Population Ecology

Life takes place in populations

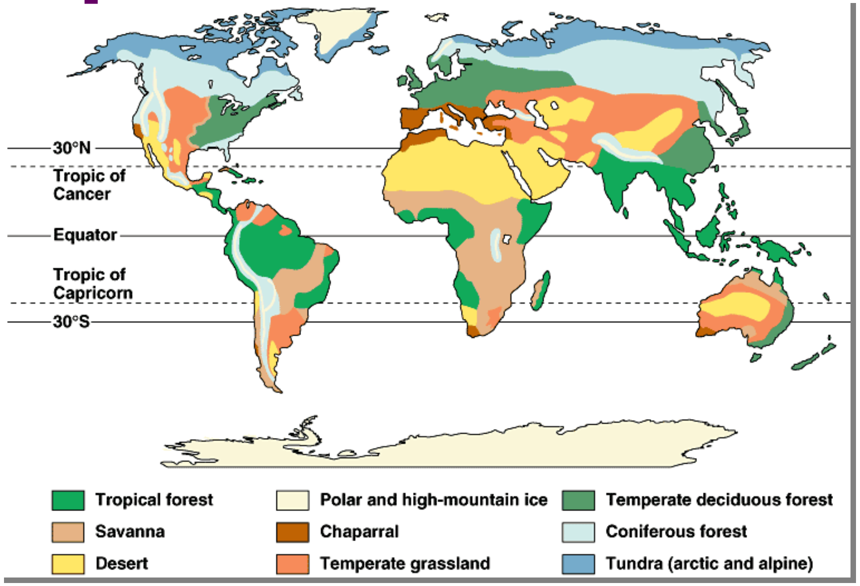
- **Population**
  - group of individuals of <u>same</u> species in <u>same</u> area at <u>same</u> time

- rely on same resources
- interact
- interbreed

Population Ecology: What factors affect a population?

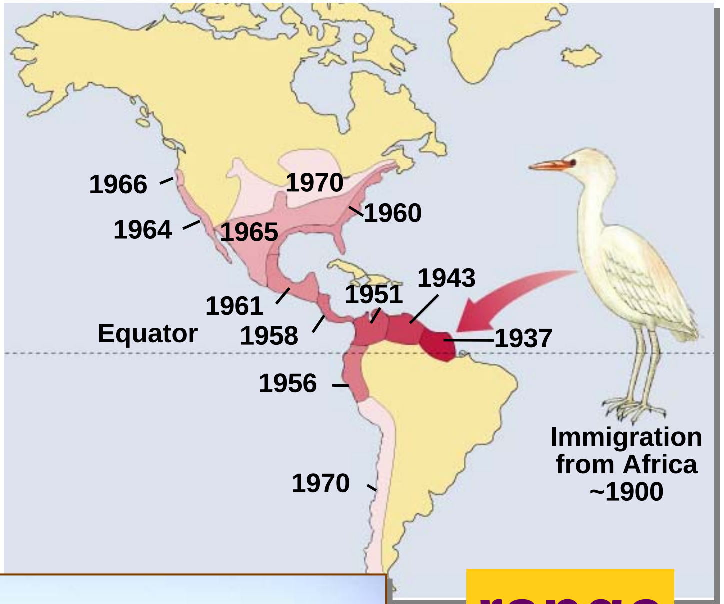
Factors that affect Population Size

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



Characterizing a Population

- **Describing a population**
  - population **range**
  - pattern of **spacing**
    - **density**
  - **size** of population



