

# Community Ecology



## Biodiversity

- Levels of biological diversity

## Biodiversity

- Species richness = # species/area
- Relative abundance = proportion of total diversity taken up by a few dominant species
- ↑ species richness + ↓ relative abundances ⇒ ↑ biodiversity stability

## 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<sub>i</sub> = 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

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

Community 1: A: 25% B: 25% C: 25% D: 25%

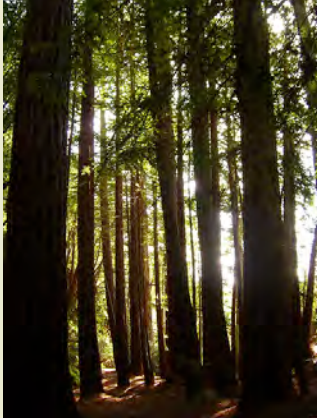
Community 2: A: 80% B: 5% C: 5% D: 10%

Community 1 calculations:  
 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

Community 2 calculations:  
 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

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

- Climate
  - especially water availability

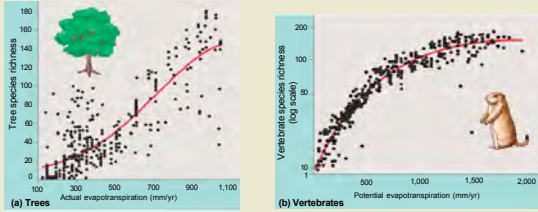


Figure 53.25

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

- Available geographical area for the community

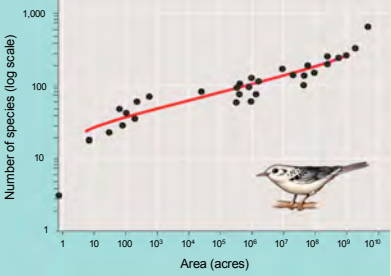


Figure 53.26

### 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


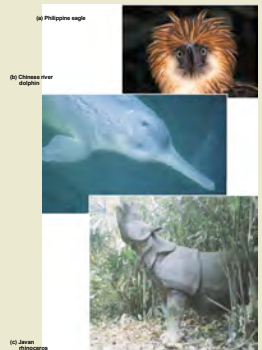


Figure 55.17

### Extinction is forever

Hundred-heartbeat club-members

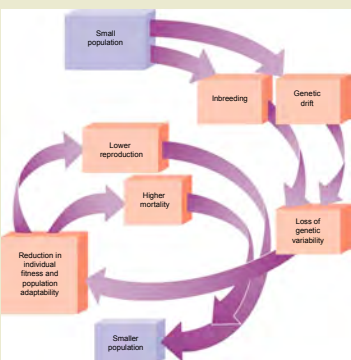
- Endangered species
  - In immediate danger of becoming extinct throughout its range
- Hundred-heartbeat Club**
  - <100 individuals left!
- Threatened species
  - Likely to become endangered in the foreseeable future if current trends continue



(a) Philippine eagle  
(b) Chinese river dolphin  
(c) Asian rhinoceros

### The Extinction Vortex

- A diminished population is prone to positive-feedback loops that draw the population down an extinction vortex
- Once population size is reduced to a critical level [the **Minimum Viable Population**], it may not be able to recover!



## 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<sup>2</sup>
- Reduce phytoplankton levels
- Loss of fish
- Cover every hard surface
- Clogged water intake pipes



## THE PROBLEM OF INTRODUCED SPECIES


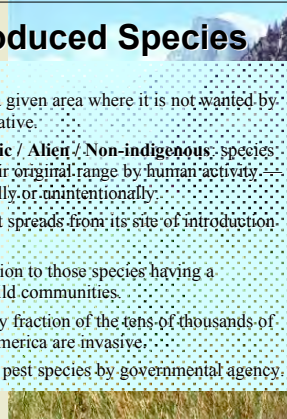


- African honeybee
- Wanted to cross-breed with honey-bee
- Escaped
- Aggressive towards humans and animals
- Ten deaths in U.S.

## 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

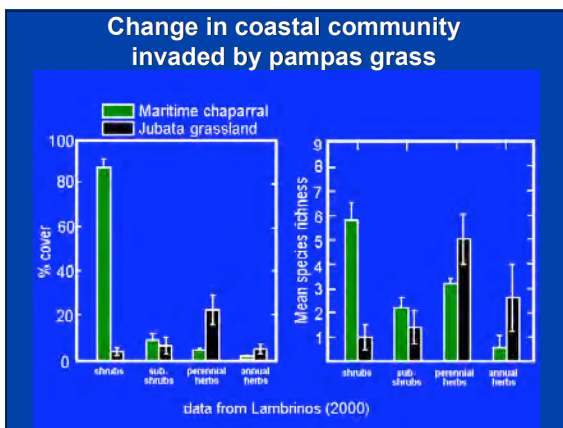


- Scotch broom (*Cytisus scoparius*, the dark green shrub) invades grasslands and marshes, converting them to shrublands.

