Types/Terms describing Interspecific Interactions

Neutralism : (0,0) neither species is adversely affected by the other's presence

amensalism: (0, -) individuals of only one species are adversely affected by the other's presence

competition: (-,-) both species are adversely affected by the other's presence

predation: (+,-) one species benefits the other loses

Distribution-related terms
allopatric: occurring in separate, non-overlapping geographic areas

sympatric: occupying the same or overlapping geographic areas
parapatric: within a *sympatric* geographic distribution areas of occurrence are **disjunct**

Competition

Occurs when animals use a shared and limited resource.

Intraspecific competition:
Between members of the same species. Intraspecific competition leads to the stable regulation of population size within limits imposed by the environment.

Interspecific competition:
Between two or more species. Interspecific competition may cause the extinction of one of the competing populations or, at the very least, profoundly affect population dynamics and carrying capacity of the competing species. (Ricklefs 1979)

Interspecific competition occurs when two or more species experience a depressed growth rate or a depressed equilibrium-population level attributed to their mutual presence in an area. (Emlen 1973)

Intraspecific Competition

How did we model intraspecific competition?

(density dependent growth – logistic growth curve)

ln(n t+1) = ln (nt) + rmax + b(nt) + F

Another form of this equation is:

dN/dt = r N (1 – N/K)

where r is the max growth rate
K is the carrying capacity

Do you recall how we add another species into the mix?

Theoretical Models of Interspecific Competition

We add term to the model that converts one species into units of another

The Lotka-Volterra model incorporates *interspecific competition* by using a parameter called *alpha*. Alpha is the *coefficient of competition* (or competition coefficient) and measures the competitive effect of one species on another. For example:

a_{12} is the effect of species 1 on species 2.
a_{21} is the effect of species 2 on species 1.

Note: the notation for competition coefficients is not consistent among textbooks or computer programs (output). For example, Begon and Mortimer (1986) define a_{12} as the effect of species 2 on species 1, which is opposite of the definition stated above. Some computer programs may use Greek symbols such alpha and beta to represent a_{12} and a_{21}, respectively. The **bottom line** is to make sure you understand the notation used by a particular author or computer model.

Regardless of the notation used, the *coefficient of competition* measures interspecific competition relative to intraspecific competition.

e.g., how many individuals of species 2 are equivalent to one individual of species 1 in terms of their use of the resource. For example:

If one elk (species 1) is equivalent to 3 deer (species 2) in terms of its use of the resource and its effect on species 2, then a_{12} = 3.0. If the effect of species 2 on species 1 is reciprocal (i.e., if 1 deer is equivalent to 0.33 elk), then a_{21} = 0.33. **Note:** the alpha's of each species do *not* have to be reciprocal.

Theoretical Models of Interspecific Competition

We add the number of species 2 converted into 'units' of species 1 to the logistic equation to account for interspecific competition:

$$\frac{dN_1}{dt} = r_1 N_1 \left(1 - \frac{N_1}{K_1} - \frac{a_{21} N_2}{K_1}\right)$$

And do the same for species 2 growth, converting species 1 into 'units' of species 2:

$$\frac{dN_2}{dt} = r_2 N_2 \left(1 - \frac{N_2}{K_2} - \frac{a_{12} N_1}{K_2}\right)$$

The **zero-growth isocline** describes expected equilibrium population sizes of one species if abundance of the second species is held constant, and vice versa.

The relationship between the two species is assumed to be linear, i.e., the isoclines for species 1 and species 2 can be written as equations for a straight line (y = a + bx).

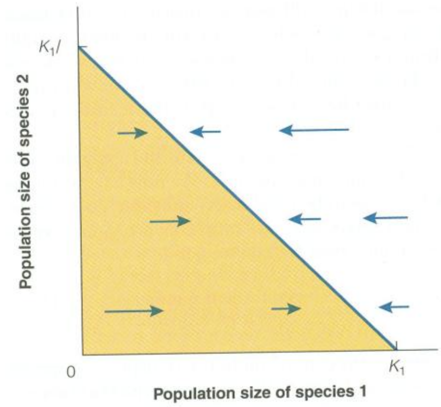


FIGURE 12.1
Changes in population size of species 1 when competing with species 2. Populations in the yellow area will increase in size and will come to equilibrium at some point on the blue diagonal line. The size of the arrows indicate the approximate rate at which the population will move toward the blue diagonal line. The blue diagonal line represents the zero growth isocline, all those points at which $dN_1/dt = 0$.

We do the same thing for species 2, converting species 1 into units of species 2

Then we can put the isoclines of both species on the same plot to see the potential outcomes of competition. These are the Lotka-Volterra equations for competition.

