Chapter 53

Community Ecology

PowerPoint Lectures for
***Biology*, Seventh Edition**
Neil Campbell and Jane Reece

Lectures by Chris Romero

Community

– Populations of various species living close enough for potential interaction

Savanna community – which species are members?

Figure 53.1

What is Community Ecology?

Definitions:

• Studies examining the interaction between organisms at a particular site or in a specific area.

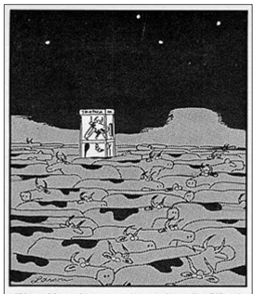
• The study of the distribution, abundance, and interactions between populations of coexisting species.

Examples:

Food webs, Species diversity, Succession, Invasion biology, Restoration ecology

---

What is Community Ecology ?



"Listen, Mom—I just wanted you to know I'm OK and the stampede seems 'bout over—although everyone's still a little spooked. Yeah, I know ... I miss the corral."

Interactions

- Competition
- Predation
- Herbivory
- Symbiosis
- Disease

Interspecific interactions

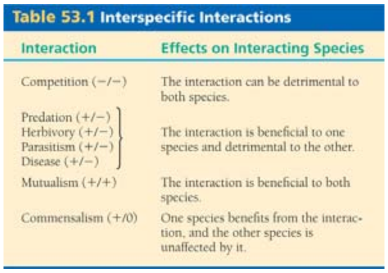


Table 53.1 Interspecific Interactions

Interaction	Effects on Interacting Species
Competition (−/−)	The interaction can be detrimental to both species.
Predation (+/−) Herbivory (+/−) Parasitism (+/−) Disease (+/−)	The interaction is beneficial to one species and detrimental to the other.
Mutualism (+/+)	The interaction is beneficial to both species.
Commensalism (+/0)	One species benefits from the interaction, and the other species is unaffected by it.

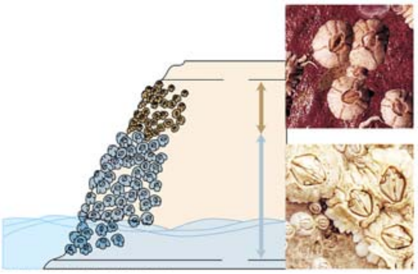
Table 53.1

Competition

- Interspecific
  - When species compete for a resource in short supply (limited)
- Can lead to competitive exclusion
  - Local elimination of one of the species

The Competitive Exclusion Principle

- Two species competing for the same limiting resources cannot coexist in the same place (cannot occupy the same niche)

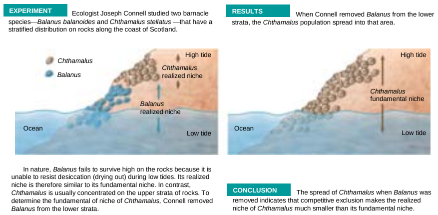


Ecological Niches

- Total of an organism's use of biotic and abiotic resources
- Habitat: organism's address
- Niche: its profession

After years of searching, Walter finally found his niche.

- Ecologically *similar* species can coexist in a community
  - If a difference in niches



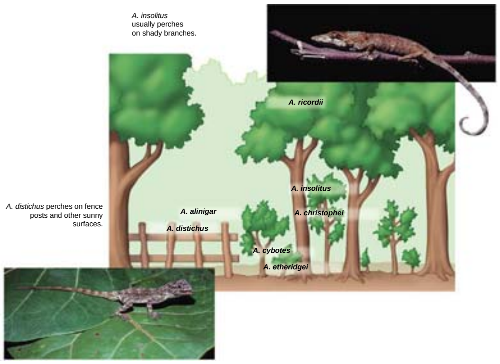
EXPERIMENT Ecologist Joseph Connell studied two barnacle species—*Balanus balanoides* and *Chthamalus stellatus* —that have a stratified distribution on rocks along the coast of Scotland.