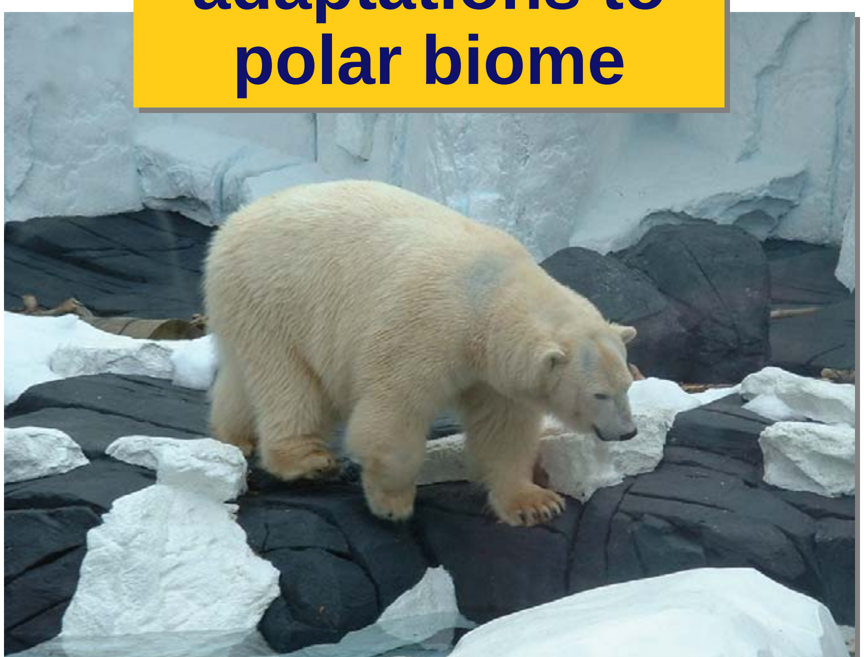
range

density

Population Range

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

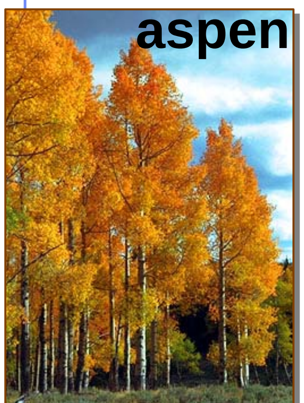
adaptations to polar biome

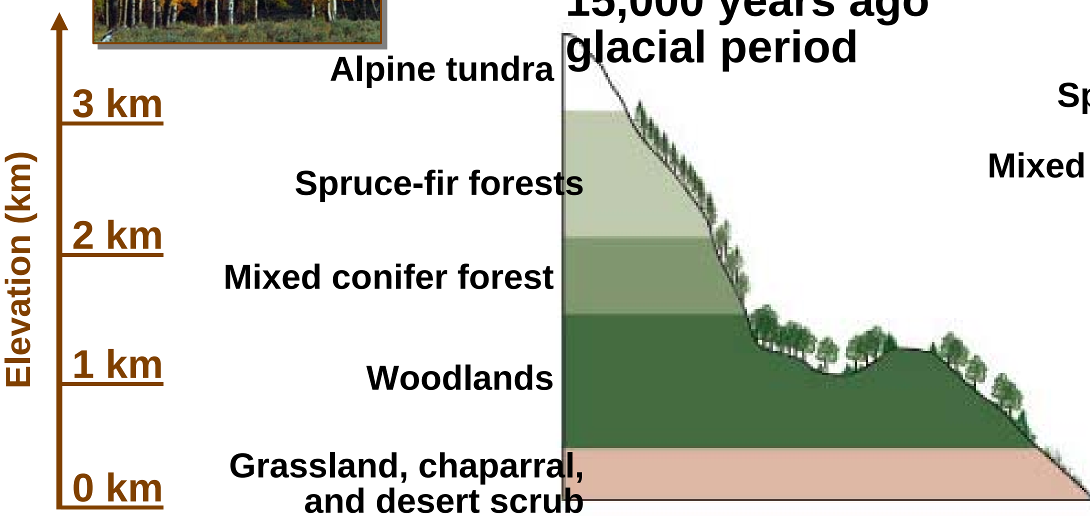


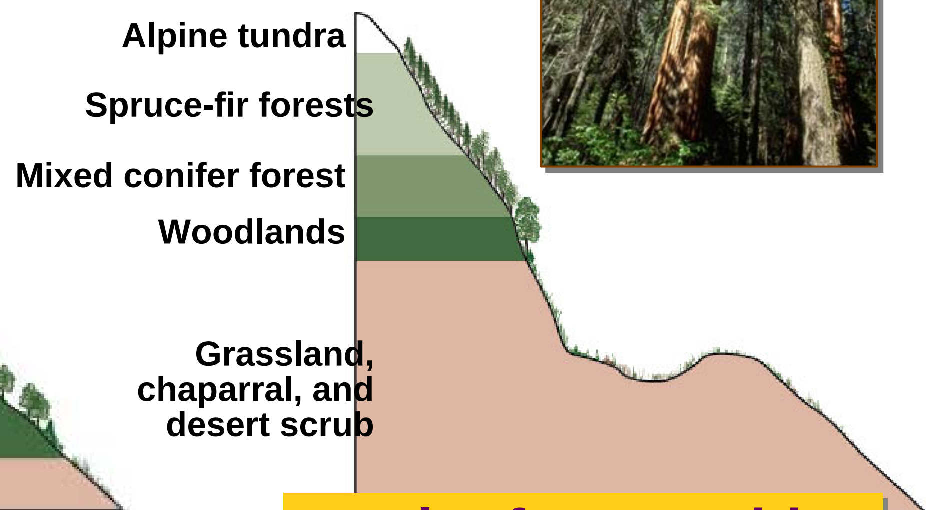
adaptations to rainforest biome

Changes in range

- **Range expansions & contractions**
  - changing environment



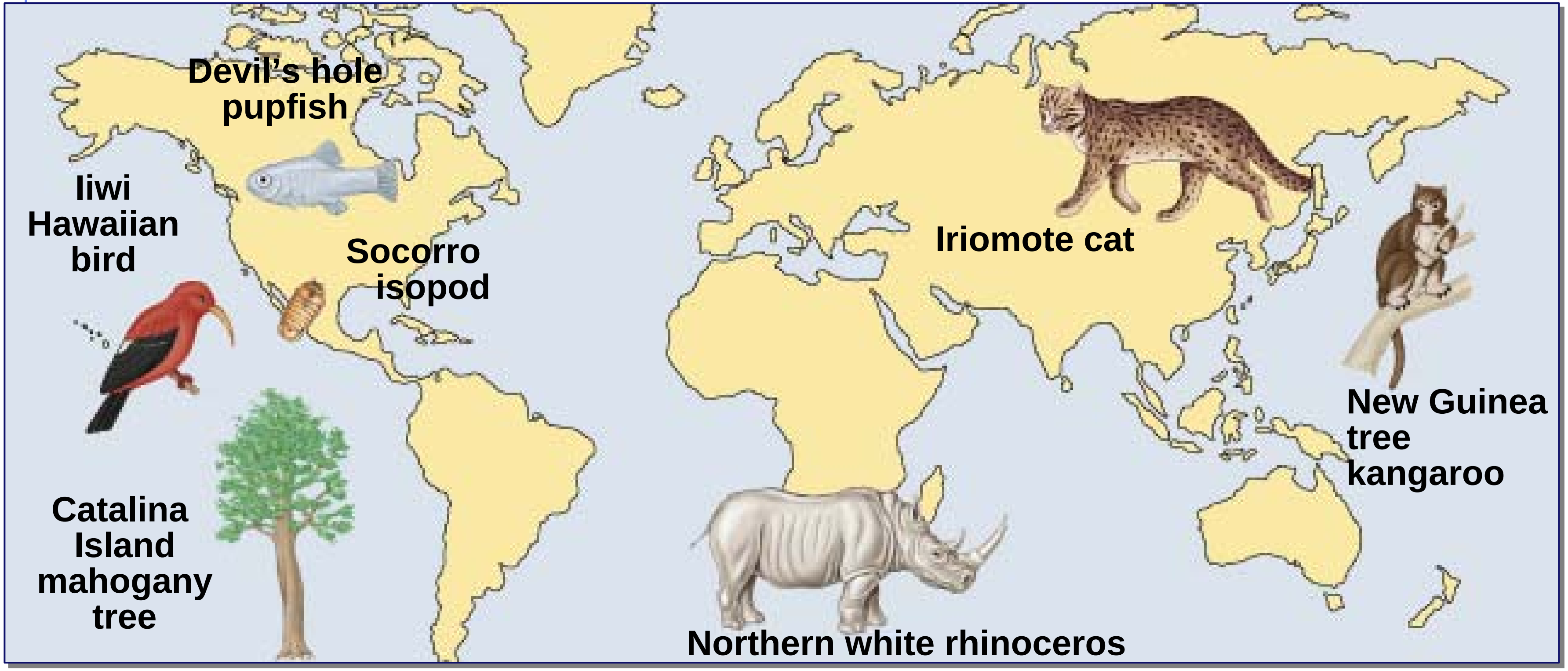




result of competition

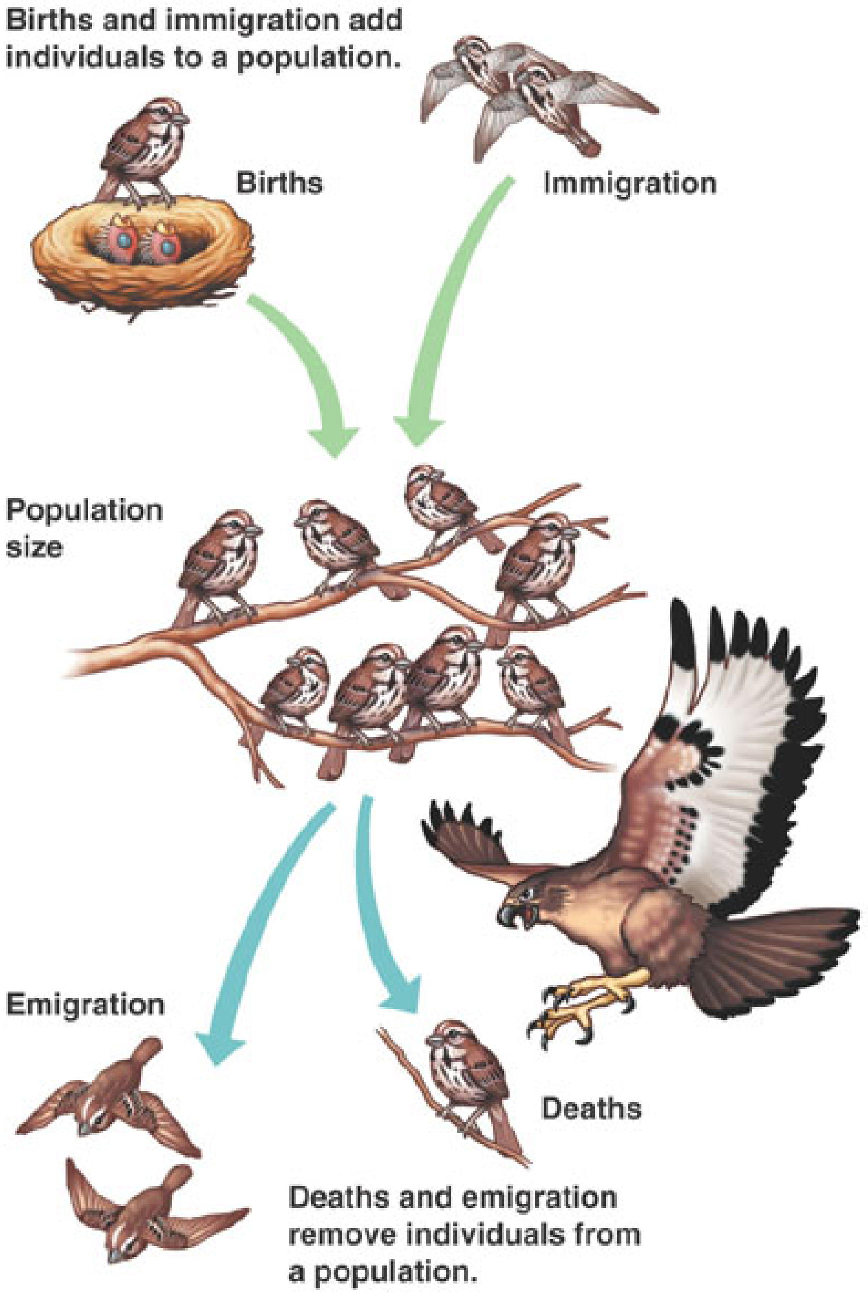
At risk populations

- Endangered species
  - limitations to range / habitat
    - places species at risk



Population Size

- Changes to population size
  - adding & removing individuals from a population
    - birth
    - death
    - immigration
    - emigration



Population growth rates

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

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 Belding Ground Squirrels (*Spermophilus beldingi*) at Tioga Pass, in the Sierra Nevada Mountains of California*

	females					males				
Age (years)	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate[†]	Average Life Expectancy (years)	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate[†]	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, ... hey are ta... separatel...
†The death rate is the proportion of individuals dying i... e specific t... e interval.
††Includes 122 females and 126 males first captured as o... -year-olds ... therefore ... t included in the ...

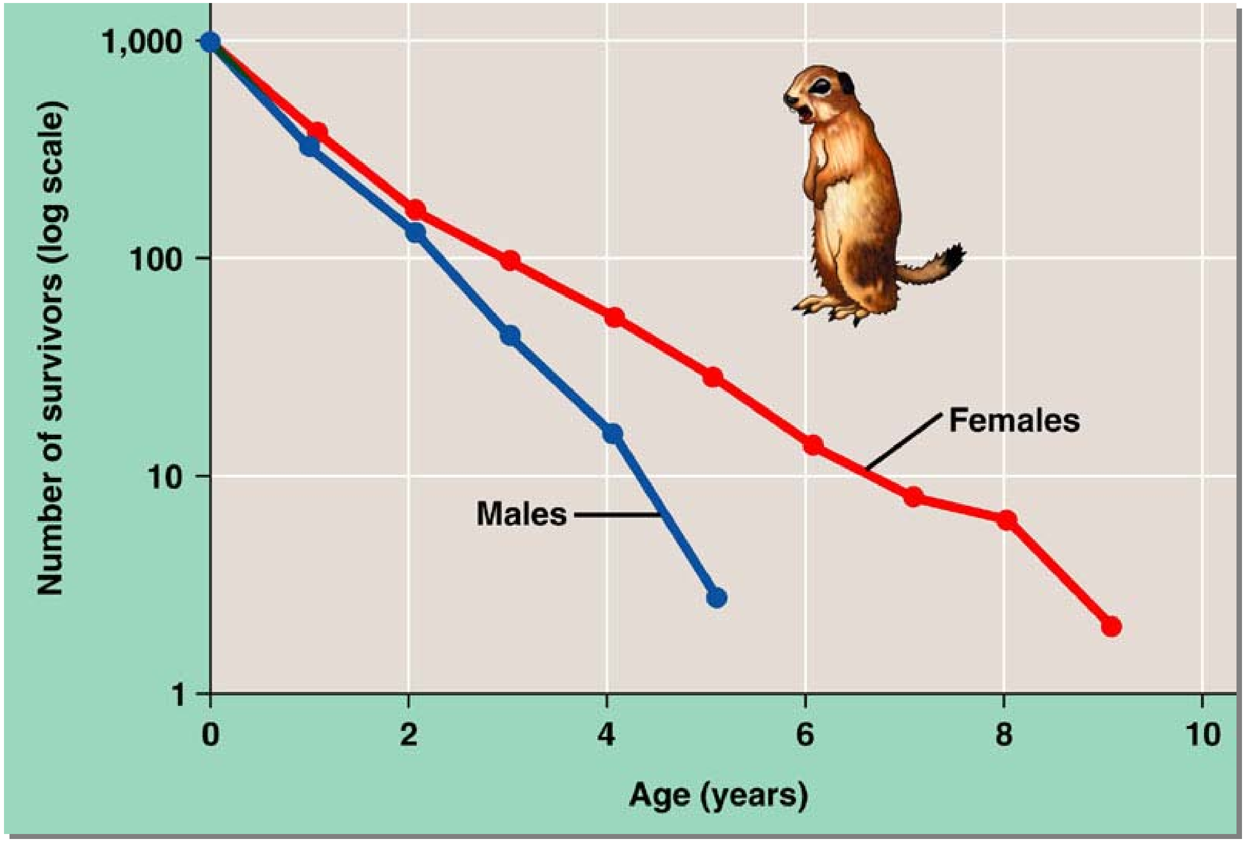
SOURCE: Data from P. W. Sherman and M. L. Morton, "... mography ... Belding's G... und Squirrel," *Ecology* 65(...
1617–1628.

