

## **Supplementary Notes: (PJ Shlachtman, Miller book)**

### **Community Processes: Species Interactions and Succession**

#### **The Ecological Niche**

##### **ecological niche**

- the role each species plays in an ecosystem; its lifestyle or way of life.
- the ranges of conditions and resources within which the organism can live.

**Habitat** - the actual physical location where a species lives.

**Conditions** - physical or chemical attributes of the environment.

**Resources** - substances that can be consumed by an organism.

**n-dimensional hypervolume** - many conditions and resources influence the maintenance, growth and reproduction of an organism. We can't describe all the conditions and resources that influence an organism, but we can determine the most important ones.

**Fundamental Niche** - the full potential range of conditions and resources it could theoretically use if there were no competition from other species. Niches of a species overlap with those of other species.

**Realized Niche** - that part of a fundamental niche that an organism occupies.

#### **Why is it important to understand the niches of species?**

Scientific curiosity

- so we can work to prevent it from becoming prematurely extinct
- assessing the human impact on changes in terrestrial and aquatic systems.

Generalist vs. Specialist (classification according to their niches)

- **Generalists:**
  - have broad niches
  - live in many different places, eat a variety of foods, and tolerate a wide range of environmental conditions. (humans, mice, rats, raccoons, etc.)
- **Specialists**
  - have narrow niches.
  - Live in one type of habitat, a narrow range of climatic and other environmental conditions, and eat only one or two types of food.
  - Therefore more prone to becoming endangered or extinct.
  - Specialists have an advantage when environmental conditions are fairly constant. When environmental conditions change, generalists are better off.

#### **Some General Types of Species**

**Native species** - species that normally live and thrive in a particular ecosystem

**Non-native, exotic or alien species** - species that migrate into an ecosystem or are deliberately or accidentally introduced into an ecosystem by humans. - Wild African bees

##### **Indicator species**

- species that serve as early warnings that a community or an ecosystem is being damaged.
- Birds are excellent biological indicators because they are found almost everywhere and respond very quickly to environmental change. The presence or absence of trout species in water at temperatures within their range of tolerance is an indicator of water quality because trout require clean water and high levels of dissolved oxygen (DO).

##### **Keystone species**

- species whose roles in an ecosystem are much more important than their abundance or biomass would suggest.
- play pivotal roles in the structure, function, and integrity of an ecosystem because they are critically linked to a large number of other species.

- dung beetle, sea otters, gopher tortoises, American alligator, elephants and rhinoceroses, beavers, wolves, leopards, lions, giant anteaters, great white shark, giant armadillo.

### **Species Interactions: Competition and Predation**

Members of species may be harmed by, benefit from, or be unaffected by the interaction.

**Interspecific competition** - (competition between species) - occurs when two or more species compete for food, space or other limited resource. this competition can harm the competing species to varying degrees

**Predation** - one species (predator) feeds directly on all or part of a living organism or another species (the prey). The predator benefits; the prey is clearly harmed. The prey may or may not die from the interaction.

**Symbiosis** - a long-lasting relationship in which species live together in an intimate association. There are three types of symbiosis:

- **Parasitism** - One species (the parasite) feeds on part of another organism (the host). The parasite benefits; the host is harmed.
- **Mutualism** - two species interact; both benefit from the relationship.
- **Commensalism** - one species benefits; the other species is neither harmed or benefits.

Symbiotic relationships help regulate the populations of species and can help them survive changes in environmental conditions.

### **How do species compete with one another?**

Interspecific competition results when parts of the fundamental niches of different species overlap. The more the niches overlap, the more they compete with one another.

One of the species must:

- migrate to another area
- shift its feeding habits
- suffer a sharp population decline
- become extinct in that area

Species compete in two ways:

**Interference competition** - one species limits another's access to some resource, regardless of its abundance. Members establish a territory and defend it against other invading species

**Exploitation competition** - competing species have equal access to a specific resource but differ in how fast or how efficiently they exploit it.

### **What is the Principle of Competitive Exclusion?**

Two species that require the same resource cannot coexist indefinitely in an ecosystem in which there is not enough of that resource to meet the needs of both species. "one-niche, one-species, one-place principle"

### **How have some species reduced or avoided competition?**

1. **Resource Partitioning** - the dividing up of available resources (hawks feed during day, owls at night.).
2. **Character displacement** - species develop physical or behavioral characteristics or adaptations that allow them to use different resources.

### **How Do Predator and Prey Species Interact?**

Predators feed on prey, but they do not live in or on the prey.

This is a positive feedback system for the predator limited by the negative feedback when the prey population falls below a certain minimum level.

Prey organisms may or may not be killed by their predators. Predation can benefit the prey by eliminating the sick, weak and aged members.

### How do predators increase their chances of getting a meal?

1. **pursuit** - run fast to catch their prey; have keen eyesight; hunt in packs; humans have invented tools (weapons and traps).
2. **ambush** - camouflage helps conceal them while they lay in hiding waiting for their prey.