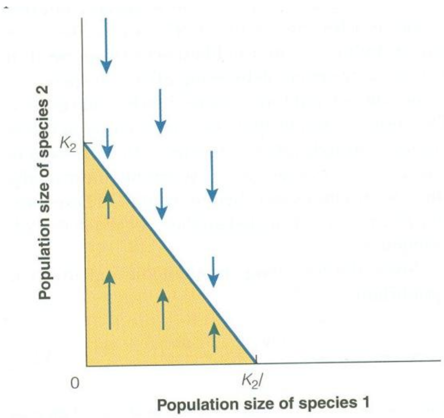
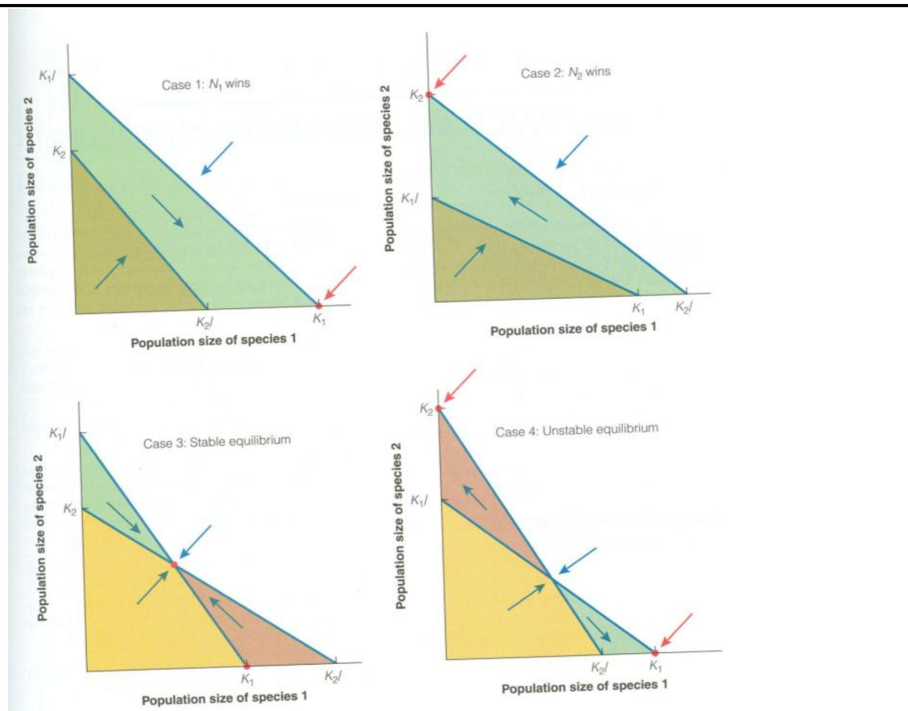
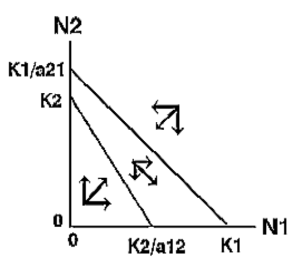


FIGURE 12.2
Changes in population size of species 2 when competing with species 1. Populations in the yellow area will increase in size and will come to equilibrium at some point on the blue zero growth isocline, *all those points at which $dN_2/dt = 0$. The sizes of the arrows indicate the approximate rates at which the population will move toward the isocline.*





SPECIES 1 WINS

Interspecific competition using mechanisms by which it occurs (Tillman's Model)

Examine competition and it's possible outcomes based on resource use, not numbers like the L-V approach

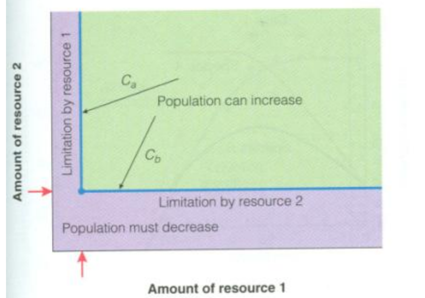
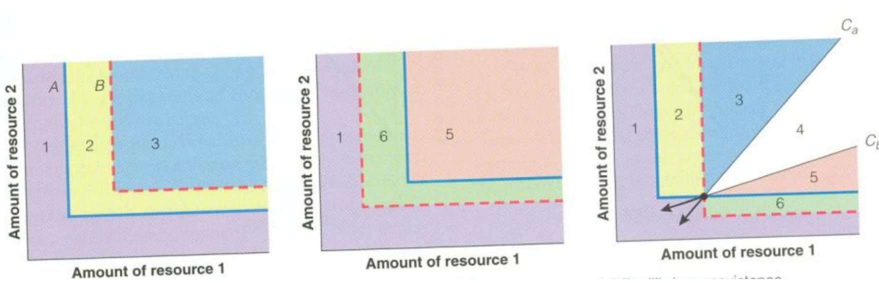


