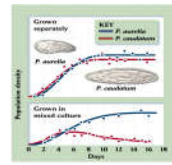
Types of Competition

- Interference vs. exploitative
- Intraspecific vs. Interspeific
- Asymmetric vs. Symmetric
- Scramble vs. contest

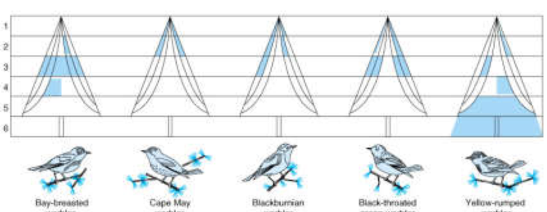
Interspecific Patterns

- When two similar species coexist, there are three outcomes:
  - **Competitive exclusion** – one species always outcompetes another.
  - **Indeterminacy** – There is always a winner, but the outcome is not predictable (advantage changes with environment).
  - **Coexistence** – niche differences allow for species to co-occur.

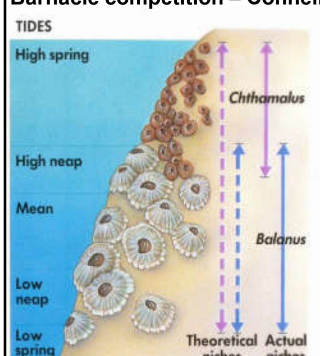


Strength of Interspecific Competition

- Intraspecific competition expected to be stronger due to niche similarity.
- Recall niche theory
  - Fundamental niche
  - Realized niche
- Competitive pressure leads to a **niche shift** or **specialization**



Barnacle competition – Connell 1961

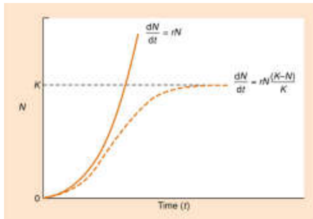


- *Balanus* outcompetes *Chthamalus* (realized niche is contracted)
- *Chthamalus* more resistant to dissication and wave action.
- Balanus niche not contracted.
- Interference competition (space)
- Asymmetric competition

Review density dependent (intraspecific)

$$\frac{dN}{dt} = rN$$

$$\frac{dN}{dt} = rN\left(\frac{K - N}{K}\right)$$



- K can be incorporated into our model by simply modifying the rate of increase (rN) by a measure of how close N is to K (Equation 4.7).

Lotka-Volterra Models of Interspecific Competition

- As N approaches K resources are more limiting, this is **intraspecific** competition
- **Interspecific** competition = competition among two species using the same resources
- Ecological equivalents:
  - α_{12} - Number of individuals of species 2 that are equivalent to one individual of species 1.
  - α_{21} - Number of individuals of species 1 that are equivalent to one individual of species 2.

Lotka-Volterra Models of Interspecific Competition

- Asymmetric competition - α_{12} not equal to α_{21}
- symmetric competition - α_{12} roughly equal to α_{21}

- Use α_{12} to calculate affect of one species on another.
  - K_1 =1000
  - N_1 = 600
  - N_2 = 300
  - α_{12} = 0.8; 0.8 * 300 = 240
  - N_1 = 600 + 240 equivalent competitors = 840

Lotka-Volterra Models of Interspecific Competition

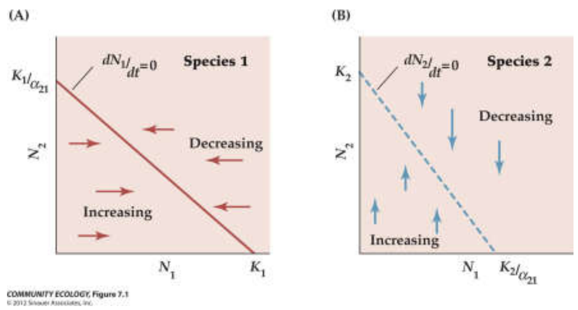
$$\frac{dN_1}{dt} = r_1 N_1\left(\frac{K_1 - N_1 - a_{12}N_2}{K_1}\right)$$

- Models change in population size of species 1, accounting for impact of species 2.

