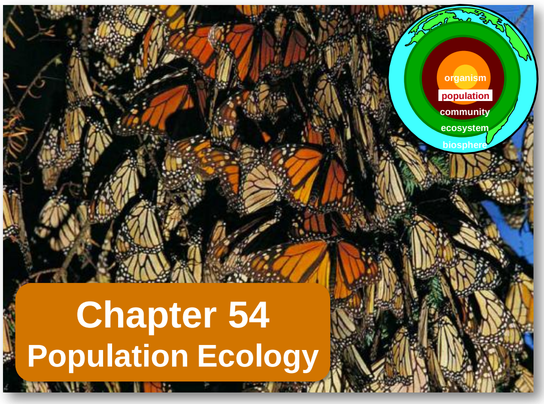


Chapter 54
Population Ecology

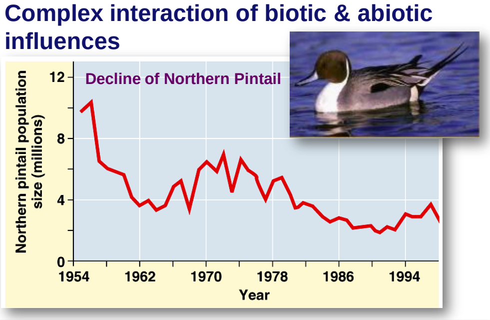
Life Takes Place in Populations

- 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 Dynamics

- Complex interaction of biotic & abiotic influences



loss of habitat, predation, climatic changes affecting food availability

Population Ecology

- study of populations in relation to environment
- environmental influences on population density & distribution, age structure, and variations in population size

<u>To answer:</u>
What environmental factors affect a population?

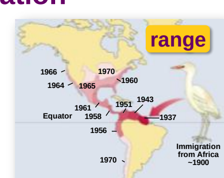
Population Spacing

- Dispersal patterns within a population

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

Characterizing a Population

- Describing a population
  - population <u>range</u>
  - pattern of <u>spacing</u>
    - <u>density</u>
  - <u>size</u> of population



Population Range

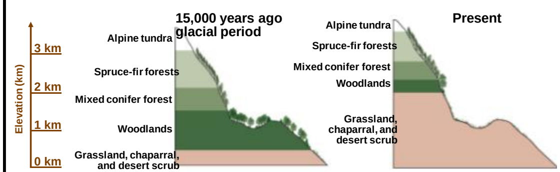
- Geographical limitations
  - biotic & abiotic factors
    - food, predators, temperature, rainfall, etc.
  - habitat

adapted to polar region

adapted to rainforest

Changes in Range

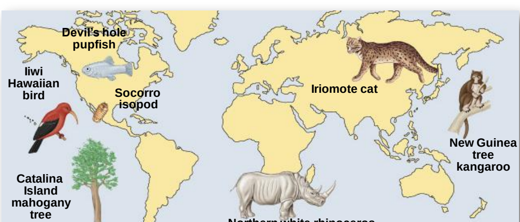
- Range expansions & contractions
  - changing environment



result of competition

At Risk Populations

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

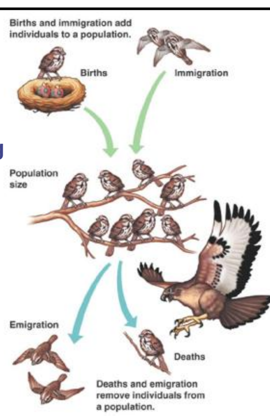


Measuring Population Density

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

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?

Demography

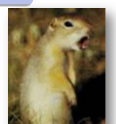
- Factors that affect growth & decline of populations
  - vital statistics & how they change over time

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, ... they are t... separate...
†The death rate is the proportion of individuals dying ... the specific ... interval...
††Includes 122 females and 126 males first captured as ...e-year-olds ...nd therefor... ot included in the count of squirrels age 0–1.
SOURCE: Data from P. W. Sherman and M. L. Morton, "Demography of Belding's Ground Squirrel," *Ecology* 65(1984):



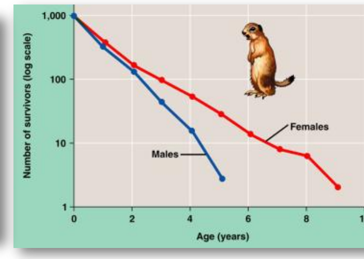
What does this tell you about the population?

Why do teenage boys pay high car insurance rates?