FIGURE 12.4
The response of an organism to variations in two essential resources (such as nitrogen and water for plants). The blue lines represent the zero growth isoclines, the lower one set by resource 2 and the left one set by resource 1 (arrows). Above these isoclines in the green shaded area, the population can increase in size; below these isoclines in the purple area, the population will decline. In the left side of the purple area, resource 1 is limiting; in the bottom side of the purple area, resource 2 is limiting. Only at the intersection point (blue dot) are both resources simultaneously limiting. At the hypothetical consumption vectors C_a *the organism uses resource 1 more rapidly and resource 2 more slowly;* C_b *represents the opposite case. (Modified from Tilman 1982.)*



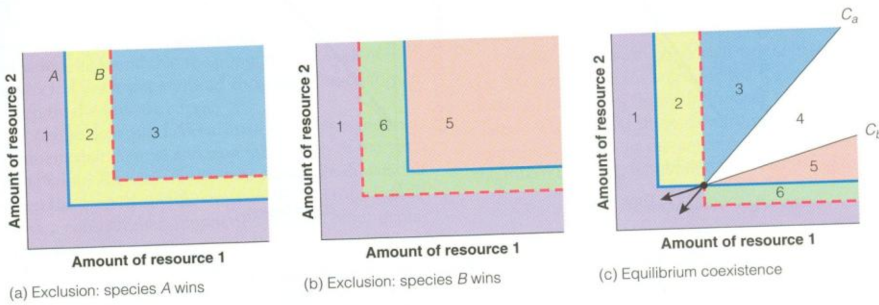


FIGURE 12.5
Tilman's model of competition for two essential resources. The zero isoclines for Species A (blue) and species B (red, dashed line) are shown, along with the consumption rate vectors for each species (C_a and C_b). For all three cases the regions are labeled and colored as follows: 1 (purple) = neither species can live; 2 (yellow) = only species A can live; 3 (blue) = species A wins out in competition; 4 (white) = stable coexistence; 5 (pink) = species B wins out in competition; 6 (green) = only species B can live. • = stable equilibrium point. (From Tilman 1982.)

How Important Is Competition in Regulation of Animal Numbers?

Two camps:

1) Competition (both intra- and inter-specific) is the dominant ecological interaction Diamond (1978) (Density dependent camp)

2) Variable environments are primary determinants of population dynamics not competition (Andrewartha and Birch 1954, Weins 1977) (Density Independent Camp)

Resources are rarely limiting, and if so rarely stay so long enough for full effects of competition to emerge

Thoughts?

How do we evaluate the potential for competition?

- *Compare resource use-distributions in presence and absence of the other species.*
- *Evaluate the similarity of the species.*
- *Best would be to compare growth rates and equilibria in presence and absence of other species.*

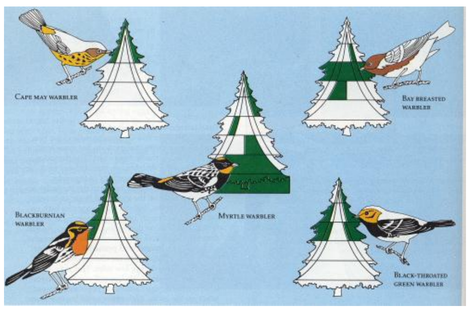
Remember Gause?

Competitive Exclusion Principle-
No two species can fill the same niche (compete for the same resource) for very long. Eventually leads to displacement / partitioning of the shared resource in space or time, or lack of coexistence.

Resource partitioning in MacArthur's Warblers

Niche shifts: fundamental vs realized niche and character displacement

How do we know if we are seeing 'current' competition versus 'ghosts of competition past'?



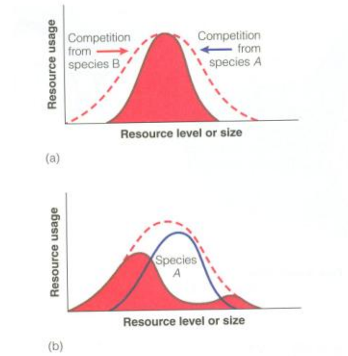
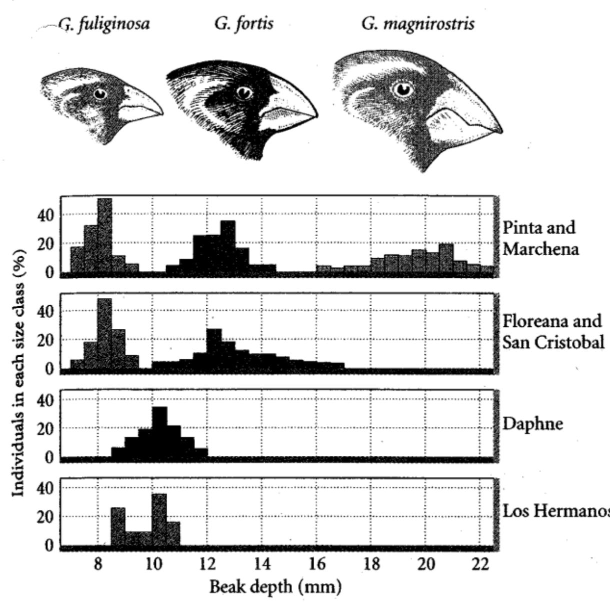