RESULTS When Connell removed *Balanus* from the lower strata, the *Chthamalus* population spread into that area.

In nature, *Balanus* fails to survive high on the rocks because it is unable to resist desiccation (drying out) during low tides. Its realized niche is therefore similar to its fundamental niche. In contrast, *Chthamalus* is usually concentrated on the upper strata of rocks. To determine the fundamental of niche of *Chthamalus,* Connell removed *Balanus* from the lower strata.

CONCLUSION The spread of *Chthamalus* when *Balanus* was removed indicates that competitive exclusion makes the realized niche of *Chthamalus* much smaller than its fundamental niche.

Resource Partitioning



Character Displacement

– Characteristics more divergent in *sympatric* populations of two species than in *allopatric* populations of the same two species

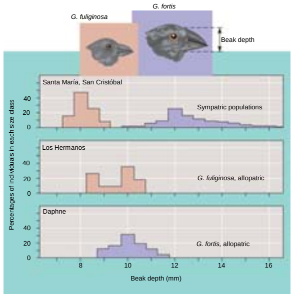


Figure 53.4

Predation

- One species kills & eats the other

Predators feeding adaptations

– Claws, teeth, fangs, stingers, and poison

Prey – defense mechanisms

- Cryptic coloration

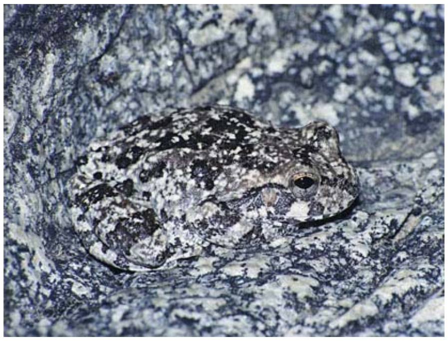


Figure 53.5

Aposematic coloration

- Warns predators

Figure 53.6

Batesian mimicry

- – A harmless species mimics a harmful one

(a) Hawkmoth larva

(b) Green parrot snake

Müllerian mimicry

- Two or more unpalatable species resemble each other

(a) Cuckoo bee

(b) Yellow jacket

Figure 53.8a, b

Herbivory

- – Has led to evolution of plant mechanical and chemical defenses and consequent adaptations by herbivores

---

Parasitism

•Parasite feeds on host, which is harmed

Disease

- Pathogens, disease-causing agents
  - bacteria, viruses, or protists

Mutualism

- interspecific interaction that benefits both species

Commensalism

•One species benefits, the other not affected

Interspecific Interactions and Adaptation

- Evidence for coevolution
  - reciprocal genetic change by interacting populations, is scarce
  - But organisms adapt to biota

Keystone species

Species diversity

- Species richness
  - Total number of different species in the community
- Relative abundance
  - Proportion each species represents of the total individuals in the community

---

- Two different communities
  - Can have the same species richness, but a different relative abundance

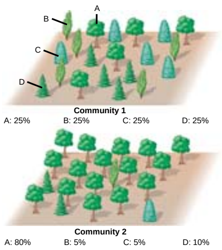


Figure 53.11

- A community with an even species abundance
  - Is more diverse than one in which one or two species are abundant and the remainder rare

