CHAPTER 53 COMMUNITY ECOLOGY

- Early Hypotheses of Community Structure
  - Communities have varying numbers of species, or its **species richness**.
    - They also vary in the **relative abundance** of species: whether with few common and many rare species, or equivalent numbers across the spectrum.
      - The relative abundance affects the characteristics of a community.
    - **Species diversity** has both species richness and relative abundance measurements.
  - *The interactive and individualistic hypotheses pose alternative explanations of community structure: science as a process.*
    - **Individualistic hypothesis**, began by H. A. Gleason, illustrates the community as a coincidental conglomeration of species in an area, due to their abiotic requirements.
      - Abiotic requirements include temperature, rainfall, or soil type.
      - Requires the study of individual species.
        - Predicts that communities lack geographical boundaries because each species is distributed independently along the gradient.
          - Species will survive along its tolerance for abiotic factors.
    - **Interactive hypothesis**, supported by F. E. Clements, states that the community is an integrated unit comprised of closely-related species associating with each other due to biotic interactions.
      - This concept was based on the pattern of particular species of plants that always associate with other particular species.
        - E.g. Oak, maple, birch, and beech trees always have certain shrubs or vines.
      - Requires broader units of study.
        - Units will be more clustered in communities, due to the presence or absence of other species.
    - Most plant species follow the individualistic hypothesis: they are usually distributed loosely without distinct boundaries and do not have mandatory relationships.
      - However, in California, although European grasses have been introduced, the magnesium content in serpentine rocks only allows development of native plants.
    - Animals follow the interactive hypothesis, more likely.
      - Evolution assisted predation: predators evolved more useful accessories for hunting or foraging.
        - Therefore, geographical distribution is restricted by distribution of prey.
        - Exception of the gray squirrel because it has no specialty food source, although it is more populous in hardwood areas.
    - Interactions with other species and abiotic factors influence communities.
      - Abiotic factors include fires, floods, and storms.
        - Disturbance is the key influence affecting communities.
- Interactions Between Populations of Different Species
  - **Interspecific interactions** are those belonging between populations of different species under one community.
  - *Interspecific interactions can be strong selection factors in evolution.*
    - E.g. British peppered moths color-changing adaptation to mix in with environment.
    - **Coevolution** is genetic change in the interactions of same evolutionary adaptations in two species.
      - When one species changes, a selective force influences the second to have a counteradapation, as well.
        - Usually found in predator-prey, mutualism, and parasite-host relationships.
          - Very important in pollinator and flower relationship.
    - Passionfruit vines develop toxin to protect from insect larvae, except *Heliconius* butterfly larvae can digest anyways.
      - This adaptation to toxins allow butterflies a better chance at survival, but they continue to develop adaptations in adult stage.
        - Butterflies lay yellow eggs on leaves to reduce competition within the specie.

    - In response, the passionfruit vine develops yellow nectaries to reduce butterfly eggs by attracting predator ants and wasps.
- *Interspecific interactions may have positive, negative, or neutral effects on a population's density: an overview.*
  - Interspecific Interactions Chart:

Interaction	Effects on Population Density
Predation & Parsitism (+/-)	Beneficial to one, harmful to other
Competition (-/-)	Hurts both species
Commensalism (+/0)	One benefits, other is unaffected
Mutualism (+/+)	Both benefit in relationship

