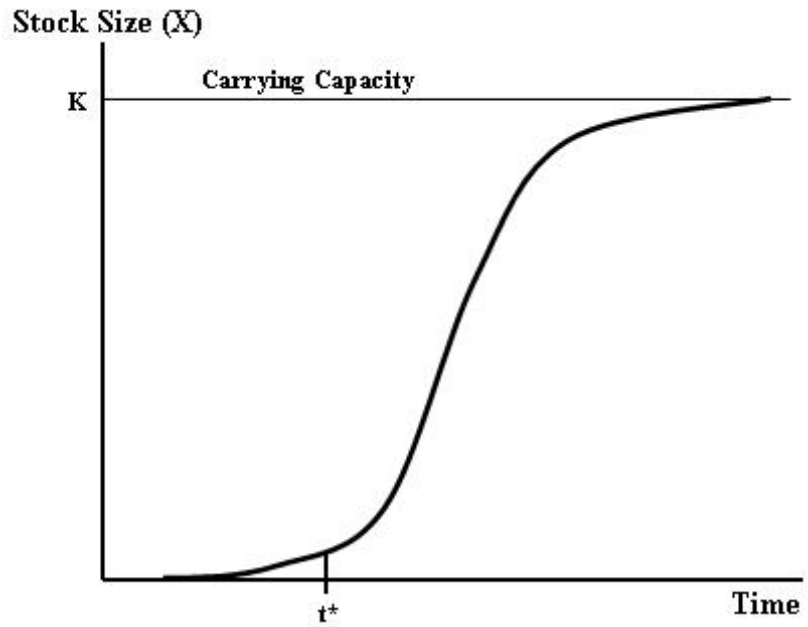


Exponential growth vs. Logistic growth



Logistic model and life history

- What are the conditions like at the beginning of the curve?
- At the end?



*Logistic model and life history

- Different types of animals take advantage of the conditions of the environment at different times.
  - High density population
    - Some species are adapted to survive and reproduce with few resources
  - Low density population
    - Some species are adapted for rapid reproduction and numerous offspring

*Selection based on life history traits

- K – selection (density dependent): Natural selection for life history traits that are sensitive to population density.
  - K – selected species: Maintain constant population size (at K), produce small numbers of offspring that need extensive paternal care and reproduce many times

- R- selection (density independent): Natural selection for life history traits that maximize success in low density environments
  - r- selected species: Have rapid growth and reproduction, produce many offspring that mature quickly with minimal parental care. Opportunistic

Key questions about population growth?

What are the characteristics that stop population growth?

Why do some populations fluctuate more than others?

Limiting factors are both biotic and abiotic factors

- Density independent- birth rate or death rate does not change with population density
- Density dependent- birth rate or death rate changes with population density

