

Population Ecology

- What is a Population?
 - groups of interacting conspecifics (i.e., inter-mating individuals)
- Population ecology explores how environmental factors influence the characteristics of a population.



Characteristics of Populations

- Populations can be studied in terms of...
 - Abundance (size)
 - Density
 - Distribution
 - Demographics
 - Rates of Growth
 - Limits on growth
 - Changes in distribution and density due to dispersal, emigration, immigration and migration



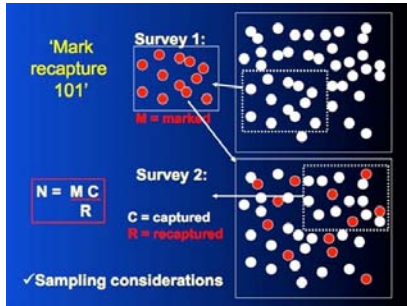
How to measure density?

- Direct Counts
- Quadrates
- Mark and recapture
- Additional sampling methods

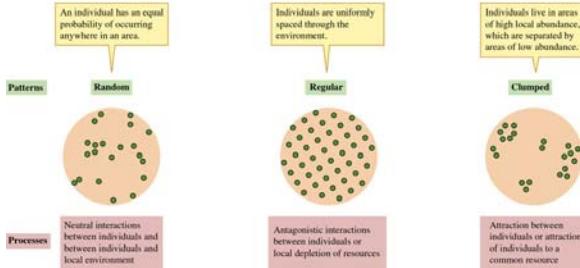


Mark and Recapture

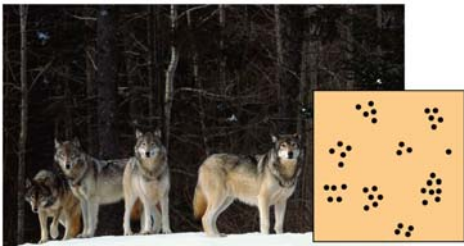
Population size = N Animals captured (visit 2) = C
 Animals marked (visit 1) = M Animals that were captured 2x = R



Dispersion of Individuals on Small Scales



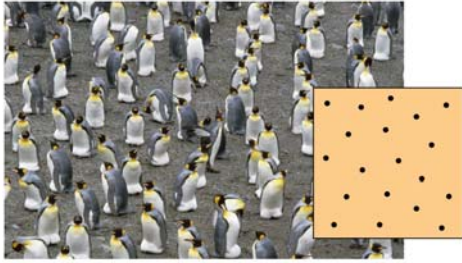
Clumped Dispersal of Population



(a) Clumped. For many animals, such as these wolves, living in groups increases the effectiveness of hunting, spreads the work of protecting and caring for young, and helps exclude other individuals from their territory.

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Uniform Dispersal of Population



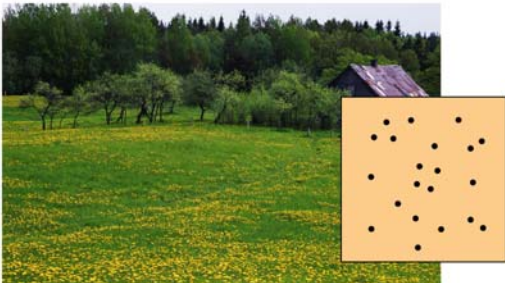
(b) Uniform. Birds nesting on small islands, such as these king penguins on South Georgia Island in the South Atlantic Ocean, often exhibit uniform spacing, maintained by aggressive interactions between neighbors.

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Uniform Dispersal of Population



Random Dispersal of Population



(c) Random. Dandelions grow from windblown seeds that land at random and later germinate.

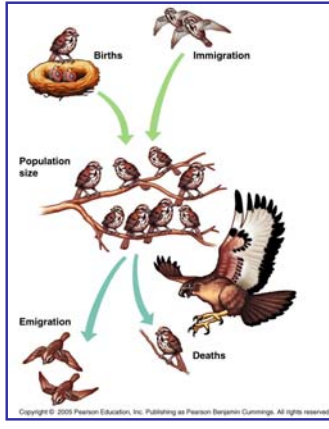
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Demographics

The vital statistics of a population

- Birth rates
- Death rates
- Sex ratios
- Reproductive age

These affect the density and distribution (abundance)



