Chapter 10: Ecological Restoration

Restoration Ecology

- New field of restoration ecology developed w/in the science of ecology.
  - Goal = return damaged ecosystems to some set of conditions considered functional, sustainable and "natural".
- Restore to what?

Balance of Nature

- Predominant belief that left undisturbed an ecosystem would achieve a single condition that would persist indefinitely.
- Major tenets of this belief
  - 1. Nature undisturbed achieves a permanency of form and structure that persists indefinitely
  - 2. If it is disturbed and the disturbing force removed, nature returns to exactly the same permanent state.
  - 3. In this permanent state of nature, there is a "great chain of being" with a place for each creature.

Balance of Nature

- Twentieth century ecologist formalized the belief in the balance of nature
  - Climate state – steady-state stage that would persist indefinitely
    - Maximum biological diversity
    - Maximum storage of chemical element
    - Maximum biological diversity

Balance of Nature

- Since the second half of the 20th century ecologist have learned that nature is not constant.
  - All ecosystems undergo change
  - Species adapted to and need change
- Dealing with change poses questions of human value
  - Controlling and managing fire

Boundary Waters Canoe Area Wilderness

- 400,000 hectares in N Minnesota designated as wilderness
  - Closed to logging and other direct disturbance
- Area has a natural history of fire
  - On average area burns once a century
  - When they occur at natural rate they have beneficial effects
  - Landscape depends on change (dynamic)

Goals of Restoration

- Frequently accepted that restoration means restoring an ecosystem to its historical range of variation and to an ability to sustain itself and its crucial functions
  - Cycling of chemical elements
  - The flow of energy
  - Maintenance of biological diversity

Goals of Restoration

- Science tells us what nature has been and what it could be.
- Our values determine what we want nature to be.
  - There is no single perfect condition.

Table 10.1 Some Possible Restoration Goals

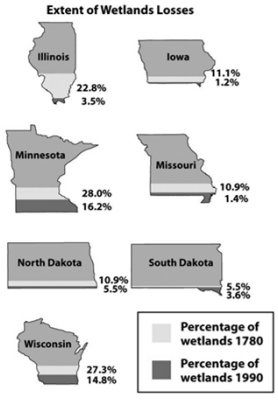
Goal	*Approach*
1. Pre-Industrial	Maintain ecosystems as they were in A.D. 1500
2. Presettlement (e.g., of North America)	Maintain ecosystems as they were about A.D. 1492
3. Preagriculture	Maintain ecosystems as they were about 5000 B.C.
4. Before any significant impact of human beings	Maintain ecosystems as they were about 10,000 B.C.
5. Maximum production	Independent of a specific time
6. Maximum diversity	Independent of a specific time
7. Maximum biomass	Independent of old growth
8. Preserve a specific endangered species	Whatever stage it is adapted to
9. Historical range of variation	Create the future like the known past

What Needs to be Restored?

- Ecosystems of all types have undergone degradation and need restoration.
- Once again discussions about restoration involves values.

Wetland, Rivers, and Streams

- Estimated that CA has lost 90% of its wetlands.
  - The US about 50%
- Kissimmee River in Florida
  - Channelized to provide ship passage
  - Now under going restoration at cost of several hundred million dollars



Prairie Restoration

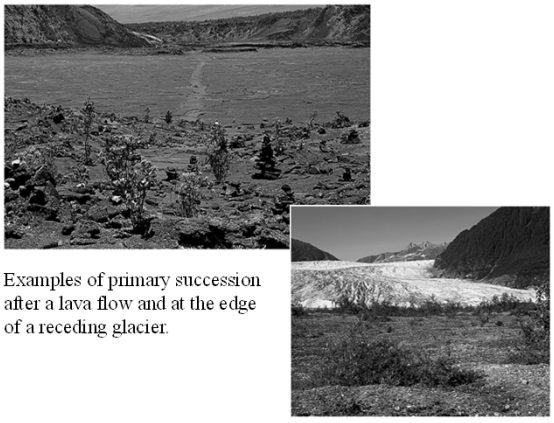
- Prairie once occupied more land in US than any other kind of ecosystem.
  - Only a few remnants remain
  - Land converted to agriculture
- Two kinds of restoration
  - Intact prairie (never been plowed)
  - Previously plowed land more complicated to restore

