- Tuesday, Feb 21. *Biological Evolution: What It Is and What It Isn't* (Joanna Masel, EEB)
- Tuesday, Mar 7. *Cosmic Evolution: From Big Bang to Biology* (Chris Impey, Astronomy)
- Tuesday, Mar 21. *Earth Evolution: The Formation of Our Planet* (Joaquin Ruiz, COS Dean, Geosciences)
- Tuesday, Mar 28. *Social Evolution: Cooperation and Conflict From Molecules to Society* (Rick Michod, EEB)
- Tuesday, Apr 11. *Animal Evolution: Recycling Ancient Genes For New Uses* (Lisa Nagy, MCB)
- Tuesday, Apr 18. *Human Evolution: Tracking Our Origins with DNA* (Michael Hammer, ARL/EEB)
- Tuesday, Apr 25. *Disease Evolution: The Example of HIV* (Michael Worobey, EEB)

http://cos.arizona.edu/evolution/

Population ecology

Outline

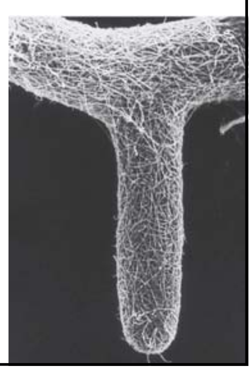
- Species interactions
- Demography: survivorship curves
- Exponential and logistic growth
- Density-dependent and density-independent effects on populations
- Population stability, subpopulations and dispersal
- Managing populations
- Human population ecology

Species interactions

- Mutualism (+/+)
- Commensalism (+/0)
- Amensalism (-/0)
- Parasitism or predator/prey (+/-)
- Competition (-/-)

Mutualism (+/+)

- Both participants benefit from the interaction
  - the plant gets…
  - the fungus gets…



Commensalism (+/0)

- Cattle egrets forage for insects near large mammals
- The movements of the large animal flush out insects, which the birds eat
- The mammal does not gain or lose anything from this interaction

Amensalism (-/0)

- e.g. trees and branches falling from trees damage smaller plants beneath them

Parasitism or predator/prey (+/-)

Competition (-/-)

Species interactions summary

		EFFECT ON ORGANISM 2		
		HARM	BENEFIT	NO EFFECT
EFFECT ON ORGANISM 1	HARM	Competition (–/–)	Predation or parasitism (–/+)	Amensalism (–/0)
	BENEFIT	Predation or parasitism (+/–)	Mutualism (+/+)	Commensalism (+/0)
	NO EFFECT	Amensalism (0/–)	Commensalism (0/+)	—

The relationship between a human and the fungus that causes athlete's foot is _______ when the fungus feeds only on dead skin cells, but becomes _______ if the fungus penetrates the skin and feeds on living cells.

a. amensalistic; commensalistic
b. commensalistic; amensalistic
c. a host–parasite interaction; commensalistic
d. amensalistic; a host–parasite interaction
e. commensalistic; a host–parasite interaction

Chthamalus stellatus and *Balanus balanoides* are both barnacles. The fast-growing *Balanus* can smother, crush, or undercut the slower-growing *Chthamalus*. Because of this, *Chthamalus* is not found in deep water unless *Balanus* is absent. *Chthamalus* is better able to withstand dehydration than *Balanus*. Because of this, *Balanus* is not found in shallow water unless *Balanus* is absent. The interaction between these two barnacles is an example of

a. mutualism.
b. commensalism.
c. amensalism.
d. competition.
e. predator–prey interaction.

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Definitions in population ecology

- Individuals of a species within a given area constitute a population
- Population density: the number of individuals of a species per unit of area (or volume)
- Population dynamics: change in population density through time and space
- Demography: study of birth, death, and movement rates that give rise to population dynamics

Studying demography

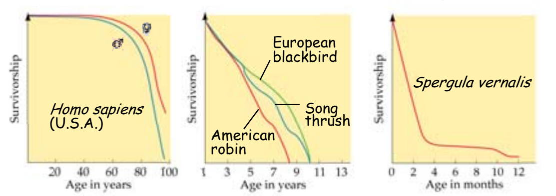
- Cohort = group of individuals that were born at the same time
- Survivorship = how many of cohort are still alive

Studying demography

Many humans survive most of their potential life span.