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

Survivorship curves

- **Graphic representation of life table**

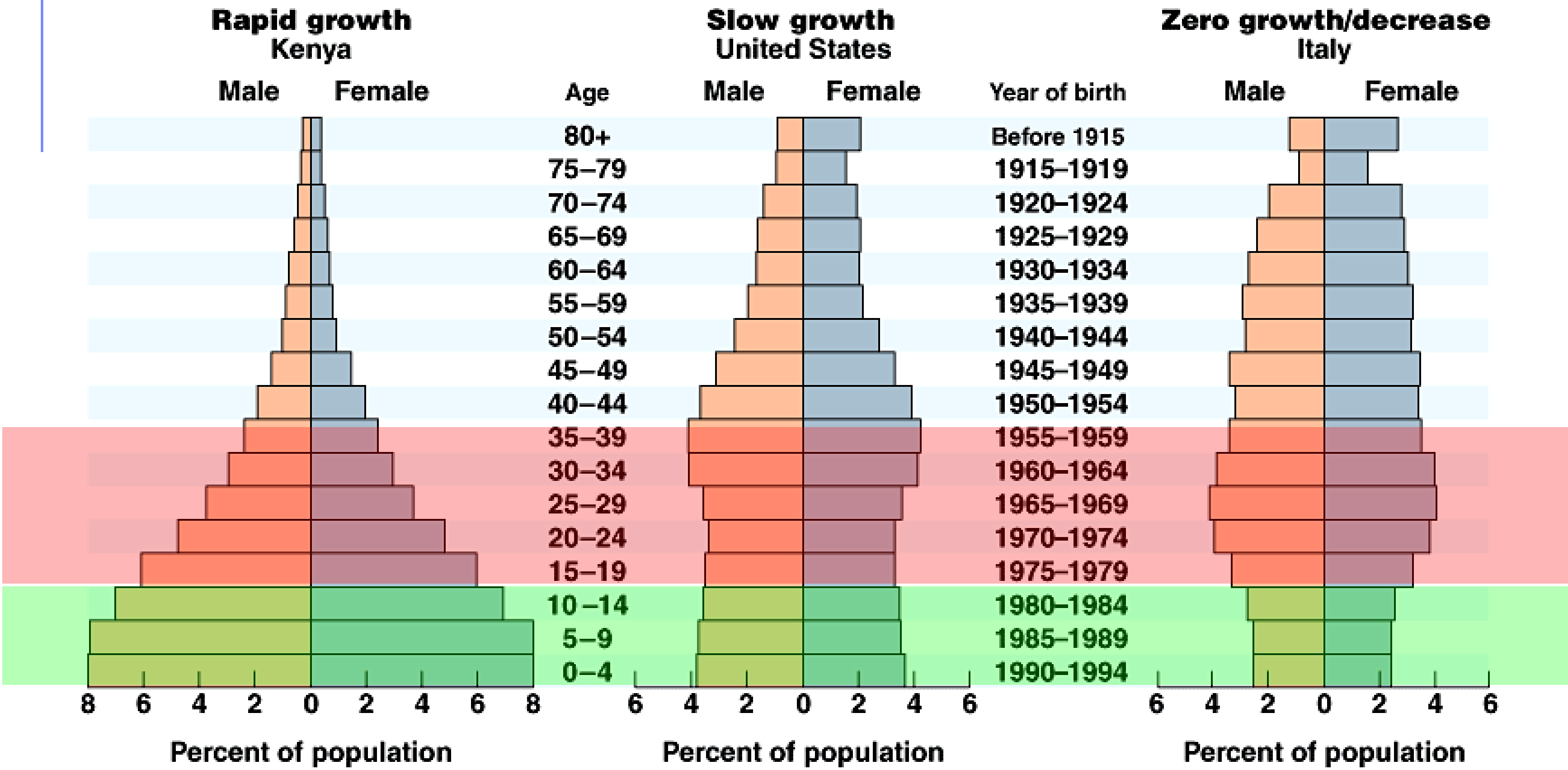
The relatively straight lines of the plots indicate relatively constant rates of death; however, males have a lower survival rate overall than females.



Age structure

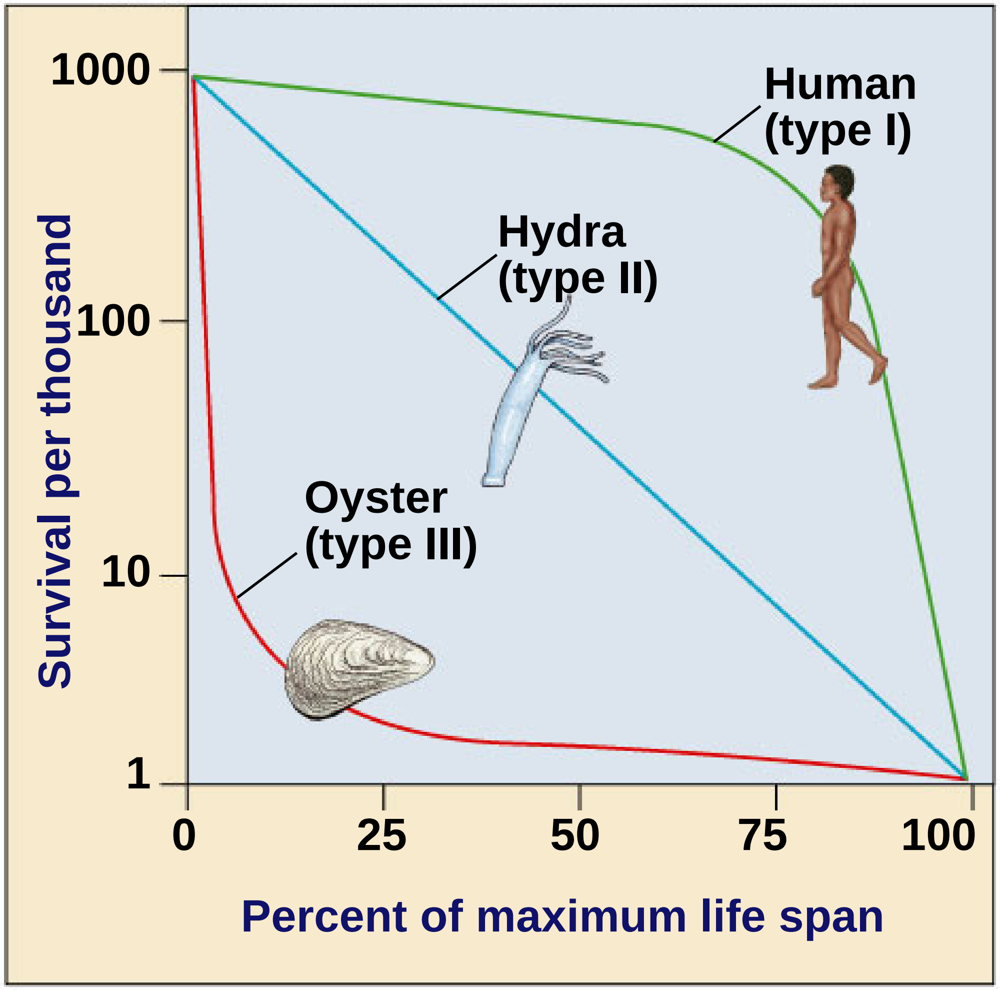
- Relative number of individuals of each age

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



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**
  - **<u>increase reproduction may decrease survival</u>**
    - **age at first reproduction**
    - **investment per offspring**
    - **number of reproductive cycles per lifetime**

Natural selection favors a life history that maximizes <u>lifetime</u> reproductive success

Parental survival

Kestrel Falcons:

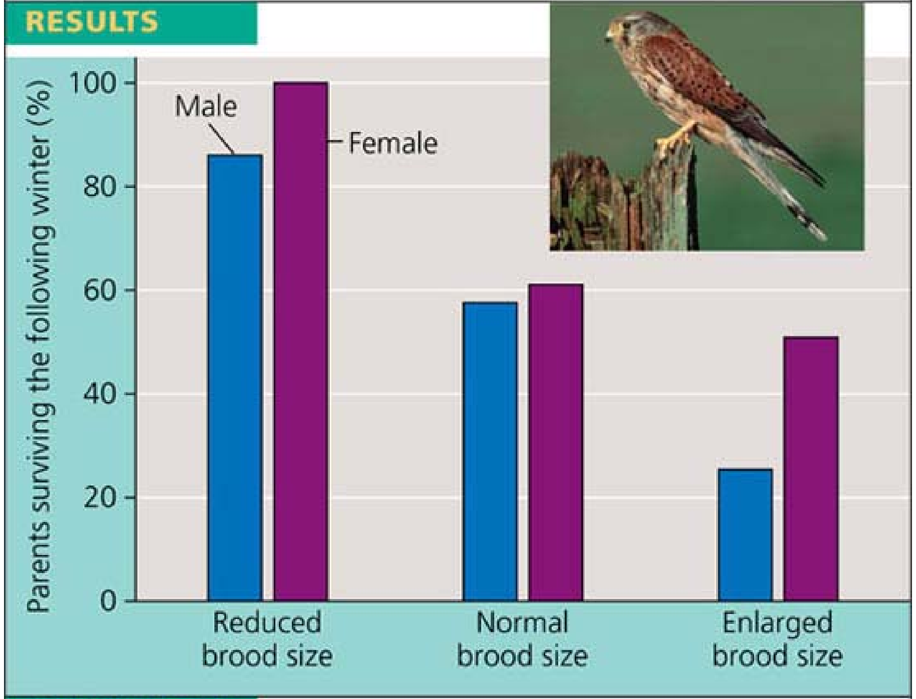
The cost of larger broods to both male & female parents

Figure 52.7

Inquiry How does caring for offspring affect parental survival in kestrels?

EXPERIMENT Researchers in the Netherlands studied the effects of parental caregiving in European kestrels over 5 years. The researchers transferred chicks among nests to produce reduced broods (three or four chicks), normal broods (five or six), and enlarged broods (seven or eight). They then measured the percentage of male and female parent birds that survived the following winter. (Both males and females provide care for chicks.)

RESULTS



CONCLUSION The lower survival rates of kestrels with larger broods indicate that caring for more offspring negatively affects survival of the parents.

Reproductive strategies

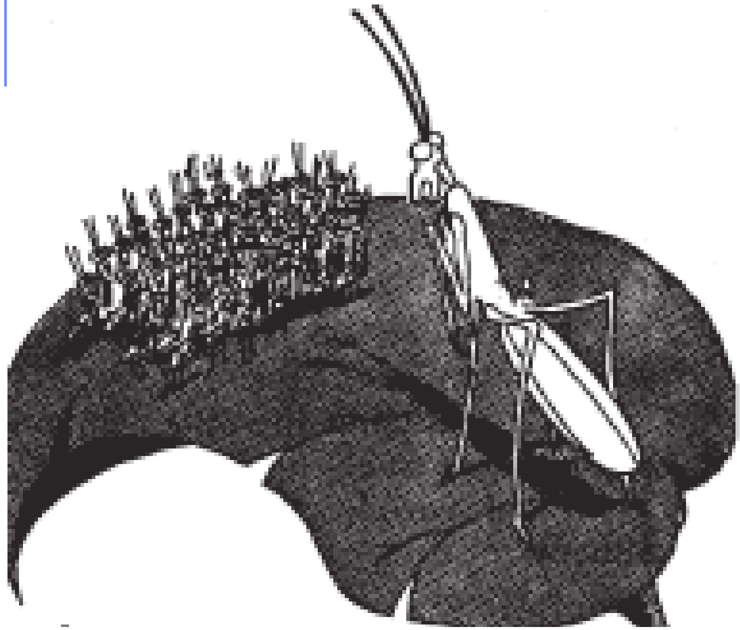
- K-selected
  - late reproduction
  - few offspring
  - invest a lot in raising offspring
    - primates
    - coconut
- r-selected
  - early reproduction
  - many offspring
  - little parental care
    - insects
    - many plants

Trade offs

Number & size of offspring

vs.