Density-independent factors

- Natural disasters
  - Fire
  - Earthquake
  - Volcano
  - Extreme weather

Density-dependent factors

- Competition for territory

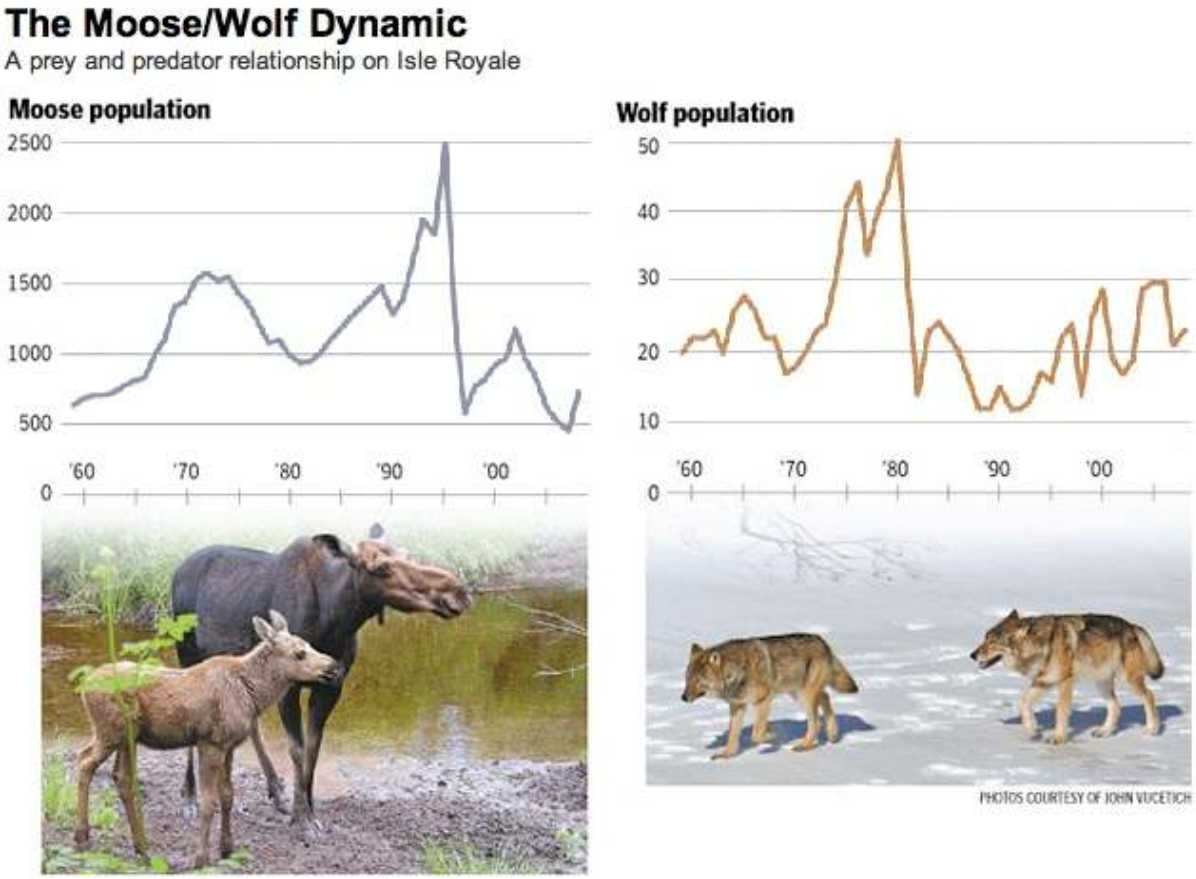
- Health: disease and parasites

- Predation
- Toxic wastes- EX: bacteria and yeasts

- Intrinsic factors – stress and aggression

Population dynamics

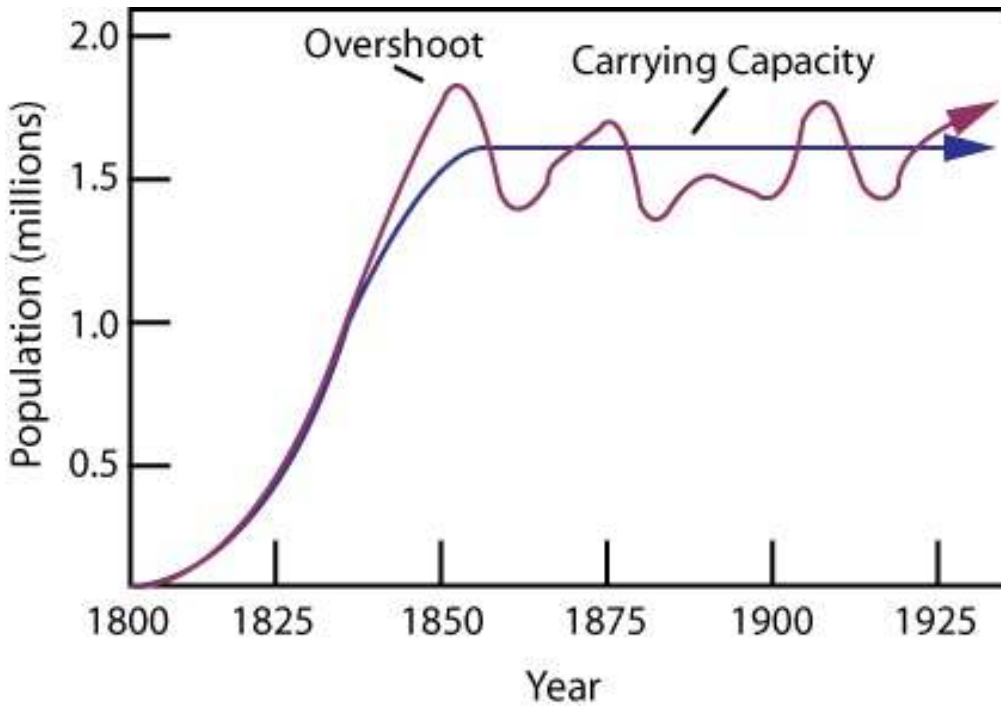
- Study of how interaction of biotic and abiotic factors cause variation in population size
  - This example shows how wolves affect moose
    - Notice the patterns



