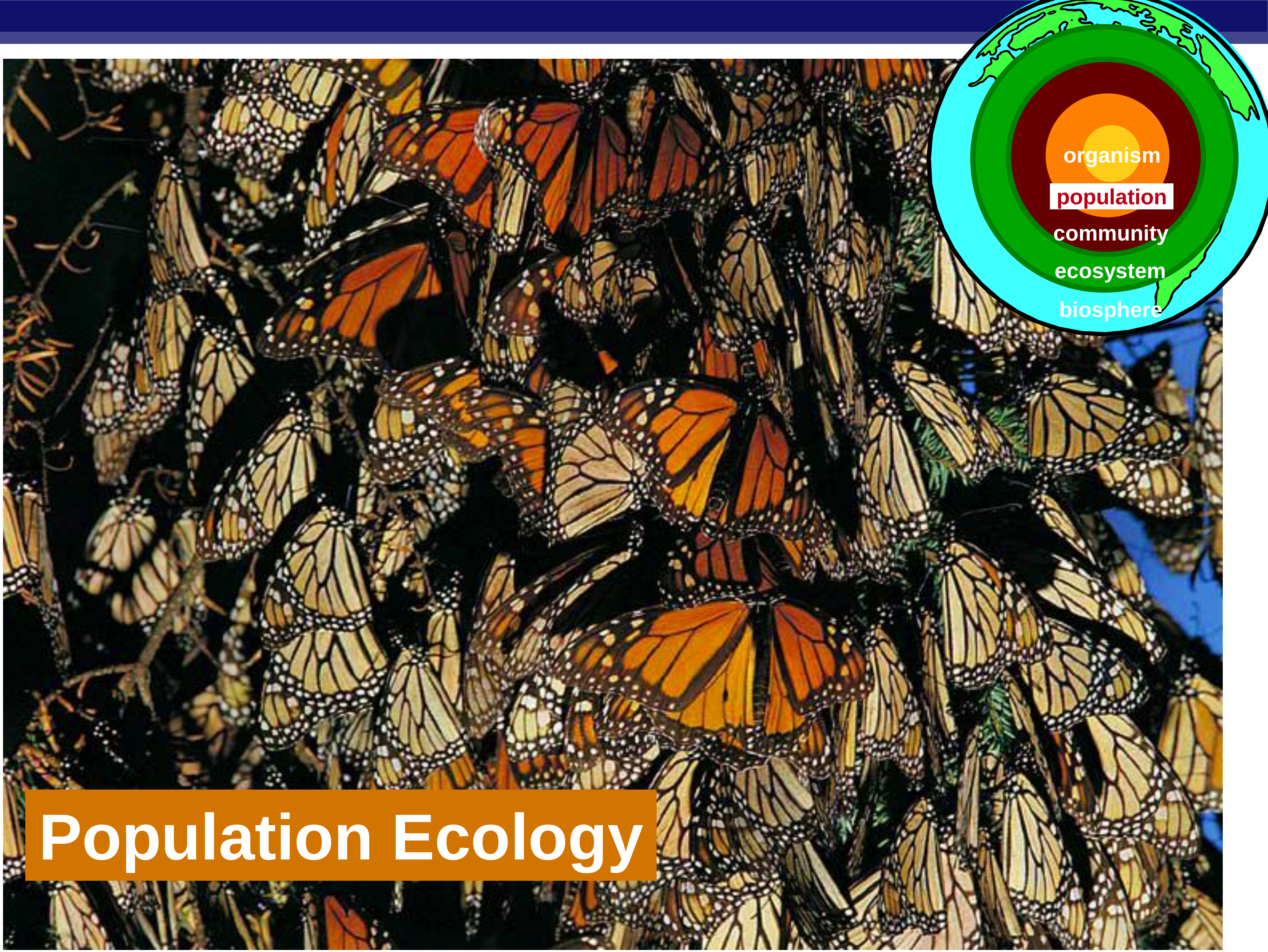


Population Ecology

Why Population Ecology?

- **Scientific goal**
  - understanding the factors that influence the size of populations
    - general principles
    - specific cases
- **Practical goal**
  - management of populations
    - increase population size
      - endangered species
    - decrease population size
      - pests
    - maintain population size
      - fisheries management
        - maintain & maximize sustained yield

Life takes place in populations

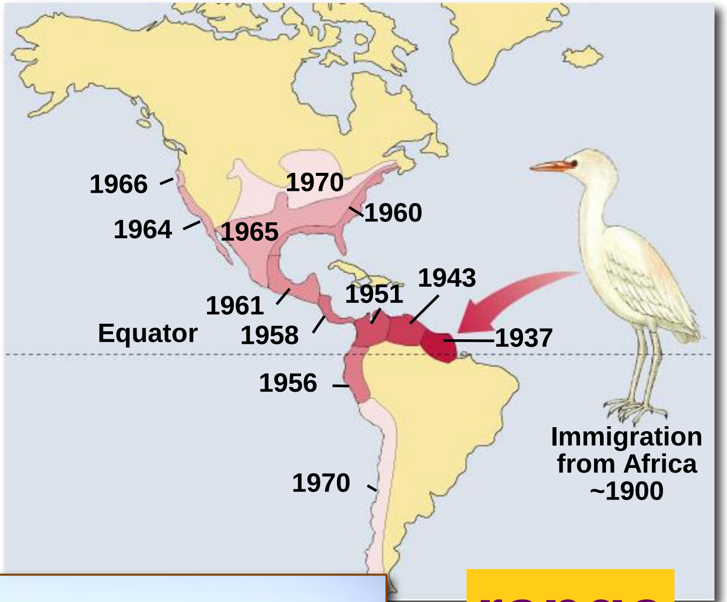
- **Population**
  - group of individuals of same species in same area at same time

- rely on same resources
- interact
- interbreed

Population Ecology: What factors affect a population?

Characterizing a Population

- Describing a population
  - population range
  - pattern of Dispersion
  - Density of population

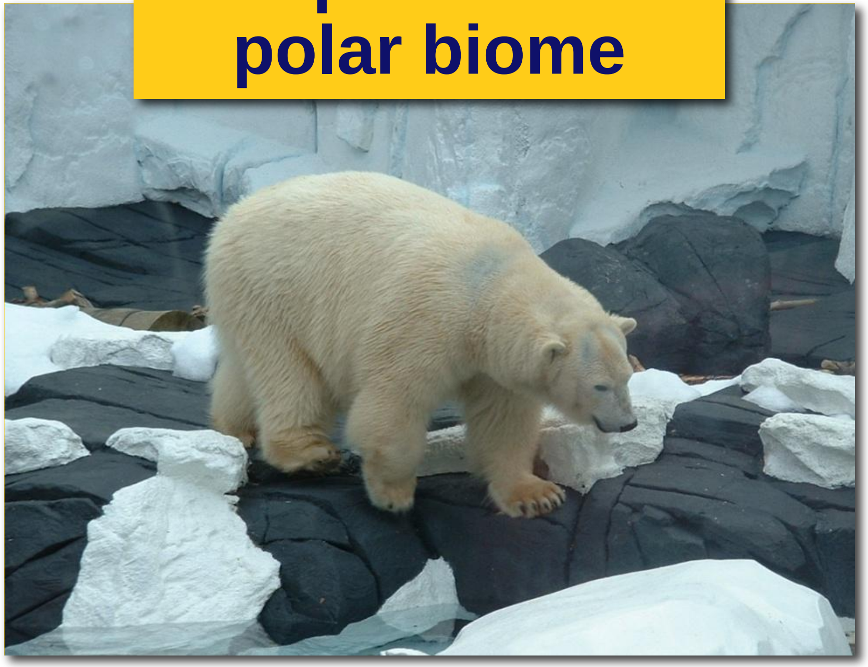


range

Population Range

- Geographical limitations
  - abiotic & biotic factors
    - temperature, rainfall, food, predators, etc.
  - habitat

adaptations to polar biome

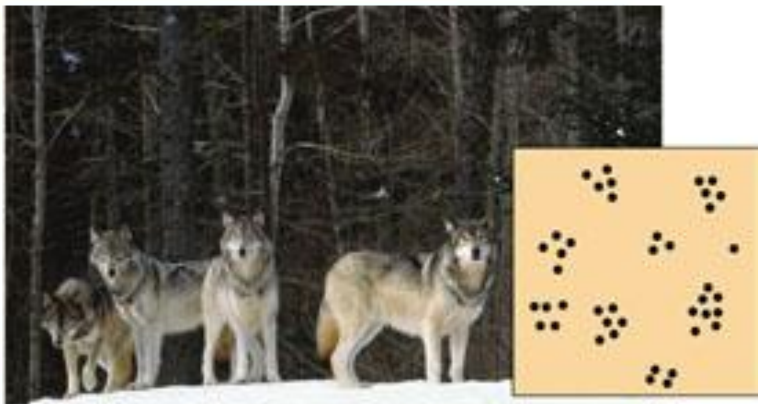


adaptations to rainforest biome

Population Dispersion

- **Spacing patterns within a population**

Provides insight into the environmental associations & social interactions of individuals in population



clumped

random

(b) Uniform

uniform

Clumped Pattern (most common)

