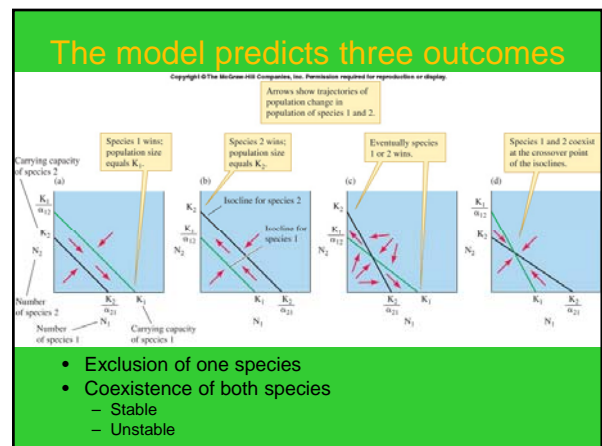
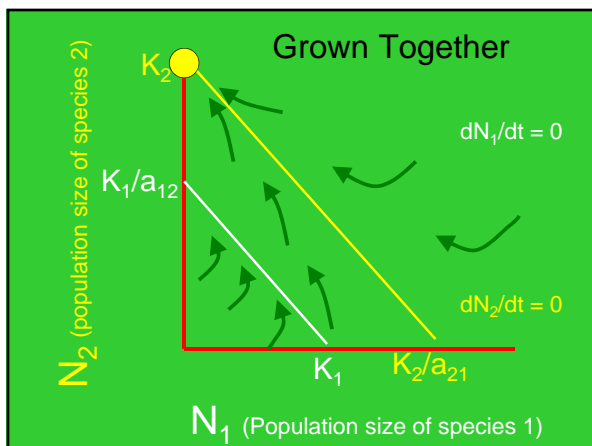
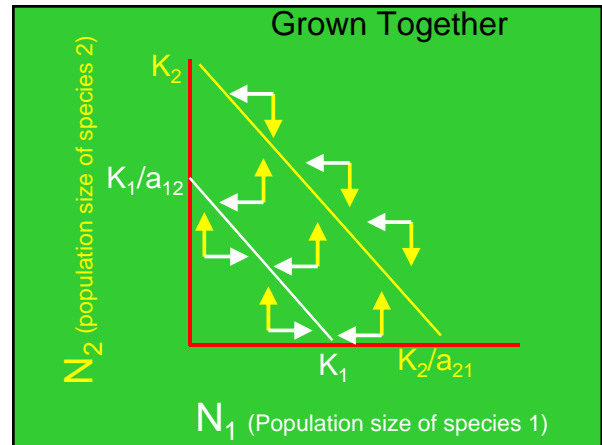
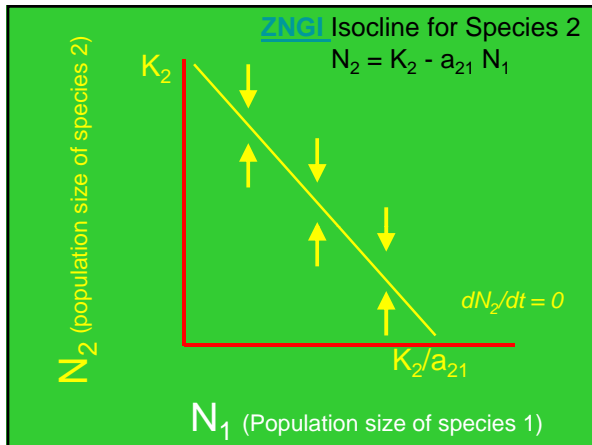
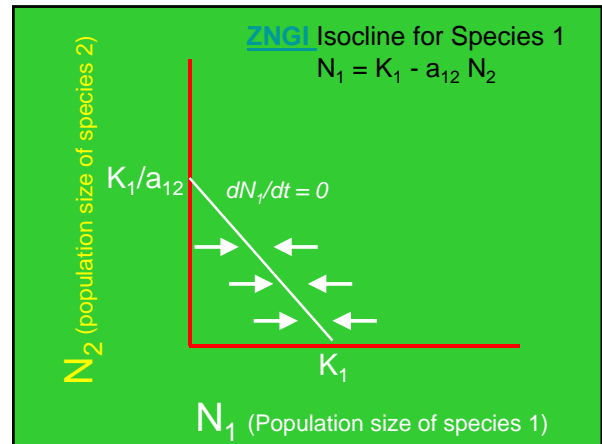
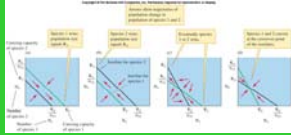


## Isoclines – making sense of those ugly conditions for coexistence

- There is an equilibrium when neither population grows:
  - $dN_1/dt = dN_2/dt = 0$
- This happens when:
  - $N_1 = -a_{12} N_2 + K_1$
  - $N_2 = -a_{21} N_1 + K_2$
- These are equations for lines
  - "Zero Net Growth Isoclines" = ZNGI
  - Combinations of  $N_1$  and  $N_2$  that stop population growth for each species (by utilizing all available resources)



## Using computers to explore this model

- Does  $K$  alter the model outcome?
  - a) yes
  - b) no
  - c) it depends
- Test:
  - Three environments with different  $K$ 's ( $a_{12}=a_{21}=0.5$ ;  $r=0.5$ )
- |       | $K_1$ | $K_2$ |
|-------|-------|-------|
| Env 1 | 225   | 75    |
| Env 2 | 150   | 150   |
| Env 3 | 75    | 225   |

