CHAPTER 47 COMMUNITY ECOLOGY

Chapter Outline

47.1 Concept of the Community

A. A **community** is a group of populations that interact with one another in the same environment.
   1. Communities vary in size and may have boundaries that are difficult to determine.
   2. A fallen log supports a community but a passing bird can eat one of its members.
   3. A forest may appear distinct but it gradually fades into the surrounding areas.

B. Community Composition and Diversity
   1. The **species composition** is a list of the species within a community; it does not reveal the relative abundance of organisms.
   2. **Species diversity** consists of two factors: richness and evenness.
      a. **Species richness** is number of species; forest with 20 tree species has more richness than a forest with 12.
      b. **Species evenness** is the number of individuals within each population; a forest with 76 yellow poplars and one American elm differs from a forest with 40 of both species.

C. Models Regarding Composition and Diversity
   3. The number of species in a community increases as we move from the poles to the equator.
   4. The **individualistic model** by H. L. Gleason states that each population is there because of its adaptations.
      a. A species range is based on its tolerance for abiotic factors including light, water, salinity, etc.
      b. Species will have independent distributions; boundaries between communities will not be distinct.
   5. Frederick E. Clements proposed the interactive model of **community structure**.
      a. A community was simply a higher level of organization beginning from cell to tissue to organism.
      b. Just as cells are adapted to each other, a community had species adapted to each other.
      c. Clements classified communities and stated that the same species will be found in the same community type.
   6. Modern ecological data supports the individualistic model.
      a. F. H. Talbot and co-workers built artificial reefs and set them in a uniform tropical lagoon.
      b. Of the 42 species that colonized the reefs, there was only a 32% similarity reef-to-reef.
      c. From month to month, 20–40% of the species changed.
      d. The reef species composition appears to depend on chance migrations.
      e. Certain animals occur near their food source and this determines their range.
      f. Most likely, community structure depends on both abiotic and biotic factors.

D. Island Biogeography
   1. Robert MacArthur and E. O. Wilson developed the general theory of **island biogeography**.
   2. Nearby islands have more species because immigration is easier.
   3. Larger islands have more species because a large island has more resources.
   4. “Islands” can also include patches of forest surrounded by cropland, housing developments, etc.
      a. The **spatial heterogeneity model** describes the patchiness of an environment.
      b. The greater the number of habitat patches, the greater the diversity.
   5. **Stratification** is an increase in vertical living spaces; a tree canopy provides a high-rise habitat and vertical patchiness.
   6. An equilibrium point is reached when the rate of species immigration matches the rate of species extinction.
   7. An equilibrium point can be dynamic with many species arriving and departing, or steady unless disturbed.

47.2 Structure of the Community

A. Interaction Between Populations Is Complex
   1. Interactions include: competition for resources, predator-prey interaction, and parasite-host interactions.
   2. Competition between two species for limited resources negatively affects the population size of both species.
   3. Predation and parasitism increase the predator population at the expense of the prey and host populations.
   4. In parasitism, one species is benefitted, the other is harmed.
   5. In commensalism, one species is benefitted, the other is neither benefitted nor harmed.
   6. In mutualism, both species benefit.

B. Habitat and Ecological Niche
   1. A **habitat** is where an organism lives and reproduces in the environment.
   2. The **ecological niche** is the role an organism plays in its community, including its habitat and its interactions with other organisms.
      a. The **fundamental niche** is the range of conditions under which it can survive and reproduce.
      b. The **realized niche** is the set of conditions under which it exists in nature.

C. Competition Between Populations
   1. **Interspecific competition** occurs when different species utilize a resource that is in limited supply.
   2. If the resource is not in limited supply, there is no competition.
   3. Lotka and Volterra (1920s) developed a formula: competition favors one species and can eliminate the other.
   4. Gause grew two species of paramecia in one test tube; only one survived if they were grown together.
   5. **Competitive exclusion principle:** no two species can occupy the same niche at the same time.
   6. Over time, either one population replaces the other or the two species evolve to occupy different niches.
   7. If it appears two species occupy the same niche, there must be slight differences; Gause found two species of paramecium coexisted if one fed on bacteria at the bottom of the tube and the other fed on suspended bacteria.
   8. **Resource partitioning** occurs when species shift niches; they no longer directly compete.
      a. Three species of Galapagos Island finches have three sizes of beaks for small, medium, and large seeds.
      b. When species live on separate islands, their beak sizes are intermediate; when they live together, their beak sizes are disparate; this is **character displacement.**
      c. Five species of warblers in same tree spent time in different tree zones to avoid competition; they had different niches.
      d. Swallows, swifts, and martins fly in mixed flocks eating aerial insects but have different nesting sites, etc.
      e. The above examples are deduced from already completed partitioning.
      f. Joseph Connell studied the competition occurring in barnacles that consistently shift to match shoreline tidal zones.
         1) By removing the larger *Balanus* barnacles from the lower zone, the smaller barnacles easily moved in.
         2) The smaller barnacle is more resistant to drying out; but the larger one can overgrow it.

D. Predator-Prey Interactions
   1. **Predation** occurs when one organism (**predator**) feeds on another (**prey**).
   2. In a broad sense, it includes not only single predator-prey kills, but also filter feeding whales that strain krill, parasitic ticks that suck blood, and even herbivorous deer that eat leaves.
   3. Predator-Prey Population Dynamics
      a. Some predators reduce the densities of their prey.
         1) When Gause reared the protozoans *Paramecium caudatum* and *Didinium nasutum* together in culture, *Didinium* ate all the *Paramecium* and then died of starvation.
         2) When prickly-pear cactus was introduced to Australia from South America, it spread wildly without competition on the desert; a natural predator moth from South America was introduced and the cactus and moth populations plummeted dramatically.

b. Natural predator-prey relationships allow persistent populations of both predator and prey populations, though both may fluctuate over time.
    1) Often a graph of predator-prey population densities shows regular peaks and valleys with the predator population lagging slightly behind the prey; two reasons are possible.
    2) The biotic potential of the predator may be great enough to overconsume the prey; the prey population declines and the predator population then follows.
    3) Or the biotic potential of the prey is unable to keep pace and the prey population overshoots the carrying capacity and suffers a crash.

4. The Classic Case of the Snowshoe Hare and the Canadian Lynx
    a. Careful records of pelts of both animals for over a century have demonstrated regular fluctuations.
    b. To test whether the lynx or hare food supply was causing the cycling, three experiments were done.
        1) A hare population was given a constant supply of food and predators were excluded; the cycling ceased.
        2) The hare populations were given a constant food supply but predators were not excluded; the cycling continued.
        3) Predators were then excluded but no extra food was added; the cycling continued.
    c. The interpretation of these results is that both a hare-food cycle and a predator-hare cycle combine to produce the overall effect.
    d. The grouse population also cycle, perhaps because the lynx switches to grouse when the hare populations decline; thus predators and prey do not normally exist as simple two-species systems.

E. Prey Defenses and Other Interactions
1. Prey have evolved a variety of antipredator defenses.
2. Plant adaptations for discouraging predation include:
    a. sharp spines,
    b. tough leathery leaves,
    c. poisonous chemicals in their tissues, and
    d. chemicals that act as hormone analogues to interfere with insect larval development.
3. Animals have defenses that include:
    a. **camouflage** for concealment; this also requires behavior (stillness),
    b. fright of the predator,
    c. warning coloration, and
    d. vigilance and association with other prey for better warning.

F. Mimicry
1. **Mimicry** occurs if one species (the mimic) resembles another species (the model) possessing an antipredator defense.
2. **Batesian mimicry,** named for Henry Bates, is a form of mimicry in which one species that lacks defense mimics another that has successful defenses.
3. **Mhllerian mimicry**, named for Fritz Mhller, is where several different species with the protective defenses mimic one another (e.g., stinging insects all share same black and yellow color bands).

G. Symbiotic Relationships
1. Symbiosis is a close relationship between members of two populations.
2. Parasitism
    a. Parasitism is similar to predation; the parasite derives nourishment from the host.
    b. Viruses are always parasitic; parasites occur in all kingdoms of life.
    c. *Endoparasites* are small and live inside the host.
    d. *Ectoparasites* are larger and remain attached to the body of hosts by specialized organs or appendages.
    e. Many parasites have several hosts.
        1) The primary host is the main source of nutrition.
        2) The secondary host may serve to transport (vector) the parasite to other hosts.
    f. Parasites are specific and require certain species as hosts.

g. Lyme Disease
    1) The bacterium *Borrelia burgdorfei* causes arthritislike symptoms in humans.
    2) The bacterium primarily lives in white-tailed deer mice.
    3) The larval deer ticks of *Ixodes dammini* or *I. ricinus* feed on deer mice and can transfer the bacteria to humans.

3. Commensalism
    a. In commensalism, one species benefits and the other is neither harmed nor benefitted.
    b. It is difficult to determine true commensalism because it is difficult to ensure that the host is not harmed.
    c. Barnacles secure a home by attaching themselves to the backs of whales and the shells of horseshoe crabs.
    d. Remora fish attach themselves to the bellies of sharks, securing a free ride and the remains of the shark's meals.
    e. Epiphytes grow in the branches of trees to receive light but take no nourishment from the tree.
    f. Clownfishes live within the tentacles of sea anemones for protection.
    g. Some relationships are so loose that it is difficult to know if they are true commensalism.
        1) Cattle egrets feed near cattle because the egrets flush insects as they graze.
        2) Baboons and antelopes forage together for added protection.
4. Mutualism
    a. In mutualism, both species benefit.
    b. Mutualism can be found among organisms in all kingdoms of life.
    c. Examples include the following:
        1) Bacteria in the human intestinal tract are provided with some of our food but also provide us with vitamins.
        2) Termites can only feed on wood because their gut contains the protozoa that digest cellulose.
        3) Mycorrhizae are symbiotic associations between the roots of fungal hyphae and plants.
        4) Flowers and insect pollinators represent a shift from insects eating pollen to eating nectar.
        5) Lichens are made of algae that produce food and fungi that preserve water, although the algae can survive alone.
    d. Classic Example of the Ant and the Acacia Tree
        1) In tropical America, the bullhorn acacia provides a home for ants in its hollow thorns.
        2) The acacia also provides ants with food from its nectaries, and protein in nodules called Beltian bodies.
        3) In return, the ant protects the plant from herbivores and other plants that might shade it.
        4) When ants on an experimental tree were killed with insecticide, the tree also died.
    e. Tree-Ant-Caterpillar Complex
        1) Trees in the genus *Croton* also have nectaries that feed ants.
        2) Ants have a mutualistic relationship with *Thisbe* caterpillars that feed on *Croton* saplings.
        3) *Thisbe* caterpillars offer nourishment to ants, keeping them nearby.
        4) The caterpillar releases the same chemical that causes the ants to defend an ant colony.
        5) The result is that the caterpillars are protected while feeding on the trees.
    f. Cleaning Symbiosis
        1) Crustacea, fish, and birds act as cleaners to a variety of vertebrate clients.
        2) Large fish in coral reefs line up at cleaning stations and wait their turn to be cleaned by small fish.
        3) The possibility of feeding on host tissues as well as on ectoparasites complicates this case of mutualism.

47.3 Community Development

A. Communities change over both short and long intervals of time due to continental drift, glaciation, etc.
B. Ecological Succession
    1. **Ecological succession** is a change involving a series of species replacements in a community following a disturbance.
    2. **Primary succession** begins in a habitat lacking soil; this might occur following a volcanic eruption.

3. **Secondary succession** begins when soil is already present but it has been disturbed and returns to a natural state, as in an abandoned cornfield.
    a. In the first years, wild grasses and other **pioneer species** invade.
    b. Soon sedges and shrubs invade.
    c. Later, there is a mixture of shrubs and trees.
4. In 1916, F. E. Clements proposed the climax-pattern model of succession: that succession leads to a climax community that is characteristic for an area.
    a. A **climax community** has a community composition that depends on climate.
        1) Dry climates eventually produce deserts.
        2) Wet climates proceed to forests.
        3) Intermediate moisture will result in grasslands, shrubs, etc.
        4) Soils will also influence the developing community.
    b. Each stage facilitates the occurrence of the next stage (called the "facilitation model").
        1) Shrubs cannot grow on dunes until the dune grass has developed the soil.
        2) Therefore the grass-shrub-forest must occur sequentially.
5. The **inhibition model** challenged Clements' view of succession.
    a. Colonists hold onto their space and inhibit the growth of other plants until the colonists die.
    b. Death releases resources that allow different, longer-lived species to invade.
6. The **tolerance model** provides yet another view of succession.
    a. Sheer chance may determine which seeds arrive first; in this case, the successional stages may merely reflect the maturation time.
    b. Trees merely take more time to develop; however, both facilitation and inhibition of growth may be taking place.
7. All models are probably involved and succession may not often reach the same final potential natural community.

47.4 Community Biodiversity

A. Community Stability
    1. Stability of communities is seen in three ways: persistence through time, resistance to change, and recovery once a disturbance occurred.
    2. A forest may remain unchanged year after year; that is persistence.
    3. A deciduous forest resists change by regrowing its leaves after an insect infestation.
    4. A chaparral community is resilient to fire and quickly recovers to its normal state.

B. The Intermediate Disturbance Hypothesis
    1. The intermediate disturbance hypothesis states a moderate level of disturbance yields the highest community diversity.
    2. Fire, wind, severe weather, and water erosion are abiotic and external factors that cause such disturbances.
    3. If disturbances affect one type of patch and not another, the effect of patchiness is to provide overall stability.
    4. If widespread disturbances occur frequently, diversity is limited and a community will be dominated by rapid growth and short life span (*r*-strategist) colonizers.
    5. When disturbances are less widespread and infrequent, species with slow growth rates and long life spans will (*K*-strategists) dominate.
    6. Therefore, too much disturbance, or not enough, may threaten the diversity of tropical rain forests and coral reefs.
    7. Archeological remains show that the Maya cultivated huge areas from 300 to 900 AD; the civilization collapsed, and 1,200 years later the community composition still remains different from a local tropical rainforest.

C. Predation, Competition, and Biodiversity
    1. Predation by a particular species can reduce competition and increase diversity.
        a. Robert Payne removed the starfish *Pisaster* from test areas along the coast of North America.
        b. In the control area, there was no change in numbers of species.
        c. In the removal area, the mussel *Mytilus* increased in number and excluded other invertebrates and algae from attachment sites.

2. Such predators that regulate competition and maintain diversity are called **keystone predators**.
3. The elephant may be a keystone species in the savannah where it feeds on shrubs and trees and causes the woodlands to become grassy savannas.

D. Island Biogeography and Biodiversity
1. Predation has changed Barro Colorado Island.
    a. This island was formed in Panama from damming a river in the 1910s.
    b. Island biogeography predicts fewer species can survive on islands; the jaguar, puma and ocelot are now gone.
    c. As a result, the medium-sized coatimundi increased in numbers; it is a predator of bird eggs.
    d. Thus, the numbers of bird species is less on the island than is expected for its size.
2. Therefore preserves must be larger in order to conserve the k-strategists, especially top predators.

E. Exotic Species and Biodiversity
1. Introduction of exotic species is devastating if they are not held in check by predators and competitors.
2. African honeybees introduced into Brazil displaced domestic honeybees.
3. The brown tree snake introduced to Guam has devastated the bird population.
4. The red fox was introduced in Australia to prey on the introduced European rabbit; it was successful but has also reduced the populations of native small mammals.