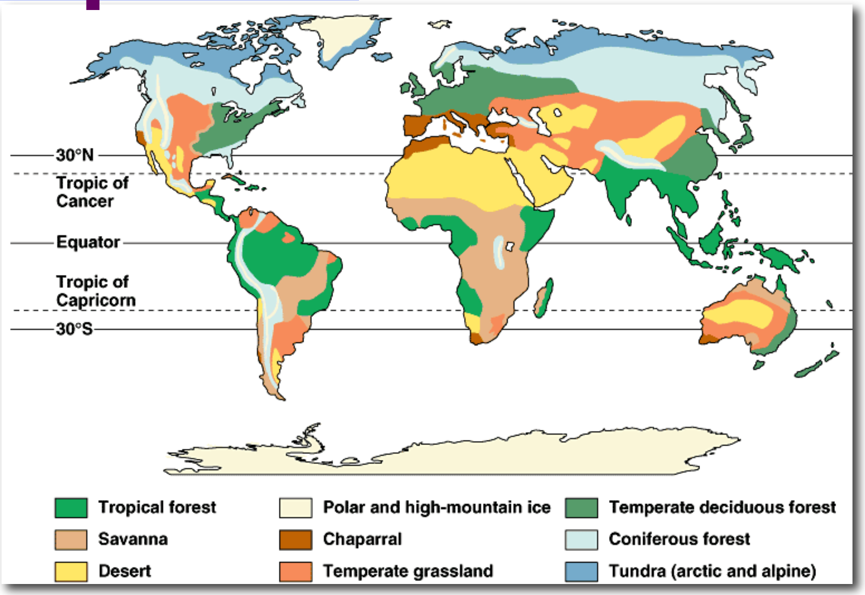
Uniform

May result from direct interactions between individuals in the population

→ **territoriality**

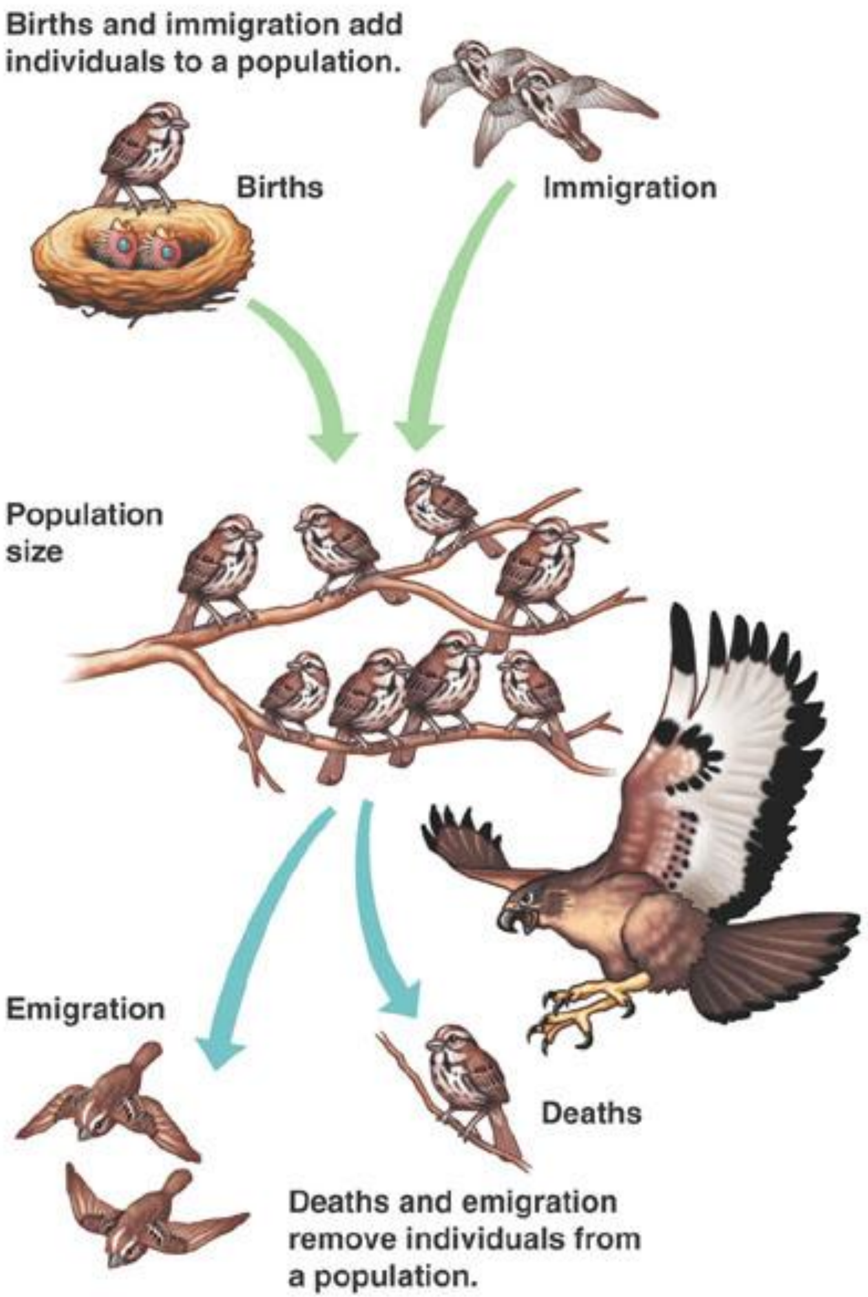
Factors that affect Population Size

- **Abiotic factors**
  - sunlight & temperature
  - precipitation / water
  - soil / nutrients
- **Biotic factors**
  - other living organisms
    - prey (food)
    - competitors
    - predators, parasites, disease
- **Intrinsic factors**
  - adaptations



Population Size

- Changes to population size
  - adding & removing individuals from a population
    - birth
    - death
    - immigration
    - Emigration
- *How can we measure a population?*



Population growth rates

- Factors affecting population growth rate
  - <u>sex ratio</u>
    - how many females vs. males?
  - <u>generation time</u>
    - at what age do females reproduce?
  - <u>age structure</u>
    - how females at reproductive age in <u>cohort</u>?

Why do teenage boys pay high car insurance rates?

Demography

- Factors that affect growth & decline of populations
  - vital statistics & how they change over time

Life table

**Table 52.1 Life Table for Bel… [females] …uirrels (*Spermophilus beldingi*) at Tioga… [males]
Sierra Nevada M… …ifornia***

Age (years)	Females: Number Alive at Start of Year	Females: Proportion Alive at Start of Year	Females: Number of Deaths During Year	Females: Death Rate†	Females: Average Life Expectancy (years)	Males: Number Alive at Start of Year	Males: Proportion Alive at Start of Year	Males: Number of Deaths During Year	Males: Death Rate†	Males: Average Life Expectancy (years)
0–1	337	1.000	207	0.61	1.33	349	1.000	227	0.65	1.07
1–2	252††	0.386	125	0.50	1.56	248††	0.350	140	0.56	1.12
2–3	127	0.197	60	0.47	1.60	108	0.152	74	0.69	0.93
3–4	67	0.106	32	0.48	1.59	34	0.048	23	0.68	0.89
4–5	35	0.054	16	0.46	1.59	11	0.015	9	0.82	0.68
5–6	19	0.029	10	0.53	1.50	2	0.003	0	1.00	0.50
6–7	9	0.014	4	0.44	1.61	0				
7–8	5	0.008	1	0.20	1.50					
8–9	4	0.006	3	0.75	0.75					
9–10	1	0.002	1	1.00	0.50					

*Males and females have different mortality schedules … they are ta…d separately.
†The death rate is the proportion of individuals dying … the specific …me interval.
††Includes 122 females and 126 males first captured as …e-year-olds …d therefore … included in the count of squirrels …