Demographics: Life Tables

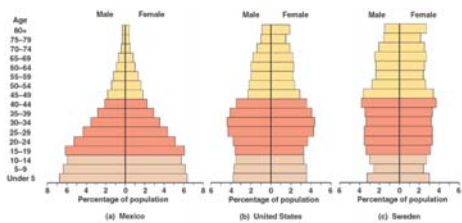
Table 53.3 Life Table for Belding's Ground Squirrels (*Spermophilus beldingi*) at Tioga Pass, in the Sierra Nevada of California*

Age (years)	FEMALES					MALES				
	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate ¹	Average Additional Life Expectancy (years)	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate ¹	Average Additional 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					

*Females and males have different mortality schedules, so they are listed separately.
[†]The death rate is the proportion of individuals dying during the specific time interval.
^{††}Includes 122 females and 128 males first captured as 1-year-olds and therefore not included in the count of squirrels age 0-1.
 Source: R. W. Sherman and M. L. Martin, Demography of Belding's ground squirrel. *Ecology* 65:1617-1628 (1984).

Demographics: Age Structures

Age structure: the number or proportion of individuals in different age groups

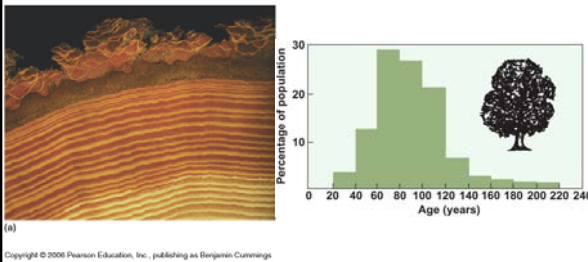


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Age pyramids for three human populations in 1989.

- Techniques used for aging animal populations
 - Mark young individuals and follow their survival
 - Study a representative sample
 - Tooth wear
 - Plumage changes
 - Growth rings in teeth, horns, ear bones, and so forth

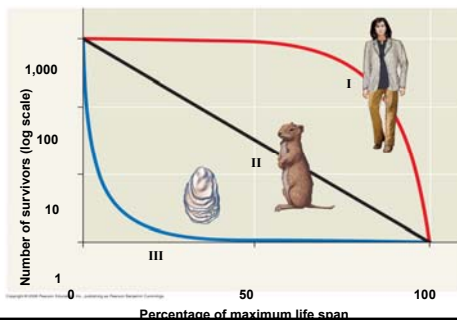
Some plant ages can be determined too



Survivorship Curves

A plot of the proportion or # of individuals in a population surviving through time

Surviving is not everything...birth rate is important too!



Reproductive Tables

Table 53.2: Reproductive Table for Belding's Ground Squirrels at Tioga Pass

Age (years)	Proportion of Females Weaning a Litter	Mean Size of Litters (Males + Females)	Mean Number of Females in a Litter	Average Number of Female Offspring*
0-1	0.00	0.00	0.00	0.00
1-2	0.65	3.30	1.65	1.07
2-3	0.92	4.05	2.03	1.87
3-4	0.90	4.90	2.45	2.21
4-5	0.95	5.45	2.73	2.59
5-6	1.00	4.15	2.08	2.08
6-7	1.00	3.40	1.70	1.70
7-8	1.00	3.85	1.93	1.93
8-9	1.00	3.85	1.93	1.93
9-10	1.00	3.15	1.58	1.58

Factors relevant to birth rates:

- Age of sexual maturity
- Clutch size
- Investment in individual progeny
- Survival vs. Reproduction
- Semelparity vs. Iteroparity

*The average number of female offspring is the proportion weaning a litter multiplied by the mean number of females in a litter.
 Source: P. W. Sherman and M. L. Martin, Demography of Belding's ground squirrel, Ecology 65:1417-1428 (1984).

Life History Strategies



Energy is limited.


- Allocation to one function (such as growth) will reduce the amount of energy an organism can devote to another function (such as reproduction).
- An organisms life history strategy involves trade-offs.

Semelparity



Iteroparity


Population Growth Equations



N = Population size
t = Time
B = Births (& Immigration)
D = Deaths (& Emigration)