Survival of offspring or parent

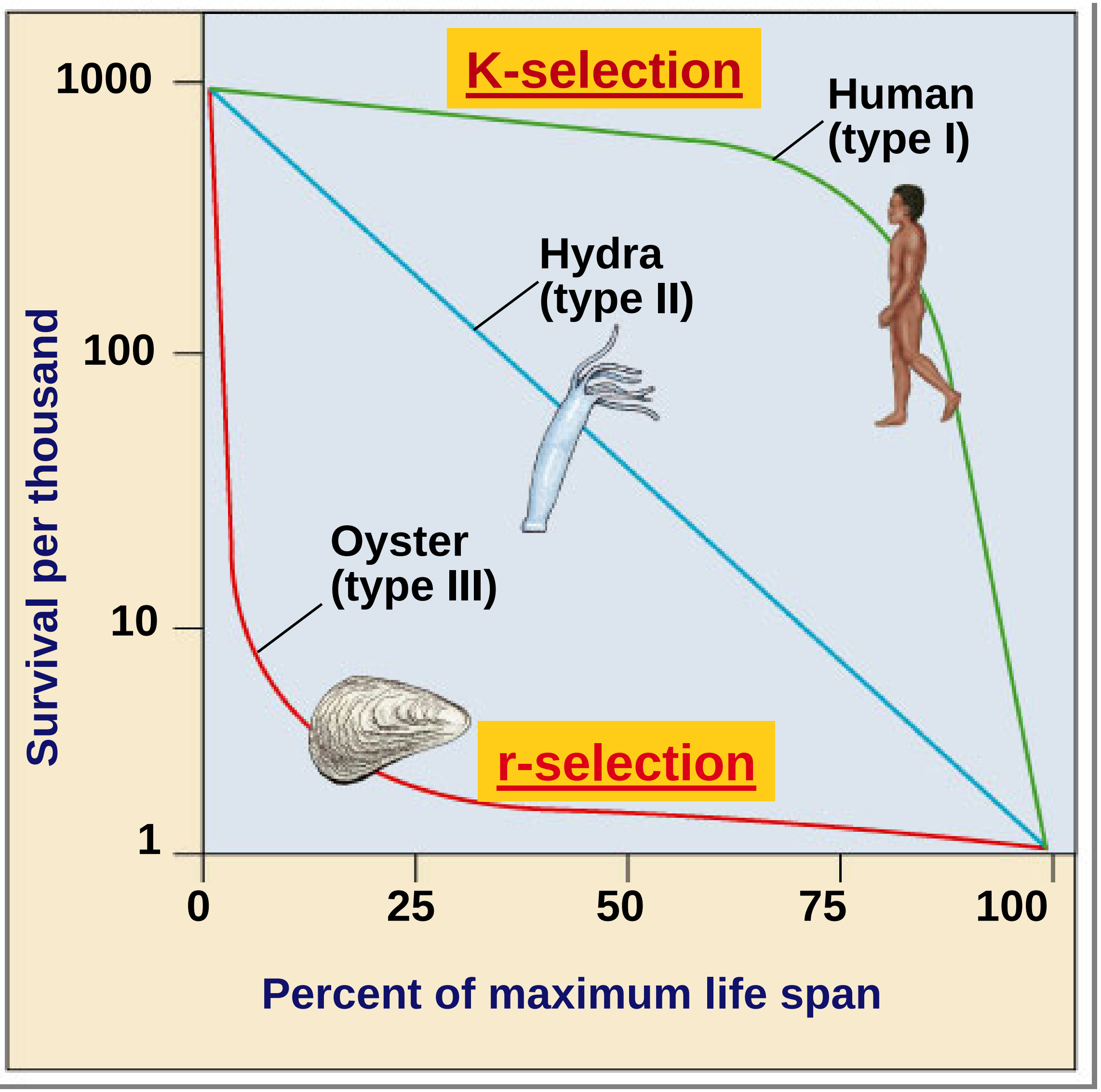


“Of course, long before you mature, most of you will be eaten.”

(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.

Life strategies & survivorship curves

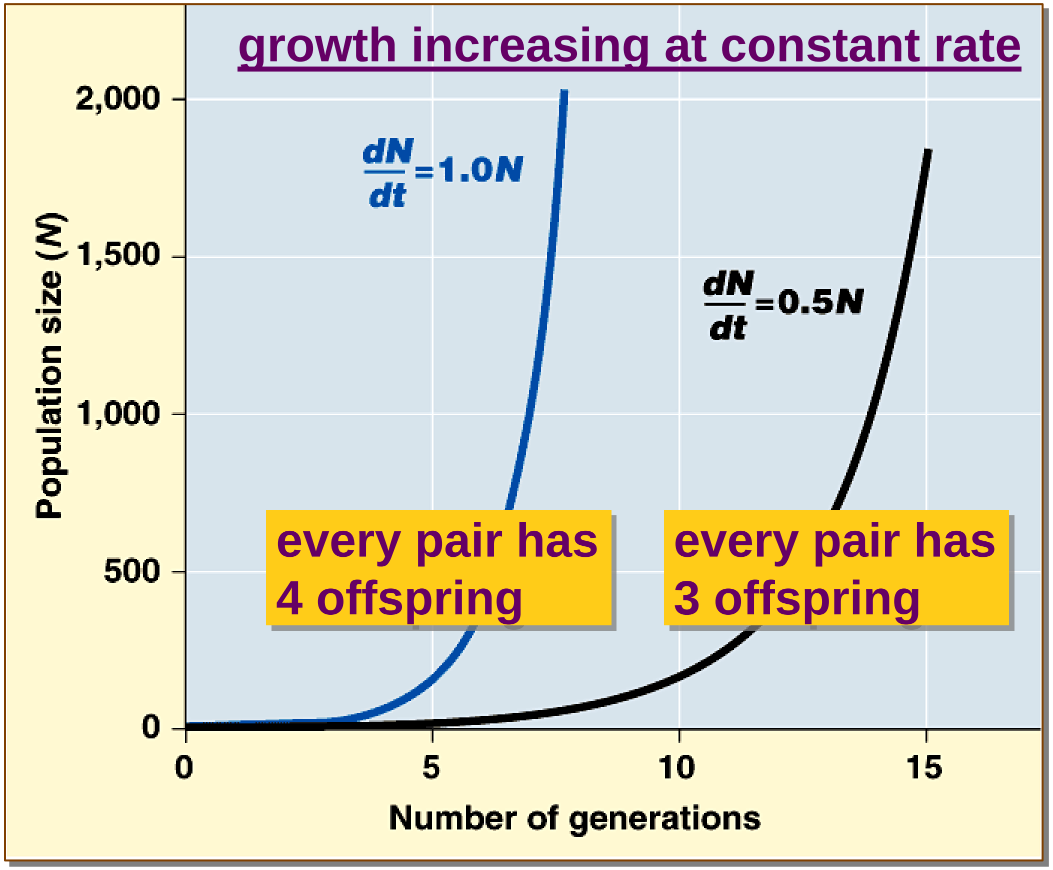


Population growth

change in population = births – deaths

Exponential model (ideal conditions)

$$\frac{dN}{dt} = r_i N$$



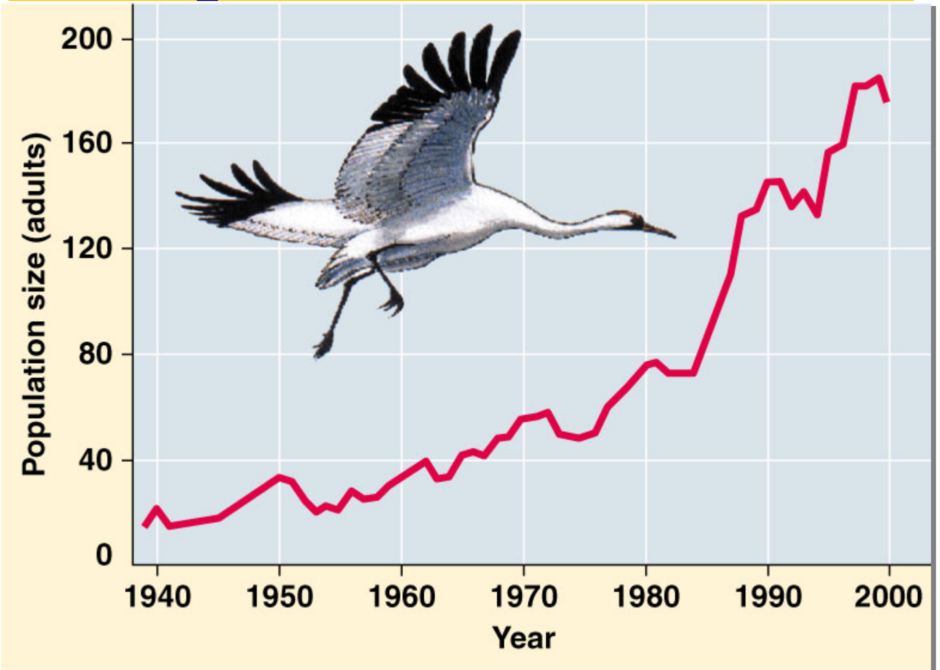
- N = # of individuals
- r = rate of growth
- r_i = intrinsic rate
- t = time
- d = rate of change