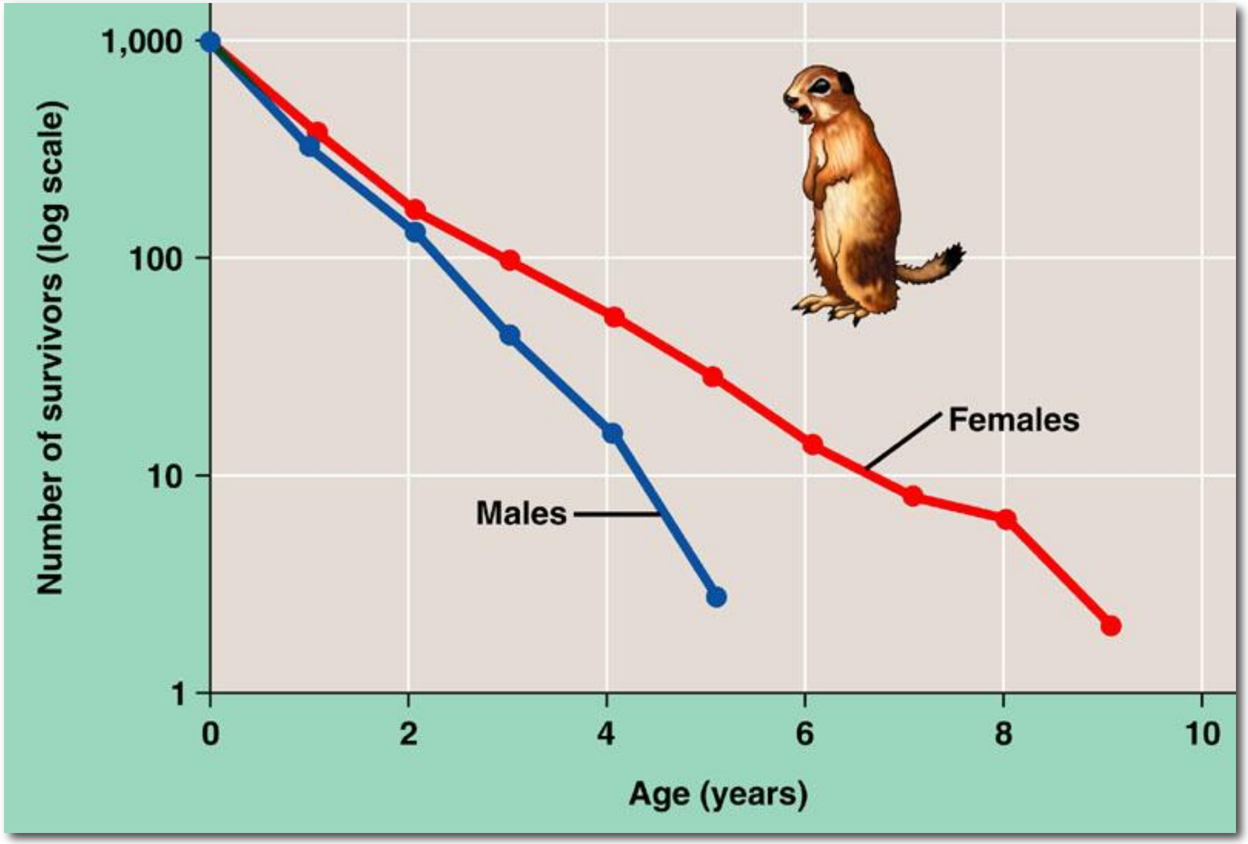
SOURCE: Data from P. W. Sherman and M. L. Morton, …emography …f Belding's G…nd Squirrel," *Ecology* 65(1984): 1617–1628.

What adaptations have led to this difference in male vs. female mortality?

Survivorship curves

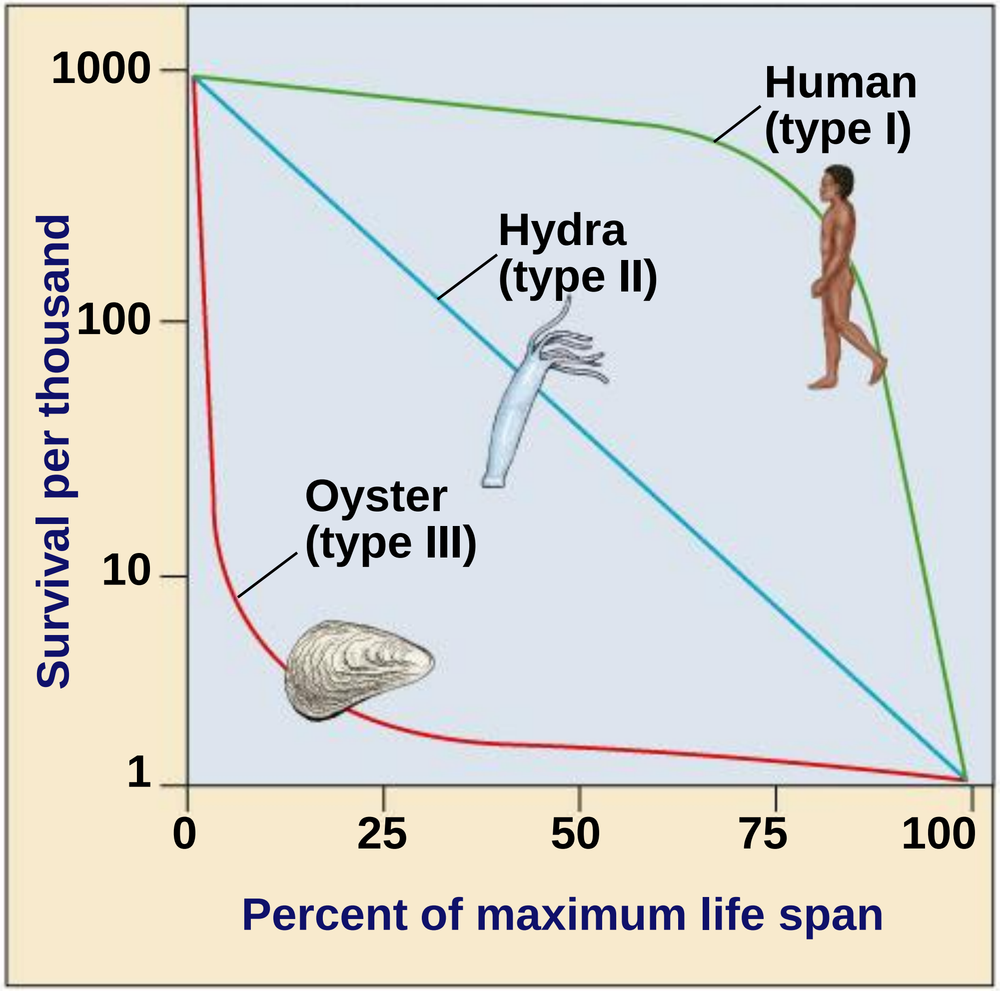
- **Graphic representation of life table**

The relatively straight lines of the plots indicate relatively constant rates of death; however, males have a lower survival rate overall than females.



Survivorship curves

- Generalized strategies



What do these graphs tell about survival & strategy of a species?

I. High death rate in post-reproductive years

II. Constant mortality rate throughout life span

III. Very high early mortality but the few survivors then live long (stay reproductive)

Trade-offs: survival vs. reproduction

- **The cost of reproduction**
  - increase reproduction may decrease survival
    - age at first reproduction
    - investment per offspring
    - number of reproductive cycles per lifetime
    - parents not equally invested
    - offspring mutations

- **Life History determined by costs and benefits of all adaptations**

Natural selection favors a life history that maximizes lifetime reproductive success

Reproductive strategies

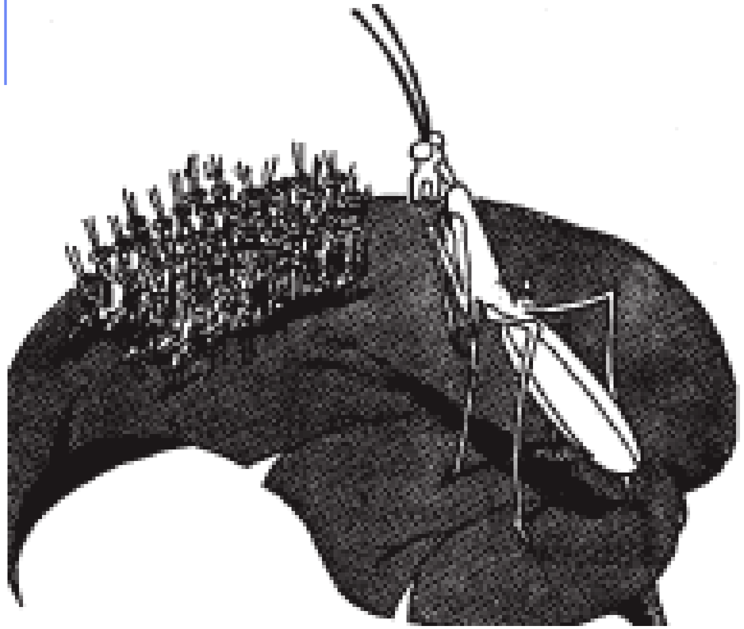
- **K-selected**
  - late reproduction
  - few offspring
  - invest a lot in raising offspring
    - primates
    - coconut
- **r-selected**
  - early reproduction
  - many offspring
  - little parental care
    - insects
    - many plants