FIGURE 12.14
Two possible relationships between fundamental and realized niches for a hypothetical species C. The fundamental niche is shown as a dashed red line and the realized niche is shaded red. (a) Species A and B compete for the resource and cause the realized niche of species C to shrink to the central optimum. Note that the curves are symmetrical and bell shaped. (b) A dominant species A (blue line) forces species C out of its optimum into the peripheral part of its fundamental niche, causing a bimodal, asymmetrical realized niche shown in red. Plants competing for nitrogen could show either of these patterns. (Modified from Austin 1999.)

Character Displacement – Darwin's Finches

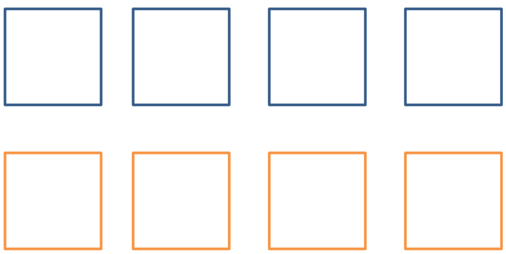


Does interspecific competition play a role in the structure of desert rodent communities? Munger and Brown 1981

Eight 50m x 50m exclosures:

4 with openings big enough for large granivores (Dipodomys spp), small granivores, and small omnivores to pass

4 with openings only small granivores and omnivores could pass



Trapped and removed all Dipodomys from small opening exclosures and then trapped monthly to document change in numbers.

If there is interspecific competition and large species influence smaller ones, what would we predict about small rodent densities after large rodent exclusion?

Would we expect the reponse to be the same for small granivore and small omnivore groups? If so what would this suggest, if not what?

What do these results suggest?

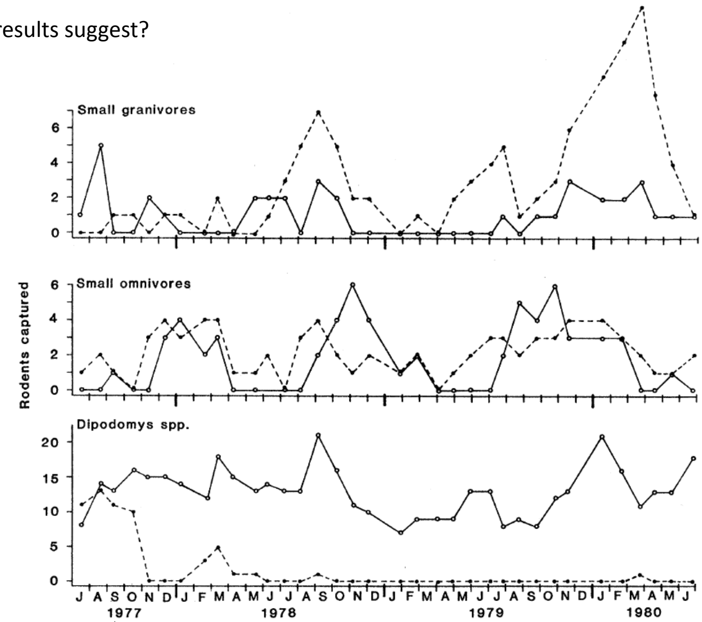


Fig. 1. Monthly sums of rodents captured on the four plots with *Dipodomys* excluded (dashed lines) and the four plots with *Dipodomys* present (solid lines). After 8 months, the density of small granivores on plots with *Dipodomys* excluded consistently exceeded that on plots where *Dipodomys* was still present. The omnivores showed no such response.

Trapped and removed all Dipodomys from small opening exclosures and then trapped monthly to document change in numbers.

If there is interspecific competition and large species influence smaller ones, what would we predict about small rodent densities after large rodent exclusion?

Appears to be, small granivore densities increased 350% in absence of large granivore species

Would we expect the reponse to be the same for small granivore and small omnivore groups? If so what would this suggest, if not what?

Omnivores did not respond as strongly as granivores suggesting competition for food resources as driving factor