- *Predation and parasitism are +/- interactions: a closer look*
  - **Predation**: the interaction of **predator** eating its **prey**.
    - Although involving common predation, parasitism also belongs.
      - **Parasitism** is when special predators – parasites – live in or on their hosts, causing their eventual demise.
      - **Parasitoidism** involves insects (usually wasps) laying eggs on living hosts.
        - The larvae feed in the host's body, causing death.
      - **Herbivory** is when animals eat plants, and can kill an entire organism.
        - I.e. bird eating seed.
          - Grazing is not a form of herbivory because it is more parasitism than predation, without killing the organism.
  - <u>Predation</u>
    - Need acute senses to locate and identify prey.
      - Also have adaptations – claws, teeth, fangs, singers, or toxins – to help capture or feed prey.
        - Rattlesnakes have heat-sensing organs between eye and nostrils, using poisons through fangs to subdue.
        - Insects have tough teeth to munch on leaves.
      - Others need speed, while camouflage may be useful for others.
    - ***Plant Defenses Against Herbivores***
      - Herbivores do not destroy the whole plant, so prey density impact is not affected as much.
        - Removal of viable plant tissues affects fitness and survivability.
          - Mechanical defenses evolved for difficult consumption: throns, hooks, spiny leaves.
      - Chemicals may also be produced, so plant is distasteful or poisonous.
        - Strychnine from *Strychnos*, morphine from poppy, nicotine from tobacco, and digitoxin from foxglove.
          - Cinnamon, cloves, and peppermint are distasteful to animals.
          - Others have chemicals like insect hormones, causing adulterations inside of the insect that consumed it.
      - Herbivores can develop counteradaptations in the descendants.
        - Some larvaes, such as monarch butterflies, can store toxins of milkweeds and use them as defense mechanisms against their predators.
    - ***Animal Defenses Against Predators***
      - Passive (hiding) or active (escaping or defending) defenses used against.
        - Fleeing is an immediate response, but expensive in energy spending.
          - Usually adaptations for short flight with short energy spending.
        - Self-defense is less common, except for protection of young.
          - Alarm calls for mobbing of predator using either harassment from safe distance or direct attack.
        - Distraction also leads attention away to more escapable potential prey.

        - **Cryptic coloration**, or camouflage, is passive defense making prey indistinguishable against background while remaining still.
            - Shape is important, such as in seaweed-like fish.
            - Deceptive markings – fake eyes or heads – can deceive momentarily for enough time to escape or strike a less important area.
        - Predators discouraged by mechanical or chemical defenses.
            - Smells of skunks, spikes of porcupines, and poisons of amphibians
            - Monarch butterflies can maintain toxin accumulation from larvae to post-metamorphosis.
                - However, they are still subject to other predators.
        - **Aposematic coloration** is bright coloration defense mechanism to warn predators of deadly toxins.
            - E.g. Wasps (black and yellow stripes) or coral snakes
    - ***Mimicry***
        - **Mimicry** is advantage of bearing resemblance to another species, usually aposematic models of related species.
            - **Batesian mimicry** is a palatable and harmless species imitating another species that is usually harmful and unpalatable.
                - The larva of the hawkmoth can puff itself up to look like a snake and it even is modified with fake eyes and hisses.
                - Models must outnumber mimics, or predators will recognize the difference soon enough.
            - **Müllerian mimicry** is when both species are unpalatable and aposematically colored, resembling each other.
                - They gain an additional advantage for population numbers.
        - Predators also use mimicry to help catch prey.
            - Snapping turtles have worm-like tongues to lure fish.
- <u>Parasitism</u>
    - A **parsite** derives nourishment from the **host** – the organism harmed that loses energy or materials in the process.
        - Organisms living inside the host are **endoparasites** – tapeworms and malarial parasites.
            - Get host by passive mechanisms.
                - Nematodes in human intestine produce eggs to the external environment, so poor sanitation can infect others.
            - Others use movement, temperature, or chemical cues to infect.
        - Organisms feeding on external surface are **ectoparasites**: mosquitoes and aphids.
    - Natural selection favors parasites with best abilities to locate hosts and feed.
        - Evolution of defensive capabilities in potential hosts also favored.
            - Plants have toxins to herbivores, fungi, and bacteria.
            - Immune system in vertebrates provide some defense against internal parasites.
                - Antibodies and different trypanosomes change, with different glycoprotein surface coats for differential antibody production.
    - Can also exploit behaviors of other organisms
        - Cowbirds and European cuckoos lay eggs in nests of other species.
            - Sometimes, the host parents eject their own eggs when hatched or feed the new brood more than their own.

- *Interspecific competitions are +/- interactions: a closer look*
    - **Interspecific competition** is when populations of 2+ species in community rely on similar limiting resources.
        - Actual fighting over resources is **interference competition**, and consumption or use of similar resources is **exploitative competition**.
            - As population density increases, each individual has less access to resource.