Trade offs

Number & size of offspring
vs.
Survival of offspring or parent

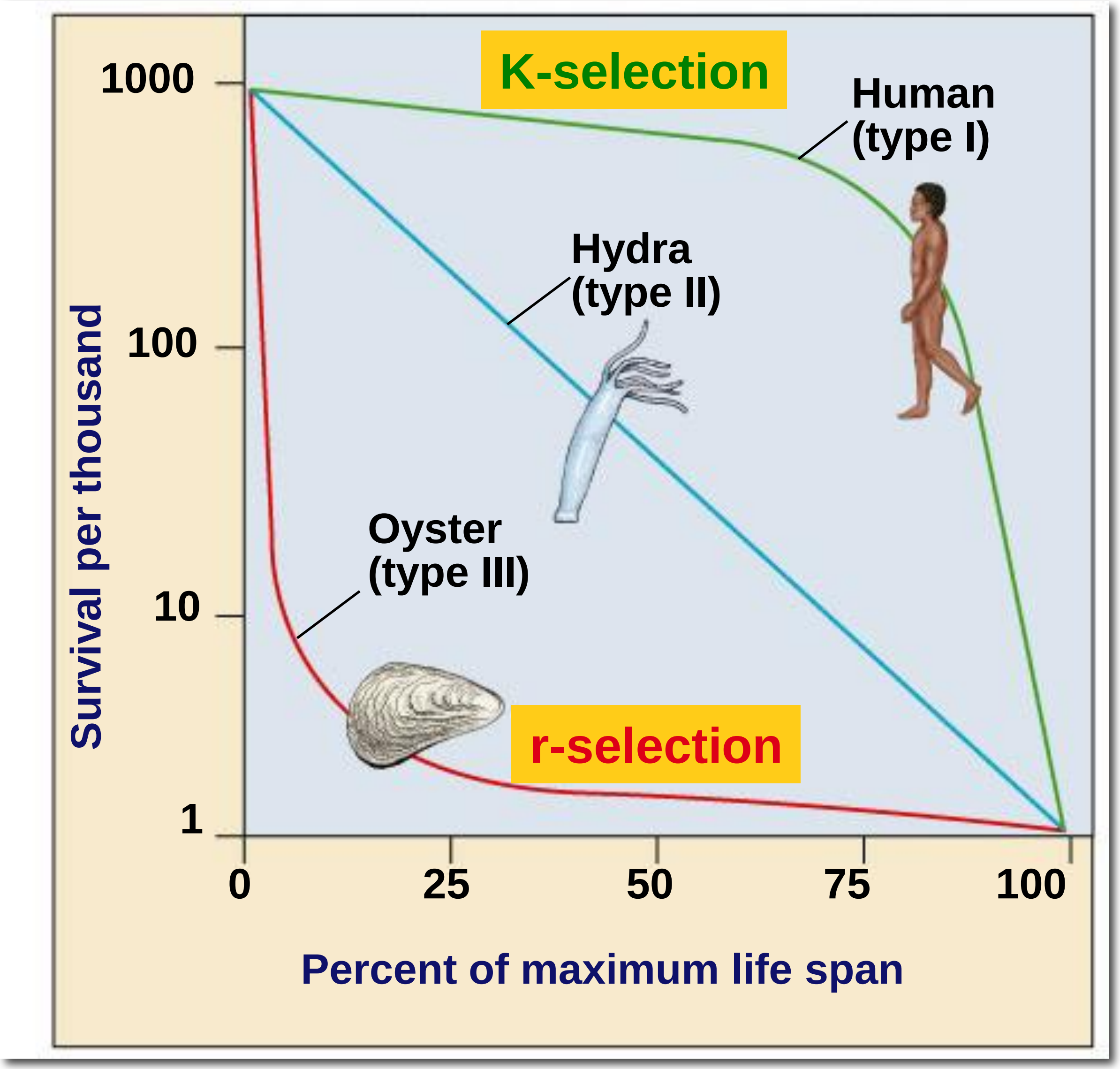
(a) Most weedy plants, such as this dandelion, grow quickly and produce a large number of seeds, ensuring that at least some will grow into plants and eventually produce seeds themselves.

(b) Some plants, such as this coconut palm, produce a moderate number of very large seeds. The large endosperm provides nutrients for the embryo, an adaptation that helps ensure the success of a relatively large fraction of offspring.



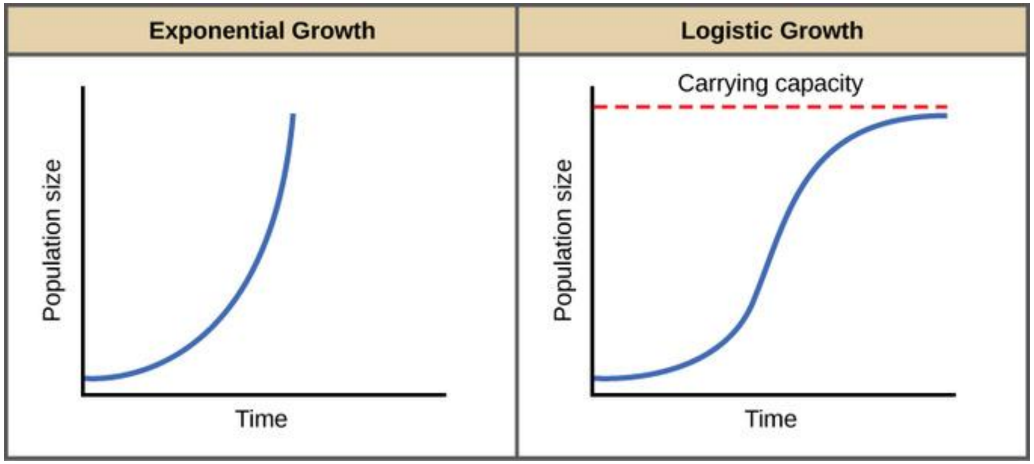
"Of course, long before you mature, most of you will be eaten."

Reproductive strategies & survivorship



Growth Rate Models

- Exponential growth
  - Rapid growth
  - No constraints
- Logistic growth
  - Environmental constraints
  - Limited growth

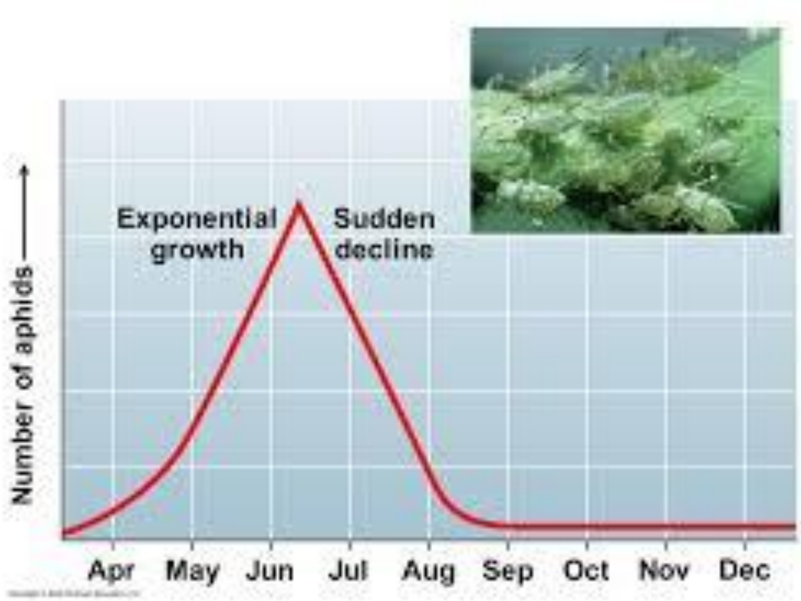


Exponential growth rate

- **Characteristic of populations without <u>limiting factors</u>**
  - Small population at start
  - introduced to a new environment or rebounding from a catastrophe, low competition, no predators
  - Ex: insects, annual plant, invasive species

"Boom and Bust"

