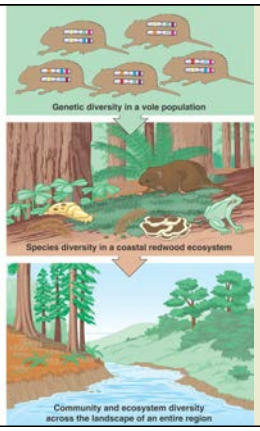
Biodiversity

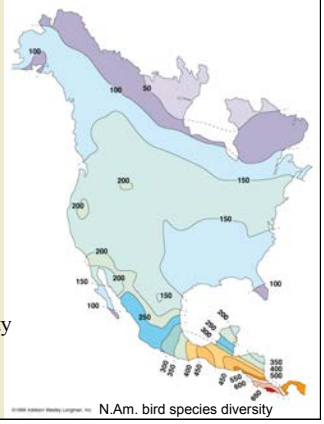
Levels of biological diversity

- Population
  - Genetic heterozygosity & allelic frequencies
  - Age structure
- Community
  - Species richness
  - Relative abundances
  - Distribution & dispersal
- Landscape
  - Patchiness
  - Ecotones



Biodiversity

- **Species richness** = # species/area
- **Relative abundance** = proportion of total diversity taken up by a few dominant species
- ⇧species richness + ⇩relative abundances ⇨⇧biodiversity stability



N.Am. bird species diversity

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

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

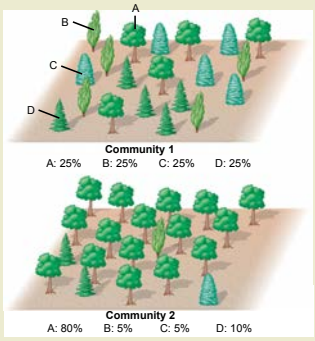


Figure 54.9

Estimating Community Diversity

- Shannon Diversity Index (H)

$$H = \sum_{i=1}^{S} -(P_i \cdot ln\, P_i)$$

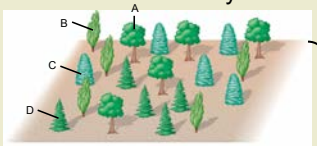
where:

H = the Shannon diversity index
P_i = fraction of entire population made up of species i
S = numbers of species encountered
Σ indicates the sum from species 1 to species S

Estimating Community Diversity

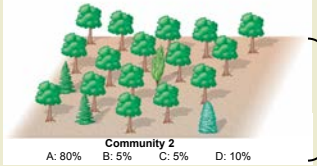
- Shannon Diversity Index

$$H = \sum_{i=1}^{S} -(P_i \cdot ln\, P_i)$$



A: (0.25 x ln 0.25)
B: (0.25 x ln 0.25)
C: (0.25 x ln 0.25)
D: (0.25 x ln 0.25)

Σ = **1.39 = H**

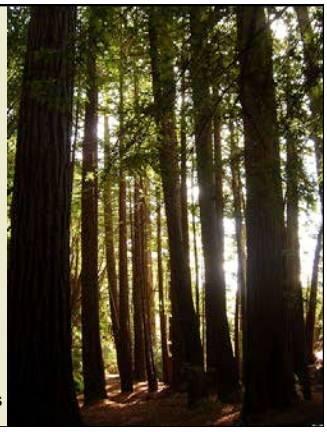


A: (0.80 x ln 0.80)
B: (0.05 x ln 0.05)
C: (0.05 x ln 0.05)
D: (0.10 x ln 0.10)

Σ = **0.71 = H**

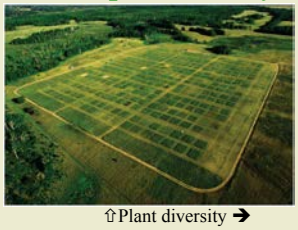
Dominant Species

- Vegetation with the highest density and/or biomass



redwoods

Effects of biodiversity on community productivity & stability



>20 year-study at Cedar Creek Ecosystem Science Reserve, MN
•manipulate vegetation diversity

