# Lecture 9

- Predator-prey population dynamics
  S&S, Chap. 14

notation warning: variable names in S&S are nonstandard, so ours will be different…



Effect on Species 1

| Effect on Species 2 | - | 0 | + |
|---|---|---|---|
| - | Competition | Amensalism | Predation<br>Parasitism |
| 0 | | Neutral | Commensalism |
| + | | | Mutualism |

# Clicker Question; Predators of Yellowstone

A. Wolf

B. Grizzly Bear

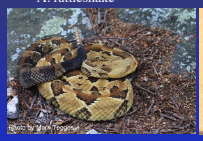
C. Mountain Lion

D. None of the above

Which animal concerns me the most (as a possible prey item!) while hiking alone in Yellowstone National Park?

## Which West Virginia animal are you most afraid of? (with you as a possible victim!)

A. rattlesnake



B. black widow spider

C. black bear

D. white-tailed deer

E. hunter

PS – It's Dick Cheney…



## Deer*

*more than 1.5 million crashes involving deer each year
*cause over $1 billion in damage
*150 of the deer collisions are fatal (vs. 80-90 *via* hunting accidents)
*there are more than 10,000 people injured

Source: http://www.car-accidents.com/deer-car-auto-accidents.html



## Terminology - caution wrt book!

- Let Prey Population = $N_1$ (S&S use $N_{prey}$)
- Let Predator Population = $N_2$ (S&S use $N_{pred}$)
- We will develop 2 population growth equations: 1 for prey, 1 for predator.

## Predator-Prey Dynamics

- Starting Point: Exponential Population Growth; prey population



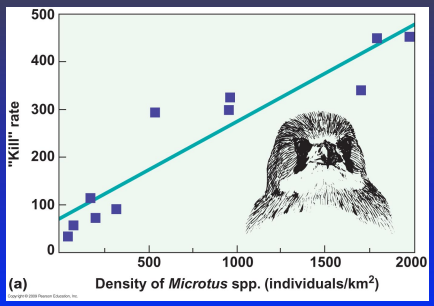
## Functional response of predator

- Functional response - the number of prey caught per predator per unit time.

p is the **proportion** of prey caught per predator per unit time (note: S&S use 'c' for this variable)



## Real Data



## *Prey* Population Growth

- Substituting $pN_1$ for the functional response:

- where, $N_1$ is the prey population size, $r_1$ is the prey intrinsic rate of increase, p is the proportion of prey caught per predator per unit time, and $N_2$ is the predator population size

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## *Predator* Population Dynamics

- Start from exponential growth equation
- Assume prey population size mainly affects predator birth rate

- The manner in which prey N affects predator births is the **numerical response** of the predator

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## Numerical response of the predator

- How many kudus does it take to yield one baby lion birth?

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## Predator numerical response

- How many ground squirrels must be caught to make one baby gyrfalcon?

## Wolves and elk

- How many elk must be caught per baby wolf produced?



## Numerical response

- Birth rate of the predator = (efficiency with which caught prey are converted to baby predators) x (the number of prey caught per predator per unit time):

Note: we use the variable 'a' for the efficiency of conversion; S&S use 'b'; I will stick with a, because b has a different meaning

## Predator Population Growth

- Integrating the numerical response into the predator population growth equation, we have:

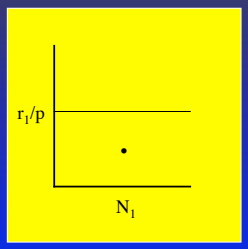


## Predator-Prey Equations

- Both equations contain $N_1$ and $N_2$
- Both equations contain p
- How to solve? FIND THE ZERO GROWTH ISOLINES!

*Find species 1's zgi now*

## Species 1 - zero-growth isoline



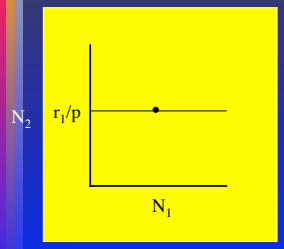

What do you think will happen to the prey population ($N_1$) if the 2-species 'community' is at the point?

A. It will increase
B. It will remain the same
C. It will decrease

(Hint: Is the predator population large or small?)