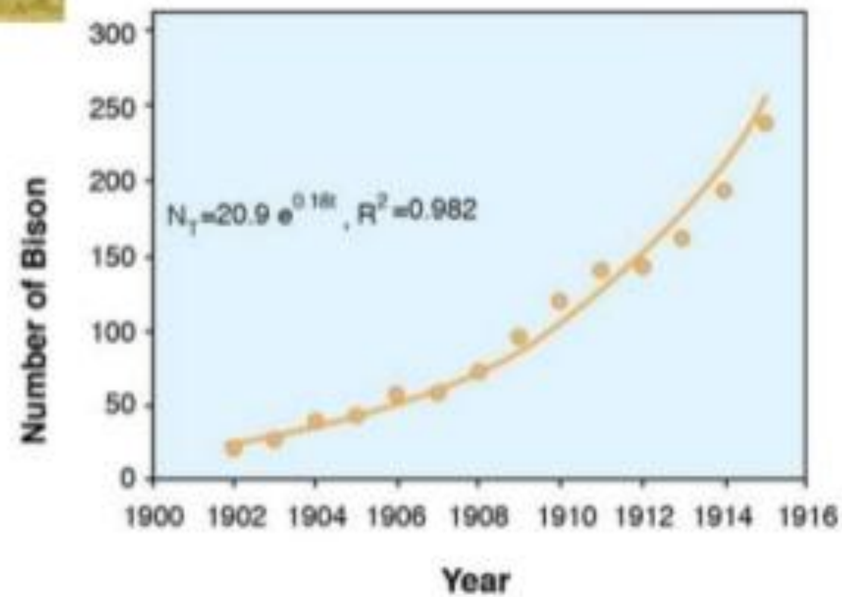
Does this growth last?



Examples of exponential population growth

Throughout the 1800's, hunters decimated the **American Plains bison** populations, and by 1889, only about one thousand bison remained.

The US government, along with private landowners, established protected herds in the late 1800's and early 1900's. The herds started small, but with plentiful resources and few predators, they grew quickly. The bison population in northern Yellowstone National Park increased from 21 bison in 1902 to 250 in only 13 years.

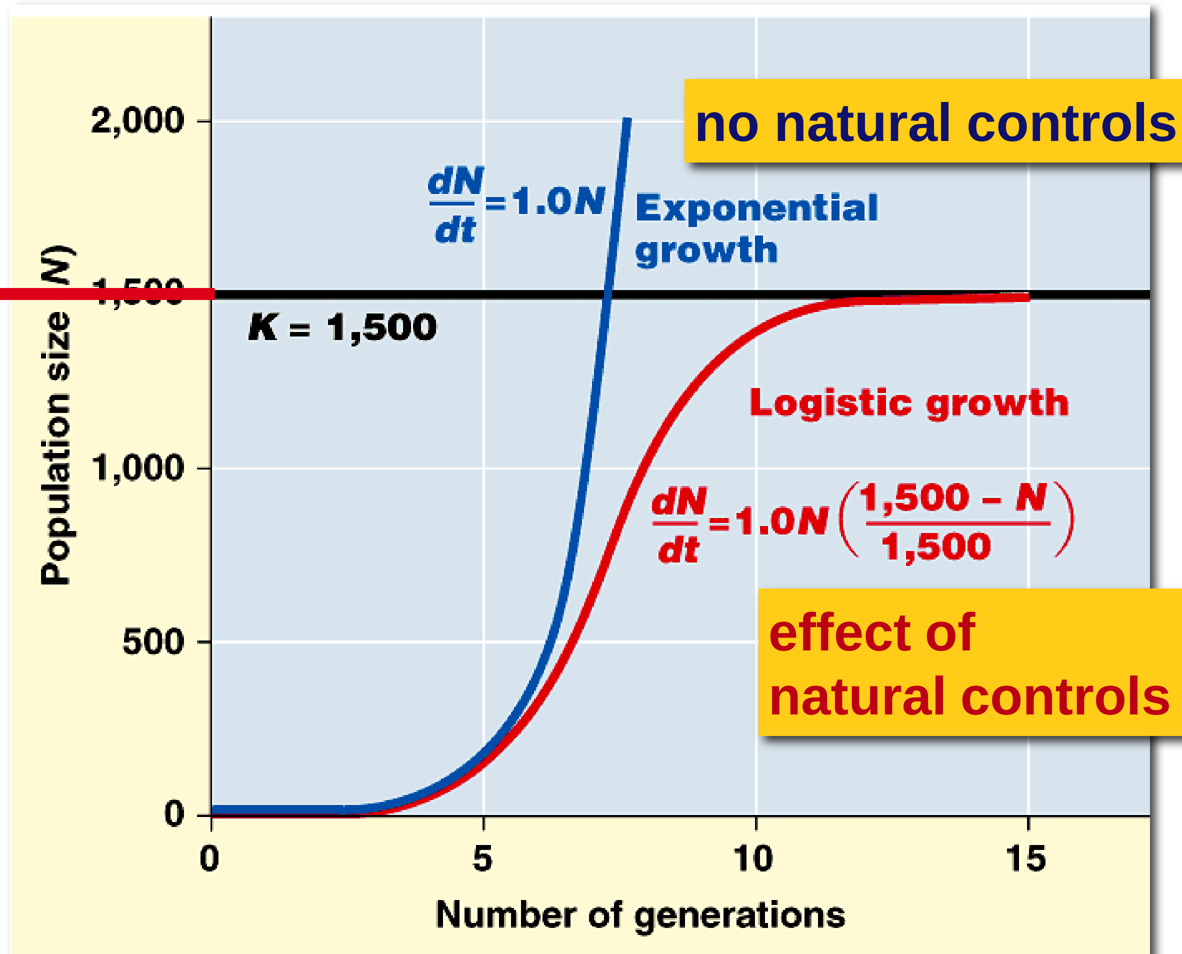


http://www.nature.com/scitable/knowledge/library/an-introduction-to-population-growth-84225544

Logistic rate of growth

- Growth rate slows as K is reached.

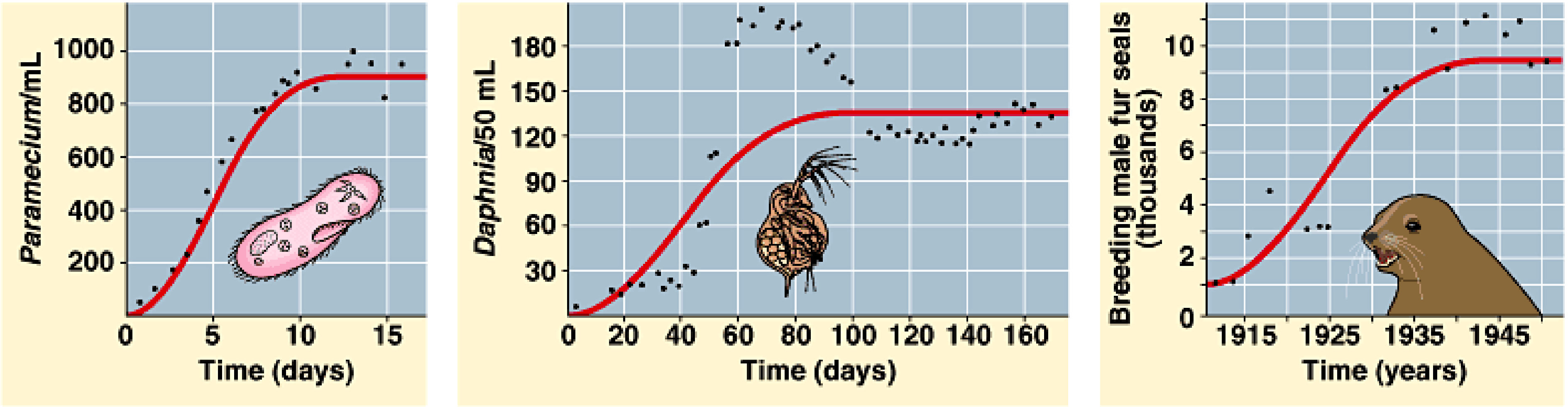
K = carrying capacity



Causes: Energy limitations, water, shelter, predators, parasites

Carrying capacity

- <u>Maximum population</u> size that environment can support
- Varies over time and space