---

Trophic Structure

- Feeding relationships between organisms
- Key factor in community dynamics

- Food chains
  - Link the trophic levels from producers to top carnivores

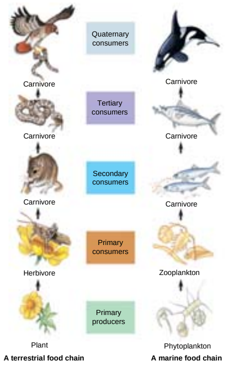


Figure 53.12

Food Webs

- A branching food chain with complex trophic interactions

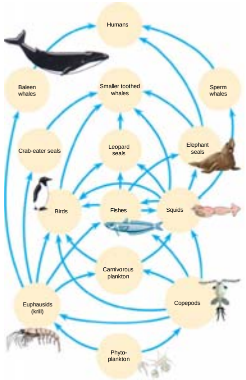


Figure 53.13

- Food webs can be simplified

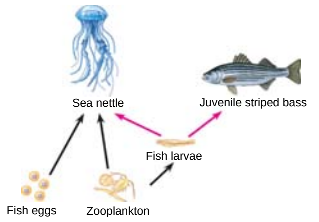


Figure 53.14

Limits on Food Chain Length

- Each food chain in a food web
  - Is usually only a few links long
- Two hypotheses
  - attempt to explain food chain length

Energetic hypothesis

- Food chain length limited by inefficiency of energy transfer

---

Dynamic stability

- long food chains are less stable than short ones

- Most data
  - Support the energetic hypothesis

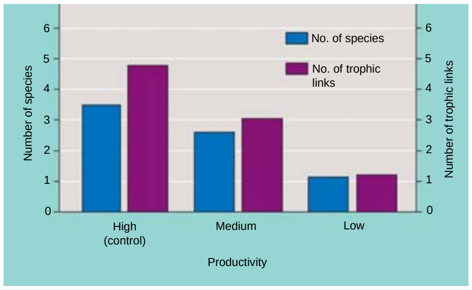


Figure 53.15

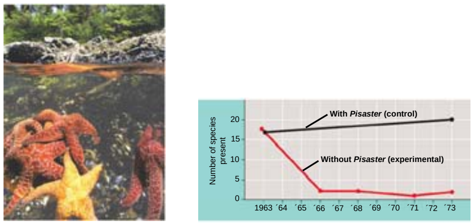
Dominant Species

- Dominant species
  - most abundant or have highest biomass
  - powerful control over presence and distribution of other species

Keystone Species

- Keystone species
  - Are not necessarily abundant in a community
  - Exert strong control on a community by their ecological roles, or niches
  - Either most competitive or,
  - Best at avoiding predation

Sea stars



(a) The sea star *Pisaster ochraceous* feeds preferentially on mussels but will consume other invertebrates.

(b) When *Pisaster* was removed from an intertidal zone, mussels eventually took over the rock face and eliminated most other invertebrates and algae. In a control area from which *Pisaster* was not removed, there was little change in species diversity.

Figure 53.16a,b

Sea otters

- Shows the effect the otters have on ocean communities

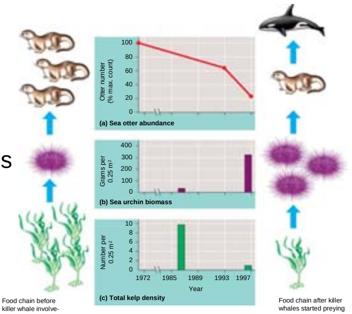


Figure 53.17

Food chain before killer whale involvement in chain

Food chain after killer whales started preying on otters

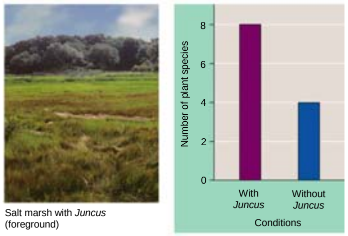
Ecosystem “Engineers” (Foundation Species)

- Some organisms exert their influence
  - By causing physical changes in the environment that affect community structure

- Beaver dams
  - Can transform landscapes on a very large scale

Figure 53.18

- Some foundation species act as facilitators
  - Positive effects on the survival and reproduction of some of the other species in the community



Salt marsh with *Juncus* (foreground)

Figure 53.19

Bottom-Up and Top-Down Controls

Bottom up

- influence from lower to higher trophic levels
- abiotic nutrients

Top-down

- control from the trophic level above
- predators control herbivores

- Long-term experiment studies have shown
  - That communities can shift periodically from bottom-up to top-down

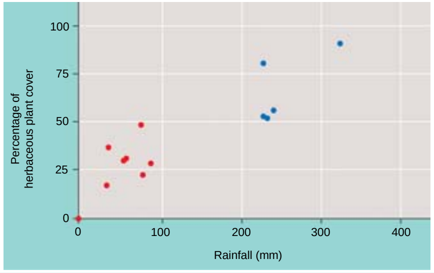


Figure 53.20

- Pollution
  - Can affect community dynamics
- But through biomanipulation
  - Polluted communities can be restored

	Polluted State	Restored State
Fish	Abundant	Rare
Zooplankton	Rare	Abundant
Algae	Abundant	Rare

What Is Disturbance?