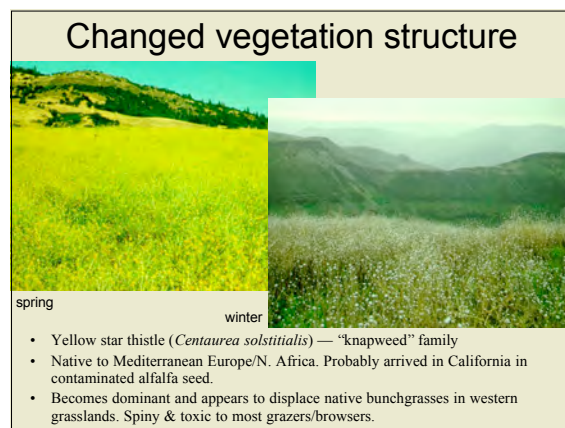
### Changed vegetation structure



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

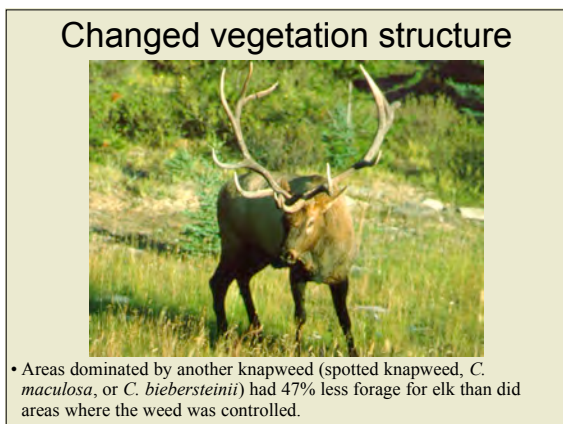


### Changed vegetation structure



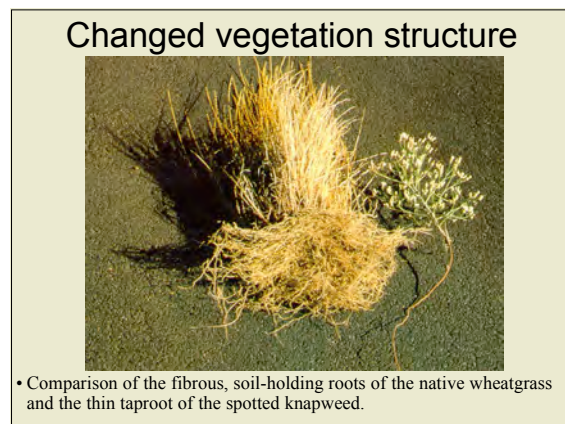
- Yellow star thistle (*Centaurea solstitialis*) — “knapweed” family
- Native to Mediterranean Europe/N. Africa. Probably arrived in California in contaminated alfalfa seed.
- Becomes dominant and appears to displace native bunchgrasses in western grasslands. Spiny & toxic to most grazers/browsers.

### Changed vegetation structure

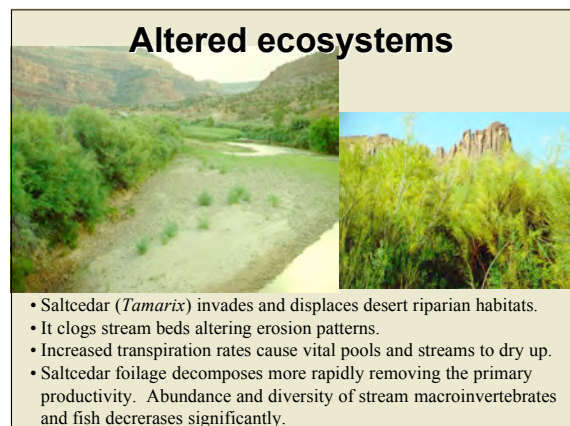
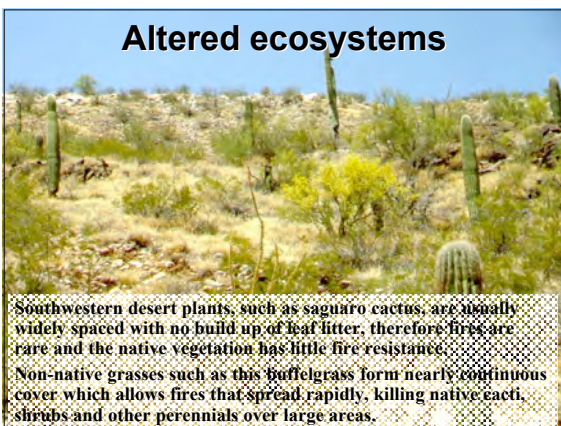
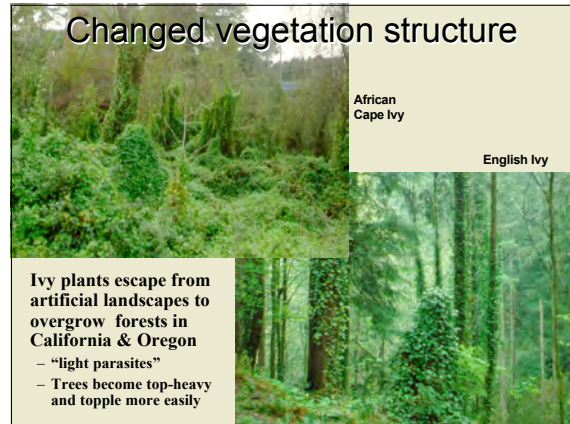
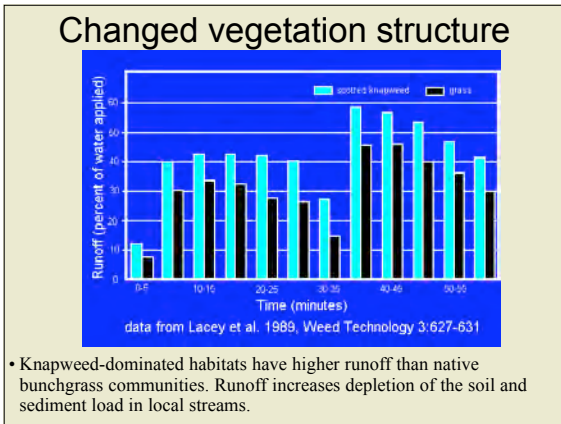