intrinsic rate = maximum rate of growth

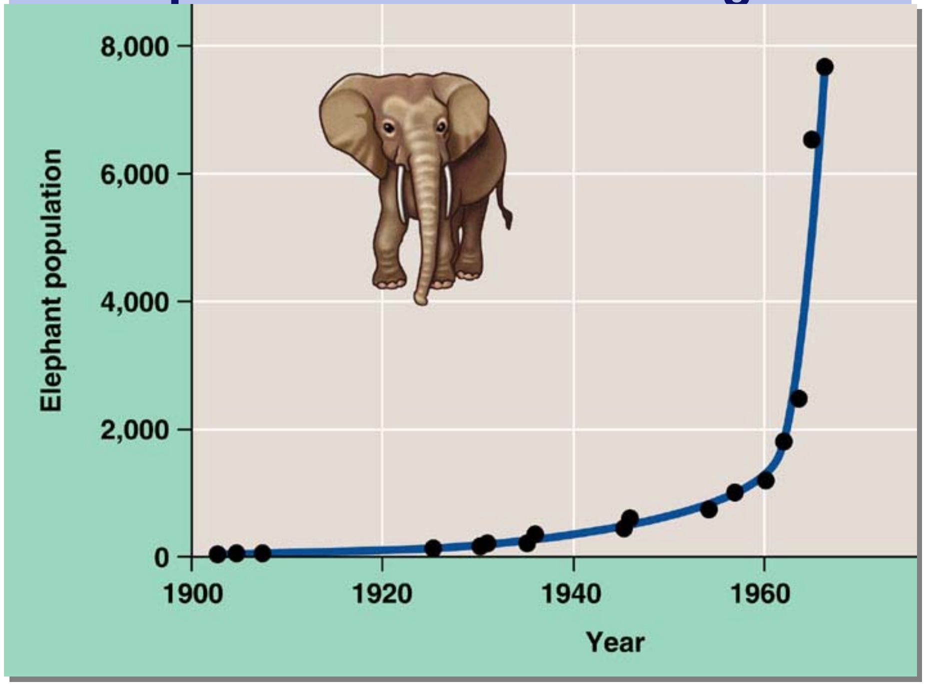
Exponential growth rate

- Characteristic of populations without limiting factors
  - introduced to a new environment or rebounding from a catastrophe

Whooping crane
coming back from near extinction



African elephant
protected from hunting

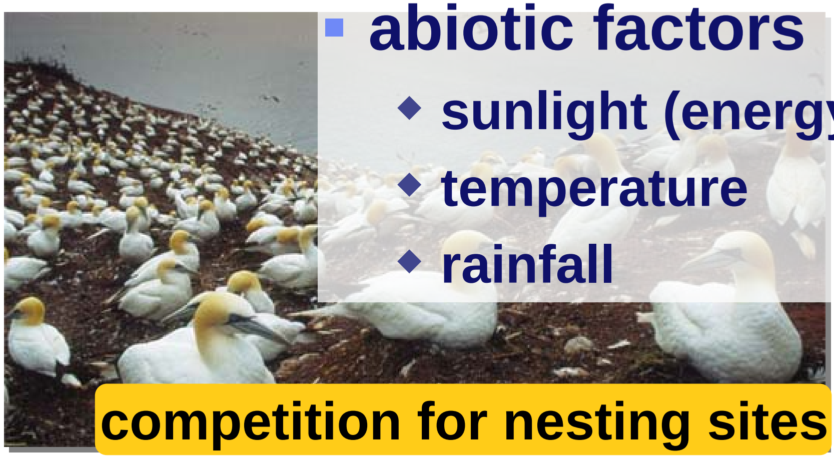


Regulation of population size

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

marking territory = competition

swarming locusts

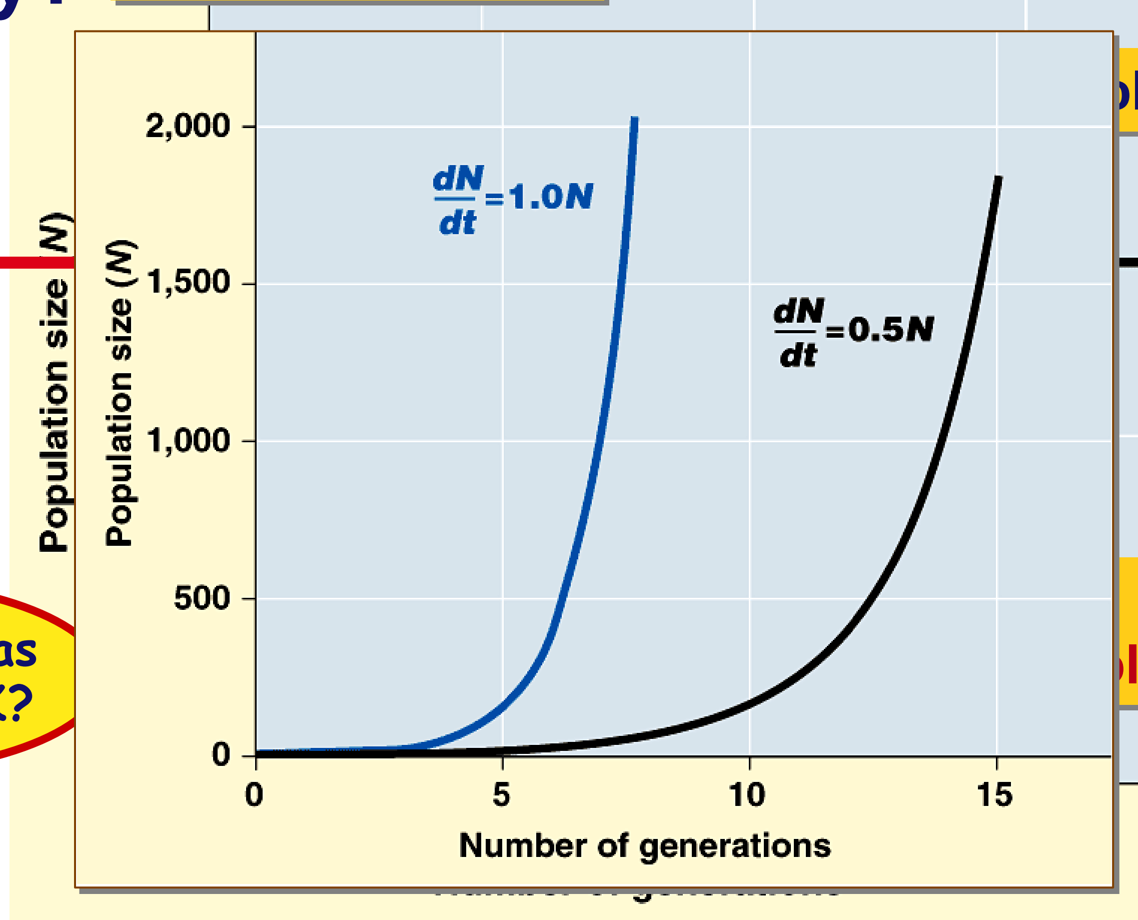


competition for nesting sites

Logistic rate of growth

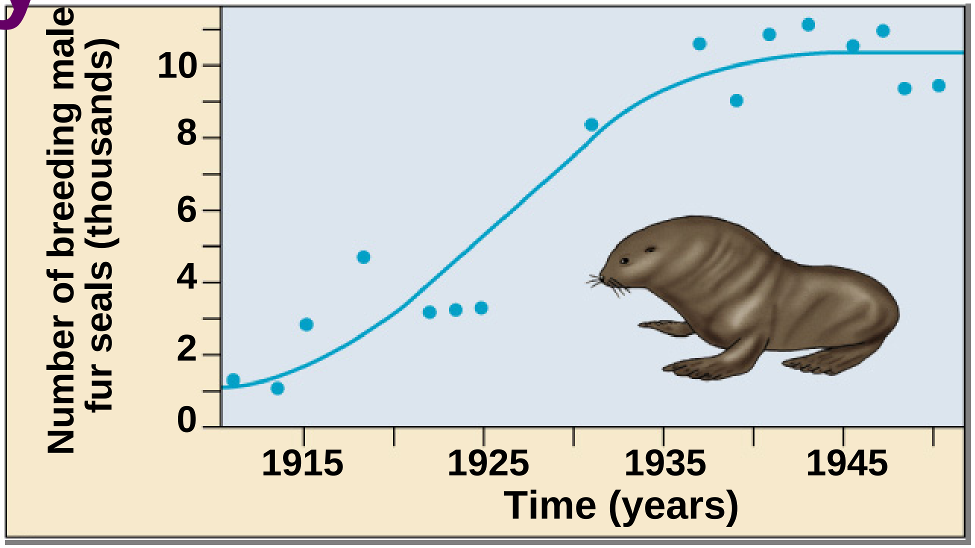
- Can populations continue to grow exponentially? **Of course not!**

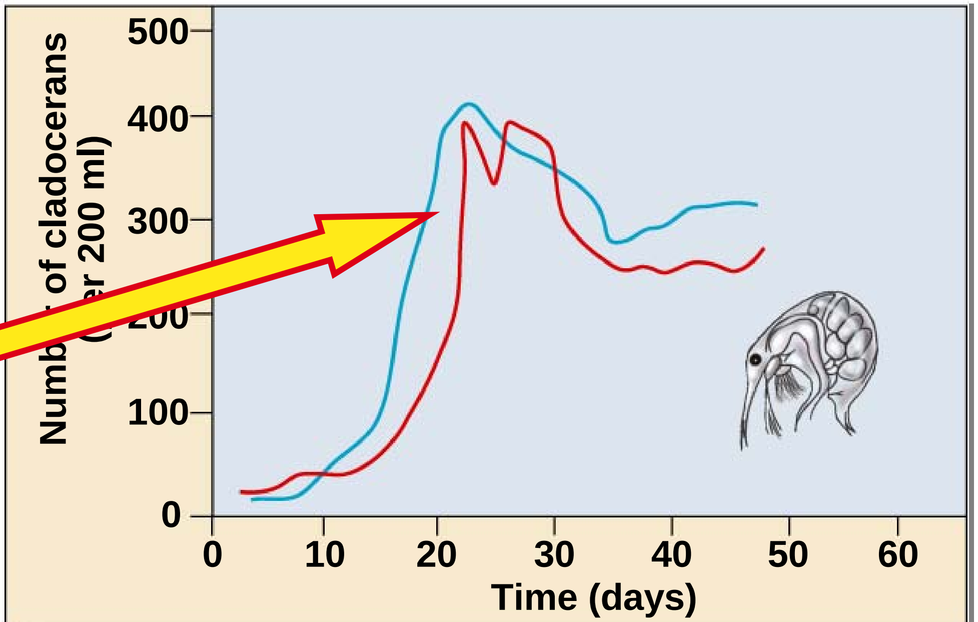
K = carrying capacity



Carrying capacity

- **Maximum population size that environment can support with no degradation of habitat**
  - varies with changes in resources