- Similarly, affect of species 1 on species 2:

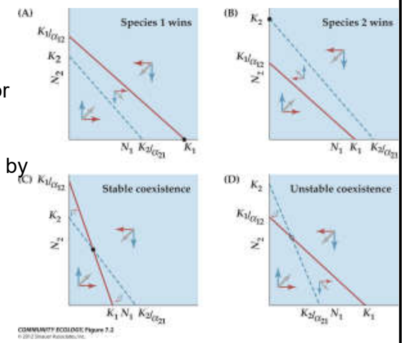
$$\frac{dN_2}{dt} = r_2 N_2\left(\frac{K_2 - N_2 - a_{21}N_1}{K_2}\right)$$

Lotka-Volterra Isoclines of Interspecific Competition



Lotka-Volterra Isoclines of Interspecific Competition

- 4 outcomes
- Stable equilibrium or the winner of competitive interactions defined by K $_{1 \text{ and } 2}$ and $\alpha_{1 \text{ and } 2}$
- Some definitive winners, some winners depend on starting points

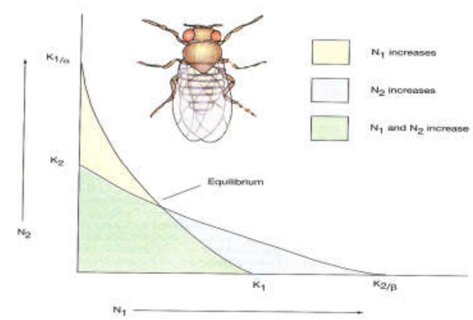


Assumptions of Lotka-Voltera Models

- No age or genetic structure, no time lags for competition
- α values fixed and difficult to estimate
- All individuals interact without spatial structure
- One resource
- Does not allow for species differences in growth or resource use
- Seems not to be particularly useful for understanding patters of coexistence
- No mechanisms for competition, effect of competing species is simply to reduce population size

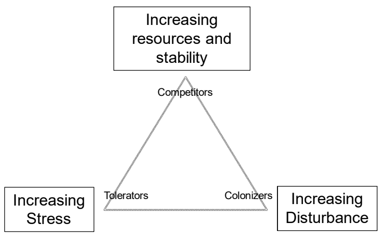
Applications

- Test of competition between fruit fly species, clear that isoclines could not be linear.
- Competitive interactions change with densities.



When and Where is Competition Important?

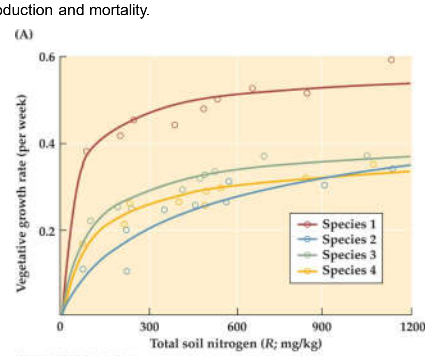
- Is competition important?
- Two alternate views:
  - **Tilman**: Competition is always important. Species differ in their ability to acquire resources. Those differences result in competitive exclusion that limits coexistence.
  - **Grimes**: Competition is rare in high stress or high disturbance settings. Grimes triangle:

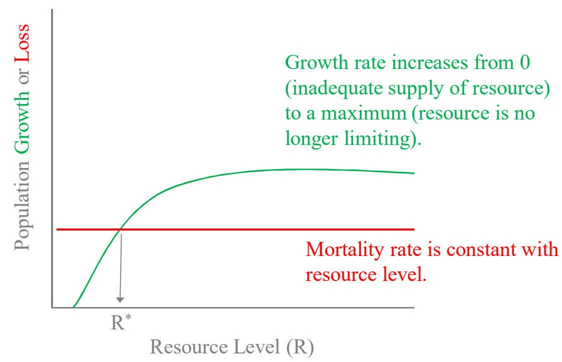


Tillman's Resource Ratio Hypothesis

- Grime's prediction was that competition only happened in stable and high resource environments. Tilman thought competition was more important and existing models were inadequate.
- Developed R* model based on:
  - **Optimal foraging** and **Liebig's law** (law of minimum). Species should balance resource use so that all are equally limiting.
  - **Resource allocation trade-offs**, being good at acquiring one resource means poor ability to acquire another.
  - Population size will be determined by the limiting resource (one where reproduction=mortality).
  - Resources have rates of consumption and supply, environments (models) contain many resources.

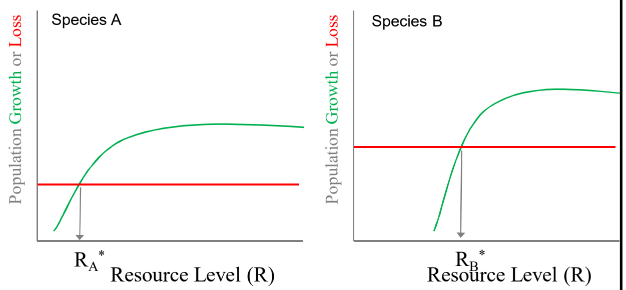
What we know:
Nitrogen (important plant resource) is limiting, species response to N is different, responses are not linear. Growth rates a function of reproduction and mortality.