Prairie Restoration

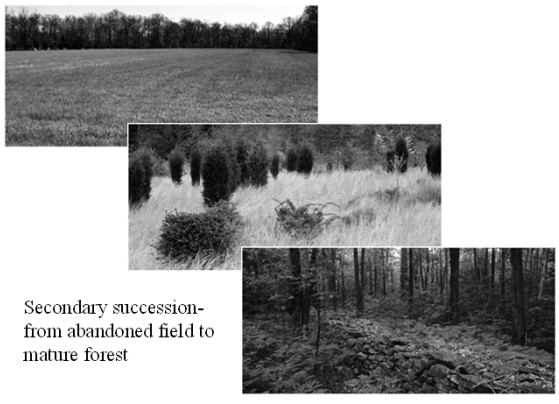
- Area along road ways not plowed
  - Narrow strips of native prairie remain
  - In Iowa 242,000 hectares of prairie along roadways
  - Reservoir for native plants
  - Used as send sources for other restoration projects

The Process of Ecological Succession

- Recovery of disturbed ecosystems can occur naturally, through a process of ecological succession.
- Primary succession
  - The initial establishment and development of an ecosystem where one did not exist previously
- Secondary succession
  - Reestablishment of an ecosystem following disturbance



Examples of primary succession after a lava flow and at the edge of a receding glacier.



Secondary succession- from abandoned field to mature forest

Patterns of Succession

- When succession occurs it follows certain general patterns.
  - Three examples include dunes, bog and abandoned farm field

Dune Succession

- Sand dunes continually formed along sandy shores.
  - Then breached and destroyed by storms
- After dune forms
  - First to be established are grasses
  - Grass runners stabilize dunes
  - Other species seeds may germinate and become established

Dune Succession

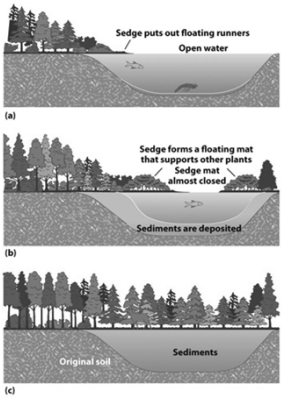
- Plants of early succession tend to be
  - Small, grow well in bright light, and withstand harshness of environment
- Over time larger plants can become established
  - Eastern red cedar, eastern white pine
  - Beech and maple later on

Bog Succession

- A bog is an open body of water with surface inlets but no surface outlets.
- Succession begins with
  - Sedge puts out floating runners
  - Wind blows particles into the mat of runners
  - Seeds that land on top don't sink in the water and can germinate
  - Mat becomes thicker and shrubs and trees can grow

Bog Succession

- The bog also fills in from the bottom
  - The the shoreward end floating mat and sediment will meet, forming a solid surface.
  - Farther from shore all the vegetation is still floating



Old-Field Succession

- A great deal of land cleared for farming in the 18th and 19th centuries
  - That land now allowed to go back to forest
- Succession
  - The first plants to enter the farm land are small plants adapted to harsh and variable conditions.
  - After they are established larger plants move in.

General Patterns of Succession

- Common element include the following
  - 1. An initial kind of vegetation specially adapted to the unstable conditions.
    - Typically small
    - Help stabilize physical environment
  - 2. A second stage with plants still of small statute, rapidly growing, with seeds that spread rapidly.

General Patterns of Succession

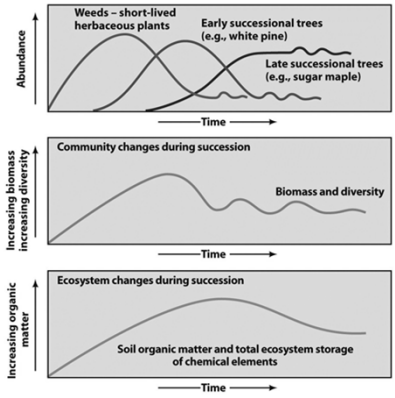
  - 3. A third stage in which larger plants, including trees, enter and begin to dominate the site.
  - 4. A forth stage in which mature forest develops.

General Patterns of Succession

- Successional stages
  - Early (1 and 2), middle, and late
- Similar patterns seen with animals and other life-forms at each stage.
  - Species characteristic of early stage are called pioneers
  - Late-successional species tend to be slower-growing and longer-lived

General Patterns of Succession

- In early stages of succession
  - Biomass and biological diversity increase
- In middle stages
  - Gross production increase and net production decrease
  - Organic material in soil increases, as does chemical element storage



Succession and Chemical Cycling

- Storage of chemical elements generally increases during progression from early to middle for two reasons.
  - 1.Organic matter stores chemical elements
    - As one increases the other will increase
    - Nitrogen fixation
  - 2. Presence of live and dead matter helps stop erosion.