        - Mortality rates increase, birthrates decrease, and growth slows for intraspecific competition.
      - In interspecific competition, the population growth is limited by density of competing species with density of own population.
  - <u>The Competitive Exclusion Principle</u>
    - A. J. Lotka and V. Volterra incorporated logistic model of population growth with interspecific competition.
      - Supposedly, two species with similar needs cannot co-live in one habitat
        - One would have an advantage, causing the other local extinction.
      - In 1935, Russian G. F. Gause proved with his Paramecium experiment.
    - **Competitive exclusion principle** is that two species with similar needs cannot share the same community.
  - <u>Ecological Niches</u>
    - **Ecological niche** is the total sum of the organism's use of biotic and abiotic resources in its habitat.
      - "If an organism's habitat is its address, the niche is its occupation … or the ecological role – how it 'fits' into an ecosystem."
    - **Fundamental niche** is the quantity of resources a population can use under ideal circumstances.
      - Although populations interact, biological restraints – competition, predation, or absence of resources – may limit the fundamental niche.
        - **Realized niche** is the actual amount of resources used.
  - <u>Evidence for Competition in Nature</u>
    - In outcomes to competition between similar-need species, either the weaker will be extinct or it will use different resources to stay alive.
      - Past competition may have influenced modern ecological relationships.
        - *Sympatric* are in same geographic area, but *allopatric* is in different.
    - **Resource portioning** is pattern of coexistence: sympatric species use varying resources in different ways.
      - Lizards on Dominican Republic use distinct perching site to eat same food.
        - This minimizes competition, while allowing adaptations of different species to specialize in their habitat.
    - Allopatric populations are similar in structure and resources, but sympatric species vary.
      - **Character displacement**: characteristics more varied in sympatric populations than in allopatric populations.
        - E.g. Galapagos finches developed various beaks to avoid competition.
      - Interference competition: one species can exclude another from the overlapping area of fundamental resources.
        - E.g. Heavier barnacles dominate lower strata, but removal helps lighter.
- *Commensalism and mutualism are +/0 and +/+ interactions respectively: a closer look.*
  - **Symbiosis**, "living together," has two species – the **host** and the **symbiont** – maintaining a close association.
    - Three types of symbiotic interactions:
      - **Parasitism**: the parasite harms the host
      - **Commensalism**: one organism benefits without hurting the host
      - **Mutualism**: both benefit from the relationship
  - <u>Commensalism (+/0)</u>
    - Few exist because almost impossible for ecological interaction to have no effect.
      - Thus, evolutionary change also benefits the beneficiary alone, as well.
    - "Hitchiking" algae growing on bellies of fish and marine mammals are examples.
      - However, if they start reducing efficiency of movement, they decrease reproductive success.
      - Cowbirds and egrets feed on bugs dug up by grazing herbivores.

        - Occasionally, because birds are opportunistic feeders, egrets will remove harmful ticks and other parasites.
        - Also can attract attention to predators nearby.
    - <u>Mutualism (+/+)</u>
        - These relationships require co-evolution of adaptations because both need in order to survive and reproduce together.
            - Nitrogen root fixation, microorganisms in termites' digestive system.
        - Might have developed from predator-prey or host-parasite interactions.
            - Angiosperms attract animals in seed dispersal, so herbivores needed to adapt to feed on pollen or nectar.
                - By sacrificing other organic material, reproductive success improves.
- Interspecific Interactions and Community Structure
    - Trophic, or feeding, relationships can separate different species.
        - All animals consuming plants are primary consumers, or herbivores.
        - Food web analysis accents the trophic connections between community members.
    - *Predators can alter community structure by moderating competition among prey species.*
        - Predator on community balances the prey species for moderate competition.
            - Heavy predation reduces competitors' population, so weaker competitors can continue to survive.
                - **Keystone species** influence community disproportionately due to an imbalance of abundance.
    - *Mutualism and parasitism can have community-wide effects.*
        - Keystone mutualists – mycorrhizal fungi and nitrogen-fixing bacteria – help sustain an ecosystem that affects other species.
            - Parasitic diseases also reduce populations of other species.
                - Bacterial infections on sea urchins that graze on algae have caused loss of coral reef because algae have overpopulated, as they have no predators.
                - Loss of sea grass in shallow waters of the Atlantic Ocean has devastated ecosystems and their organisms.
            - Parasites can also affect host behavior.
                - Amphipods infected with tapeworm larvae more susceptible to predatory fish, whereas before they would dive to escape death.
                - Trypanosomes and African sleeping sickness also use deterioration of host to benefit own health.
                    - Tsetse flies with trypanosomes suck more blood than normal because mechanoreceptors blocked, so trypanosomes' chances of infecting vertebrate host increases.
                        - Agricultural and urbanization limited by disease in Africa.
            - Humans try to limit effects of malaria and yellow fever from mosquito hosts.
                - Habitat alteration, better sanitation, and chemical pesticides reduce mosquito populations and chance of infecting human hosts.
                    - Wetland drainage for agriculture and sanitation have eliminated malaria in US, but use of DDT have caused more resistant mosquitoes.
                        - Other species are affected by habitat changes and chemicals in pesticides (chlorinated hydrocarbons).
    - *Interspecific competition influences populations of many species and can affect community structure.*
        - In 1960s, ecologists thought competition was limiting factor in diversity of species for a community.
            - Most influential evidence comes from introduction of an introduced species, **exotic species**, by humans.
                - Exotic species have overtaken resources needed by native members and changed community structure.
                    - Introduction of zebra mussel, a bivalve mollusk from the Caspian Sea, has caused clogging of pipes from reservoirs.
                        - Mollusk also has competed for space and plankton food.