  - Look at both the "N vs. t" and phase plane ( $N_1$  vs  $N_2$ ) graphs

<http://biosci.umn.edu/populus/>  
[http://www.kimvdlinde.com/professional/popdyn/popdyn\\_en.html](http://www.kimvdlinde.com/professional/popdyn/popdyn_en.html)

## Using computers to explore this model

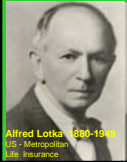
- Does  $r_{max}$  affect the outcome?
  - A) yes
  - B) no
  - C) it depends

## Coexistence Criteria


- The Lotka-Volterra Competition Equations predict that coexistence will depend on:
  - $K$
  - $a_{ij}$
- Coexistence will NOT depend on  $r$ !

$$\hat{N}_1 = \frac{K_1 - a_{12}K_2}{1 - a_{12}a_{21}}$$

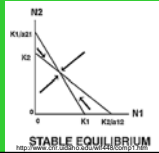
$a_{12}a_{21} < 1$



**Alfred Lotka** 1880-1949  
US - Metropolitan Life Insurance



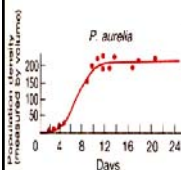
**Vito Volterra** 1860-1940  
Italy - University of Turin, University of Rome La Sapienza



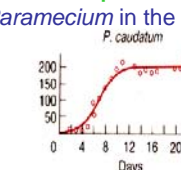
**STABLE EQUILIBRIUM**

## Gause's empirical Study

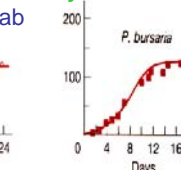
### Paramecium in the Lab



*P. aurelia*



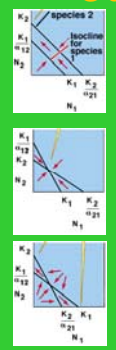
*P. caudatum*



*P. bursaria*

- Two outcomes observed
  - (b) Exclusion: *P. aurelia* and *P. caudatum* together. *P. aurelia* wins, *P. caudatum* goes extinct.
  - (c) Coexistence: *P. caudatum* and *P. bursaria* together. Both reach stable equilibrium at lower population levels than their respective single-species carrying capacities.

## Outcomes of L-V Competition



- Exclusion** of one or the other species
  - Isoclines don't cross
  - Species with highest isocline wins
- Stable equilibrium**: both species coexist
  - Isoclines cross
  - Intraspecific competition is stronger than interspecific competition
  - $K_2/a_{21} > K_1$  &  $K_1/a_{12} > K_2$
- Unstable equilibrium**: coexist briefly, then one goes extinct.
  - Isoclines cross
  - Competition within species is WEAKER than between
  - Loser depends on initial conditions ( $N_1, N_2$ )

## Assumptions of the Lotka-Volterra Model of Competition

- Shared Resources are Limiting
  - Requires identification of appropriate resource
- Competition coefficients are constant
- Carrying capacity is constant
- Density dependence is linear
  - Violating these assumptions strongly affects model behavior

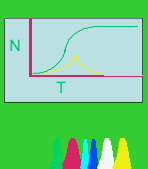

## Exercise on Competition

- The savannas of Africa have several large herbivores coexisting (Zebra, Giraffe, Wildebeast, Eland)
- ALONE: generate TWO possible reasons that these potential competitors can coexist
- SMALL GROUPS:
  - Explain and compare your answers.
  - How could you test one of your explanations?



## Coexistence in Nature

- Generally possible if:
  - Weak competition**  $a_{12}a_{21} < 1$ 
    - Within species  $>$  between
  - Not at equilibrium**
    - Exclusion will happen eventually
  - Niche partitioning** or Character Displacement
    - Use different subsets of the shared resource
  - Limited by something other than the shared resources**
  - Different Niches**
    - Differences in use of or requirements for another niche axis

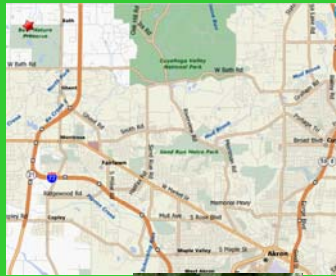

## Conclusions

- Studies of Intraspecific competition provide evidence for resource limitation
- Competition is usually asymmetric, with one species "winning"
- Competitors can coexist if competition within species  $>$  competition between species ( $a_{ij}a_{ji} < 1$ )
  - More likely when there is little niche overlap (**resource partitioning**)
- Long-term resource partitioning can lead to character displacement
- Best evidence for competition comes from experiments





## Extra Credit

- Another 'seminar' for the list
- Garlic mustard pull
- April 16 (Saturday)
- Bath Nature Preserve / UA Field Station  
**4240 Ira Rd**
- 1PM (until 4PM)
- Meet at trailhead or see me about getting a ride from campus

## Exploitation Questions


Examples (Field and Lab)  
Model  
Assumptions



## Exploiters

Kills Victim:

	Immediately	Eventually	Never/seldom
Predator	YES		
Parasitoid		YES	
Parasite		Sometimes	Sometimes
Herbivore	Sometimes	Sometimes	Sometimes



Detritivores utilize detritus, but do not reduce population growth of resource