Survivorship of many wild birds is the same throughout their life span once fledged.

In organisms that produce many offspring, survivorship is low among the juveniles and high after that.



If a graph shows that the percent survivorship declines in a straight line with age, this means that

a. young individuals have the highest death rates.
b. death rates increase following reproduction.
c. the probability of death is about the same for all ages.
d. most individuals die at about the same age.
e. the majority of individuals survive to old age.

If a graph shows that the percent survivorship is high at young ages but declines rapidly at high ages, this means

a. each individual produces many offspring.
b. each individual produces few offspring.
c. old individuals have the highest death rates.
d. young individuals have the highest death rates.
e. the probability of death is about the same for all ages.

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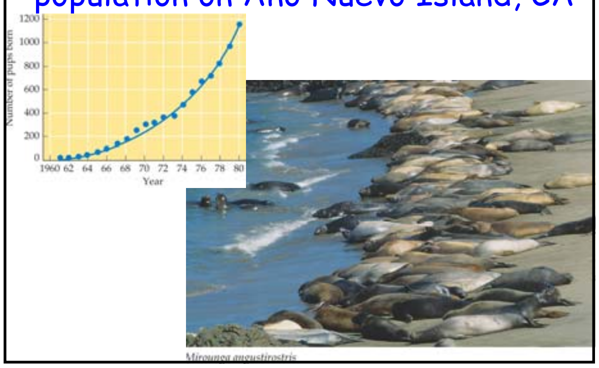
Exponential growth

- If one bacterium grew without limit for a month… the colony would weigh as much as the visible universe and would expand at the speed of light
- The number of individuals added per unit time increases with the population size, even though the per capita population increase is constant
- constant birth and death rates ⇒ J-shaped curve = exponential growth

Exponential growth of elephant seal population on Año Nuevo Island, CA



Mathematics of exponential growth

- ΔN = the change in number of individuals
- Δt = the change in time
- b = the average per capita birth rate (includes immigrations)
- d = the average per capita death rate (includes emigrations)

Mathematics of exponential growth

- The difference between per capita birth rate (b) and per capita death rate (d) is the net reproductive rate (r)
- When conditions are optimal, r is at its highest value (r_{max}), called the intrinsic rate of increase
- r_{max} is characteristic for a species
- The equation for population growth can be written

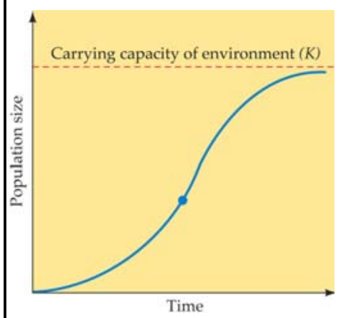
$$\Delta N/\Delta t = r_{max}N$$

Mathematics of exponential growth

- For a limited time, some populations may grow at nearly r_{max}
- Real populations do not grow exponentially for long because of environmental limitations
- Environmental limitations include food, nest sites, shelter, disease, and predation

- Natural population growth more closely resembles an S-shaped curve

Mathematics of logistic growth



Which of the following concerning exponential growth is TRUE?

a. Exponential growth curves resemble an S.
b. No population can grow exponentially for long.
c. Bacterial colonies have been observed to maintain exponential growth for over a month.
d. The per-capita birth and death rates are NOT constant during exponential growth.
e. Exponential growth has never been observed.

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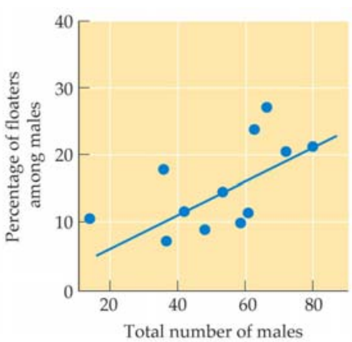
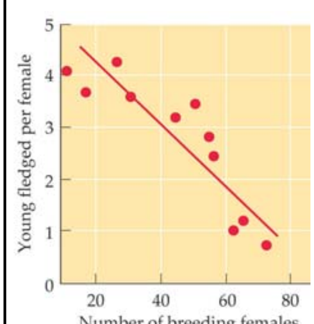
Density-dependent factors stabilize the population