(a) A *Paramecium* population in laboratory culture

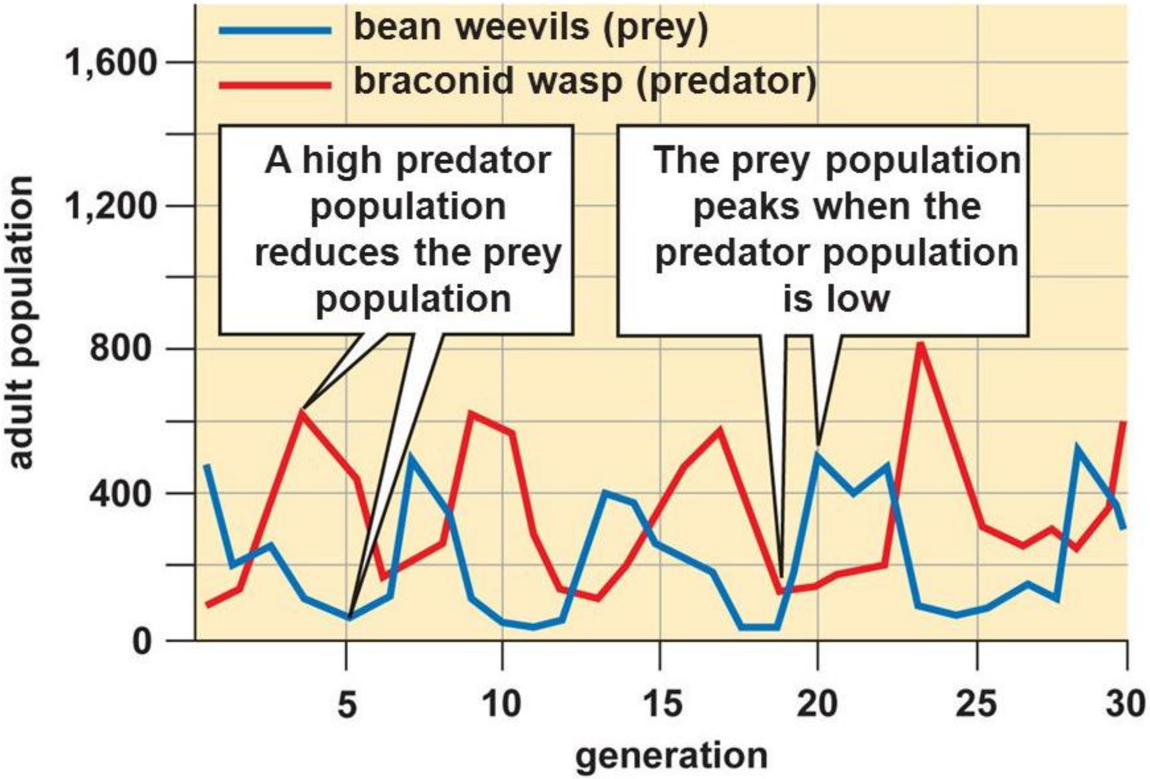
(b) A *Daphnia* population in laboratory culture

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

Population cycles

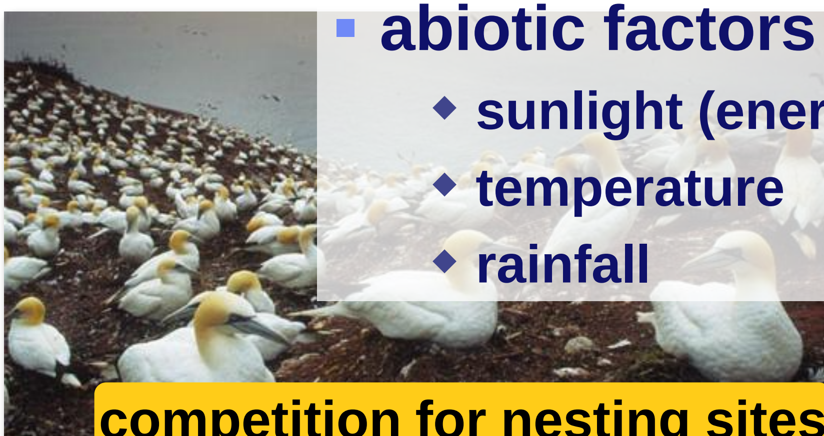
- predator – prey interactions
- Hard to define K

Negative feedback response to regulate populations



Regulation of Population Size

- Limiting factors
  - density dependent
    - competition: food, mates, nesting sites
    - predators, parasites, pathogens
  - density independent
    - abiotic factors
      - sunlight (energy)
      - temperature
      - rainfall



Population growth math

change in population = births – deaths

$$\frac{\Delta N}{\Delta t} = B - D$$

ΔN is the change in population size
Δt is the time interval
B is the number of births
D is the number of deaths

Need to know:

- **Number of organisms = N**
- **Rate of growth = r**
  - **r = birth rate – death rate**
  - **Birth rate (b) = B (#births)/N**
  - **Death rate (d) = D (#deaths)/N**

- **r is always a decimal**
- **When r = 0, no growth is occurring!! ZPG**
  - ***Births and deaths still occur but in equal #'s***

Exponential Population Growth

- **Rewritten with "r" when max growth rate is needed.**
- **If rate is faster then growth is faster**

$$\frac{\Delta N}{\Delta t} = rN$$

Logistic Population Growth

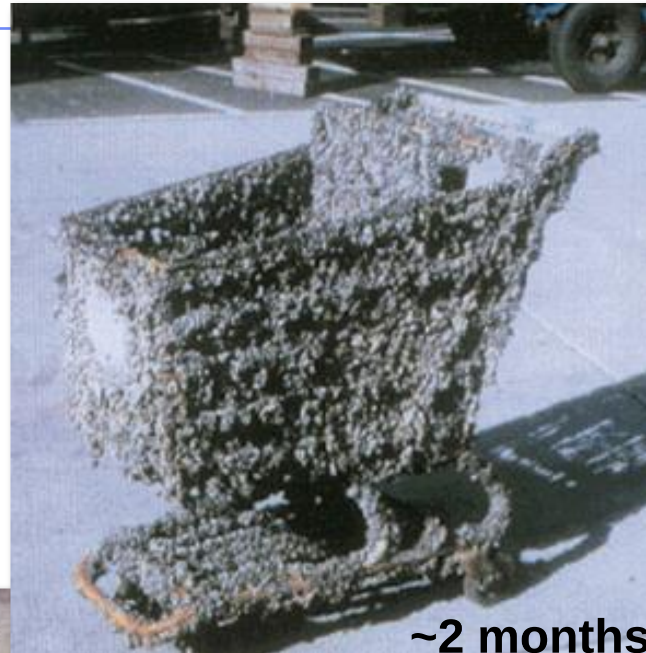
- Carrying Capacity must be added…
- Population is greatest at approx. ½ the carrying capacity
- K = carrying capacity; fixed number

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

Invasive Species

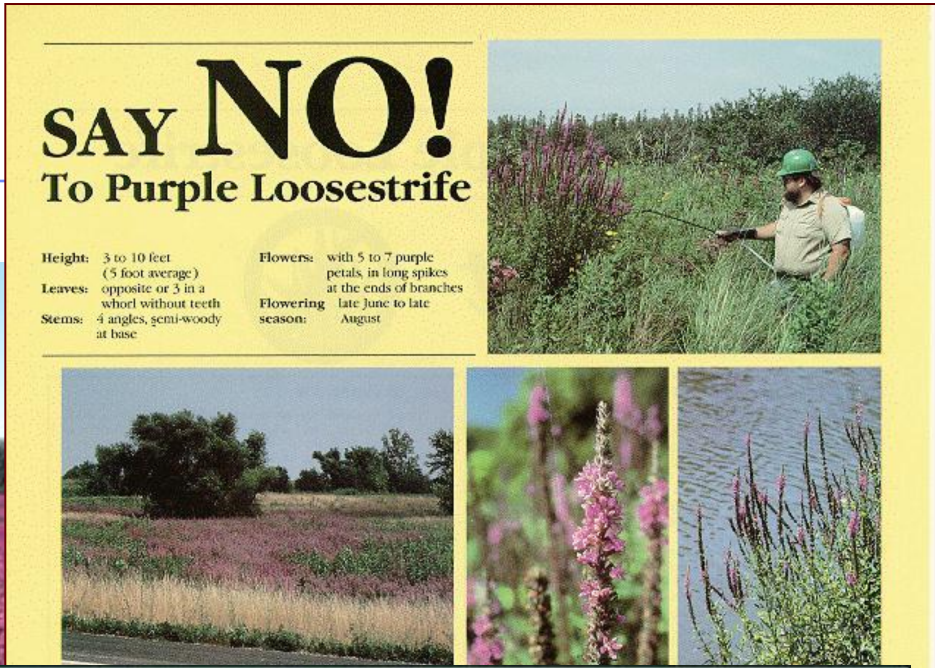
- Non-native species
- Exponential growth
  - out-compete native species
    - loss of natural controls
    - lack of predators, parasites, competitors
  - reduce diversity
  - examples
    - Cane toads
    - Zebra mussel
    - Purple loosestrife