⇧Plant diversity ➔
- ⇧Productivity (biomass)
- ⇧Stability
  - ✓ Consistent productivity
  - ✓ Withstand/recover from environmental stress
  - ✓ Resist invasive species

In addition to habitat complexity, other major factors related to community diversity:

- Climate
  - especially water availability

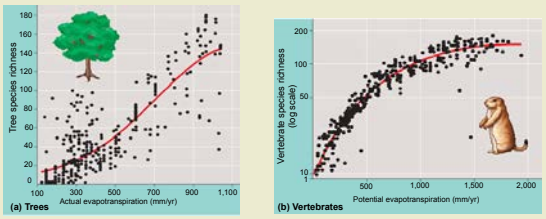
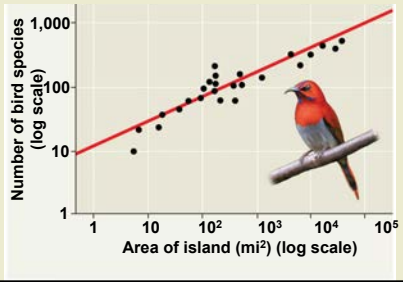


Figure 53.25

In addition to habitat complexity, other major factors related to community diversity:

- Available geographical area for the community



Species-area curve (log-log)
$S=cA^z$
S: # spp.
c: constant
A: area
Z: slope of line = rate of Δ S

Figure 54.26

Biodiversity Hot Spots

- A biodiversity hot spot is a relatively small area with an exceptional concentration of endemic species and a large number of endangered and threatened species
- Particularly resulting from habitat destruction.
- Most impacted biomes:
  - Tropical rain forest
  - Chaparral

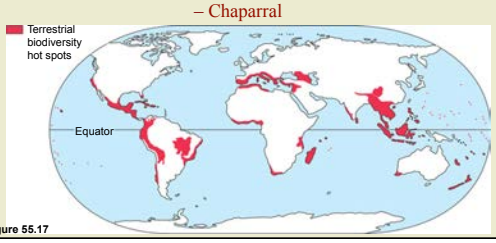


Figure 55.17

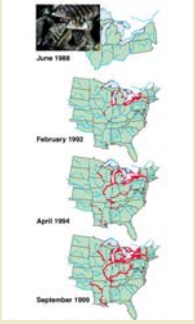
Invasive Introduced Species

"On a global basis...the two great destroyers of biodiversity are:
1. **habitat destruction,**
   and
2. **invasion by exotic species"**

The Nature Conservancy / University of California, Davis Wildland Invasive Species Team
- http://tncweeds.ucdavis.edu

European bull thistle in Yosemite National Park

THE PROBLEM OF INTRODUCED SPECIES



- **Zebra mussels**
- Introduced from Caspian Sea
- Ballast water
- 750,000 per m^2
- Reduce phytoplankton levels
- Loss of fish
- Cover every hard surface
- Clogged water intake pipes

Invasive Introduced Species

Terms:

- **Weed**: an organism growing in a given area where it is not wanted by humans. May be native or non-native.
- **Introduced / Non-native / Exotic / Alien / Non-indigenous**: species introduced to an area outside their original range by human activity — directly or indirectly / intentionally or unintentionally.
- **Invasive:** non-native species that spreads from its site of introduction into new areas.
  - –Some authors limit this definition to those species having a measurable effect on native wild communities.
  - –By either definition, only a tiny fraction of the tens of thousands of introduced species to North America are invasive.
- **Noxious**: legally designated as a pest species by governmental agency.

Invasive?

- *Berteroa incana* is native to Eurasia but now widespread in grasslands in North America. However, it is rarely if ever abundant in wildlands and not known to have negative impacts on biodiversity.