- Per capita birth and death rates fluctuate in response to population density
- e.g., dense population may deplete food supply, reducing the amount of food each individual gets. Poor nutrition may increase death rates and decrease birth rates
- e.g., diseases, which may increase death rates, spread more easily in dense populations than in sparse populations

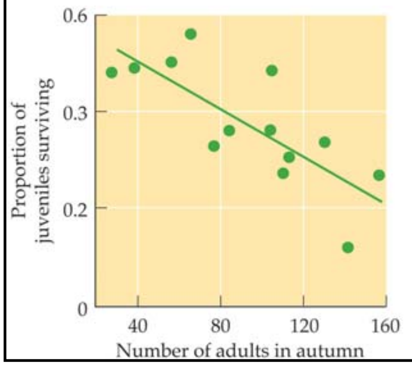
Stabilizing population density



Stabilizing population density



Stabilizing population density



The more birds alive in the autumn,

the poorer are the chances that juveniles born that year will survive the winter

Density-independence

- Factors that affect birth and death rates in a population independent of its density
- e.g., a severely cold winter may kill large numbers of a population regardless of its density

Which of the following is an example of DENSITY-INDEPENDENT population regulation?

a. A contagious disease sweeps through a dense population of lemmings.
b. Jaegers, which are predators of lemmings, search widely for places where lemmings are abundant and concentrate their hunting in those areas.
c. An outbreak of lemmings leads to a depletion of the food supply. As a result, lemmings are underfed and produce few offspring.
d. An early cold spell kills 80 percent of the lemmings in a particular area.
e. When lemmings are abundant, arctic foxes switch from a primary diet of mice to a primary diet of lemmings.

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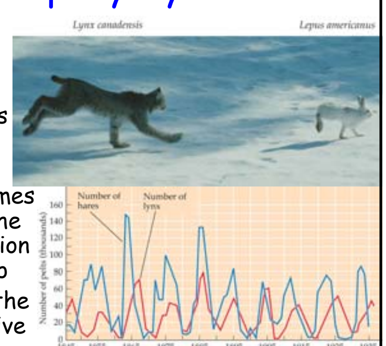
Population stability

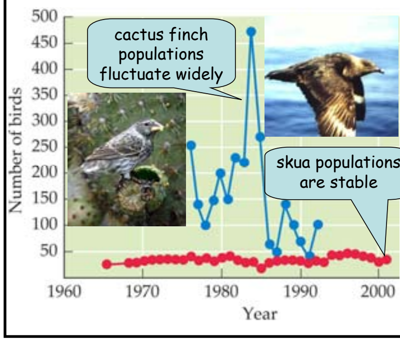
- Populations fluctuate due to all factors, both density-dependent and density-independent
- Populations can fluctuate both because of
  - what they eat
  - what eats them

Predator-prey dynamics

- When prey is scarce, predator does badly
- When predator is scarce, prey can multiply
- When prey becomes plentiful again, the predator population increases back up
- Food supply for the prey may also drive the dynamics



Some populations are more stable than others



Polar skuas are long-lived, with a low reproductive rate

Galapagos cactus finches are short-lived: more vulnerable to environment

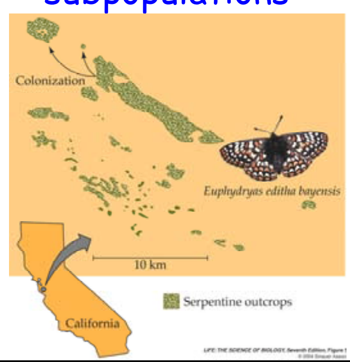
Some populations are more stable than others

- Populations with low reproductive rates are more stable eg skuas
- Populations that depend on limited resources fluctuate more than those using a variety of resources: cactus finch populations fluctuate with the annual production of seeds that they eat
- Small populations fluctuate more

