Community Ecology

Some important concepts

- **What is a niche?**
  - The ‘role’ of an organism
  - Its use of abiotic and biotic resources, and its reaction to them (e.g., Tolerance plays a role here)

- **Competitive Exclusion Principle**
  - No two species can occupy the same niche - it will always result in competition

Vultures: multiple niches or multiple species per niche?

A: resource/niche partitioning!

### Table 53.1: A simplistic summary of the kinds of species interactions.

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Species Interactions: interspecific

-/- (competition)
  - What leads to competition?
  - What is the result?
  - Leave
  - Adapt: resource partitioning
  - Competitive Exclusion Principal

Competition

- Realized Niche vrs.
- Fundamental Niche
- Who exists in which?

Figure 53.2 Testing a competitive exclusion hypothesis in the field. Removal of Balanus results in Chthamalus occupying a larger part of the rock. Thus, Balanus is competitively excluding Chthamalus from parts of the rock.
Figure 53.4 Coevolutionary impact of competition: Character displacement. Two species have different beak sizes when occurring together and competing for seeds, compared to when they live apart.

Effects of competition

- One species dominates (within a functional group): low species diversity. What is the role of 'lesser' species within the same functional group (e.g., diversity)?
- Resource partitioning leads to variation (phenotypic) in sympatric species.
- Competition can lead to genotypic differences - speciation.
- Competition is an important factor in maintaining ecosystem function. When one species is removed, the structure of competition is changed too.
- Introduced species?

Species with large impact

- **Keystone species** - is there such a thing?
  - A species whose 'role' or niche has a major impact on the structure of an ecosystem.
- **Indicator Species**
  - Sensitive to change.
- **Dominant species**: most biomass.
- **Ecosystem engineers**: foundation species/facilitators.

Ecosystem change: an example

Reduction of coral = increase in Algae. This shifts functional Groups of species, and affects Primary productivity.

Sea Otters and Sea Urchins: a kelp forest paradigm

**Sea Urchins** eat kelp, especially new recruits. If kept in check, they eat drift kelp. If populations expand, they will eat established kelp.

**Sea Otters** eat urchins, especially exposed ones. They will keep sea urchin populations in check.

The Aleutian Island studies

Sea Otters as a keystone predator.
Community Ecology

- What is species diversity: both
  - Species richness
  - Relative abundance
- What leads to high diversity?
  - Habitat heterogeneity
  - High levels of competition
  - Other... interspecific interactions, functional group diversity, abiotic factors?

Some important concepts

- Functional groups
  - Several ‘related’ niches, eg. scavengers, grazers, decomposers etc.

Species Interactions: interspecific

- Positive
- Negative
- Neutral (can it be?)

The reality of species interactions

1. There is a continuum of possibilities between the major four types. For example, an interaction between a plant and a mycorrhizal fungus can range from mutualism to commensalism to parasitism as soil nutrients range from scarce to abundant.

2. Most species interactions are asymmetric, i.e. Species A has a much greater impact on Species B than Species B has on Species A.

Species Interactions: interspecific

- +/- (predation and parasitism)
  - Plant defenses against herbivory
  - Animal defenses against predation
  - Parasites: endo and ecto
- Co-Evolution

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Predation

- Predation includes a variety of interactions in which one species consumes all or part of another organism: predators, herbivores, and parasites all engage in predation

- Examples:
  - Lynx eating the snow shoe hare
  - Caterpillar eating plant leaves
  - Parasitic nematode living in the gut of a dog

Aposematic markings / colors allow for evolution of mimics

- Mullerian mimicry: organisms that share a defense (e.g. poison) have similar appearances
- Batesian mimicry: model has defense, mimic does not

Species Interactions: interspecific

- +/0, +/- (mutualism & commensalism)
- Does commensalism exist?
- Mutualism requires evolution of adaptations in both species: a true partnership.
  - Nitrogen fixation on plant roots
  - Digestion track bacteria
  - Zooxanthellae in corals
  - Anemones and fish
  - Cleaning stations on reefs

Mutualism

- Mutualisms include mutually beneficial interactions between a wide variety of species.

- Examples:
  - Plants and their pollinators, seed dispersers, mycorrhizal fungi, and Rhizobia
  - Lichens: fungi and their symbiotic algae or cyanobacteria

Mutualism between Acacia trees and ants. Trees provide food for the ants in the form of nectar and fatty Beltian bodies (yellow objects at leaf margins), and also provide shelter in their thorns. Ants remove and/or kill other insects, fungal spores, and clip off the leaves of any vegetation that grows too close to the Acacia.

In a commensalism, one species benefits, and the other is not affected. Shown here is a commensalism between a bird and mammal, whereby the bird picks small parasites off the mammal. The bird benefits, but the mammal probably does not.
Zooxanthellae: the key to coral reef productivity - a mutualism

The role of ecosystem disturbance

- Equilibrium and stability: over what time scale do we measure this?
- ‘Natural’ and anthropogenic disturbance
- Short term and long-term disturbance
- Succession and disturbance: climax communities?
- What does ‘disturbance adapted’ mean?