Invasive Introduced Species

- **Community and Population Level Impacts**
  - **Vegetation structure**
  - **Community composition**
  - **Resource competition**
  - **Negative impacts on native animals**
  - **Promotion of non-native invasive animals**
  - **Population reductions, eliminations**
  - **Reduced recruitment of natives (succession)**
  - **Hybridization with native species**
- **Ecosystem Level Impacts**
  - **Disturbance regimes (i.e. fires)**
  - **Hydrology**
  - **Geomorphological processes (i.e. erosion, sedimentation)**
  - **Soil chemistry (i.e. nutrients, salinity, pH)**

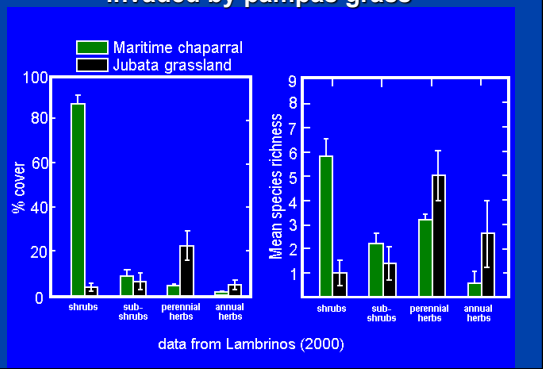
Changed vegetation structure

- **Scotch broom (*Cytisus scoparius*, the dark green shrub) invades grasslands and marshes, converting them to shrublands.**

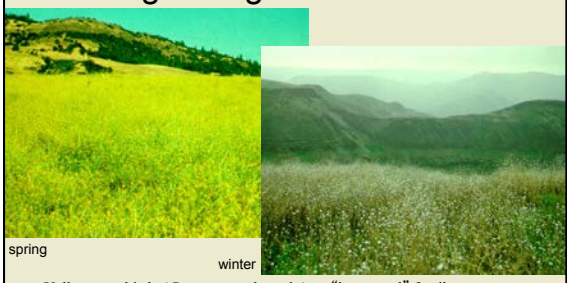
Changed vegetation structure

- Pampas grass (*Cortaderia selloana* and *C. jubata*) invade coastal sage scrub and maritime chaparral communities along the California coast converting them to alien grasslands.

Change in coastal community invaded by pampas grass



Changed vegetation structure



- Yellow star thistle (*Centaurea solstitialis*) — "knapweed" family
- Native to Mediterranean Europe/N. Africa. Probably arrived in California in contaminated alfalfa seed.
- Becomes dominant and appears to displace native bunchgrasses in western grasslands. Spiny & toxic to most grazers/browsers.

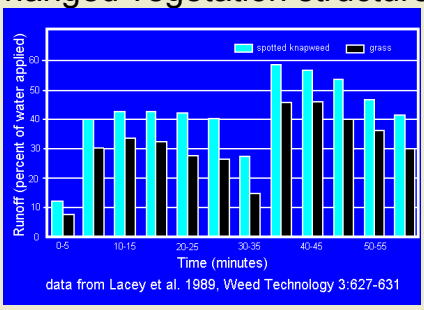
Changed vegetation structure

- Areas dominated by another knapweed (spotted knapweed, *C. maculosa*, or *C. biebersteinii*) had 47% less forage for elk than did areas where the weed was controlled.

Changed vegetation structure

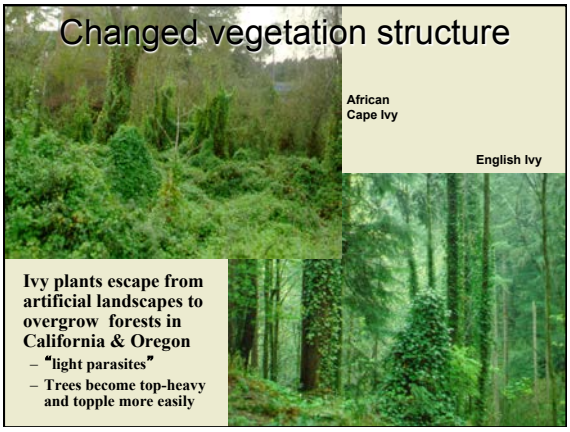
- Comparison of the fibrous, soil-holding roots of the native wheatgrass and the thin taproot of the spotted knapweed.