### How do prey defend themselves against predators?

1. run, swim or fly fast; keen sight or sense of smell to alert them to the presence of predators; protective shells; thick bark; spines; thorns; camouflage to hide from predators
2. **Chemical warfare** - chemicals that are poisonous, irritating, foul smelling, bad tasting
3. **Warning coloration** so predators know that this animal is bad tasting
4. **Mimicry** - species take on the appearance of another animal that may be very poisonous.

### Symbiotic Species Interactions: Parasitism, Mutualism and Commensalism.

**Parasitism** - a form of predation; the parasite is usually smaller than its host prey; remains closely associated with its host and rarely kills its host.

- **Parasitoids** - parasites that routinely kill their hosts as part of their life cycle (used by farmers to control pest species).
- **endoparasites** - live inside their hosts
- **ectoparasites** - live outside their hosts (often move from one host to another)
- Parasites play important ecological roles.

**Mutualism** - both species benefit from the relationship; each species benefits by exploiting the other.

- e.g., pollination relationship between flowering plants and insects
- **Nutritional mutualism** - lichens: photosynthetic algae and chlorophyll-lacking fungi. The fungi and algae cannot live apart. This is called obligatory mutualism.
- Nutritional and protection mutualism
- Mutualism is more common when resources are scarce.

**Commensalism** - one species benefits; the other species is neither helped nor harmed significantly.

- Redwood sorrel benefits from growing in the shade of tall redwood trees
- relationship between some trees and plants called epiphytes

### Ecosystem Structure and Ecological Succession

Ecosystem structure is described in terms of four characteristics

1. physical appearance
2. niche structure
3. species diversity or richness
4. species abundance

### How do Ecosystems Respond to Change?

Structures of ecosystems change in response to changing environmental conditions.

**Ecological Succession** - the gradual and fairly predictable change in species composition of a given area. Some species colonize and flourish, while others decline and even disappear.

**Primary Succession** - the gradual establishment of biotic communities in an area that has not been occupied by life before.

**Secondary Succession** - the reestablishment of a biotic community in an area where a biotic community was previously present.

**Primary Succession** - starts with a lifeless area (no soil)

- **Pioneer species** - lichens and mosses
- **Early successional plant species** - grow close to the ground; help break up rock and make more soil.
- **Midsuccessional plant species** - herbs, grasses and low shrubs;
- **Late successional plant species.** - trees

**Secondary Succession** begins in an area where the natural community has been disturbed, removed or destroyed, but the soil or sediment remains. (abandoned farmlands, burned or cut forests, heavily polluted streams, etc.)

### How do species replace one another in ecological succession?

**facilitation** - species behave in such a way that facilitates the growing/survival of other species - e.g., legumes convert nitrogen to nitrates thus making the soil more suitable for other plants.

**inhibition** - early species hinder the establishment and growth of other species

**tolerance** - late successional plants are largely unaffected by plants at earlier stages of succession.

### What is the role of *Disturbance* in Ecological Succession?

A disturbance is a discrete event in time that disrupts an ecosystem or community

**Natural disturbance** - fires, hurricanes, earthquakes, droughts, floods, ...; play an important role in ecosystems. The immediate effect is to change conditions and release resources.

**Intermediate disturbance hypothesis** - communities that experience fairly frequent, moderate disturbances have the greatest diversity of species.

### *Ecological Stability and Sustainability*

#### What is Stability?

Stability of an ecosystem is maintained only by constant dynamic change in response to changing environmental conditions.

**Inertia (or persistence)** - the ability of a living system to resist being disturbed or altered.

**Constancy** - the ability of a living system to maintain a certain size or keep its numbers within the limits imposed by available resources.

**Resilience** - the ability of a living system to bounce back after an external disturbance that is not too drastic.

The **signs of ill health in a stressed ecosystem** include

- a drop in primary productivity
- increased nutrient losses
- decline or extinction of indicator species
- Increased populations of insect pests or disease organisms
- decline in species diversity
- the presence of contaminants

### Does Species Diversity Increase Ecosystem Stability?

An ecosystem with a diversity of species and feeding paths has more ways to respond to most environmental stresses; but there may be many exceptions to this rule.

Ecosystems with more species tend to have higher net primary productivities than simpler ecosystems.

Grasslands: much less diverse than forests and they have low inertia; have high resilience and recover quickly.

### What determines the Number of Species in an Ecosystem?

Two main factors are: **size and degree of isolation**

**Species Equilibrium Model or Theory of Island Biogeography** (MacArthur and Wilson)

- the number of species found on an island is determined by a balance between two factors: the immigration rate of species to the island from other inhabited areas, and the extinction rate of species established on the island. At some point these two rates should be equal and a stable ecosystem should result.
- **Immigration** and **extinction rates** are affected by two important variables: **the size of the island** and **the distance from a mainland source of immigrant species**

**Human-caused disturbances - deforestation, overgrazing, plowing**