            - Interspecific competition does not always cause competitive exclusion.
                - Competing species can coexist, although not in dense populations.
                    - Competition may be important only if population sizes are at carrying capacity and resources are deficient.
            - MacGillivray's warblers nest low, but black-headed grosbeaks nest higher.
                - Though it may appear competition for nesting sites is reduced, predation is reduced because clumping protects the young.
    - *A complex interplay of interspecific interactions and environmental variability characterizes community structure.*
        - Varied habitats can support more species because more ecological niches available.
            - Environmental heterogeneity is based on vegetation structure because vegetation affects animals found.
                - Microhabitats more if structurally complex vegetation, and vice versa.
        - Patchiness is spatial and temporal trait of all ecosystems.
            - E.g. Minerals in soil differs from chemicals in rocks; soil moisture changes with topography.
                - Adaptations to patchiness can increase diversity by facilitating resource division among competitors.
                    - With varying local factors and non-uniform distribution of abiotic factors, no species would out-compete the other.
        - Temporal heterogeneity, with seasonal changes, affect diversity.
            - Spring migrant birds attracted by spring flowers are replaced by summer and fall organisms.
                - In a day, nocturnal creatures overtake the daytime ones.
- Disturbance and Nonequilibrium
    - Biological communities should be in equilibrium, unless disturbed by humanity.
        - Interspecific interactions maintain stability in communities for "balance of nature."
            - **Stability** is the ability of community to reach and sustain a relatively constant condition (equilibrium) in disturbance.
    - *Nonequilibrium resulting from disturbance is a prominent feature of most communities.*
        - **Disturbance** are events that hurt the community, remove organisms, and change resource quantities.
            - May include storms, fires, floods, overgrazing, droughts, or human activity
                - Fire benefits terrestrial biomes, such as grasslands and chaparral
                - Many water bodies freeze, with seasonal drying of streams and ponds
                    - These provide opportunities for new species to establish.
            - Communities recuperating, most likely, from last disturbance.
    - *Humans are the most widespread agents of disturbance.*
        - Animals are usually disturbing means by overgrazing on grasslands or forests.
            - I.e. Beavers, elephants, deer, and gypsy moths
        - Humans affect communities most through urbanization processes.
            - Logging, clearing, mining, and farming have reduced forests in US and Europe.
                - Deforestation causes weeds and shrubs to dominate the lands instead.
                - Agriculture developed instead in grasslands.
            - Deforestation in the rainforests, overgrazing, and agricultural disturbance are only some problems contributing to community decrease.
        - Human disturbance reduces species diversity in communities.
            - 60% of Earth's land is in use as cropland, forest, and rangeland.
                - Most crops are monocultures – the production of only one variety of plant species in a large area.
                - Forests used for wood and lumber are only replanted with single species.
                    - Overgrazing removes native species with a couple introduced species.
        - Small-scale disturbances can enhance environmental patchiness that affects maintenance of species diversity in a community, ironically.

