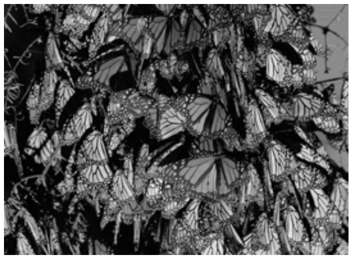
Population Ecology

1. Density and Distribution
2. Growth
   a. Exponential
   b. Logistic
3. Life Histories
4. Population Limiting Factors
5. Human population growth



Human population growth video, calculate ecological footprint

For chapter 52, focus on:

- Sections 52.1, 52.2, and 52.3
- Don't need Boxes 52.1 and 52.2 (unless you want).
- Be sure you understand
  - The highlighted text
  - How those main points are illustrated by the figures and examples
  - The lynx/hare experiment
  - How exponential growth, logistic growth, and age structure apply to human population growth.

Population. Individuals of same species that can potentially interbreed (i.e., occupying same general area).

Density: the number of organisms in a given area

Distribution: how the organisms are spaced in the area

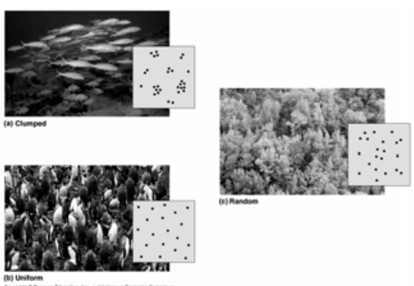
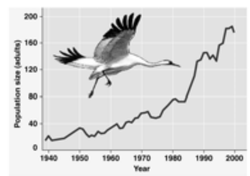


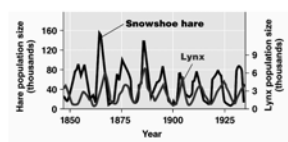
Fig. 52.2

Changes in population size



Growing Fig. 52.9

Shrinking Fig. 52.16



Fluctuating

Fig. 52.19

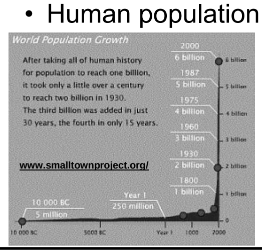
Questions

- Why do populations change in size?
- What factors determine rates of population growth or decline?
- How do these differ among species?

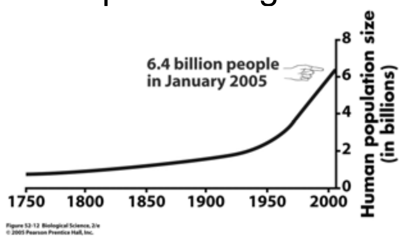
Examples of applications

- Invasive species
- Pest control (e.g., agriculture)
- Endangered species
- Human population growth

http://www.nap.edu/staff/mjensen/aaup2006/kudzu-car.jpg



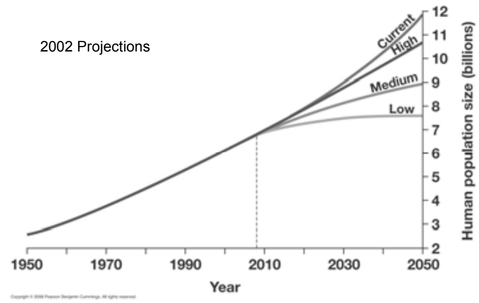
Exponential growth: humans



Population Clocks
U.S. 308,054,334
World 6,800,385,270
18:16 UTC (EST+5) Nov 30, 2009
http://www.census.gov/main/www/popclock.html

Human population growth: the future?

2002 Projections



Number of offspring per female
Current: 2.7
High: 2.5
Med: 2.1 (replacement)
Low: 1.7

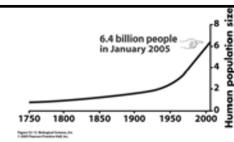
1992 Projections

Fertility rate	Projected population in 2050
High	12.5 billion
Medium	10.15 billion
Low	7.8 billion

The 1992 projections for 2050 are higher than those from 2002, primarily because the earlier projections did not account for the impact of AIDS.