Changed vegetation structure



- Knapweed-dominated habitats have higher runoff than native bunchgrass communities. Runoff increases depletion of the soil and sediment load in local streams.

Changed vegetation structure



Ivy plants escape from artificial landscapes to overgrow forests in California & Oregon

- **"light parasites"**
- **Trees become top-heavy and topple more easily**

Escalating invasion cycle:

1. Pink passionflower vines overgrow Hawai'ian forests
2. Pink passionfruits attract and feed invasive feral pigs.
3. Pigs uproot native vegetation.
4. Pigs spread pink passionflower seeds.
5. Back to 1.

Altered ecosystems

Crystalline iceplant invades California coastal communities.
It accumulates salts to the soil, preventing or retarding native species

Altered ecosystems

Southwestern desert plants, such as saguaro cactus, are usually widely spaced with no build up of leaf litter, therefore fires are rare and the native vegetation has little fire resistance.

Non-native grasses such as this buffelgrass form nearly continuous cover which allows fires that spread rapidly, killing native cacti, shrubs and other perennials over large areas.

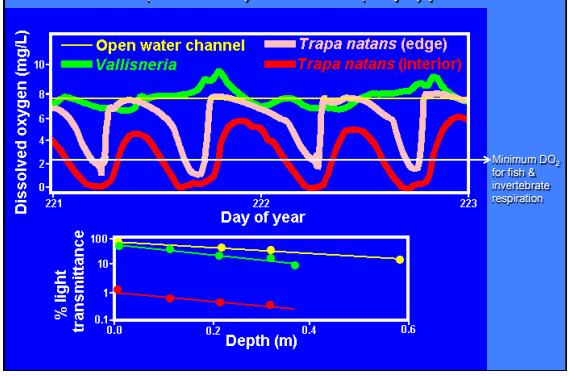
Altered ecosystems

- Saltcedar (*Tamarix*) invades and displaces desert riparian habitats.
- It clogs stream beds altering erosion patterns.
- Increased transpiration rates cause vital pools and streams to dry up.
- Saltcedar foilage decomposes more rapidly removing the primary productivity. Abundance and diversity of stream macroinvertebrates and fish decrerases significantly.

Altered ecosystems

- Invasive aquatic plants can sharply reduce light levels and dissolved oxygen concentrations in the waters they occupy.

Dissolved oxygen and light penetration in the Hudson River with native (*Vallisneria*) or invasive (*Trapa*) plant cover

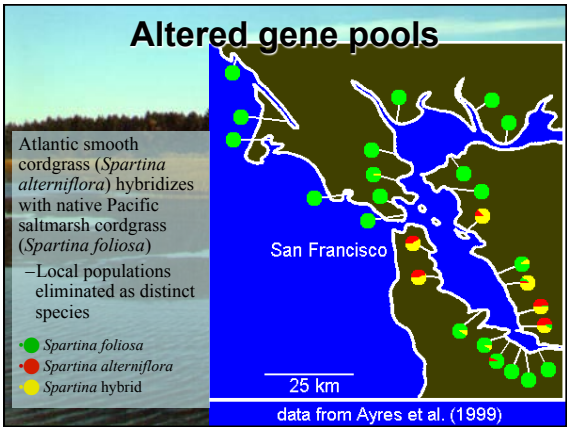


Altered ecosystems

Atlantic smooth cordgrass (*Spartina alterniflora*) has invaded mudflat communities in Pacific coast estuaries

- Encroaches further over mudflats than native cordgrass
- Reduces tidal flow over saltmarsh

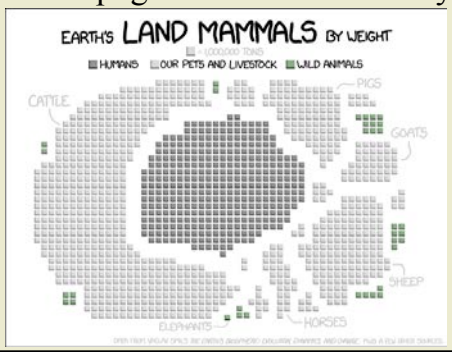
Altered gene pools



Invasives from North America!