Zebra mussels



- reduces diversity
- loss of food & nesting sites for animals
- economic damage

Purple loosestrife



- reduces diversity
- loss of food & nesting sites for animals

Human population growth

<u>Doubling times</u>

250m → 500m = y ()

500m → 1b = y ()

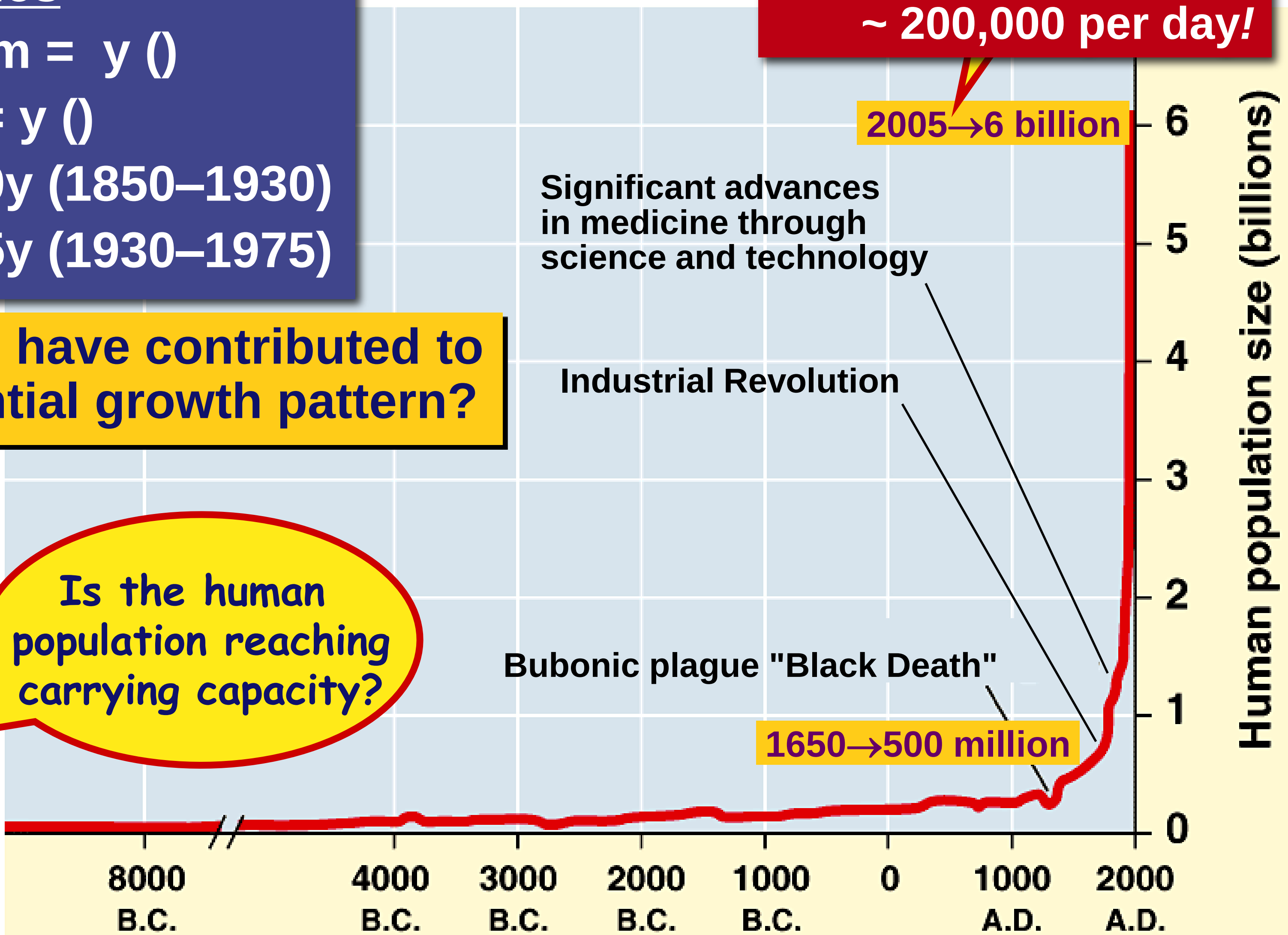
1b → 2b = 80y (1850–1930)

2b → 4b = 75y (1930–1975)

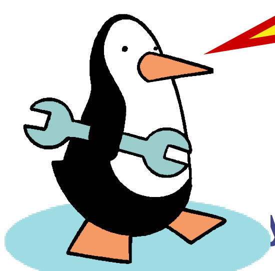
What factors have contributed to this exponential growth pattern?

Population of…
China: 1.3 billion
India: 1.1 billion

adding 82 million/year ~ 200,000 per day!



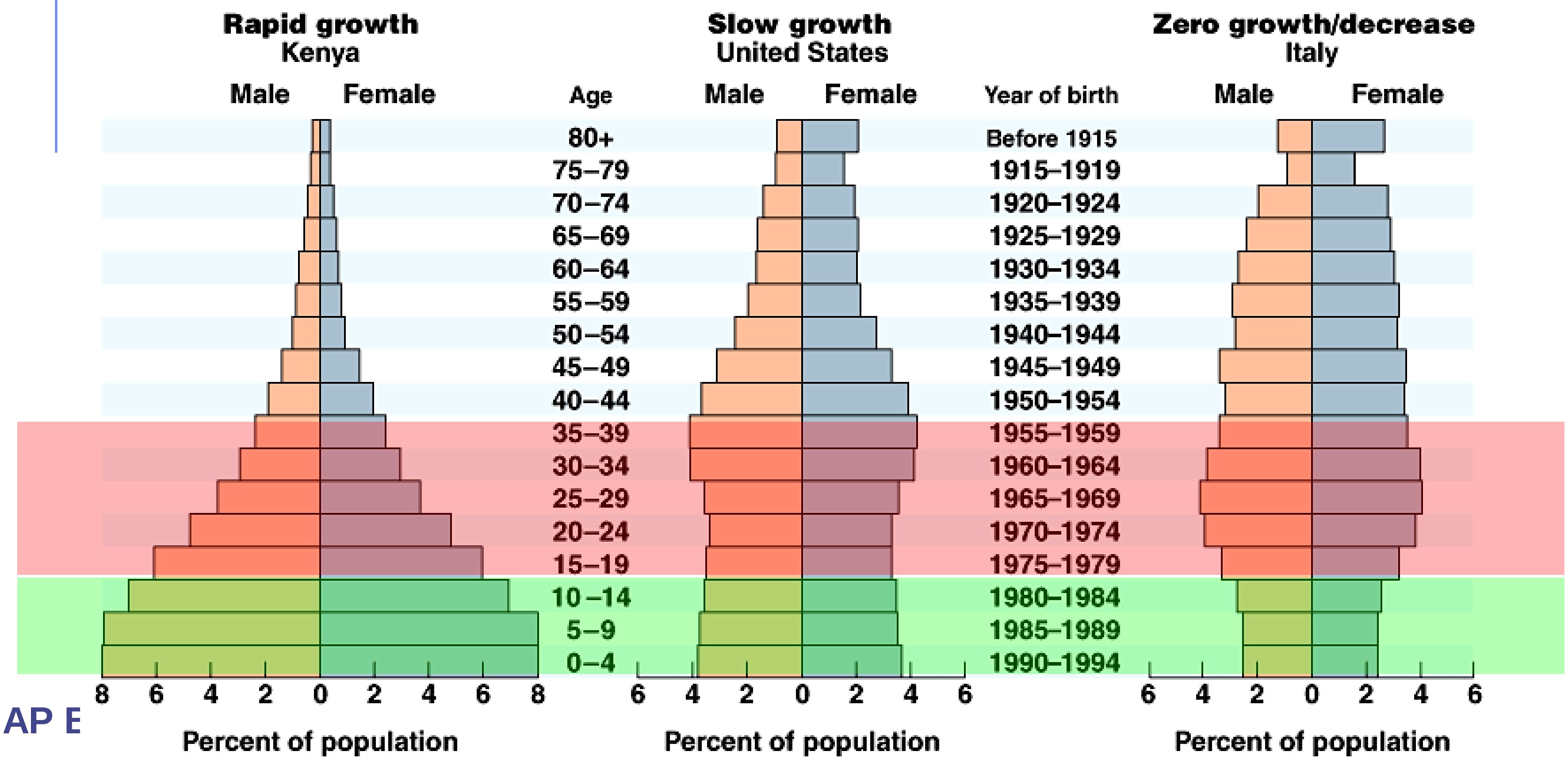
Is the human population reaching carrying capacity?