        - Frequent small disturbances reduce large profound ones.
            - I.e. Yellowstone National Park has lodgepole pines, which require intensive heat to open the cones.
                - In 1988, due to fire prevention laws, a massive fire of 250-300 year old trees caused immediate new vegetation the next year.
- *Succession is a process of change that results from disturbance in communities.*
    - Changes in community are most obvious after a disturbance.
        - Re-colonization or replacement of other species may occur.
            - **Ecological succession** is transition in species over ecological time.
    - **Primary succession** is ecological succession in lifeless area without soil (volcanic island or glacial areas).
        - Autotrophic bacteria first introduced, then lichen and mosses from windblown spores become first macroscopic photosynthesizing colonizers.
            - Soil develops from destruction of rocks and organic materials.
                - With soil, plants (grasses, shrubs, trees) develop from windblown seeds.
                - The process may take hundreds or thousands of years to complete.
    - **Secondary succession** is when previous community with soil cleared by disturbance.
        - Area returns to similar past, such as in cleared forests.
            - Herbaceous species from windblown seeds recolonize first.
            - If area not burned or grazed, shrubs will replace herbaceous species.
                - Eventually, forest trees replace the shrubs.
        - Competition and resource availability determines successional stages.
            - Early successional stages begin with good colonizers – "fugitive" or "weedy" r-selected species – due to high fecundity and dispersal mechanisms.
        - Tolerance also affects: K-selected species will not grow in abundance if extreme.
    - Changes in community structure may come from *inhibition* through exploitative or interference competition
        - These organisms affect abiotic environment, causing *facilitation* – organisms "pave the way" for next stage species.
            - Alders lower soil pH, helping conifer trees needing acidic soil to grow.
        - Horseweed colonizes farm fields first, but their death creates organic matter to soil to hold moisture.
- *The nonequilibrial model views communities as mosaics of patches at different stages of succession.*
    - Succession causes a stable climax community via web of sufficient quantities of interspecific interactions – *wrong concept*.
        - All communities change via time: pollen sediments in lakes reveal change.
    - Succession really should be an orderly, linear progression caused by interspecific interactions.
        - Nonequilibrium and constant disturbance are inevitable.
            - Disturbances and destabilizing environment affect and initiate change.
        - "Mosaic patches" at different stages of succession prevent equilibrium formation.
    - Disturbances causes loss, so niche spaces are available for other species to enter.
        - Recolonization occur from unburned plant roots or migration of species.
            - No significant change because species from past fill up niche.
        - **Recruitment** is species from distant areas not associated with disturbed area recolonize the area, leading to enormous changes in community.
            - Recruits are different species than the ones of present.
    - Nonequilibrial model proposes that high diversity comes from environmental patchiness, due to consistent abiotic disturbances.
        - **Dynamic equilibrium hypothesis** of 1970s proposes that it is effect of disturbance on the competitive interactions of populations.

    - Species diversity increases when disturbance quantities prevent competitive exclusion, as poorer competitors still live.
        - Keystone species disturbance is evidence.
  - **Intermediate disturbance hypothesis** states that high diversity comes from moderation in both frequency and intensity of disturbances.
    - Organisms found at different stages will be present, proven by rainforests.
      - If severe and constant, community will only have early; if mild and rare, late-successional will be predominant.
- On small scale, rodents and worms disturb soil by burrowing constantly.
  - Storms cause environmental patches, too.

- Community Ecology and Biogeography
  - **Biogeography** is the study of distribution of individual species and entire communities throughout history to modern times.
    - Analyzes the true background of species constituting a community.
      - Biogeographical realms follow patterns of continental drift from Pangaea.
  - *Dispersal and survivability in ecological and evolutionary time account for the geographical ranges of species.*
    - Species are limited to a particular range because of:
      - 1. Species cannot disperse farther than its current boundaries.
      - 2. Pioneers spreading further than boundaries cannot survive.
      - 3. Over evolutionary time, area has shrunk to its current boundaries.
        - Elephants and camels used to live in North America, but local extinctions prevent their survival there.
    - Transplant experiments by moving individuals outside their range can identify between first or second explanations.
      - E.g. Puerto Rican lizards moved in elevation areas because no adaptations to attain high body temperature to get or consume food.
  - *Species diversity on some islands tends to reach a dynamic equilibrium in ecological time.*
    - Islands with limited size and isolation help study species diversity of communities.
    - Robert MacArthur and E. O. Wilson have general hypothesis of island biogeography to identify determinants of species diversity.
      - Rate at new species' immigration to island and rate of species becoming extinct determine number of species to inhabit island.
        - Size of island and distance from mainland limit rates.
          - Smaller islands are more difficult to reach, and have higher extinction rates than larger islands.
            - Fewer resources and fewer diverse habitats increase likelihood of competitive exclusion
          - Closer islands will have higher immigration rates.
      - Immigration also affected by number of species already living on island.
        - As numbers increase, immigration decreases and extinction increases.
    - Equilibrium is dynamic.
      - Immigration and extinction continues, and exact species composition changes over time.
        - Equilibrium species number is greater on large island and on nearer island.
          - Species richness increases with island size.
    - Wilson and Daniel Simberloff tested on mangrove islands on Florida.