- event that changes a community
- removes organisms
- alters resource availability

- Fire
  - significant
  - often a necessity

Figure 53.21a–c

(a) Before a controlled burn. A prairie that has not burned for several years has a high proportion of detritus (dead grass).

(b) During the burn. The detritus serves as fuel for fires.

(c) After the burn. Approximately one month after the controlled burn, virtually all of the biomass in this prairie is living.

---

intermediate disturbance hypothesis

- moderate levels of disturbance fosters higher species diversity

Human Disturbance

- Introductions
- Land clearing

Ecological Succession

- sequence of community and ecosystem changes after a disturbance

- Primary succession
  - Occurs where no soil exists
- Secondary succession
  - Soil present

- Early-arriving species
  - May facilitate later species
  - May inhibit later species
  - May tolerate later species

- Retreating glaciers

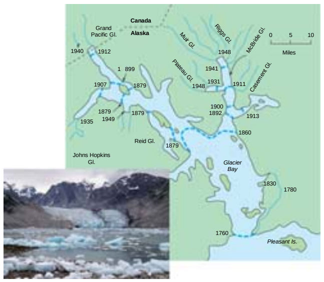
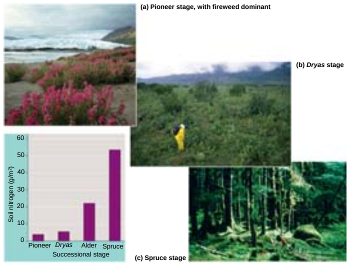


Figure 53.23

McBride glacier retreating

- Succession on the moraines in Glacier Bay, Alaska
  - Follows a predictable pattern of change in vegetation and soil characteristics



(a) Pioneer stage, with fireweed dominant

(b) *Dryas* stage

(c) Spruce stage

(d) Nitrogen fixation by *Dryas* and alder increases the soil nitrogen content.

Figure 53.24a–d

Equatorial-Polar Gradients

- The two key factors in equatorial-polar gradients of species richness
  - Are probably evolutionary history and climate

- 2 main climatic factors correlated with biodiversity
  - solar energy and water

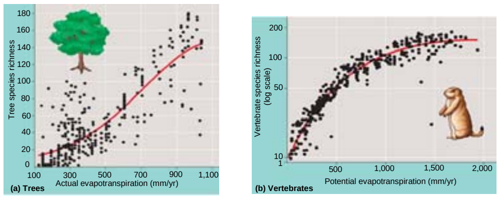


Figure 53.25a, b

Area Effects

- Species-area curve quantifies the idea that
  - All other factors being equal, the larger the geographic area of a community, the greater the number of species

---

- species-area curve of North American breeding birds

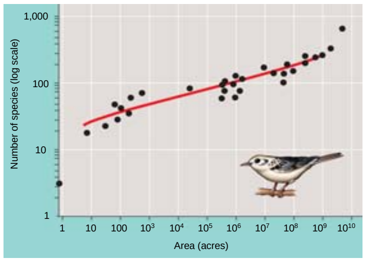


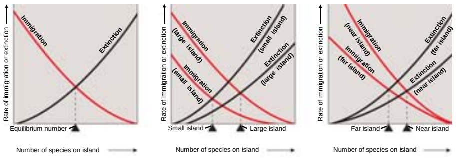
Figure 53.26

Island Equilibrium Model

- Species richness on islands
  - Depends on island size, distance from the mainland, immigration, and extinction

---

- The equilibrium model of island biogeography maintains that
  - Species richness on an ecological island levels off at some dynamic equilibrium point



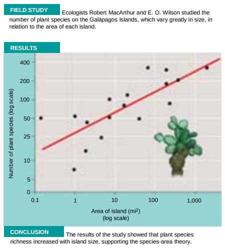
(a) Immigration and extinction rates. The equilibrium number of species on an island represents a balance between the immigration of new species and the extinction of species already there.