How many people can Earth support?

2. Population Growth
a. exponential growth



The change in population size (N) in an interval of time is: number of births – number of deaths, or

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

(ignoring immigration and emigration)

If b (birth rate) is the number of offspring produced over a period of time by an average individual, and d (death rate) is the average number of deaths per individual, then

$$\frac{\Delta N}{\Delta t} = bN - dN \quad \text{or} \quad \frac{\Delta N}{\Delta t} = (b - d)N$$

Population Growth: exponential growth

The difference between the birth rate and the death rate is the per capita growth rate

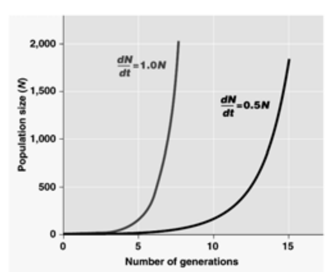
$r = b - d$

The growth equation can be rewritten as

$$\frac{\Delta N}{\Delta t} = rN \quad \text{or} \quad \frac{dN}{dt} = rN$$

Exponential growth occurs when resources are unlimited and the population is small (doesn't happen often). The r is maximal (r_{max}) and it is called the intrinsic rate of increase.

Population Growth: exponential growth



C&R Fig. 52.8; see also Freeman fig. 52.5

Note that:
1. r is constant, but N grows faster as time goes on.
2. What happens with different r's in terms of total numbers and time to reach those numbers?
3. You can predict N at any time t if you know the starting population size (N_o) and r: $N_t = N_o e^{rt}$

(see pp 1179-80 for details)

r can also be negative (population decreasing) (draw)

if r is zero, the population does not change in size

thus, the rate of increase (or decrease) of a population can change over time.

2. Exponential Population growth – examples

Exponential growth happens only when conditions are optimal: low population size relative to resource availability

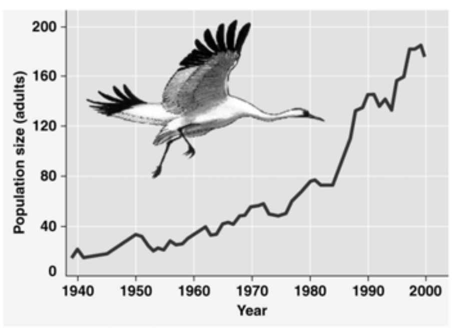


Fig. 52.9 – Whooping crane

Exponential growth doesn't happen indefinitely:

Reindeer on the Pribalof Islands, Bering Sea

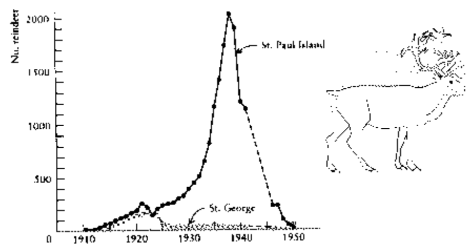
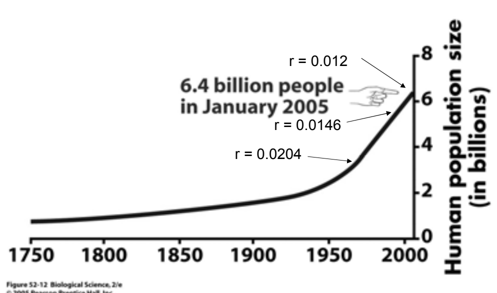


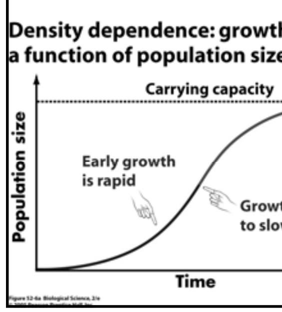
Figure 12.10 Reindeer population growth on two of the Pribilof Islands, Bering Sea, from 1911, when they were introduced, until 1950. (After Scheffer 1951.)

