Chapter 4: Ecosystem Diversity
Biomes and biodiversity

• Biodiversity hotspots
  – Norman Myers (Oxford University) and Russell Mittermeier (Conservation International)
  – criteria for classification as a hotspot
    • how biologically unique is the area = number of endemic plant species
    • how severe is the threat of development = ≥70% loss of natural vegetation
Myers and Mittermeier’s biodiversity hotspots
Global biodiversity hotspots

• 25 global areas with exceptionally high biodiversity are in danger of being lost to development
  – 1.4% of the land area on earth
    • 44% of all plant species
    • 35% of all vertebrate species (excluding fishes)
  – California is the only N. American hotspot
  – why aren’t these areas on the on list?
    • Amazon rainforest
    • most of N. America and Europe
Biomes and biodiversity: problem

• Traditional conservation efforts have been aimed at tropical moist forests (rainforests) because they harbor 50% of the earth’s species

• If we want to conserve earth’s biodiversity, what about the other 50%?

• E.g., tundra, dry forests, grasslands, lakes, polar seas
Global 200 Ecoregions (WWF)

- **Ecoregion**: “relatively large unit of land or water containing a characteristic set of natural communities that share a large majority of their species, dynamics and environmental conditions”

- Described **233 ecoregions**
  - 136 terrestrial
  - 36 freshwater
  - 61 marine

- **Representation approach**
Selection criteria

- Species richness
- Species endemism
- Number of unique higher taxa
- Unusual ecological or evolutionary phenomena
- Global rarity of major habitat types (MHT)
Global 200 terrestrial ecoregions

• Tropical and subtropical moist broadleaf forests
• Tropical dry forests
• Tropical and subtropical conifer forests
• Temperate broadleaf and conifer forests
• Boreal forests and tundra
• Arctic tundra
• Temperate grasslands, savannas, shrublands
Global 200 terrestrial ecoregions

- Tropical and subtropical grasslands, savannas and shrublands
- Flooded grasslands and savannas
- Tropical montane grasslands and savannas
- Deserts and xeric shrublands
- Mediterranean shrublands and woodlands
Global 200 aquatic ecoregions

- Freshwater ecoregions
- Marine ecoregions
Focal 25 ecoregions

• Africa and Madagascar: 6
• Asia and the Pacific: 7
• Latin America and the Caribbean: 8
• North America: 5
• North America
  – Bering Sea
  – Klamath-Siskiyou forests
  – Chihuahuan deserts
  – Rivers and streams of the southeastern U.S.
  – Florida Everglades
WWF Ecoregions in U.S.

- Klamath – Siskiyou forests
- Chihuahuan desert
- SE rivers and streams
- Everglades
Everglades and Florida Keys

- **Characteristics**
  - 60 x 300 miles of south Florida from the Kissimmee River through Florida Bay
  - “river of grass”
  - seldom >2 feet deep
  - today is half its original size
Everglades and Florida Keys
Everglades and Florida Keys

• Plant biodiversity
  – **plant communities**
    • sawgrasses
    • sloughs
    • tropical hardwood hammocks
    • cypress swamps
    • mangrove estuaries
  – 11,000 species of seed plants
  – 25 species of orchids
  – tropical palms, temperate oaks, cactus and yucca
Everglades and Florida Keys

- **Animal biodiversity**
  - number of species
    - >300 species of birds
    - >400 land / water vertebrates
    - *Liguus* tree snails with 52 color forms
  - >60 federally listed species
Everglades and Florida Keys

- Threats
  - diversion of water
  - saltwater intrusion
  - loss of species
    - seagrasses
    - sponges
    - fish
    - shrimp
    - lobsters
Rivers / streams of the U.S. southeast

• Characteristics
  – Virginia to Florida and Carolinas to Mississippi
  – Appalachians through Carolina piedmont to Gulf coastal plain
  – 250,000 square miles