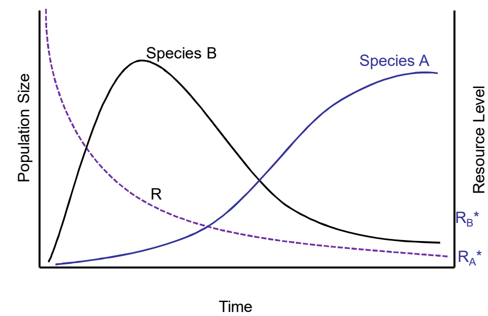
R* - equilibrium point between population growth and mortality rates. Stable population, zero growth or decline.

Two species competing for one resource…what is the outcome here?

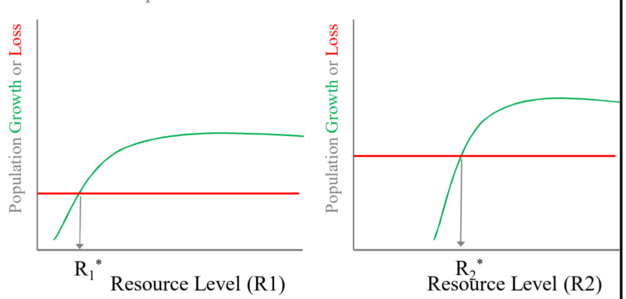


Two species competing for one resource…what is the outcome here?

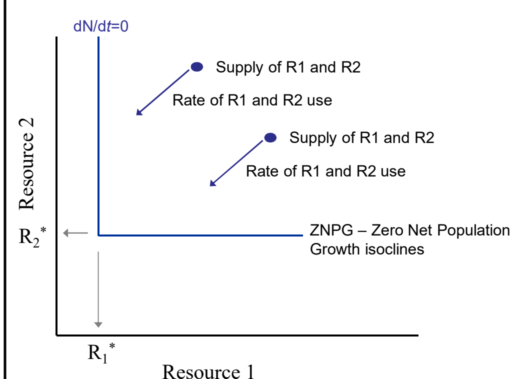
Which species grows fastest?
Does one species deplete resources below the minimum level for the other?

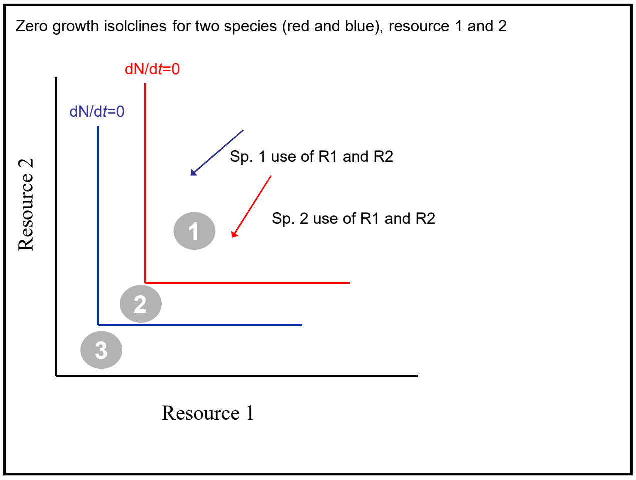


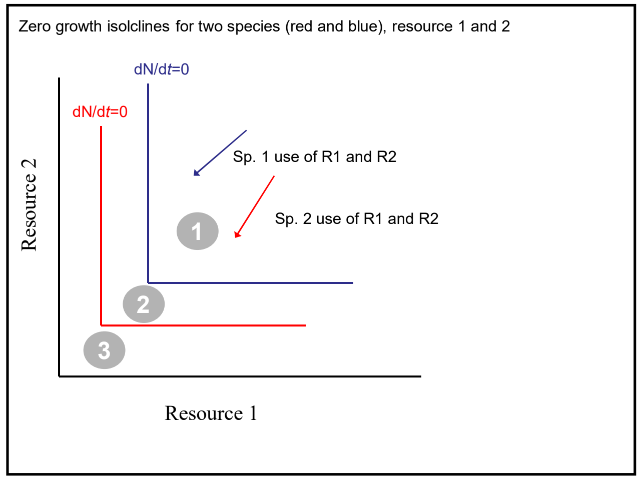
What about multiple resources?