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

Population Growth Equations



More predictive
 Use average (*per capita*) birth and death rates:
 (ignores immigration/emigration)

b = per capita birth rate (e.g. 78/1000)
d = per capital death rate (e.g. 32/1000)

$$\frac{\Delta N}{\Delta t} = bN - dN$$

Exponential Growth

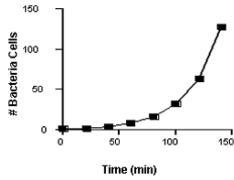
More interesting

- Use the difference (r) between per capita birth and death rates
- Use differential calculus format to express population growth
- Assume ideal conditions (r really equals r_{max})

$$r = b - d$$

$$d = \frac{\Delta}{t}$$

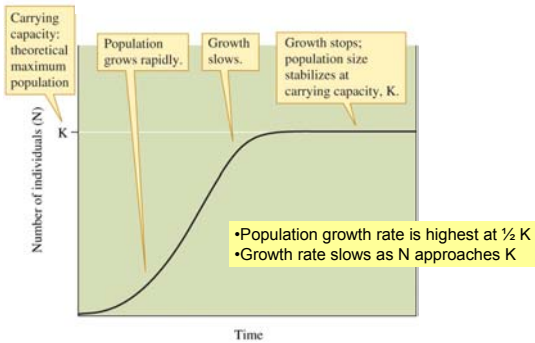
$$\frac{\Delta N}{\Delta t} = bN - dN$$



- Replace $(b - d)$ with r
- Replace $\frac{\Delta}{t}$ with d

Exponential growth cannot be sustained in nature for very long!!

Logistic Growth



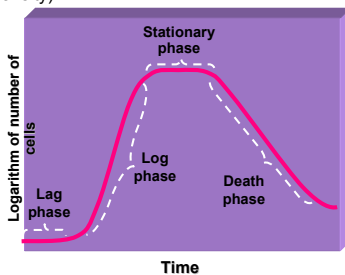
Carrying Capacity

What's going on at K?

Density-dependent interactions

(b and/or d are affected by density)

- Competition
- Territoriality
- Disease
- Predation
- Intrinsic factors
- Toxic wastes



Dynamics of a population

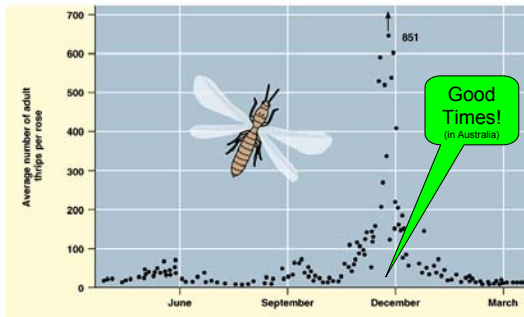
Sometimes population dynamics are not tied to the population's density

Density-independent interactions

- Natural disasters
- Weather (drought, flood, etc.)
- Some biotic interactions

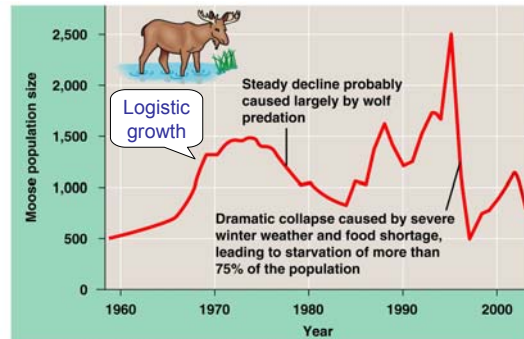


Density-Independent Factors



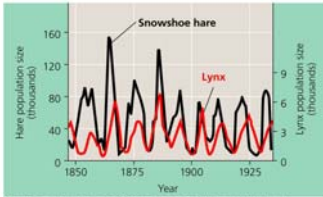
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Impact of Environment/Predators



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Dynamics of a population



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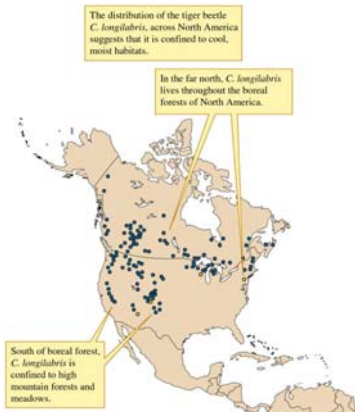
Dispersal Influences Abundance

Passive: Seeds carried by wind or animals

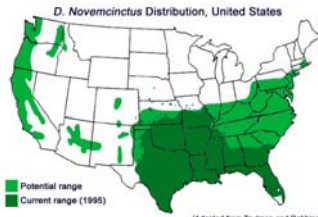
Active: Emigration, Immigration & Migration



Tiger Beetle of Cold Climates



Nine-banded Armadillo (*Dasyus novemcinctus*)



Migration: A Round Trip

Migratory pathways of Ring-necked ducks and gray whale.

