Previous Lecture

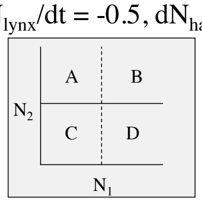
- Predator-prey theory developed from exponential growth equations
- Predicts neutrally-stable cycling of predator and prey populations

Lecture 10

- Predator-prey cycling in the real world
- Prudent Predation
- Volterra Principle
- Critique and possible improvements to the model
- Other relationships among organisms:
  - Mutualisms

Clicker Practice Problem

- If $dN_{lynx}/dt = -0.5$, $dN_{hare}/dt = 1$,



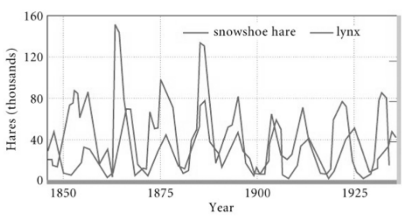
- which quadrant of the predator prey cycle is this two-species community in?

Lynx-Hare Dynamics

- Of the lynx, Ernest Thompson Seton wrote "It lives on rabbits, follows the rabbits, thinks rabbits, tastes like rabbit, increases with them, and in their failure dies of starvation in the unrabbitted woods"

Lynx-hare cycle

- Hudson's Bay Company records show:



What feature(s) of the above graph match the predictions of the Volterra Predator-Prey Equations?

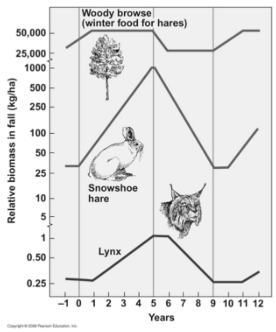
What feature(s) of the above graph DO NOT match the predictions?

Apparent and actual correspondence of theory and real world

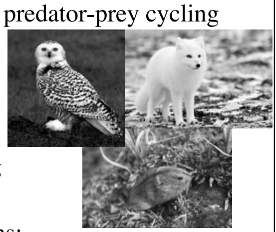
- Hudson Bay data are flawed - lynx pelts were from western Canada; hare pelts from eastern Canada - the cycles were not directly linked
- Cycles **do exist** in the same region; however, prey populations often cycle **in the absence of predators!**
- Predator-prey cycles may be 'driven' by underlying **prey-vegetation** cycles.

Greater Complexity

S&S,
Fig. 14-24



Other examples of predator-prey cycling

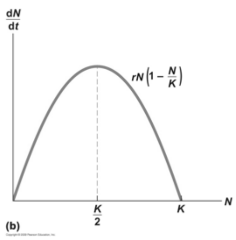


- Natural populations:
  - Snowy owl - lemming
  - Fox - lemmings
- Laboratory populations:
  - Azuki bean weevil - braconid wasp
  - Paramecium - Didinium
  - Six-spotted mite - predatory mite

Real-World Predictions Flowing From Theory

- Exponential ->Invasive species outbreaks
- Logistic ->Prudent predator behavior*
- Competition -> Limiting similarity, character displacement
- Volterra Predator-Prey -> Volterra Principle*

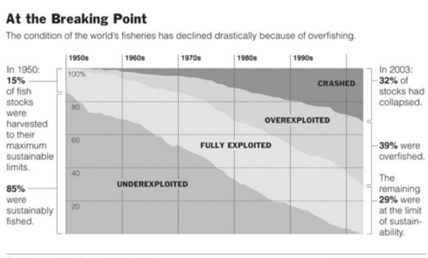
A 'prudent predator'



In a prey population being regulated by density-dependent population growth, a 'prudent predator' will keep it's prey N at K/2.

Why? The largest sustainable harvest is possible there (=dN/dt at that N)

Are Humans 'Prudent Predators'?



Want to do something about it? Get Monterey Bay Aquarium's 'Seafood Watch' app. Use it in restaurants and grocery stores to select seafood to eat

Volterra Principle

- Assumptions:
  - Pest populations are often under intense predation
  - General pesticides may affect both predator and prey populations
  - Effect of pesticide in Volterra model:
    - _______________
    - _______________

Volterra Principle

Maximum N_1 (=pest) is <u>greater</u> **<u>after</u>** general pesticide application because the pesticide affects both predator and prey.

Critique of the Volterra model

- Amplitude (height) of oscillations is arbitrary
- Predicts one kind of result - neutrally stable oscillation
- Ignores density-dependence and competition

Improvements to the model

- Add logistic prey population growth rate (i.e., add prey density-dependence):

Stable equilibrium point

Improvements to the model

- Including prey-density dependence AND predator satiation produces:

OR

Modifying the Model for Parasites?