Survivorship Curves

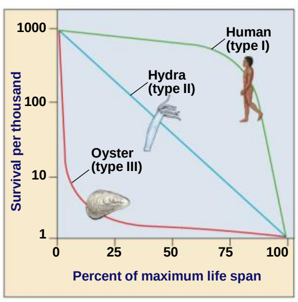
- Graphic representation of life table

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
    - investment per offspring
    - reproductive events per lifetime
    - age at first reproduction

Natural selection favors a life history that maximizes lifetime reproductive success

Parental Survival

Kestrel Falcons:
The cost of larger broods to both male & female parents

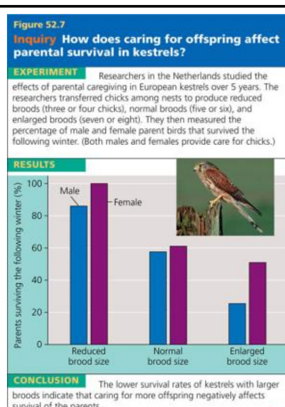


Figure 52.7
Inquiry How does caring for offspring affect parental survival in kestrels?

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

(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.

Population Growth

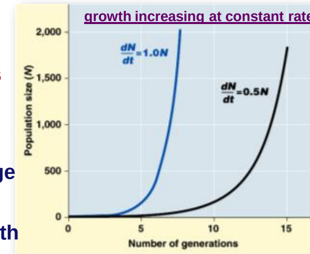
change in population = births – deaths

Exponential model (ideal conditions)

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

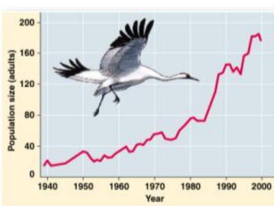
N = # of individuals
r = rate of growth
r_i = intrinsic rate
t = time
d(Δ) = rate of change

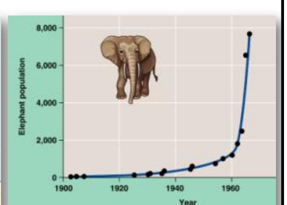
intrinsic rate = maximum rate of growth



Exponential Growth Rate

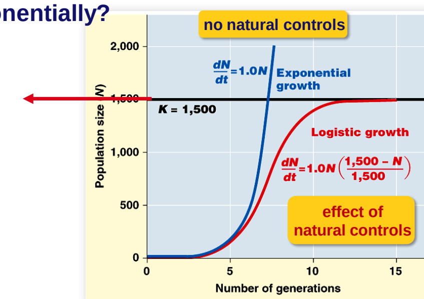
- Characteristic of populations without limiting factors
  - introduced to a new environment or rebounding from a catastrophe



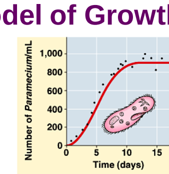


Logistic Rate of Growth

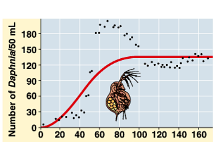
- Can populations continue to grow exponentially?



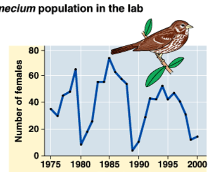
Logistic Model of Growth



(a) A *Paramecium* population in the lab



(b) A *Daphnia* population in the lab



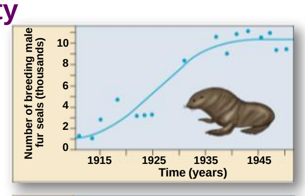
(c) A song sparrow population in its natural habitat

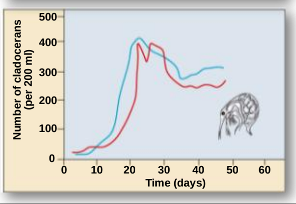
Carrying Capacity

- Can populations continue to grow exponentially?
  - of course NOT!
  - what sets limit?
- Carrying Capacity (K)
  - maximum population size that environment can support with no degradation of habitat
  - not fixed; varies with changes in resources

Carrying Capacity

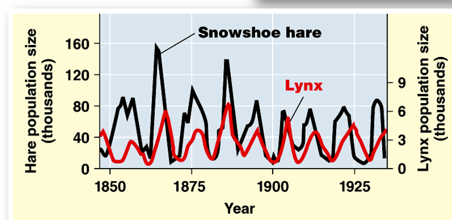
- **Maximum population** size that environment can support with **no degradation** of habitat
  - varies with changes in resources





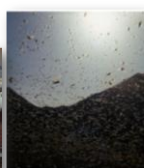
Changes in Carrying Capacity

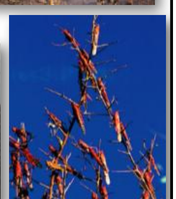
- Population cycles
  - predator – prey interactions



Regulation of Population Size

- Limiting factors
  - density dependent
    - food supply, competition
    - predators
    - disease
  - density independent
    - abiotic factors
      - sunlight
      - temperature
      - rainfall