Cahaba River, Alabama
Rivers / streams of the U.S. southeast

Cahaba River, Alabama
Rivers / streams of the U.S. southeast

• Biodiversity
  – Cahaba River fish
    • >131 species
    • 18 endemic species
    • more fish species per mile than in any other North American river
Rivers / streams of the U.S. southeast

• Biodiversity
  – mollusk diversity
    • among world’s highest
    • 90% of mussels and 73% of aquatic snails in U.S.
    • among most threatened
  – alligators, turtles
Rivers / streams of the U.S. southeast

• Threats
  – rapid population growth in Appalachia and Atlanta
  – dam and canal construction; excessive water withdrawals
  – clear cutting for timber; pine tree farming
  – water pollution from agriculture, timber and mining
  – transfer of water and sewage from one basin to another
  – introduction of non-native game fish
  – water pollution from urban development
Klamath-Siskiyou forests

• Characteristics
  – California-Oregon border
  – geologically unique ecoregion at junction of
    • uplifted Coast Ranges
    • volcanic Cascades
    • ancient Sierra Nevadas
  – old, forest covered mountains with ancient trees
  – inaccessibility
Klamath-Siskiyou forests
Klamath-Siskiyou forests

• Biodiversity
  – plants
    • over 1,800 species
    • 131 endemic species
    • more species of conifers than anywhere else north of Mexico
    • conifers can live >1000 years
  – endangered animal species
    • northern spotted owl
    • marbled murrelet
    • bald eagle
    • several species of Pacific salmon (CA coho)
    • steelhead trout
Klamath-Siskiyou forests

• Threats
  – only 25% still intact and only 10% legally protected from logging
    • old growth and mature riparian forests critically endangered
    • 10 plant communities and 155 species of plants and animals found only in this region
  – resource extraction
  – habitat fragmentation
Klamath-Siskiyou forests

• Threats
  – fire suppression
  – overgrazing, irresponsible mining and logging endanger aquatic habitats
  – spread of waterborne root rot fungi by logging and road building
  – urban sprawl
Chihuahuan deserts

• Characteristics
  – 250,000 square miles from southeast Arizona across New Mexico and west Texas southward into Mexico
Chihuahuan deserts

• Characteristics
  – habitat diversity
  • dunes, grasslands, mountains, spring-fed pools
Chihuahuan deserts

• Characteristics
  – habitat diversity
Chihuahuan deserts

• Area ranks #3 in biodiversity compared to all deserts of the world
• More species of mammals than Yellowstone
• More species of birds than Everglades
• More species of plants than forests of the Pacific northwest
• More reptile species than Sonoran desert
Chihuahuan deserts

- Characteristics
  - biodiversity
  - 250 species of cactus
Chihuahuan deserts

• Characteristics
  – biodiversity
    • northernmost range of many tropical bird species
    • 250 species of butterflies
Chihuahuan deserts

- Characteristics
  - biodiversity
  - largest population of prairie dogs in the world
Chihuahuan deserts

- Characteristics
  - biodiversity
    - Mexican wolves
    - pronghorn antelope
    - jaguars
    - javalina
    - many rodent species
    - many reptile species
Chihuahuan deserts

• Threats
  – human population growth and development
  – resource extraction: copper, gypsum, salt, lime, sand
  – overgrazing
Ecoregions of North America
Ecoregions of Texas

"Natural Regions of Texas" map adapted from Texas Parks & Wildlife Dept.
Ecological succession

- Directional, orderly change in vegetation over ecological time
- **Sere**: community at one point in time
- Process goes in one direction but is not smooth
Ecological succession

- **Primary succession**
  - one time process in which the physical and/or chemical properties of a site are modified in such a way that more complex plant/animal communities are possible

- **heterotrophic succession**
  - decomposing log
  - decomposition of a carcass
Primary succession

Exposed rocks

Lichens and mosses

Small herbs and shrubs

Heath mat

Jack pine, black spruce, and aspen

Balsam fir, paper birch, and white spruce climax community

Time
Ecological succession

• **Secondary succession**
  – reoccurs in same place following temporary disturbances
  – predictable based on four factors
    • climate
    • etaphic factors
    • fire regime
    • grazing pressure
Secondary succession
Ecological succession