Species diversity and disturbance

- Size, frequency and severity of disturbance are important
- Non-equilibrium model: environmental patchiness
- Dynamic equilibrium model: effect of disturbance on competitive interactions—disturbance preventing competitive exclusion (dominance)
- Intermediate disturbance model: moderate in frequency and severity
Biogeography

• Regions defined by species assemblages
• Dispersal (range/tolerance/adaptations), and survivability account for geographical ranges of species
• Geology and geographical barriers play a key role

Range explanations

• A species never dispersed beyond its present boundaries
• Pioneers failed to survive
• Range has been reduced over evolutionary time
• Pioneers became isolated/separated: phylogeography

Phylogeography: ecological genetics

• Study of populations (not species), their distributions, and the degree of genetic separation between populations
• Investigates the cause of population structure

Island Biogeography

• Depth of the water, or degree of difficulty to cross a ‘barrier’
• Distance away from ‘source’
• Size of the island
• Species diversity is highest on large ‘near’ islands: immigration and extinction (competitive exclusion and small islands)
Key Points

- Species diversity (richness and abundance) is determined in part by habitat heterogeneity and species interactions.
- Niches and the CEP - resource partitioning or exclusion
- Keystone species and functional groups
- Interspecific interactions are a driving force in evolution: examples?
- Ecosystem disturbance affects community structure, composition, and diversity
- Species assemblages can be explained in part through historical ranges and the establishment of ‘barriers’.

Ecosystem Ecology (energetics)

We started with food chain lengths, bottom up/top down trophic cascades, and energy transfer up trophic levels. We did a lot of this on the board...

Trophic levels—energy flow through ecosystems

- **Autotrophs**: primary producers
- **Heterotrophs**: consumers
  - Primary, secondary, tertiary
- **Decomposers**
- Food webs depict complex relationships: omnivores? Many cross trophic levels
Productivity and energy

- **Production** is the amount of energy stored by a trophic level (kilocalories/sq meter). **Productivity** is a rate.
- **Gross productivity** is the amount of energy taken in by photosynthesis or by consuming the bodies of other orgs.
- **Net productivity** is the amount of energy left after losses due to autotrophic respiration are taken into account. Available to heterotrophs.
- **Primary productivity** is a measure of how much energy an ecosystem has to work with.
- **Net community productivity** is the net primary minus heterotroph respiration.

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- **Gross productivity**
- **Net productivity**

In the oceans, while light is an important limiting factor, it is most often nutrients, specifically nitrogen, that limit primary productivity. Most often, nitrogen is the limiting nutrient. To increase production, nitrogen must be added.

**Vertical distribution of temperature, nutrients, and production in the upper layer of the central North Pacific during summer**

**Figure 54.3** Productivity of different ecosystems

**Figure 54.10** Energy partitioning within a consumer trophic level of the food chain:

- **Secondary production** is the amount of chemical energy in a consumer’s food that is converted to their own new biomass.

**Ecological pyramids**

- **# individuals**: Often first level is largest, but not always. Note that secondary carnivores are almost always less numerous.
- **Biomass**: Usually greatest at the bottom level: plants can store organic matter better than heterotrophs.
- **Energy**: 10% transferred at each level. 90% of energy eaten in food by consumers is not stored as body structures (as in trees), but is lost in waste or used in maintaining the animal (eg lost in respiration). All that they do requires energy.
Is it more efficient to eat vegetarian? In other words, does it take more corn to feed a vegetarian or a meat-eater? Why?

Figure 54.13 A pyramid of numbers. Not only is energy lost at each level, but organisms usually must be larger than the food items that they are eating. Hence, a steep decline in numbers of organisms along the food chain.

Why is the world green?

plant defenses (the world is prickly and it tastes bad)
Limits to herbivores:
predators
parasites
diseases
abiotic factors
nutrient requirements
Chemical cycling
Elements accumulate in three major places
- In the bodies of living organisms
- In exchange pools: readily available water soluble reserves of a mineral nutrient, such as nitrates in soil water easily taken up by plants
- Reservoirs: harder to get to places such as air, bones of animals, shells etc.

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Carbon Cycle
- Global scale
- Balance of respiration releasing CO₂ into atmosphere and photosynthetic assimilation of C and release of O₂
- Historically: net sequestration of C in fossils
- Since industrial revolution: net release of CO₂ from burning fossil fuels

The water cycle. Note: the major processes are evaporation and precipitation, which differ in relative importance over land and the oceans. (Numbers indicate flow in grams*10⁸ per year)

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**Nitrogen Cycle**

- Animals can only use nitrogen from organic compounds, plants mainly use NO$_3^-$ and can’t use N$_2$
- Bacteria important in releasing N from detritus, converting to NH$_4^+$, NO$_2^-$ to more usable forms
- Short term: local cycles in soil dominate
- Long term: N$_2$ fixation from atmosphere (global)

**Phosphorous Cycle**

- Mostly local: soil particles bind phosphates
- Only one significant chemical form, no gaseous state
- Weathering of rocks
- In ocean it accumulates in sediments and makes it back to land through geologic processes

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Some of the best long-term thorough studies of nutrient cycling in ecosystems are taking place at Hubbard Brook Experimental Forest in New Hampshire. Concrete dams (left) were constructed to help measure water and nutrient runoff from watersheds. Watersheds were logged at different intensities (right) to understand the impact of forest trees on nutrient cycling.

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Figure 54.17 The nitrogen cycle. Notice the long-term importance of nitrogen-fixing bacteria. However, keep in mind that most nitrogen cycling takes place locally among organisms, soil, and water, via decomposition and reassimilation.

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Figure 54.17 The phosphorous cycle is simpler than the nitrogen and carbon cycles, in that phosphorus has no gaseous form and occurs in only one inorganic form (the phosphate ion). As with nitrogen, most phosphorus cycling is quite local.

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Figure 54.19 Nutrient cycling in the Hubbard Brook Experimental Forest: an example of long-term ecological research.