SOURCE: Isle Royale Wolf/Moose Study | GRAPHIC: By Patterson Clark, The Washington Post - July 21, 2008

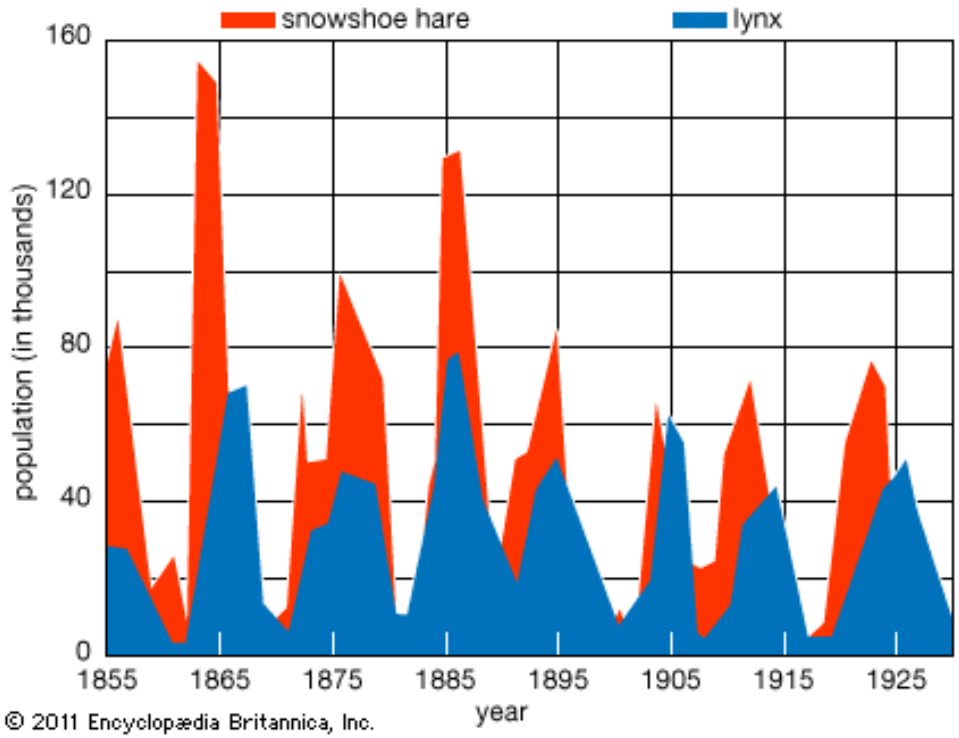
Population cycles

- The effect of carrying capacity
  - Natural populations constantly overshoot the carrying capacity
    - Individuals die off
  - Populations naturally hover around the carrying capacity