- Successional communities
  - pioneer
  - intermediate / transitional
  - climax
Ecological succession

• Successional process: grasses → shrubs → pines → hardwoods
  – **simple**: succession → grassland
  – **complex**: succession → hardwood forest
  – Why is succession simple in places that look like it could be complex?
Models for ecological succession

Facilitation Model

A → B → C → D

Tolerance Model

A → B → C → D

Inhibition Model

A → B → C → D
Facilitation model

- Only certain pioneer species are able to colonize the site due to hostile conditions (low nutrients, poor soil, etc.)

- Pioneers modify environment and increase its suitability for later species (increase N, change pH, break up soil, etc.)

- Suitability for offspring of pioneers decreases

- Species shift from pioneers to next stages

- Climax species replace themselves
Tolerance model

• Any species can colonize the site following a perturbation

• No alteration of the environment occurs to increase its suitability for later species

• Later species present early on but do not dominate community

• Later species gradually outcompete early species because they can better utilize space and tolerate conditions

• Succession continues until no species exist that can invade and grow in the presence of the resident species
Inhibition model

- Any species can colonize the site following a perturbation
- The first species present occupy the site to the detriment of later species (physical or chemical)
- Change occurs only when early species are physically removed
Comparison of succession models

- **Facilitation model**
  - specific pioneer species change environment and therefore facilitate the later species
  - each stage ruins the site for its offspring

- **Tolerance model**
  - any species can colonize the site
  - later species outcompete early species over time

- **Inhibition model**
  - any species can colonize the site
  - first species present inhibit the establishment of others
  - species composition changes only after a disturbance
Current thoughts on succession

• Succession occurs in **mosaics** across the community

• What is a **climax community**?
  – classic: oak-maple hardwood forest
  – E. Texas: beech-magnolia forest?
  – mountains, deserts, tundra, coastal areas?

• Effects of **human interference** on natural successional processes
  – logging
  – power line easements
  – fire control
  – pollution
Examples

- Krakatau
- Mt. St. Helens
- Yellowstone
Primary succession on Krakatau Islands, Indonesia

- 1883: No life
- 1903: Blue-green algae and grasses
- 1923: Grassland with trees and shrubs
- Complete forest canopy formed about 1928
- 1943: Forest increasing in canopy height
- 1963: Species composition changing slowly
- 1983: Canopy height (m)
Mt. St. Helens: pre-1980 eruption

• Dense, temperate coniferous rainforests
• Large areas modified by timber extraction
• Sparse alpine vegetation above treeline
• Crystal clear lakes and cold, fast flowing streams
Mt. St. Helens: post-1980 eruption

• Eruption on May 18, 1980
• Removed or leveled 350 km² of old-growth and younger aged forests
• Dramatically altered many ecosystems in the area
Mt. St. Helens: comparison
Mt. St. Helens: post-1980 eruption
Mt. St. Helens

NASA Photo, September 1994; Modified with text, Lyn Topinka, USGS/CVO, 1999
Succession and recovery

• Terrestrial vegetation
  – blowdown zone succession patterns
    • wind dispersed herbaceous plants (e.g., fireweeds) colonized barren surfaces within one year
    • mix of late successional understory trees and pioneers
    • differential survival of species
      – Pacific silver fir, mountain hemlock survived
      – shade adapted plants mostly died out
  • fast recovery of riparian areas
Succession and recovery

• Terrestrial vegetation
  – pyroclastic flow zone succession patterns
    • no individuals survived initial blast
    • classical succession theory predicted long recovery: mosses, liverworts $\rightarrow$ shrubs $\rightarrow$ conifers
    • >20 years after eruption, many areas in this zone still only sparsely vegetated
    • only 2 main types of plant assemblages
      – willow-herb communities, restricted to springs and seeps
      – patches of lupines on pumice plains, N fixing bacteria (facilitation model)