Deliberately Introduced Species

Anthropogenic Loss of Diversity



Community Stability

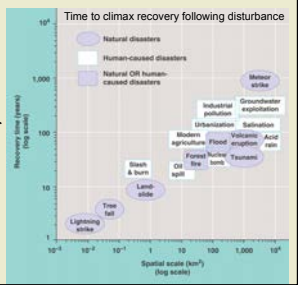
- Community stability may be due to lack of disturbance or community resistance or resilience in the face of disturbance
  - –Stability: Absence of change.
  - –Resistance: Ability to maintain structure and function in face of potential disturbance.
  - –Resilience: Ability to recover from disturbance.

Community Succession

- **Succession**: The gradual change in community structure, composition and distribution over time, generally following a significant disturbance to the environment.
- A **disturbance** is an event that changes a community
  - – Removes organisms from a community
  - – Alters resource availability

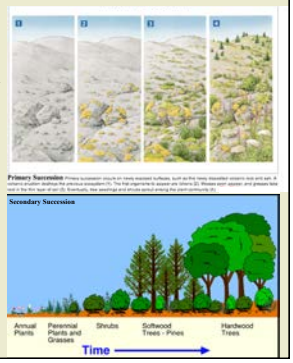
Community Succession

- **1° succession** is a change from a prebiotic to a biotic habitat following a catastrophic disturbance.
  - – The **pioneer community** is typified by rapid colonizing opportunistic (r-type) species.
- **2° succession** is the gradual replacement of opportunistic species by more specialized competitors.
- Stability is the end-product of succession when it is not interrupted by significant disturbances.
  - – The **climax community** is a stable association of dominant K-type specialists.



Community Succession

- **1° succession**.
  - Earliest **pioneer species** mostly lichens
    - fungal/algal symbionts — Survive on sunlight, air moisture & dust
  - Lichen acids + physical erosion ⇒ minimal soil ⇒ non-vascular mosses/liverworts
  - Further erosion + organic detritus ⇒ more soil ⇒ herbaceous grasses & N-fixers
- **Early 2° succession**.
  - Grass fibrous roots stabilize soil and moisture
  - N-fixation + organic deposition ⇒ ↑ quality & quantity of soil ⇒ ↓ "bulk density" of soil



Primary succession on moraines behind retreating glaciers

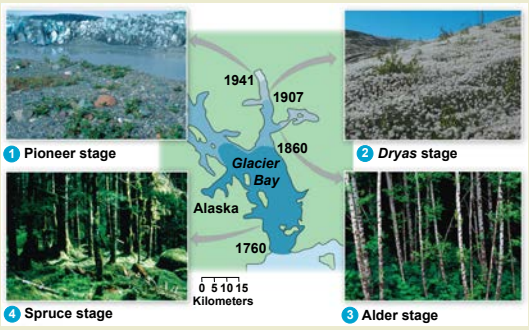
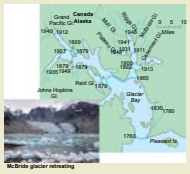


Figure 54.22

Primary succession on moraines behind retreating glaciers

- Pioneer community species may facilitate the appearance of later species by making the environment more favorable



- Glacier Bay, Alaska
  - Succession follows a predictable pattern of change in vegetation and soil characteristics

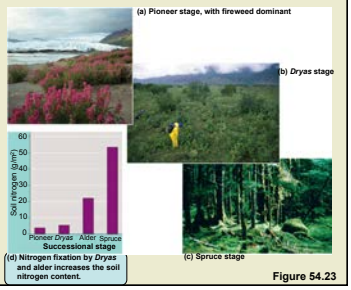
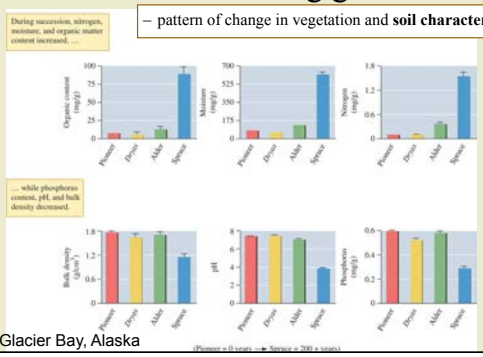