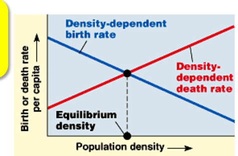




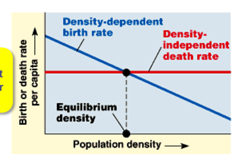
Limits to Growth

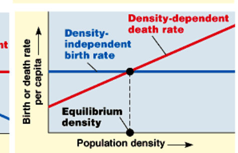
- Negative feedback prevents unlimited growth

density dependent death rate rises as birth rate rises



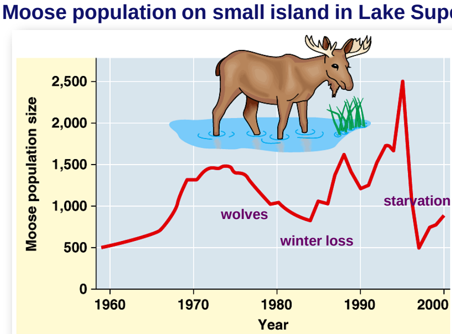
density independent death rate or birth rate





Isle Royale Studies

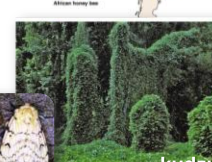
- Moose population on small island in Lake Superior



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
    - snakehead fish

gypsy moth



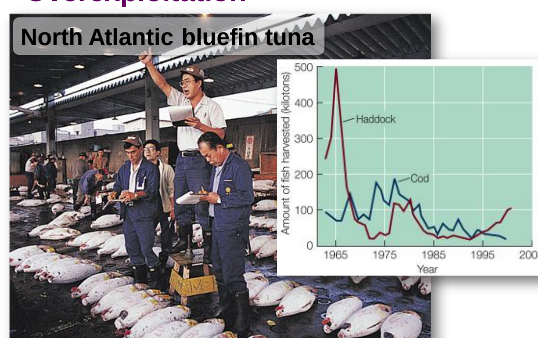
Zebra Mussel

Purple Loosestrife

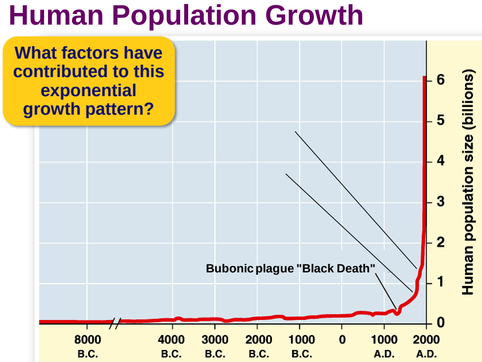
Biological Controls

- using an introduced predator (or other population growth inhibitor) to limit the population of a pest or other unwanted species
- can backfire as in case of *Bufo marinus* in Australia

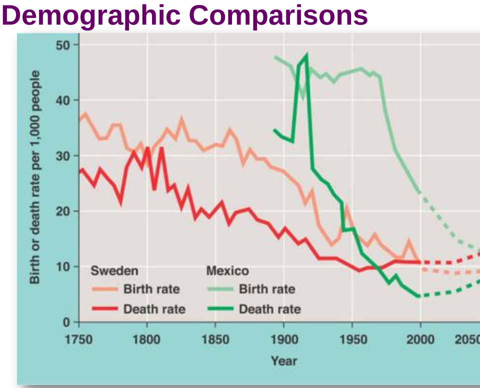
Overexploitation



Human Population Growth

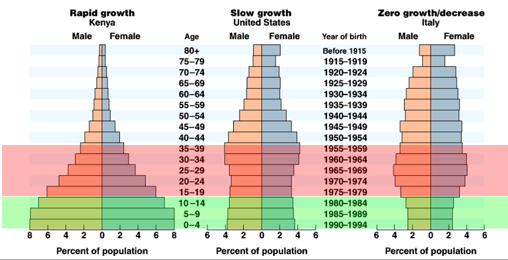


Demographic Comparisons

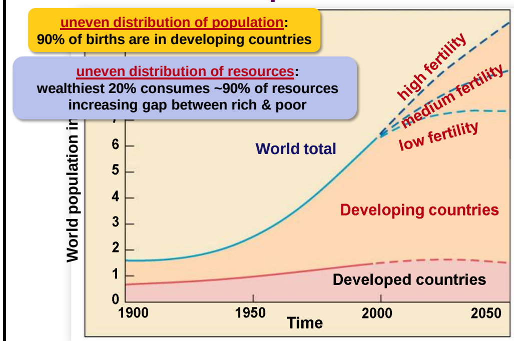


Age Structure

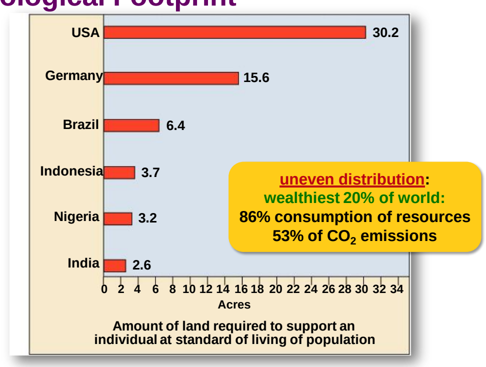
- Relative number of individuals of each age



Distribution of Population Growth



Ecological Footprint



Ecological Footprint—1997