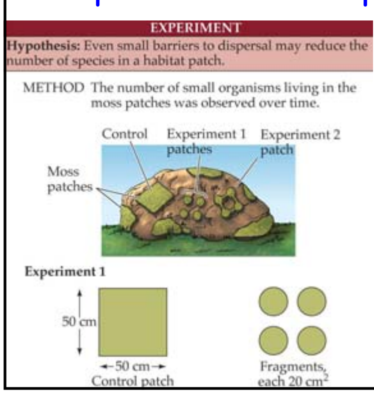
Subpopulations

- Population may be divided among separated patches of habitat
- Each subpopulation can be "born" (colonized) and "die" (extinction)
- Subpopulations are often small, therefore prone to extinction
- Migration between subpopulations may prevent extinction (rescue effect)

Bay checkerspot butterfly subpopulations

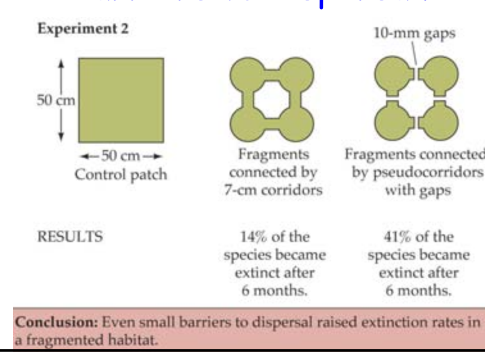


Experiment on subpopulations



- Experimental patches of habitat
- Number of species on fragments declined 40% in 1 year
- Rarer species declined more than common ones

What about very small barriers to dispersal?



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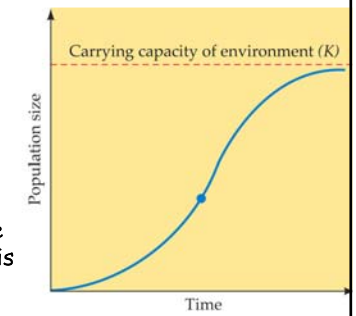
Managing populations



- Hunting seasons are established with this in mind

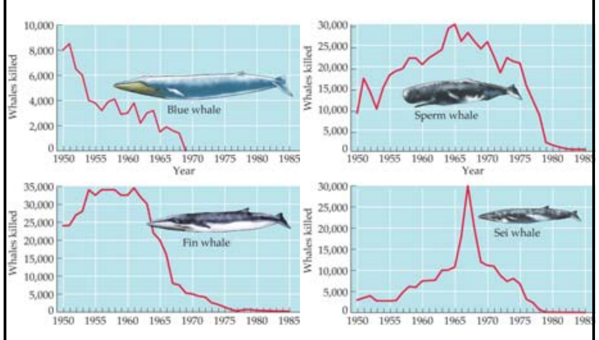
Managing populations

- Populations with high reproductive capacities can sustain growth high harvesting
- eg. modest number of surviving adult female fish can produce a huge number of eggs.
- However, any species—even those with high reproductive capacity—can be overharvested.

Managing whale populations

- Excessive harvests almost caused the extinction of blue whales
- Whale management depends on co-operation between different countries (difficult to achieve).

Large whales were exploited first



How to reduce a population

(discuss)

Which would be the most effective way to minimize a rat population in an alley?

a. Kill as many rats as possible by poisoning and trapping them.
b. Clean up the alley so that the rats have no garbage to feed on.
c. Lure the rats away to another site where they will be less harmful.
d. Search out and kill very young pre-reproductive rats.
e. Release cats into the alley.

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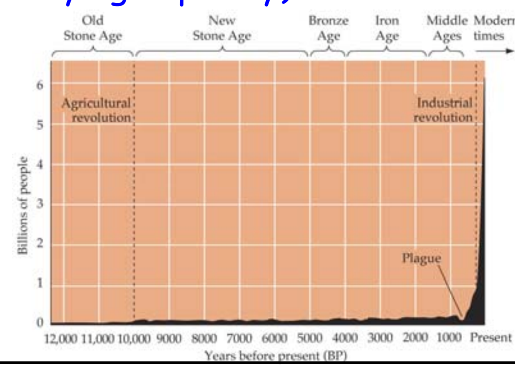
Carrying capacity of humans

Earth's carrying capacity for humans used to be set at a low level by

(discuss)

Human population size (and carrying capacity) have increased



Why has human carrying capacity increased?

(discuss)

What sets human carrying capacity now?

(discuss)

Reaching new carrying capacity will cause extinction of millions of other species to accommodate our use of Earth's resources