Draw an arrow showing the population change for the prey

## Species 1 - zero-growth isoline

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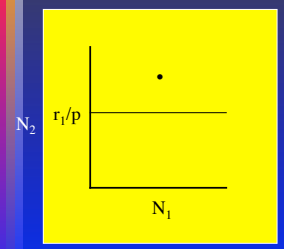
## Species 1 - zero-growth isoline

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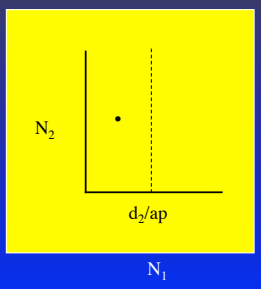
## Predator-Prey Equations

- Both equations contain $N_1$ and $N_2$
- Both equations contain p
- How to solve? FIND THE ZERO GROWTH ISOLINES!

*Find species 2's zgi now*

## Species 2 - zero-growth isoline



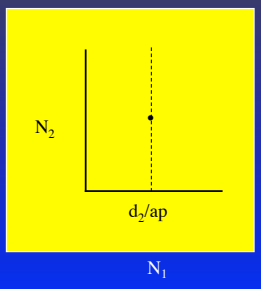

What do you think will happen to the predator population ($N_2$) if the 2-species 'community' is at the point?

A. It will increase
B. It will remain the same
C. It will decrease

Hint: Note the prey N at the dot



## Species 2 - zero-growth isoline

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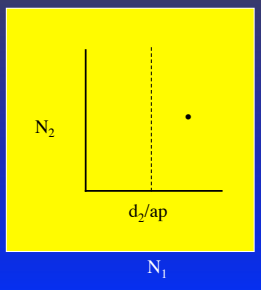
## Species 2 - zero-growth isoline




What do you think will happen to the predator population ($N_2$) if the 2-species 'community' is at the point?

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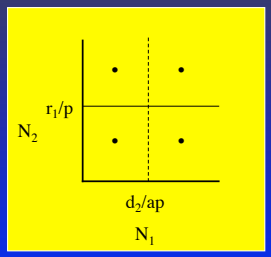
## Neutrally-stable cycle




Now, put the two graphs together. Place arrows for each species at each point.

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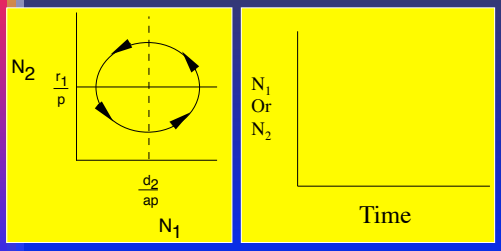
## N vs. time

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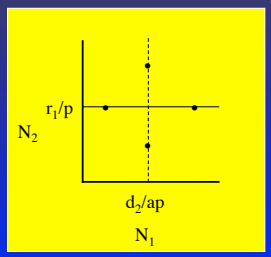
## Try this one on your own!




Place arrows at each of the dots, showing how the 2-species community is changing at each point.

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## Theory Summary

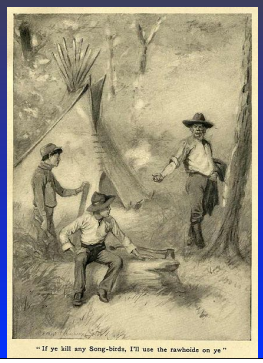
- Predator-prey theory developed from exponential growth equations based on two premises:
  - prey population growth rates are reduced by predation via death
  - predator births are positively influenced by prey population size
- Predicts neutrally-stable oscillations of both predator and prey population sizes



## 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"

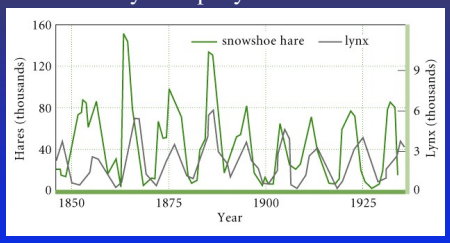
## Ernest Thompson Seton



"If ye kill any Song-birds, I'll use the rawhide on ye."

## Lynx-hare cycle

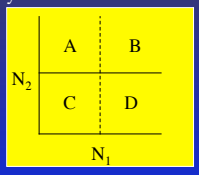
- Hudson's Bay Company records show:




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?

## Sample (Easy) Exam Problem

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



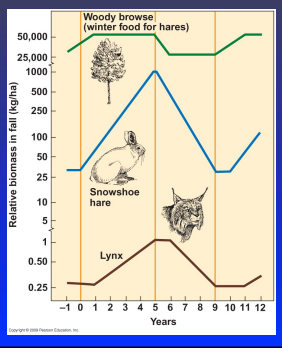

- which quadrant of the predator prey cycle is this two-species community in?

## 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*