Zero growth isoclines for resource 1 and 2




Zero growth isolclines for two species (red and blue), resource 1 and 2
dN/dt=0
dN/dt=0
Sp. 1 use of R1 and R2
Sp. 2 use of R1 and R2
1
2
3
Resource 2
Resource 1


Zero growth isolclines for two species (red and blue), resource 1 and 2
dN/dt=0
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Sp. 1 use of R1 and R2
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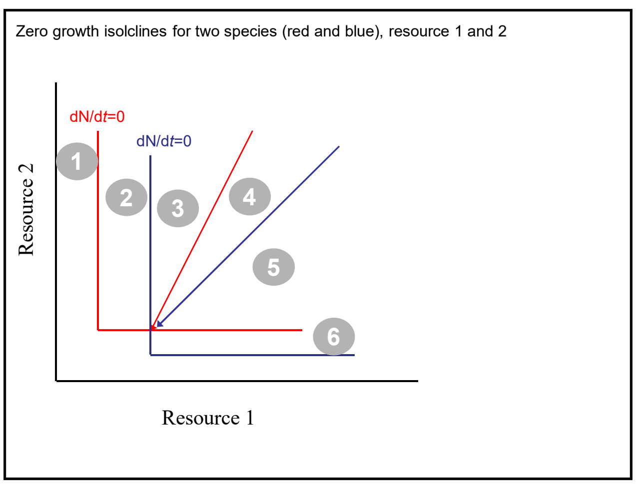
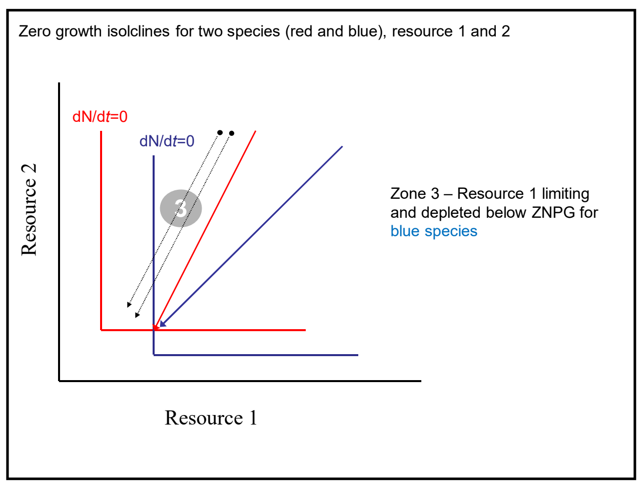
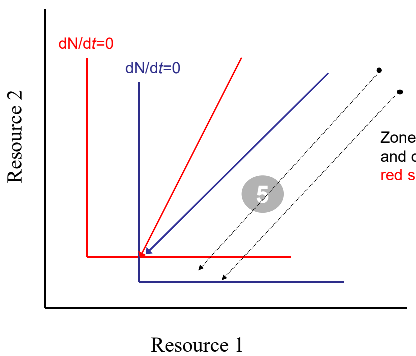
1
2
3
Resource 2
Resource 1


Zero growth isolclines for two species (red and blue), resource 1 and 2
dN/dt=0
dN/dt=0
1
2
3
4
5
6
Resource 2
Resource 1

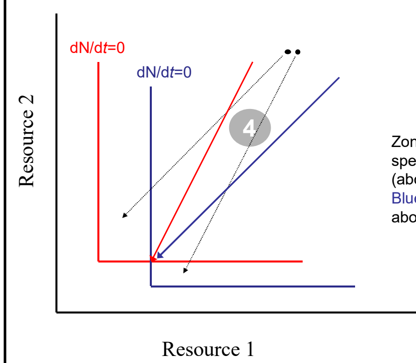

Zero growth isolclines for two species (red and blue), resource 1 and 2
dN/dt=0
dN/dt=0
3
Zone 3 – Resource 1 limiting and depleted below ZNPG for blue species
Resource 2
Resource 1

Zero growth isolclines for two species (red and blue), resource 1 and 2



Zone 5 – Resource 2 limiting and depleted below ZNPG for red species

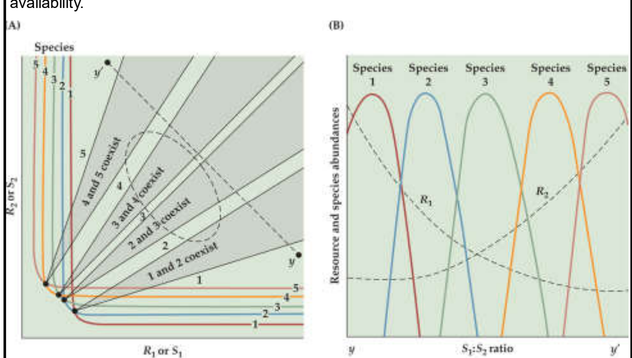
Zero growth isolclines for two species (red and blue), resource 1 and 2



Zone 4 – Coexistence. Red species limited by resource 2 (above minimal level for Blue). Blue limited by resource 1 above minimal level for 1.

Coexistence and Community Structure with R*

Coexistence a function of resource availability and tradeoffs in use efficiency. Predicts transitions in species composition along gradients as resources change in availability.



COMMUNITY ECOLOGY, Figure 7.9