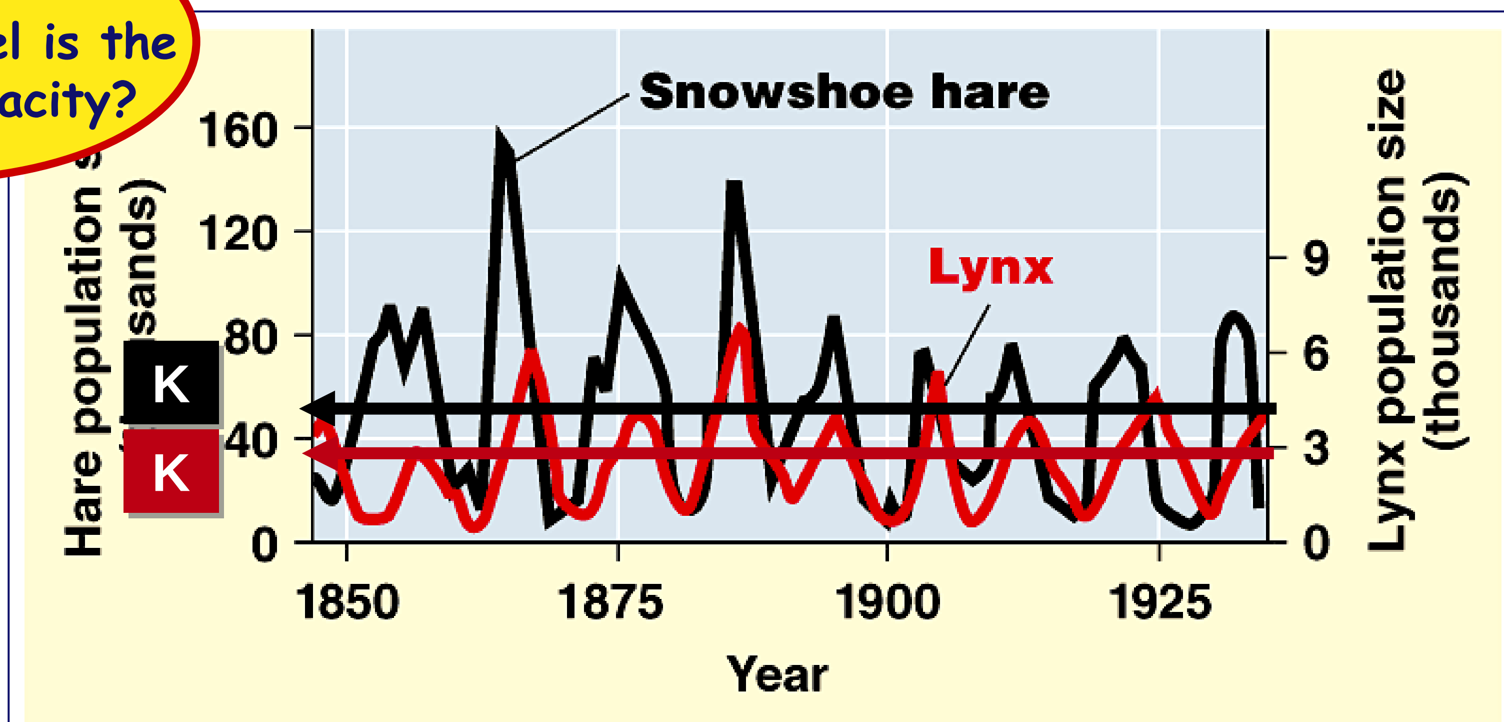


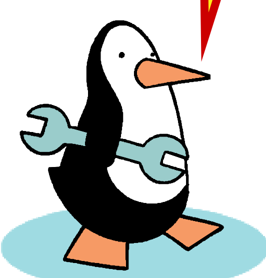


Changes in Carrying Capacity

- **Population cycles**
  - <u>predator – prey interactions</u>

At what population level is the carrying capacity?





Human population growth

Doubling times

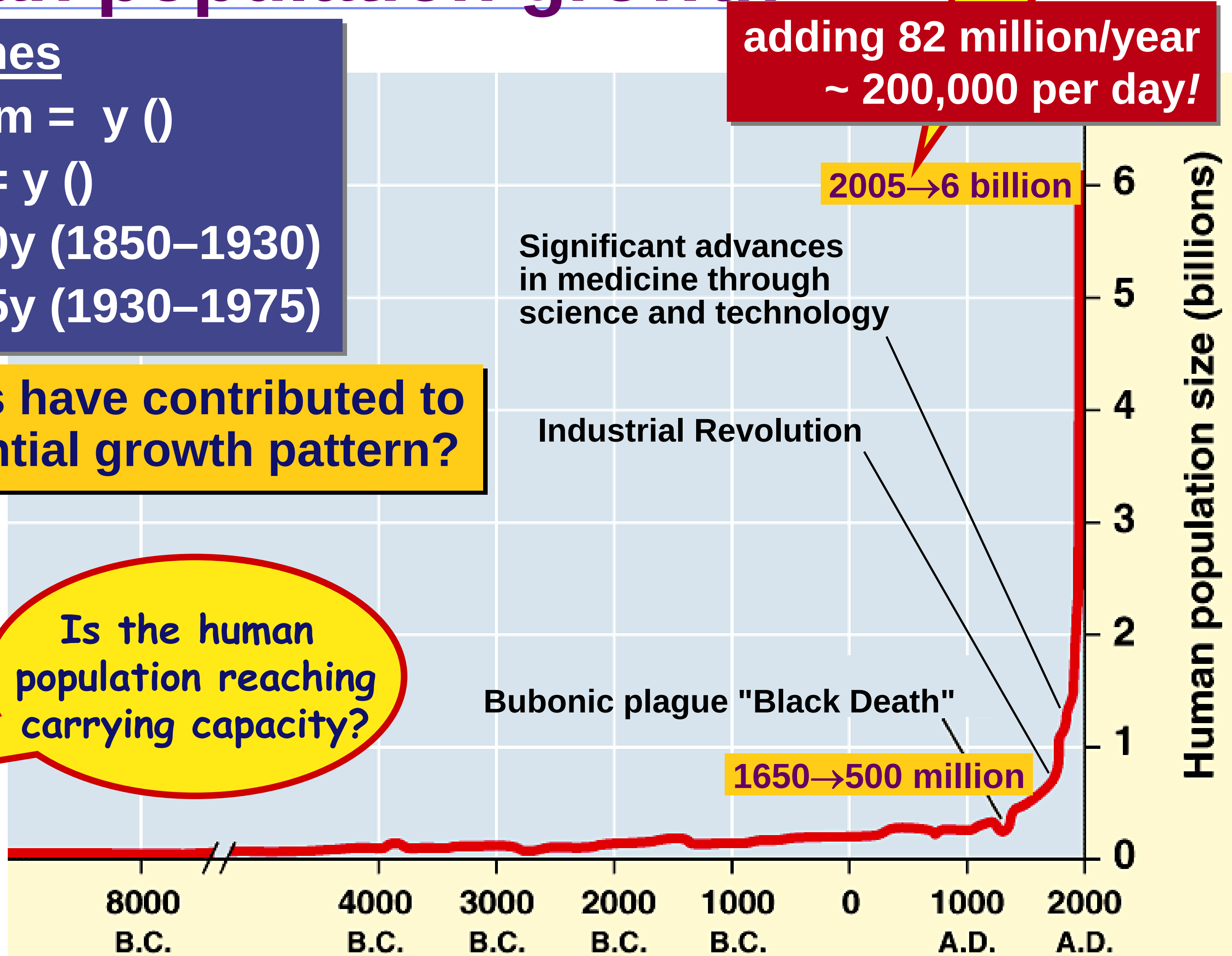
250m → 500m = y ()

500m → 1b = y ()

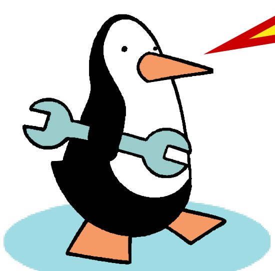
1b → 2b = 80y (1850–1930)

2b → 4b = 75y (1930–1975)

What factors have contributed to this exponential growth pattern?



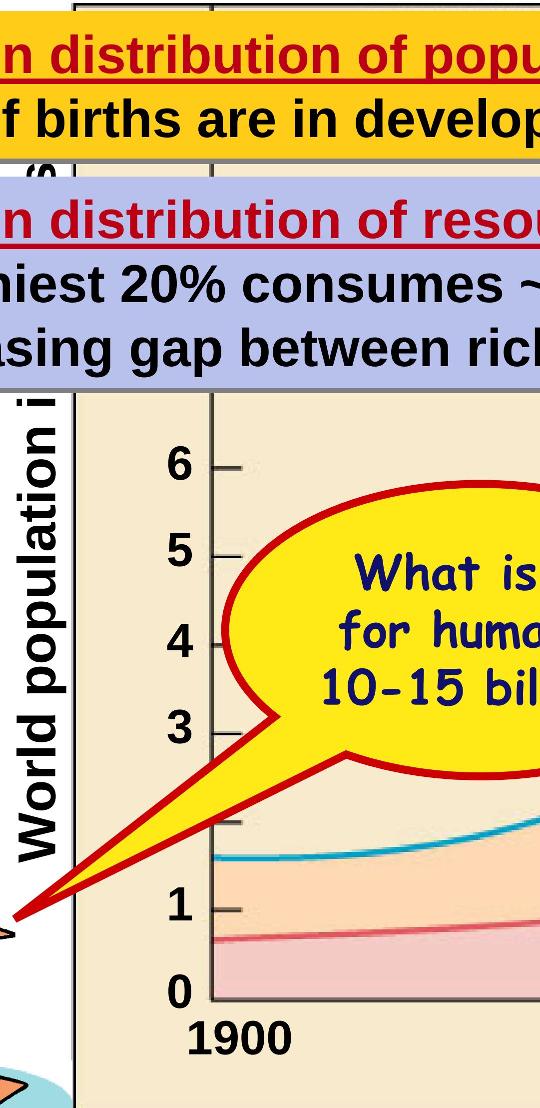
Is the human population reaching carrying capacity?