Age structure

- Relative number of individuals of each age

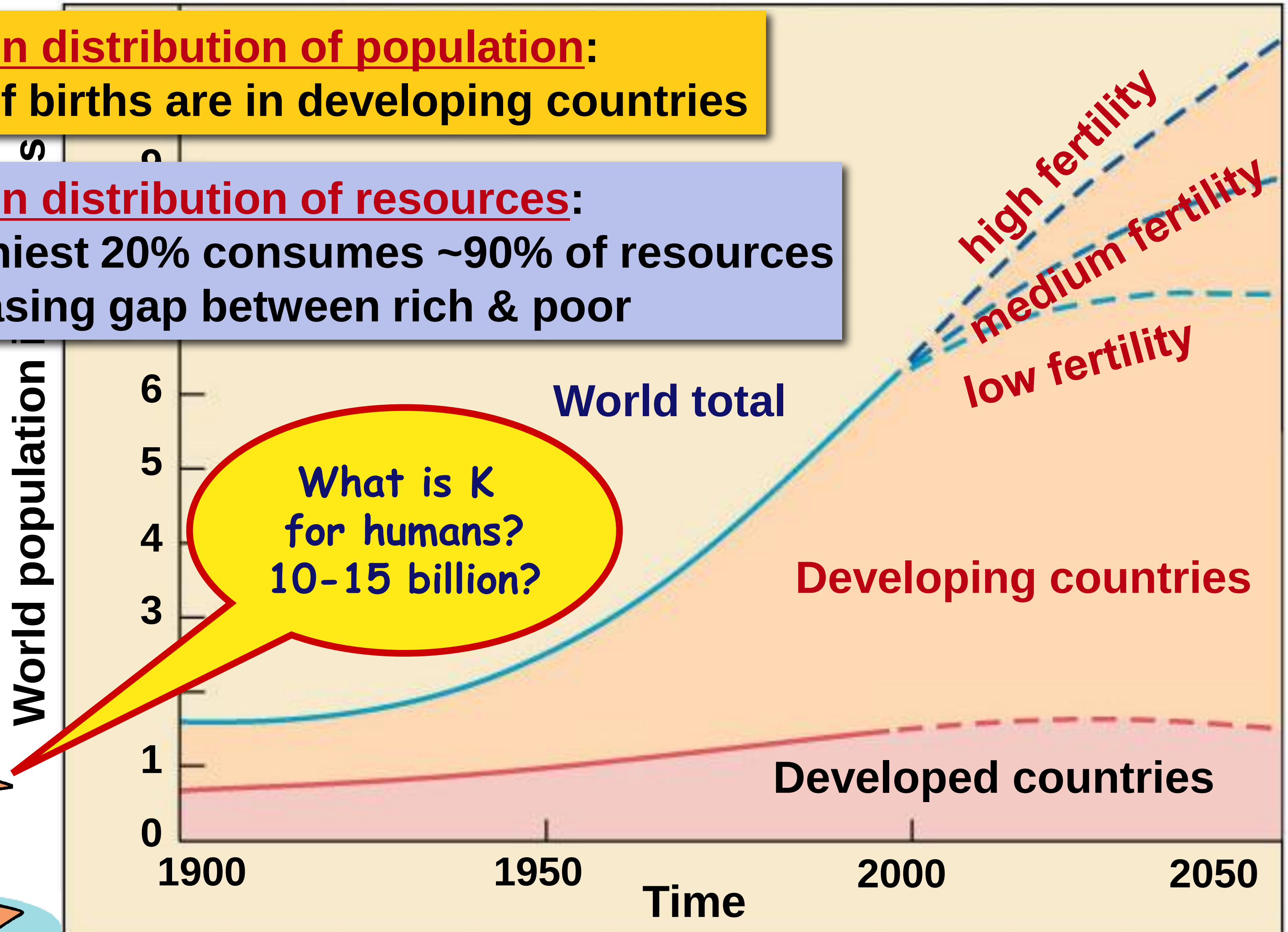
What do these data imply about population growth in these countries?

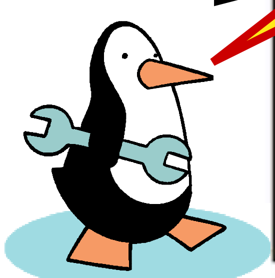


Distribution of population growth

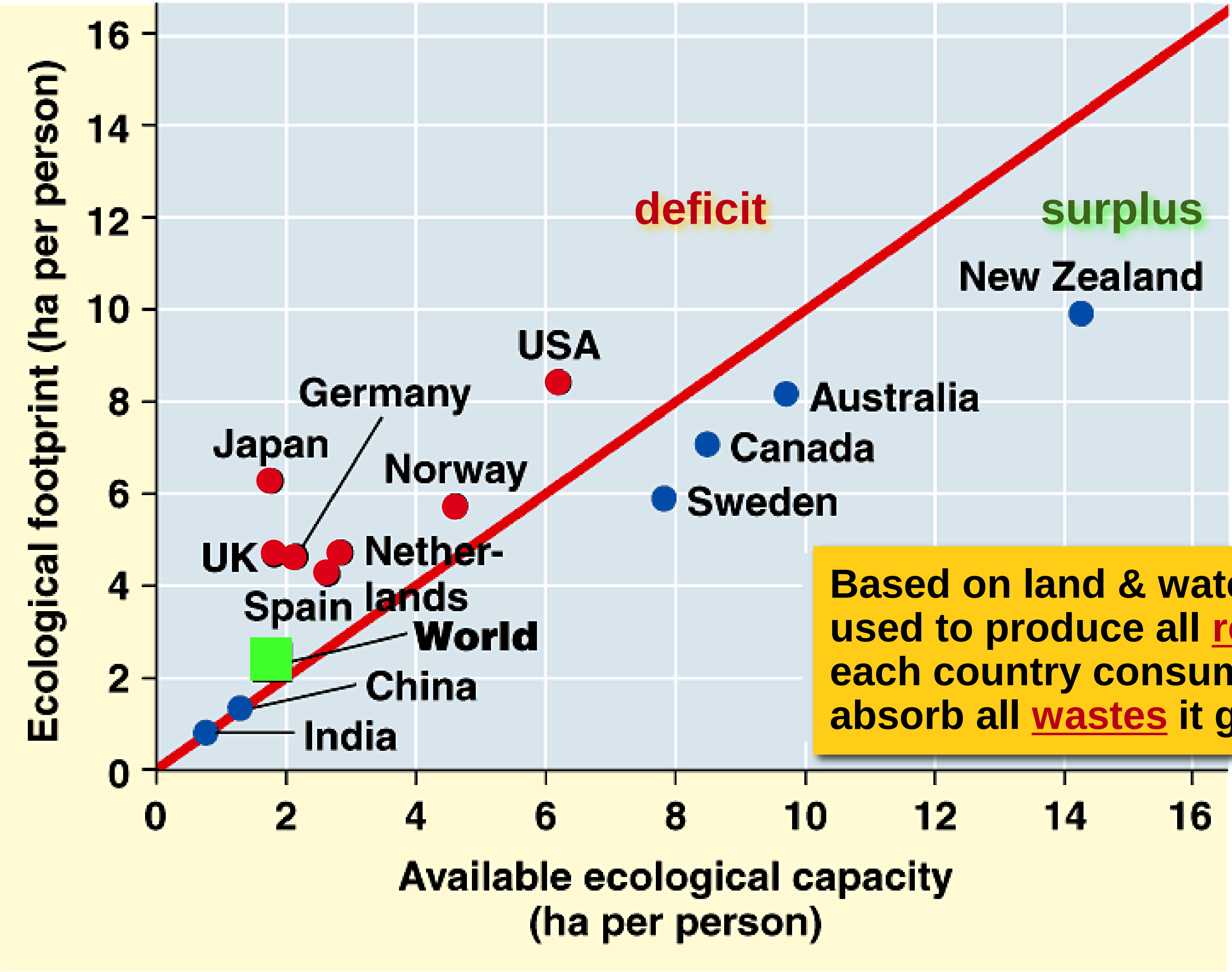
uneven distribution of population:
90% of births are in developing countries

uneven distribution of resources:
wealthiest 20% consumes ~90% of resources
increasing gap between rich & poor





Ecological Footprint



Based on land & water area used to produce all resources each country consumes & to absorb all wastes it generates

Any Questions?