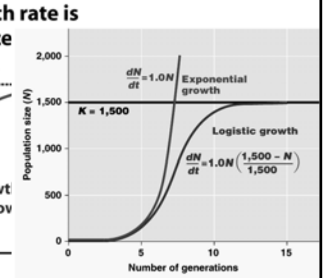
Exponential growth: humans



2.b. Logistic growth

Most populations are limited in growth at some carrying capacity (K) (the maximum population size a habitat can accommodate)





Logistic Growth Equation: incorporates changes in growth rate as population size approaches carrying capacity.

INCORRECT FIG, THAT'S REALIZED R NOT DN/DT

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

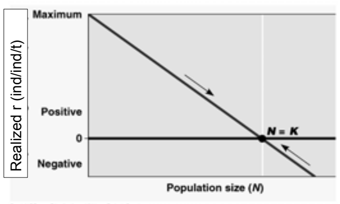


Fig. 52.10

Table 52.3 A Hypothetical Example of Logistic Population Growth, Where $K = 1{,}000$ and $r_{max} = 0.05$ per Individual per Year

Population Size (N)	Intrinsic Rate of Increase (r_{max})	$\left(\frac{K-N}{K}\right)$	Realized r = rmax*(1-N/K)	ΔN*
20	0.05	0.98	0.049	+1
100	0.05	0.90	0.045	+5
250	0.05	0.75	0.038	+9
500	0.05	0.50	0.025	+13
750	0.05	0.25	0.013	+9
1,000	0.05	0.00	0.000	0

*ΔN is rounded to the nearest whole number.

At what point is the "realized" r the highest?
At what point are the most individuals added to the population?
Are these the same?

Logistic Model

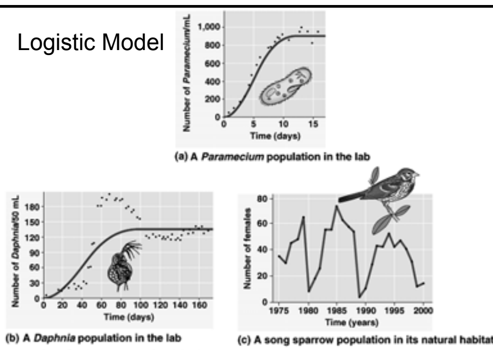


Fig. 52.12

Fits some populations well, but for many there is not stable carrying capacity and populations fluctuate around some long-tem average density.

3. What Limits Growth Rates and Population Sizes?

Density-dependent

Any characteristic that varies according to a change in population density relative to K

These reflect:

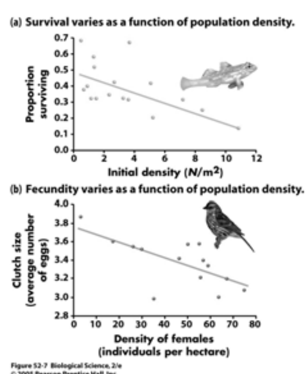
- Competition for resources (food/energy, nutrients, space/territories).
- Risk of predation, parasites, disease
- Waste accumulation (e.g., ethanol)

Density-independent

Any characteristic that does not vary as population density changes.

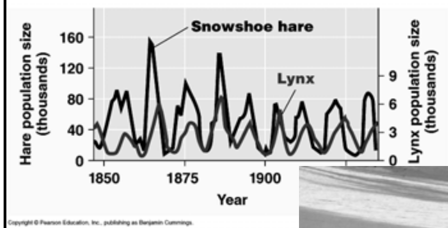
Disturbance, weather events, salinity, temperature

Density dependent survival and reproduction



Population-Limiting Factors

Some populations have regular boom-and-bust cycles.