(b) Effect of island size. Large islands may ultimately have a larger equilibrium number of species than small islands because immigration rates tend to be higher and extinction rates lower on large islands.

(c) Effect of distance from mainland. Near islands tend to have larger equilibrium numbers of species than far islands because immigration rates to near islands are higher and extinction rates lower.

Figure 53.27a–c

- Studies of species richness on the Galápagos Islands
  - Support the prediction that species richness increases with island size


FIELD STUDY Ecologists Robert MacArthur and E. O. Wilson studied the number of plant species on the Galápagos Islands, which vary greatly in size, in relation to the area of each island.

RESULTS

CONCLUSION The results of the study showed that plant species richness increased with island size, supporting the species-area theory.

Figure 53.28

- Concept 53.5: Contrasting views of community structure are the subject of continuing debate
- Two different views on community structure
  - Emerged among ecologists in the 1920s and 1930s

Integrated and Individualistic Hypotheses

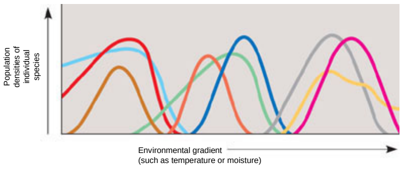
- The integrated hypothesis of community structure
  - Describes a community as an assemblage of closely linked species, locked into association by mandatory biotic interactions

---

- The individualistic hypothesis of community structure
  - Proposes that communities are loosely organized associations of independently distributed species with the same abiotic requirements

---

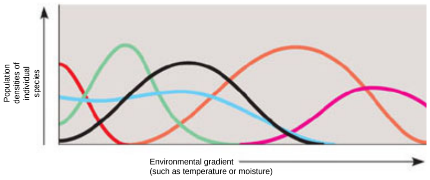
- The integrated hypothesis
  - Predicts that the presence or absence of particular species depends on the presence or absence of other species



(a) Integrated hypothesis. Communities are discrete groupings of particular species that are closely interdependent and nearly always occur together.

Figure 53.29a

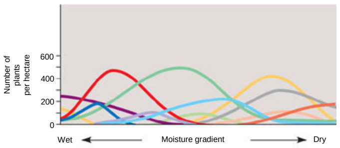
- The individualistic hypothesis
  - Predicts that each species is distributed according to its tolerance ranges for abiotic factors



(b) Individualistic hypothesis. Species are independently distributed along gradients and a community is simply the assemblage of species that occupy the same area because of similar abiotic needs.

Figure 53.29b

- In most actual cases the composition of communities
    - Seems to change continuously, with each species more or less independently distributed



(c) Trees in the Santa Catalina Mountains. The distribution of tree species at one elevation in the Santa Catalina Mountains of Arizona supports the individualistic hypothesis. Each tree species has an independent distribution along the gradient, apparently conforming to its tolerance for moisture, and the species that live together at any point along the gradient have similar physical requirements. Because the vegetation changes continuously along the gradient, it is impossible to delimit sharp boundaries for the communities.

Figure 53.29c

Rivet and Redundancy Models

- The rivet model of communities
    - Suggests that all species in a community are linked together in a tight web of interactions
    - Also states that the loss of even a single species has strong repercussions for the community

---

- The redundancy model of communities
    - Proposes that if a species is lost from a community, other species will fill the gap

---

- It is important to keep in mind that community hypotheses and models
    - Represent extremes, and that most communities probably lie somewhere in the middle