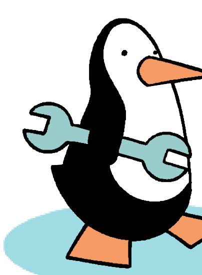


Distribution of population growth

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

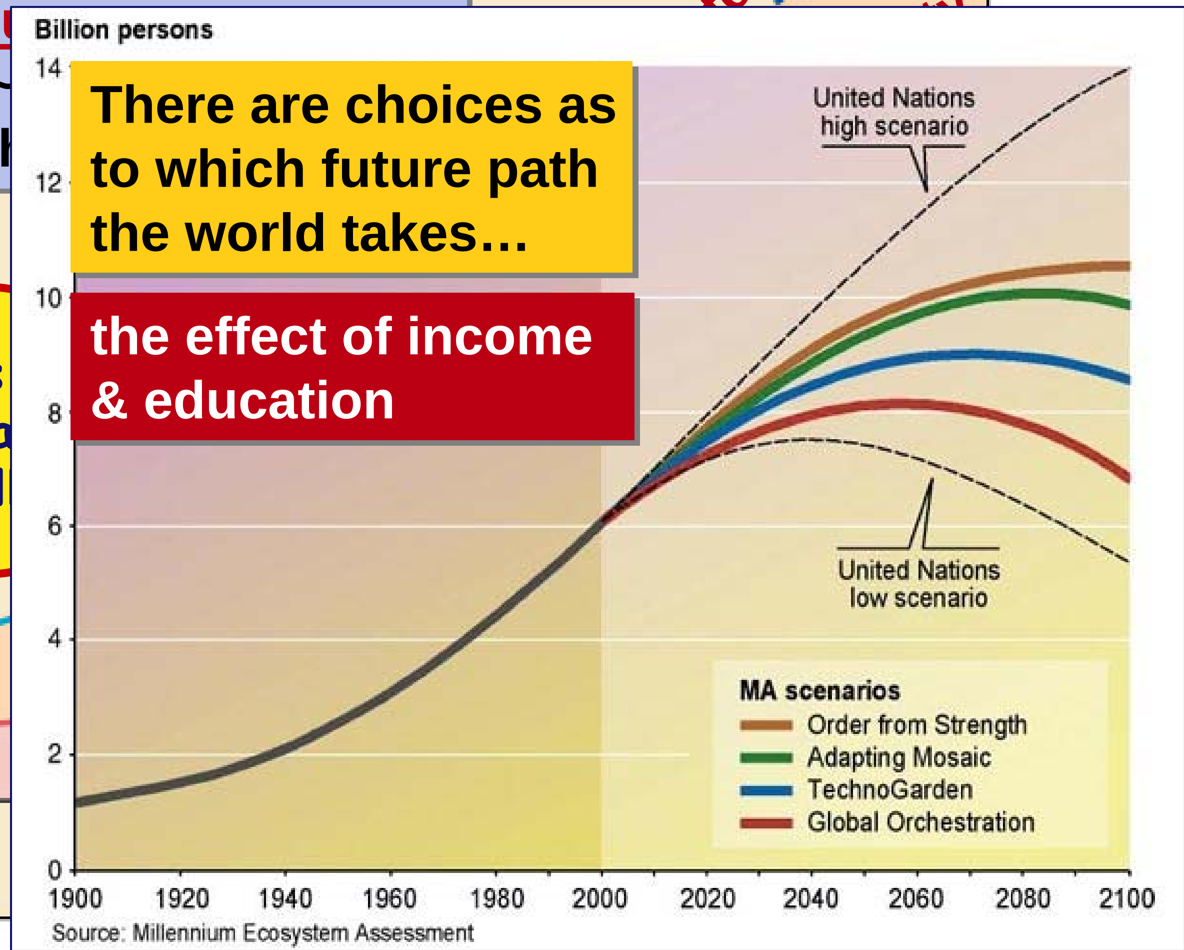
uneven distribution of reso
wealthiest 20% consumes ~
increasing gap between rich



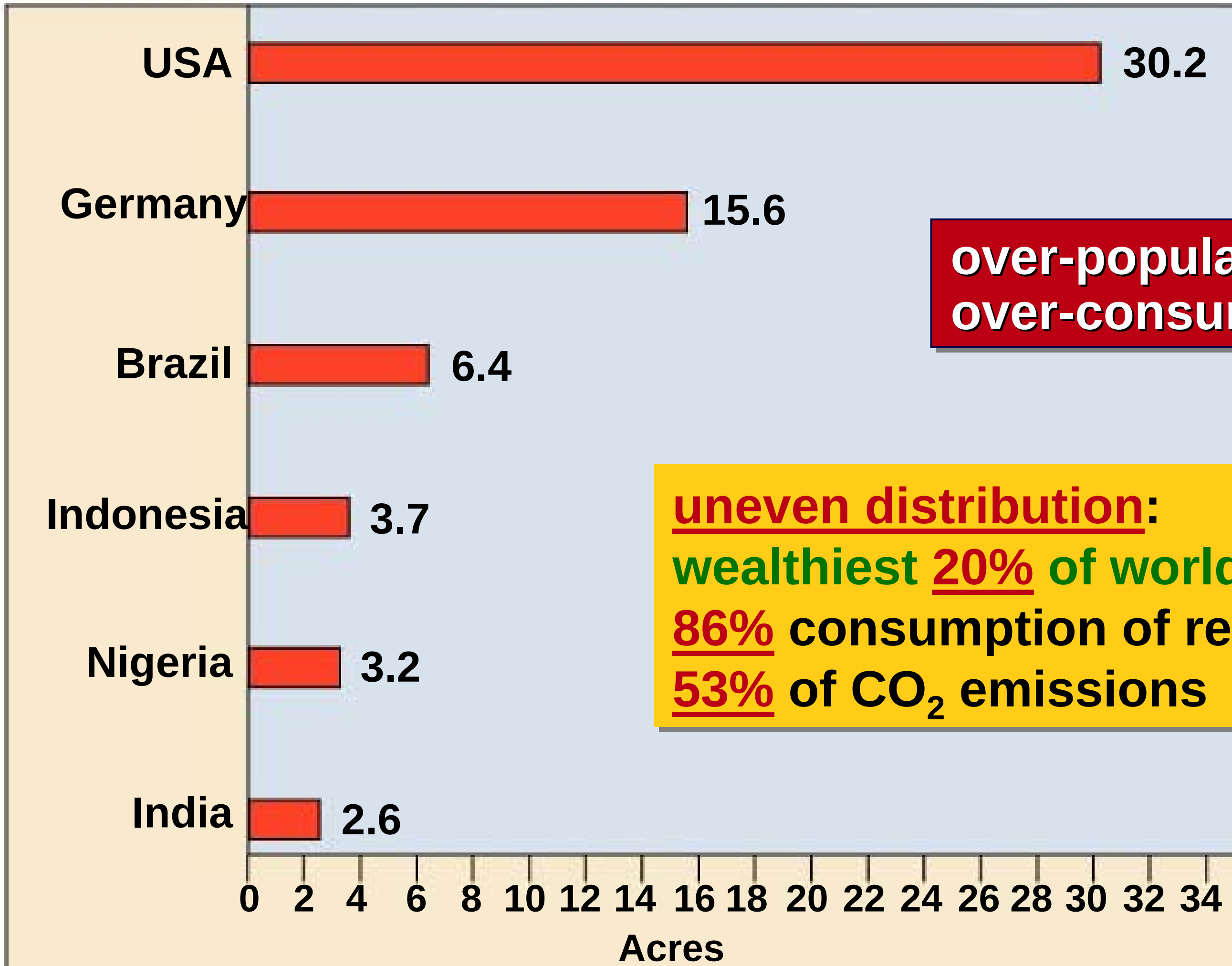


There are choices as to which future path the world takes…

the effect of income & education



Ecological Footprint

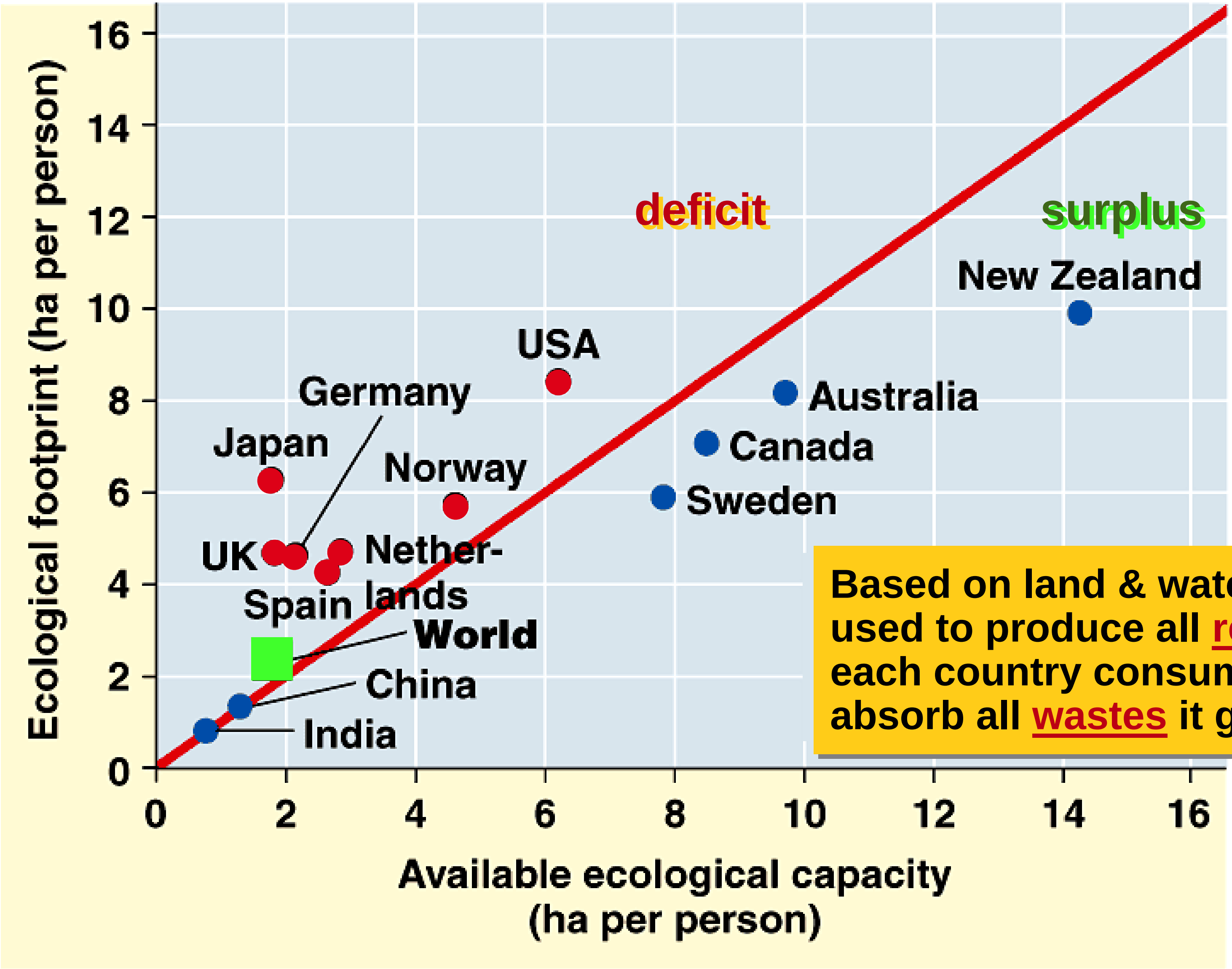


Amount of land required to support an individual at standard of living of population

over-population or over-consumption?