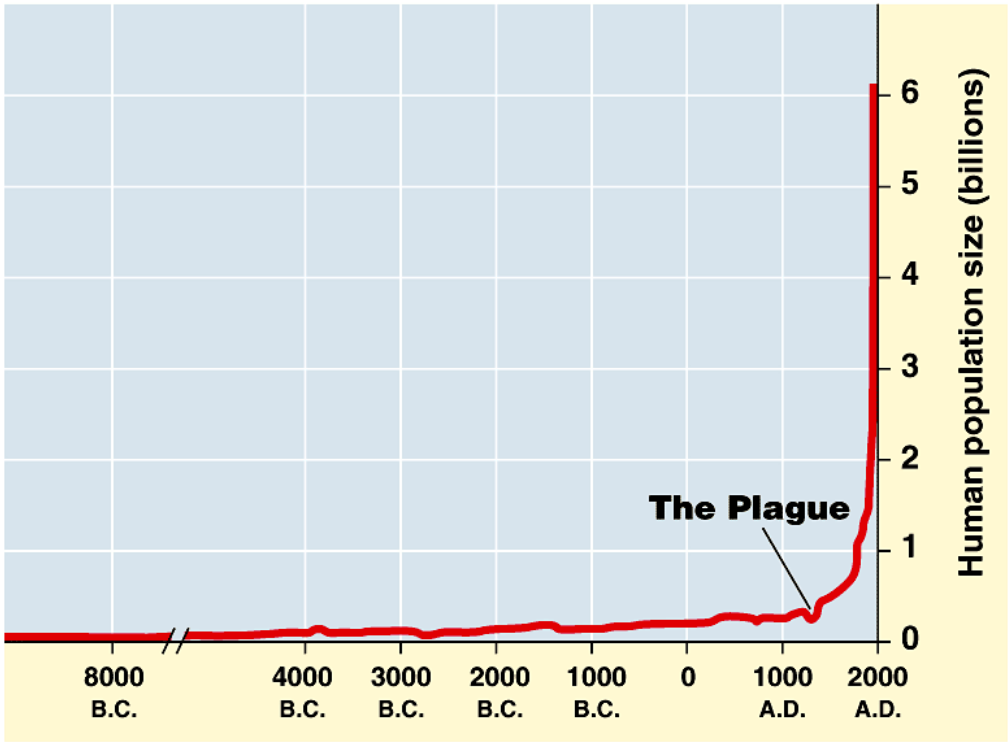
Population cycles

- EX: Hare and Lynx
  - 3 and 10 year cycles



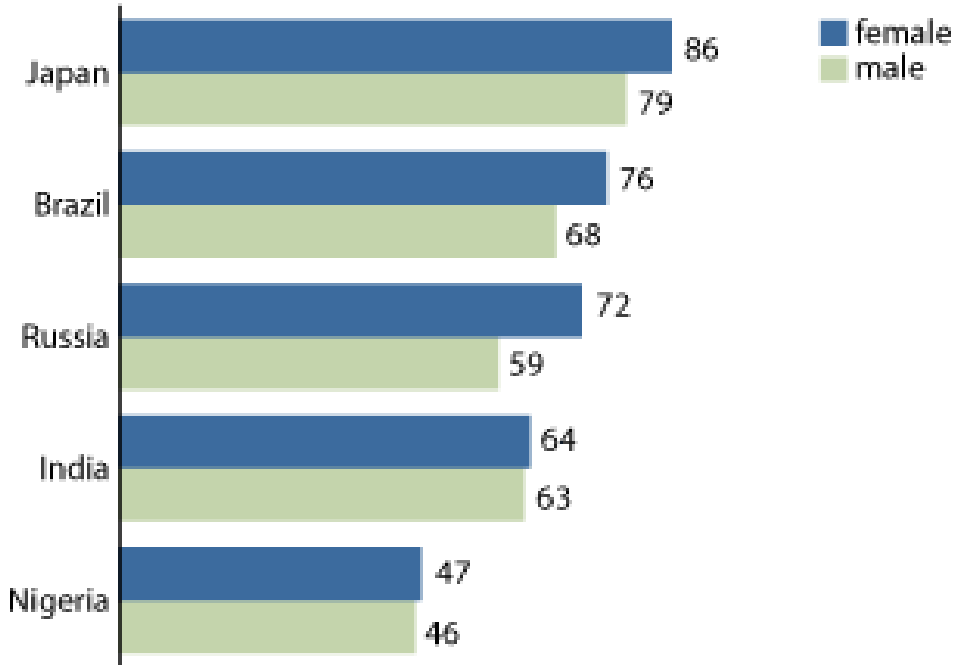
Human population growth

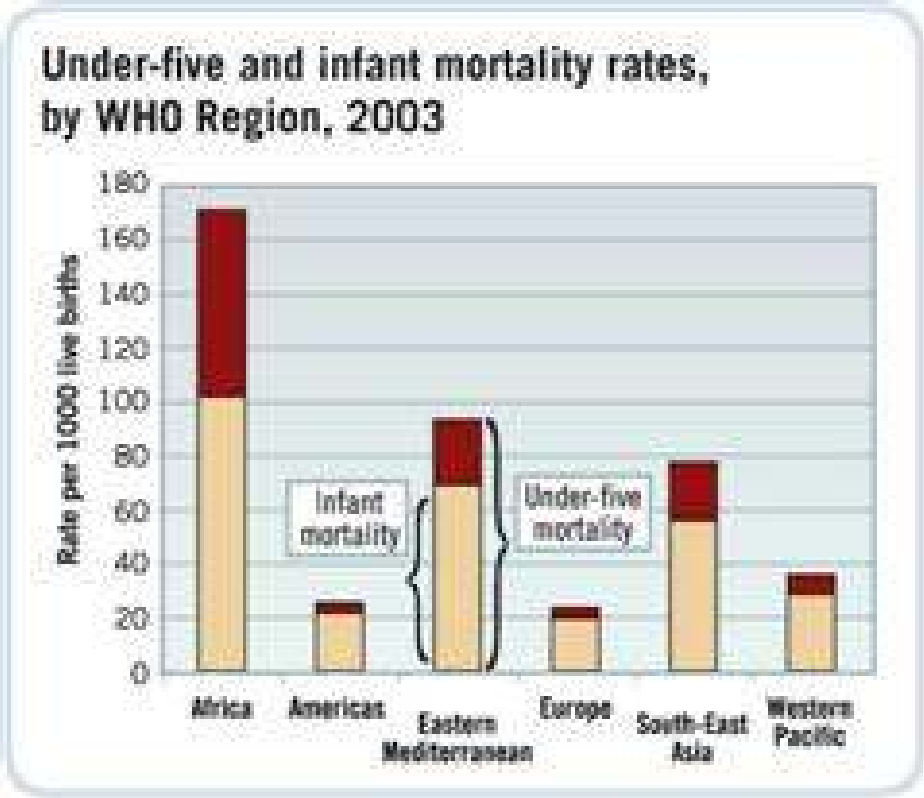
- Its really growing! Over 7 billion today
- Check it out! http://www.census.gov/popclock/
- Approx. 200,000 people each day
- Estimates
  - 8 billion by 2027
  - 9 billion by 2046
- Rate is slowing
  - 1963: 2.19%
  - 2003: 1.16%



Infant Deaths and Life Expectancy

- Developed Countries vs Developing Countries





Human population growth

- How have we overcome the natural carrying capacity?
  - Improvements in food and water supply
  - Improvements in medicine
  - Improvements in waste reduction technology
  - Expansion of habitat

Human population growth

- Is there a true natural carrying capacity for humans?

- What are we doing to our ecological footprint? (ecological services)