But populations and species do not exist in a vacuum...
Species interactions...

Community Ecology

A) Five fundamental types of species interactions:

<table>
<thead>
<tr>
<th>Effect on species</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Predation</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Mutualism</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Commensalism</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Amensalism</td>
<td>−</td>
<td>0</td>
</tr>
</tbody>
</table>

B) Concept of the Niche

1) Best known definition of niche is Hutchinson (e.g., 1957)
   a) role organism plays in environment
   b) role can be determined by measuring all of an organism’s activities and requirements

2) Examples
   - 2-factors
   - 3-factors

3) By extension... niche defined as an N-dimensional hyperspace (encompasses all effects and requirements of a species)

B) Concept of the Niche

3) Two types of niche
   a) fundamental: niche space determined by physical factors and resource requirements. Manifest in the absence of other organisms.
   b) realized: niche space determined by combined physical and biological factors. Realized in presence of other organisms

fundamental niche always bigger (or at least as large) - biological interactions can (usually do) limit realized niche
C) Competition

Defined: The common use of a resource that is in limited supply.

1) Within and between species
   a) Intraspecific - among individuals of the same species
      source of density dependence discussed last time
   b) Interspecific - among individuals of two or more species

2) Two types of competition
   a) Interference
   b) Exploitative

2) Two types of competition
   a) Interference - direct competition
      i) e.g., aggression
      ii) e.g., territoriality (fishes, birds, limpets)
   b) Exploitation - indirect competition
      i) Compete through a resource (R)
      ii) e.g., sessile spp. -- space, filter feeders -- plankton

C) Competition

3) Competitive exclusion principle
   The more similar organisms are, the more likely they are to compete.
   a) Species occupying the same niche cannot coexist.
   b) The greater the niche overlap, the greater the likelihood of competitive exclusion, leading to local extinction of one species.
   c) Leads to “resource partitioning”

4) Resource partitioning
   * e.g.,
   - seed / plankton size
   - elevation
   - height on tree / alga

   * Resource gradient

   Adaptation

   Species “packing”

   Number of individuals
C) Competition

5) Manifested in patterns
   a) non-overlapping spatial (or temporal) distribution

\[ \text{Abundance} \text{ sp. A} \]
\[ \text{Abundance} \text{ sp. B} \]

C) Competition

6) Competitive release
   a) Change in distribution (or some other response such as growth) when separate and together

C) Competition

7) Competitive symmetry
   a) Relative competitive strength
      b) superior, inferior (or) dominant, subordinate

Symmetrical
   \[ A = B \]
   \[ A \rightarrow B \]

Asymmetrical
   \[ A > B \]
   \[ A \rightarrow B \]
   \[ A < B \]
   \[ A \rightarrow B \]

How would you assess this??
C) Competition

7) Effects on measured variables

a) Individual responses:
   - Behavioral (feeding rates, foraging distribution)
   - Physiological (growth rate, reproductive rate)
   - Morphological (body size, biomass)

b) Population responses:
   - Abundance (density)
   - Distribution (zonation)
   - Demographic rates (population growth)

D) Predation

Consumption of one organism (prey) by another (predator), which by definition, occurs between organisms on different trophic levels (vs. competition: within same trophic level)

1) diagrammatically:

```
Predator  A  C  F
          B  E
Herbivore B  E
Primary producer  C  D  F
```

2) Effects on prey (direct and indirect):

"Direct effects": direct losses (removal of individuals)
   - death of individuals
   - mortality rate of population

"Indirect effects": influence of predator on variable other than death or mortality
   - behavioral (feeding rates, foraging distribution)
   - physiological (growth rate, reproductive rate)
   - morphological (body size, biomass)

3) Effects on prey (individual and population):

Individual responses:
   - behavioral (feeding rates, foraging distribution)
   - physiological (growth rate, reproductive rate)
   - morphological (body size, biomass)
   - oh yeah... and you can get completely or partially eaten

Population responses:
   - abundance, density
   - distribution (habitat use)
   - structure (e.g., size, age, sex ratio, genetic, spatial)
   - dynamics and persistence (regulation)
D) Predation

4) Complex interactions (with other processes)

E.g., competition:

- e.g., predator that specializes on barnacles and is restricted to the mid and lower intertidal

*With predators*

*Without predators*

In absence of predator, barnacle out-competes mussels and expands distribution down into the mid intertidal

**D) Predation**

4) More complex predation interactions:

**Apparent competition**

Where, A and B are prey and C is a common predator.

Presence of both prey increases overall predation rates, leading to negative *indirect* effect on one another.

**Trophic cascade**

Where, A is primary producer, B is an herbivore, and C is a predator.

Effect of species on adjacent trophic level has net positive *indirect* effect on next trophic level.

**A linear food chain**

- **Predator**
- **Herbivore**
- **Plants**

**Trophic cascades**

Strong “top-down” effects that produce downward rippling effects through a food chain.

Higher tropic level predators *indirectly* affect plant biomass via their impacts on herbivore populations.

Strong “bottom-up” effects that produce upward rippling effects through a food chain.

Lower tropic level producers *indirectly* affect predator biomass via their impacts on herbivore populations.
Oksanen/Fretwell Model: Productivity and Food Chain Length

- Depending on productivity of community, food chains can have fewer or more than three trophic levels.
- As primary productivity increases, trophic levels will be sequentially added.
- Food chains that have an odd number of trophic levels should be filled with lush vegetation, because herbivores are kept in check by predators.
- Food chains that have an even number of trophic levels should have low plant abundance because plants are herbivore limited.
E) Mutualism / commensalism

1) Occurs within or between trophic levels, more often between trophic levels
   a) mutualisms: e.g., pollinators
      - obligate: required for each other's existence - pollinators
      - facultative: not required - cleaner fish and parasitized hosts
   b) commensalisms: e.g., facilitation
      - mutualism: $A = B$
      - commensalism: $A < B$

How would you assess this?

E) Community metrics

1) Species richness: number of species in a community
2) Species composition: identity of species that constitute a community
3) Species diversity: species richness and relative abundance

Shannon-Weiner index of diversity:

$$ H' = -\sum p_i \ln p_i $$

Where $p_i$ is the proportion of individuals in the community that are species $i$

E) Illustration of diversity

Evenness: measure of the relative similarity of species abundance in a community

$$ E = \frac{H'}{\ln S} $$

where, $S$ is species richness
F) Scales of species diversity

1) Alpha (α): within habitat diversity
2) Beta (β): between habitat diversity