uneven distribution:
wealthiest 20% of world:
86% consumption of resources
53% of CO_2 emissions

Ecological Footprint



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

Measuring population density

- **How do we measure how many individuals in a population?**
  - number of individuals in an area
  - mark & recapture methods

Population Spacing

- **Dispersal patterns within a population**

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

clumped

random

uniform

Clumped Pattern (most common)



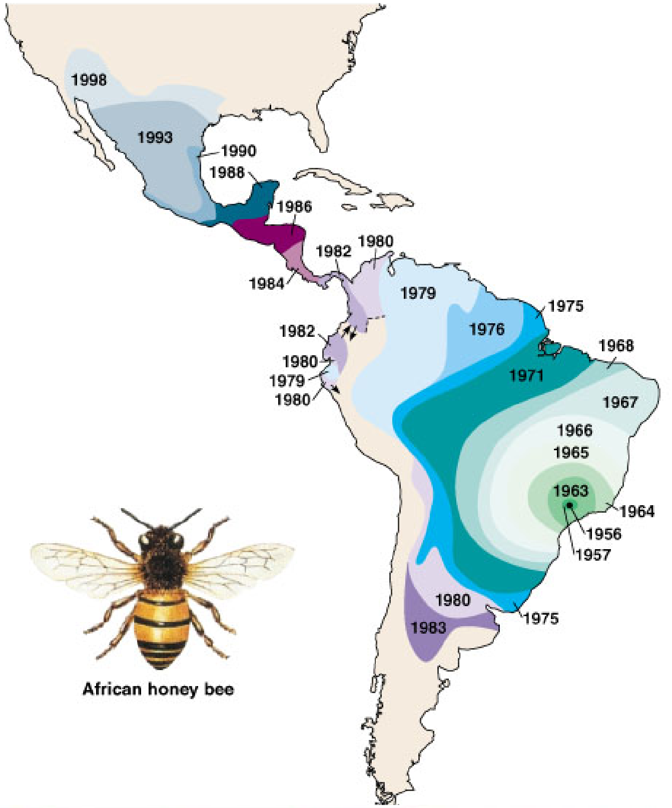

Uniform

May result from direct interactions between individuals in the population

→ territoriality

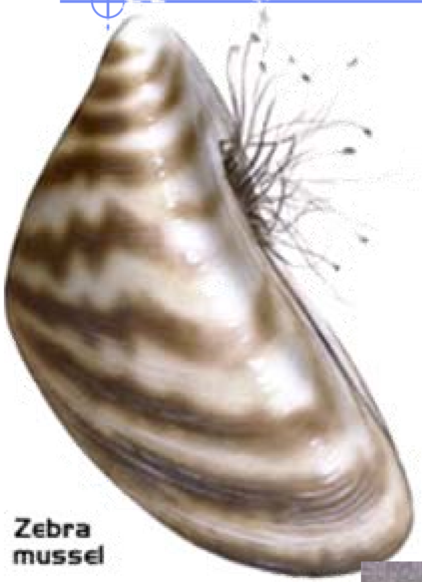
Introduced species

- **Non-native species**
  - transplanted populations grow exponentially in new area
  - **out-compete native species**
    - loss of natural controls
    - lack of predators, parasites, competitors
  - **reduce diversity**
  - examples
    - African honeybee
    - gypsy moth
    - zebra mussel
    - purple loosestrife

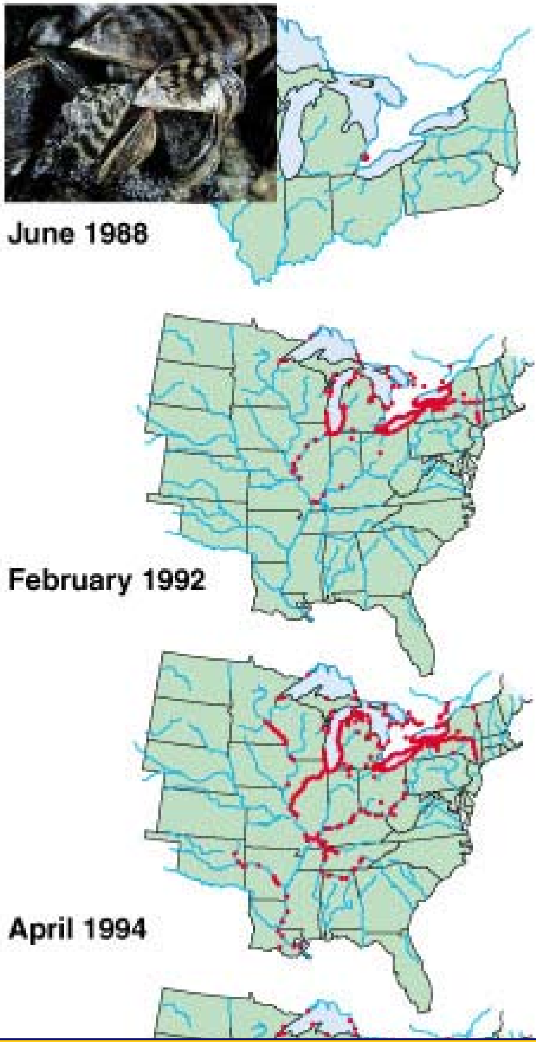


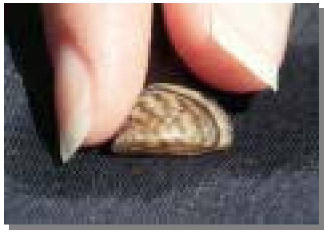
gypsy moth

Zebra mus



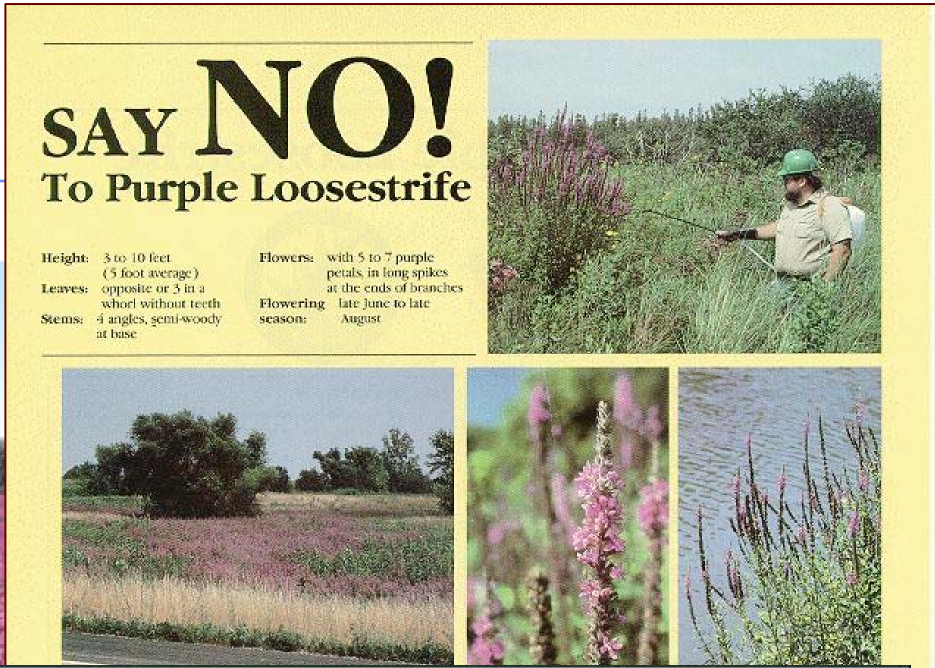
Zebra mussel





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

Purple loosestrife



1968

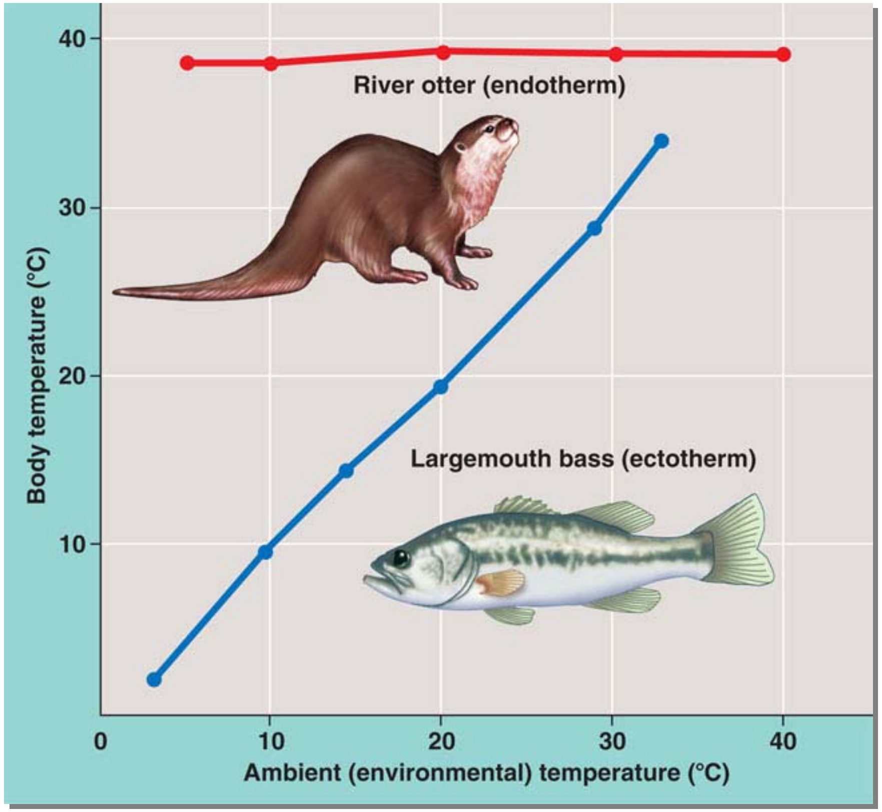
1978

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

Any Questions?

Evolutionary adaptations

- **Coping with environmental variation**
  - regulators
    - endotherms
    - homeostasis
    - (“warm-blooded”)
  - conformers
    - ectotherms
    - (“cold-blooded”)



Bright blue marble spinning in space

Studying organisms in their environment