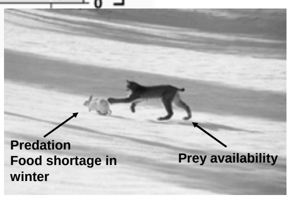
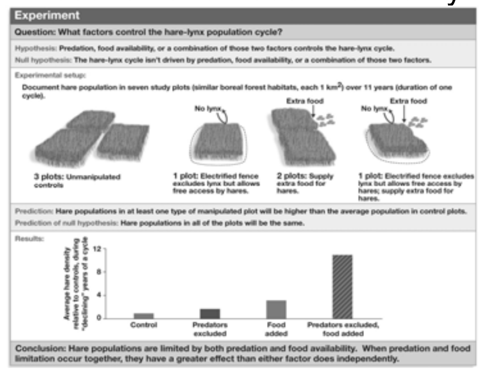


Fig. 52.19

Predation and Food Availability

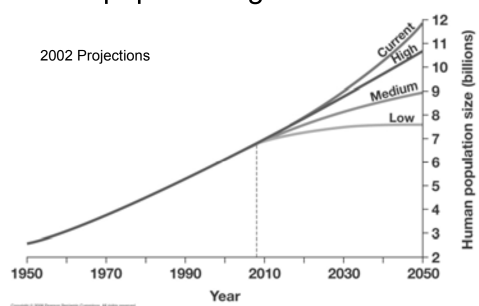


4. When and how will human population growth stop?

- This question is likely to be answered one way or another in your lifetime.
- What is Earth's carrying capacity for human's?
- Have we already exceeded K?
- What are consequences of human population growth for other species on this planet?

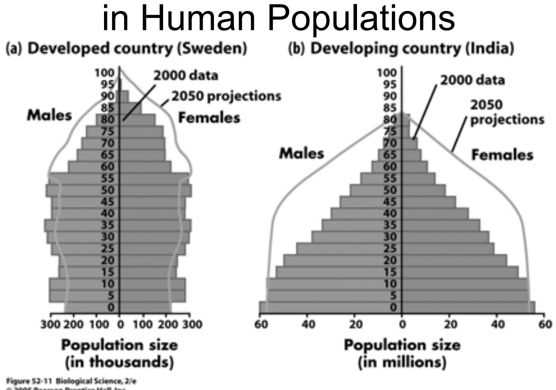
Human population growth: the future?

2002 Projections



Number of offspring per female
Current: 2.7
High: 2.5
Med: 2.1 (replacement)
Low: 1.7

Age Structure in Human Populations



K depends on human impact

- Depends on
  - Total human population
  - Consumption by each individual
  - Ecological impact of each unit of consumption
- I = PAT (Ehrlich and Ehrlich)
  - P = population
  - A = affluence
  - T = technology

Unknown what the carrying capacity of Earth for humans is. A useful concept is the ecological footprint: land needed to produce resources and absorb wastes for a given country.

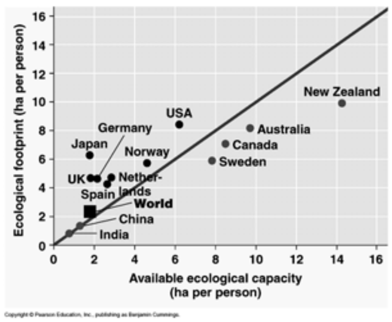


Fig. 52.23 – Ecological footprints for various countries and the world

Your assignment: Calculate your own ecological footprint

- Go to http://www.footprintnetwork.org/gfn_sub.php?content=myfootprint on the web (use Internet Explorer).
- Take the quick survey (~5 min)
- Email me your results. Subject line: footprint
- Give me your footprint in # of acres and # of planets
- Have them to me no later than 6 a.m. on Wed.

5. Demography & Life Histories (Section 52.1)

- How do we figure out r for different populations?
- What accounts for different patterns or rates of population growth among different species?
  - For example, different r_{max}

Life histories - questions

- What two main factors are documented in a life history table?
- What are survivorship curves and how do they reflect life history strategies?
- What do we mean by "life history tradeoffs"? Give an example.
- How might different life history strategies reflect the habitat in which a population lives?