Figure 54.23

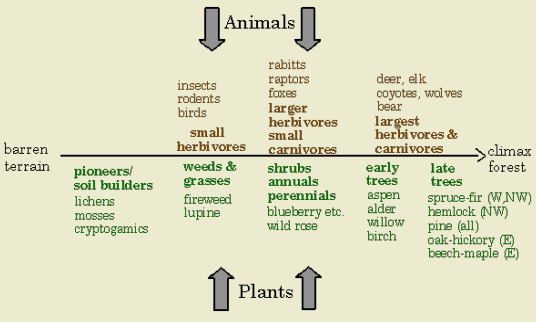
Primary succession on moraines behind retreating glaciers

- pattern of change in vegetation and **soil characteristics**



- Glacier Bay, Alaska

Succession of Vegetation ⇒ Succession of Community



Community Succession

- You can see we've come full circle back to those life history concepts of r and K.
- Dunes in Indiana were the first place succession was studied: from sand dunes to invading grasses to low shrubs to birches to other hardwoods.
- Ponds and bogs will slowly fill with vegetation and transform into terrestrial habitat, eventually becoming forest.

Community Succession — The Intermediate Disturbance Hypothesis

- Although few species are hardy enough to pioneer the colonization of a harsh, prebiotic habitat, most disturbances are not severe enough to reduce the environment to bare rock. Therefore most disturbances propagate only 2^{o} succession.
- Climax communities are dominated by a few long-lived ultra-competitors which may limit species diversity.
- Therefore community diversity is greatest before the climax community is reached — while competitive interactions have not yet eliminated many of the species.
  - Disturbances, by preventing the climax community, may be important for maintaining high species diversity in tropical reefs and forests.

Intermediate Disturbance Hypothesis
stream ecology

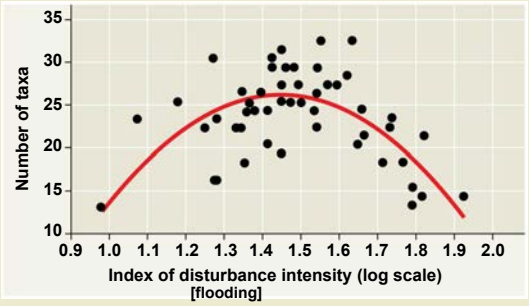
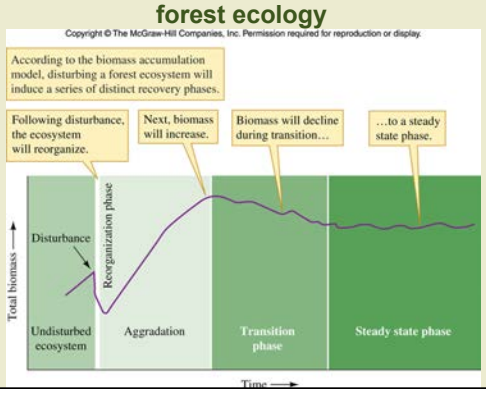


Figure 54.20

Intermediate Disturbance Hypothesis
forest ecology



Secondary succession following FIRE

- Fire is a significant disturbance in most terrestrial ecosystems
  - It is often a necessity in some communities

Figure 53.21

(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.

Secondary succession following FIRE

- The large-scale fire in Yellowstone National Park in 1988

(a) Soon after fire. As this photo taken soon after the fire shows, the burn left a patchy landscape. Note the unburned trees in the distance.

(b) One year after fire. This photo of the same general area taken the following year indicates how rapidly the community began to recover. A variety of herbaceous plants, different from those in the former forest, cover the ground.

Figure 53.22

Succession is not always predictable
Variations in stages may result in different climax communities