- Challenging because:
  - Hosts can develop immunity (to varying degrees)
  - Parasites may spend part of their life cycle in another host, or be free-living; there may be 3 or more species involved
  - Environmental conditions may unpredictably affect all species involved in the interaction

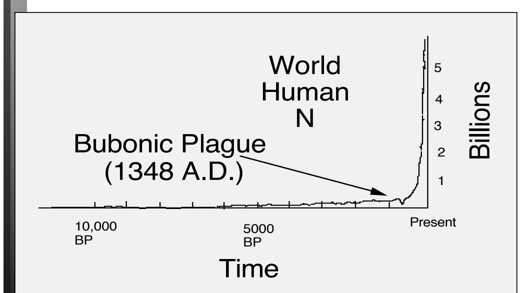
Bubonic plague

- Caused by a bacterium, bubonic plague is endemic in many wild populations of rodents
- The bacterium spreads to humans from rodents fleas.
- Human mortality rises rapidly, then falls as individuals die or acquire immunity or virulence of the bacterium decreases.

Bubonic plague - a population problem

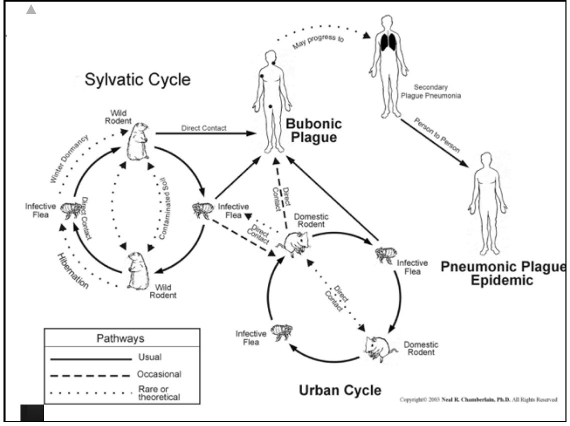
- Conditions conducive to plague outbreak:
  - ___________________________
  - ___________________________
  - ___________________________

Effect of bubonic plague on human population size



Subtlety and Complexity of Parasitism

- Effect on host often not immediate
- Host may develop immunity
- Parasite dN/dt tied to presence of susceptible individuals
- Parasite life-cycles may contain intermediate hosts

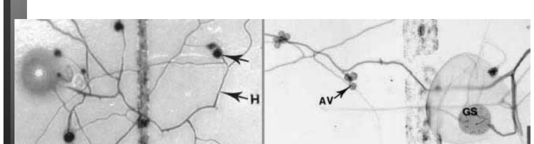


Effect on Species 1

Effect on Species 2	-	0	+
-	Competition	Amensalism	Predation Parasitism
0		Neutral	Commensalism
+			Mutualism

Mutualism - three varieties

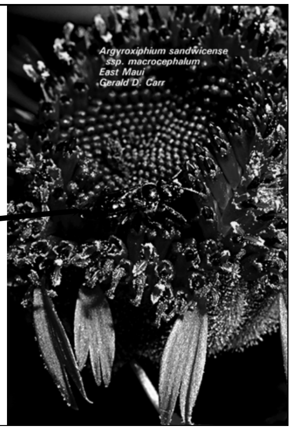
- (1) Trophic mutualisms - partners have complementary ways of obtaining nutrients or energy:



Vesicular-arbuscular mycorrhizae. Photo by Mark Brundrett

Mutualisms

- (2) Dispersive mutualisms:



Specialist pollinators – threatened by Argentine ant invasion

Argyroxiphium sandwicense

Mutualisms

- (3) Defensive mutualisms:

Ant-acacia mutualism

- Mutualism may involve evolution of both species with respect to each other (=coevolution)

Acacia

Beltian bodies

daphne.palomar.edu/wayne/acacia.htm

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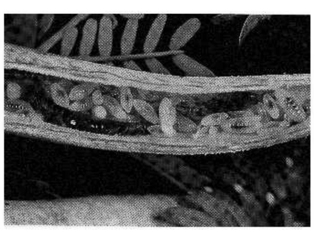
Ant

Swollen thorns



Molles 1999

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Benefits for:

- Plant
- Ant

Summary

- Predator-prey cycles are found in nature, however they may not have the same cause-effect relationship as predicted by the model
- Although the Volterra equations are overly-simple, they predict a general pesticide may have the opposite of its intended effect (Volterra principle)
- Modifications of the model (density-dependence, predator satiation) may produce more realistic predictions

Next lecture

- Other relationships among species