Succession and Chemical Cycling

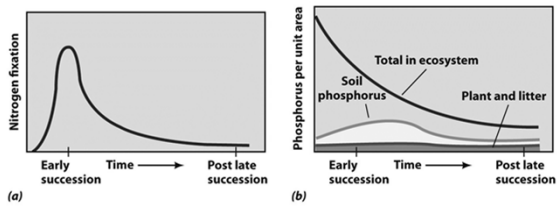
- As general rule, the greater the volume of soil and the greater the % of organic matter in the soil , the more chemical elements will be retained.
  - Varies with average size of soil particles

Succession and Chemical Cycling

- The chemical storage capacity of soils varies w/ average size of the soil particle.
  - Large coarse particles, like sand, have a smaller total surface area and can store a smaller quantity of chemical elements.
  - Smaller particles, like clay, store greater quantity of chemical elements.
- Soils store large quantities of c.e. but not as readily available as those in living organisms.

Succession and Chemical Cycling

- The increase in chemical element does not continue indefinitely.
- With no disturbance ecosystem will have a slow loss of stored chemical elements
  - Becoming depauperate



Species Change in Succession

- Earlier and later species in succession may interact in three ways
  - Facilitation
  - Interference
  - Life history differences
- If they don't interact the result is chronic patchiness

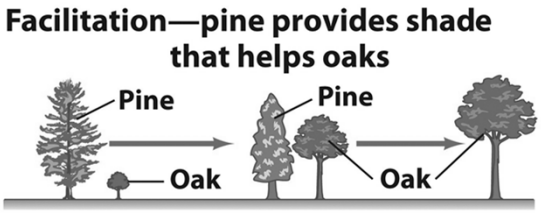
Table 10.2 Patterns of Interaction among Earlier and Later Species in Succession

1. ***Facilitation*. One species can prepare the way for the next (and may even be necessary for the occurrence of the next).**
2. ***Interference*. Early-successional species can, for a time, prevent the entrance of later-successional species.**
3. ***Life history differences*. One species may not affect the time of entrance of another; two species may appear at different times during succession because of differences in transport, germination, growth, and longevity of seeds.**
4. ***Chronic patchiness*. Succession never occurs, and the species that enters first remains until the next disturbance.**

Source: **J. H. Connell and R. O. Slatyer, "Mechanisms of Succession in Natural Communities and Their Role in Community Stability and Organization," *American Naturalist* III (1977): 1119–1144; S. T. A. Pickett, S. L. Collins, and J. J. Armesto, "Models, Mechanisms, and Pathways of Succession," *Botanical Review* 53 (1987): 335–371.**

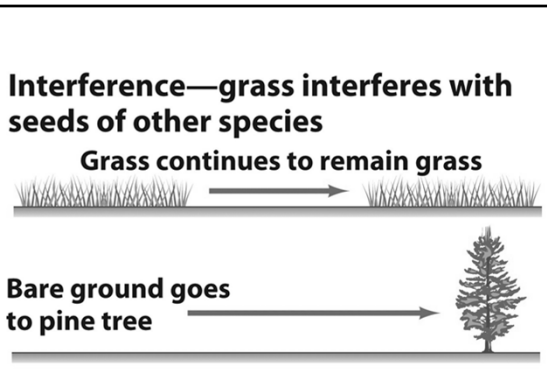
Facilitation

- In the dune and bog the facilitators are the dune grass and floating sedge, respectively.
  - They prepare the way for other species
- Knowing the role of facilitation helps w/ restoration
  - These plants can be planted first



Interference

- Certain early species interfere w/ the entrance of other species.
  - Grasses may form dense mats blocking other seeds from germinating.
  - Breaks in the mat allow other to be established

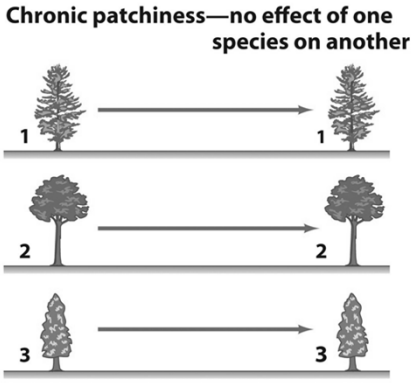


Life History Differences

- An example of life history differences is seed dispersal.
  - Early-successsional species are readily transported by wind or animals.
    - Reach clearing sooner
  - Late-successional species seeds take longer to travel and seedlings can tolerate shade.

Chronic Patchiness

- Common in deserts
  - Major shrub species grow in patches
  - Patch persist for long period of time until next disturbance.
- Life tends to build up, aggrade
- Non-biological processes tend to erode or degrade.
  - In harsh environments degrading dominates and succession does not occur.



Applying Ecological Knowledge

- Undo mining damage in Great Britain
  - To remove toxic pollutants
  - Restore biological production
  - Restore attractiveness of landscape
- Agricultural approach failed
  - Grasses soon died and land was barren again
- Ecological approach has been successful
  - Planting early successional species