- Areas dominated by another knapweed (spotted knapweed, *C. maculosa*, or *C. biebersteinii*) had 47% less forage for elk than did areas where the weed was controlled.

### Changed vegetation structure


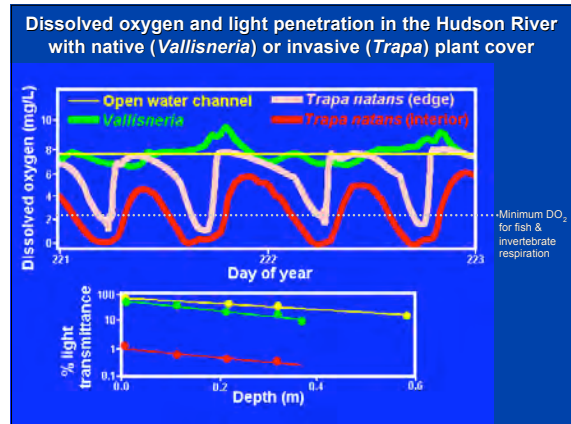


- Comparison of the fibrous, soil-holding roots of the native wheatgrass and the thin taproot of the spotted knapweed.



### Altered ecosystems

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


### 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



Atlantic smooth cordgrass (*Spartina alterniflora*) hybridizes with native Pacific saltmarsh cordgrass (*Spartina foliosa*).  
 - Local populations eliminated as distinct species.

- *Spartina foliosa*
- *Spartina alterniflora*
- *Spartina* hybrid

San Francisco

25 km

data from Ayres et al. (1999)

### Invasives from North America!



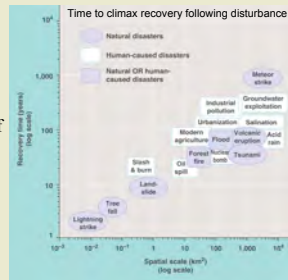
North American pines invading grassland and riparian habitat in southern Brazil

### 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

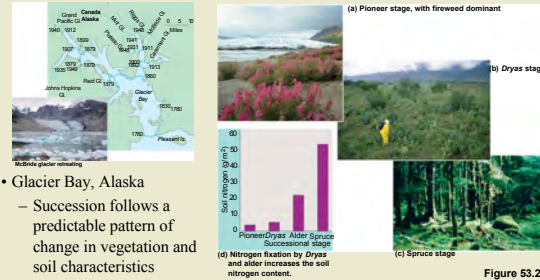
### Community Succession

- **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.



### 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 53.24

### 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.

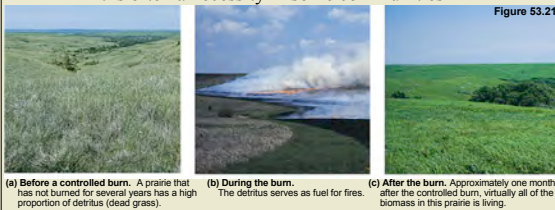
### Community Succession —

#### 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° 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.

### Secondary succession following FIRE

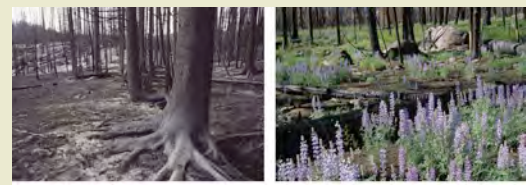
- Fire is a significant disturbance in most terrestrial ecosystems
  - It is often a necessity in some communities



(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