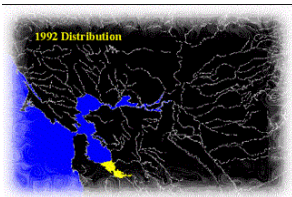


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Invasive (Introduced) Species



Chinese Mitten Crab
(*Eriocheir sinensis*)



- Damage fishing nets
- Eat Salmon eggs
- Damage aquatic plants

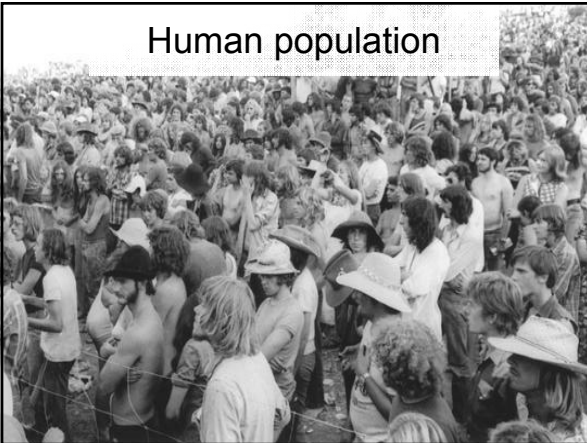
http://www.iisgcp.org/exoticsp/chinese_mitten_crab.htm

Invasive (Introduced) Species

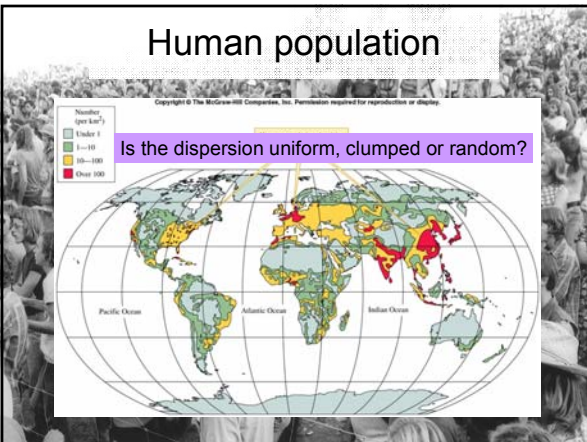
English & Algerian Ivy
(*Hedera spp.*)



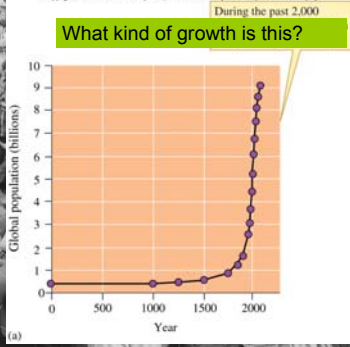
Human population



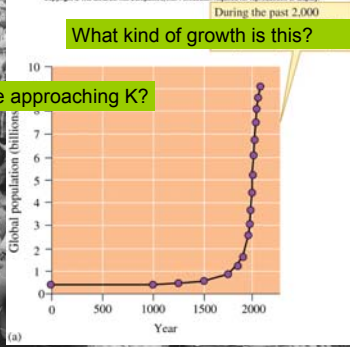
Human population



Human population

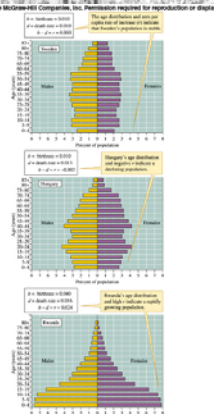


Human population

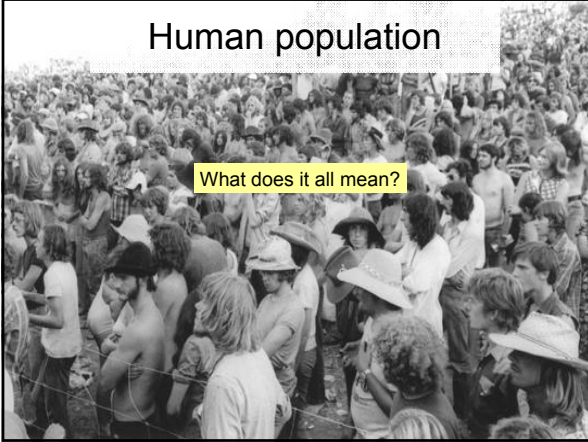


Human Population

What do these age structures tell us about human population growth?



Human population



What does it all mean?

Summary

- Populations are described by their distribution, size, density, and dispersion
- Population dynamics include: survivorship, fertility schedules, growth
- Two dominant life history strategies (r and K) represent evolutionary trade-offs
- The human population is clumped, growing (unevenly), and the growth can likely not be sustained