Life tables

- 2 things used to determine the size of r
  - # of individuals surviving
  - the reproductive schedule (# of female offspring per female, and when that happens)
- These determine birth and death rates (b and d), which determine r.
- Delayed reproduction alone can reduce r.
- Don't worry about actual calculations (Box 52.1)

How do we figure out r?

a. Life History Tables : follow a cohort from birth until all are dead.

TABLE 52.1 Life Table for *Lacerta vivipara*

Year	Number alive	Survivorship	Fecundity	Survivorship × fecundity = average number of offspring produced per female born
0	1000	1.000	0.00	0.00
1	424	0.424	0.08	0.03
2	308	0.308	2.94	0.91
3	158	0.158	4.13	0.65
4	57	0.057	4.88	0.28
5	10	0.010	6.50	0.07
6	7	0.007	6.50	0.05
7	2	0.002	6.50	0.01

Data are from Strijbosch

$R_o = 2$

Table 52-1 Biological Scie

© 2005 Pearson Prentice H

Cohort
Age class
Survivorship
fecundity

b. Life history strategies

Life histories are determined by traits that affect
- when and how much an organism reproduces
- how well it survives.

b. Life history strategies

i. reproduction

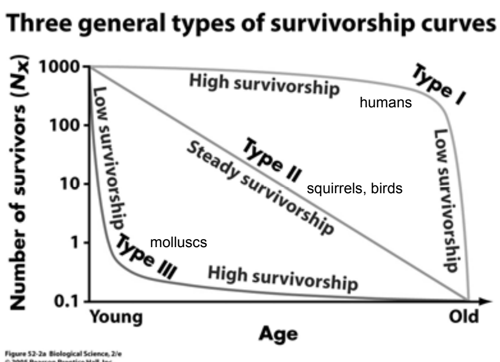
Semelparity: "big-bang" reproduction

very high reproductive rates per event

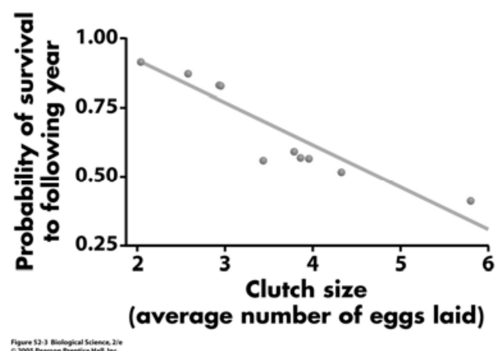
Iteroparity: reproduce for consecutive years

fewer young produced per event but often more parental care

ii. Mortality



iii. Tradeoffs: survival and reproduction



Life history tradeoffs in *Lacerta vivipara*

	France	Netherlands	Austria
m_x	high	medium	low
l_x	low	medium	high

SUMMARY

Population. Individuals same species occupying same general area.
Have geographic boundaries and population size.

Key characteristics
Density. Individuals per unit of area or volume.
Distribution: uniform, clumped, random.

Demography. Studies changes in population size.
Additions (+) : Births and Immigration.
Subtractions (-) : Deaths and emigration.

Life histories. Affect reproductive output and survival rate and thus population growth.
Life history strategies are trade-offs between survival and reproduction.

Population Growth
  Exponential. J-shaped. Idealized, occurs in certain conditions.
  Logistic. S-shaped. A little more realistic. Carrying capacity.
    Density-dependent selection.
    Density independent selection.

Population growth is slowed by changes in birth and death rates with density.

Interaction of biotic and abiotic factors often results in unstable population sizes. In some populations they result in regular cycles.

SUMMARY

Human population has been growing exponentially for a long time.

A reduction is expected either through lower birth rates or higher death rates. The age-structure suggests different scenarios for individual countries.

Humans appear to be above Earth's carrying capacity.

The End