CHAPTER 4

ECOLOGY AND GEOLOGY

Ecology & Geology Linkage

Ecology

- Study of relationships between living things and their environments; the study of control factors over the distribution, abundance, and health conditions of living things

Environmental Geology

- Study of geological processes and their effects on environment

The linkage

- complex linkages, varies at different scales

Fundamental Ecology Terms

- Species: a group of individuals capable of interbreeding; can be indigenous or exotic
- Population: a group of individuals of the same species living in the same area
- Community: a group of the populations of different species living in the same area
- Biota: all organisms living in an area or a region
- Biosphere: the part of Earth where organisms exist and function

Ecosystem

- An ecological community and its surrounding environment in which the flows of energy and cycles of chemicals support the living community

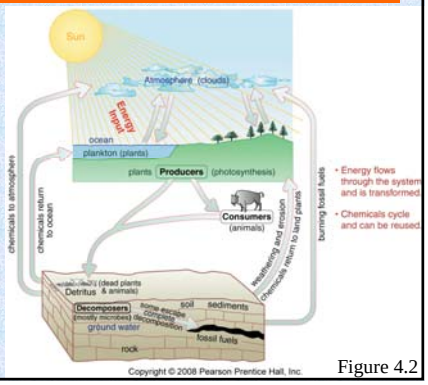


Figure 4.2

Types of Ecosystems

- Natural indigenous: ecosystem as the result of completely natural evolutional processes, rarely exist
- Human modified: the one modified by human use and interest, almost all the major ecosystems
- Human constructed: man-made ecosystem for many different purposes at many sites, such as ponds, canals, wastewater treatment pools

Natural Service Functions of Ecosystems

- Natural Service Functions are those processes responsible for producing clean water, air, and living matter
- Direct functions
  - Cycle of chemical elements, e.g., CO_2, O_2
  - