Chapter 53 - Community Ecology

Introduction

- A community is defined as an assemblage of species living close enough together for potential interaction.

What Is a Community?

- Communities differ in their species richness, the number of species they contain, and the relative abundance of different species.
- Contrasting views of communities are rooted in the individualistic and interactive hypotheses
  - An individualistic hypothesis depicts a community as a chance assemblage of species found in the same area because they happen to have similar abiotic requirements.
  - An interactive hypothesis depicts a community as an assemblage of closely linked species locked in by mandatory biotic interactions.
  - These two very different hypotheses suggest different priorities in studying biological communities.
  - In most actual cases, the composition of communities does seem to change continuously.
- The debate continues with the rivet and redundancy models
  - The rivet model of communities is a reincarnation of the interactive model.
  - The redundancy model states that most species in a community are not closely associated with one another.
  - No matter which model is correct, it is important to study species relationships in communities.

Interspecific Interactions and Community Structure

- There are different interspecific interactions, relationships between the species of a community.
- Populations may be linked by competition, predation, mutualism and commensalism
  - Possible interspecific interactions are introduced in Table 53.1, and are symbolized by the positive or negative affect of the interaction on the individual populations.
  - Competition.
    - Interspecific competition for resources can occur when resources are in short supply.
    - There is potential for competition between any two species that need the same limited resource.
    - The competitive exclusion principle: two species with similar needs for same limiting resources cannot coexist in the same place.
      - The ecological niche is the sum total of an organism's use of abiotic/biotic resources in the environment.
        - An organism's niche is its role in the environment.
    - The competitive exclusion principle can be restated to say that two species cannot coexist in a community if their niches are identical.
      - Classic experiments confirm this.
        - Resource partitioning is the differentiation of niches that enables two similar species to coexist in a community.
        - Character displacement is the tendency for characteristics to be more divergent in sympatric populations of two species than in allopatric populations of the same two species.
      - Hereditary changes evolve that bring about resource partitioning.
  - Predation.

- A predator eats prey.
  - Herbivory, in which animals eat plants.
  - In parasitism, predators live on/in a host and depend on the host for nutrition.
  - Predator adaptations: many important feeding adaptations of predators are both obvious and familiar.
    - Claws, teeth, fangs, poison, heat-sensing organs, speed, and agility.
    - Plant defenses against herbivores include chemical compounds that are toxic.
    - Animal defenses against predators.
      - Behavioral defenses include fleeing, hiding, self-defense, noises, and mobbing.
      - Camouflage includes cryptic coloration, deceptive markings.
      - Mechanical defenses include spines.
      - Chemical defenses include odors and toxins
        - Aposematic coloration is indicated by warning colors, and is sometimes associated with other defenses (toxins).
        - Mimicry is when organisms resemble other species.
          - Batesian mimicry is where a harmless species mimics a harmful one.
          - Müllerian mimicry is where two or more unpalatable species resemble each other.
  - Parasites and pathogens as predators.
    - A parasite derives nourishment from a host, which is harmed in the process.
    - Endoparasites live inside the host and ectoparasites live on the surface of the host.
    - Parasitoidism is a special type of parasitism where the parasite eventually kills the host.
      - Pathogens are disease-causing organisms that can be considered predators.
- Mutualism is where two species benefit from their interaction.
- Commensalism is where one species benefits from the interaction, but other is not affected.
  - An example would be barnacles that attach to a whale.
- Coevolution and interspecific interactions.
  - Coevolution refers to reciprocal evolutionary adaptations of two interacting species.
    - When one species evolves, it exerts selective pressure on the other to evolve to continue the interaction.

• Trophic structure is a key factor in community dynamics
- The trophic structure of a community is determined by the feeding relationships between organisms.
- The transfer of food energy from its source in photosynthetic organisms through herbivores and carnivores is called the food chain.
  - Charles Elton first pointed out that the length of a food chain is usually four or five links, called trophic levels.
  - He also recognized that food chains are not isolated units but are hooked together into food webs.
- Food webs.
  - Who eats whom in a community?
    - Trophic relationships can be diagrammed in a community.
    - What transforms food chains into food webs?
      - A given species may weave into the web at more than one trophic level.
  - What limits the length of a food chain?
    - The energetic hypothesis suggests that the length of a food chain is limited by the inefficiency of energy transfer along the chain.
    - The dynamic stability hypothesis states that long food chains are less stable than short chains.

- Dominant species and keystone species exert strong controls on community structure
    - Dominant species are those in a community that have the highest abundance or highest biomass (the sum weight of all individuals in a population).
        - If we remove a dominant species from a community, it can change the entire community structure.
            - Keystone species exert an important regulating effect on other species in a community.
            - If they are removed, community structure is greatly affected.
- The structure of a community may be controlled bottom-up by nutrients or top-down by predators
    - Simplified models based on relationships between adjacent trophic levels are useful for discussing how communities might be organized.
        - The bottom-up model postulates Vegetation-Herbivore linkages, where nutrients and vegetation control community organization.
        - The top-down model postulates that it is mainly predation that controls community organization Vegetation-Herbivore linkages.
        - Other models go between the bottom-up and top-down extreme models.

Disturbance and Community Structure

- Disturbances affect community structure and stability.
- Stability is the ability of a community to persist in the face of disturbance.
- Most communities are in a state of nonequilibrium owing to disturbances
    - Disturbances are events like fire, weather, or human activities that can alter communities.
        - Some are routine.
    - Marine communities are subject to disturbance by tropical storms.
    - We usually think that disturbances have a negative impact on communities, but in many cases they are necessary for community development and survival.
- Humans are the most widespread agents of disturbance
    - Human activities cause more disturbances than natural events and usually reduce species diversity in communities.
- Ecological succession is the sequence of community changes after a disturbance
    - Ecological succession is the transition in species composition over ecological time.
        - Primary succession begins in a lifeless area where soil has not yet formed.
            - Mosses and lichens colonize first and cause the development of soil.
                - An example would be after a glacier has retreated.
        - Secondary succession occurs where an existing community has been cleared by some event, but the soil is left intact.
            - Grasses grow first, then trees and other organisms.
            - Soil concentrations of nutrients show changes over time.

Biogeographic Factors Affecting the Biodiversity of Communities

- Two key factors correlated with a community's biodiversity (species diversity) are its size and biogeography.
- Community biodiversity measures the number of species and their relative abundance
    - The variety of different kinds of organisms that make up a community has two components.
    - Species richness, the total number of species in the community.
    - Relative abundance of the different species.
    - Imagine two small forest communities with 100 individuals distributed among four different tree species.
        - Species richness may be equal, but relative abundance may be different.
        - Counting species in a community to determine their abundance is difficult, especially for insects and smaller organisms
- Species richness generally declines along an equatorial-polar gradient

Tropical habitats support much larger numbers of species of organisms than do temperate and polar regions.

What causes these gradients?

The two key factors are probably evolutionary history and climate.

Organisms have a history in an area where they are adapted to the climate.

Energy and water may factor into this phenomenon.

- Species richness is related to a community's geographic size

The species-area curve quantifies what may seem obvious: the larger the geographic area, the greater the number of species.

- Species richness on islands depends on island size and distance from the mainland

Because of their size and isolation, islands provide great opportunities for studying some of the biogeographic factors that affect the species diversity of communities.

Imagine a newly formed island some distance from the mainland.

Robert MacArthur and E. O. Wilson developed a hypothesis of island biogeography to identify the determinants of species diversity on an island.

Two factors will determine the number of species that eventually inhabit the island.

The rate at which new species immigrate to the island.

The rate at which species become extinct.

Studies of plants on many island chains confirm their hypothesis.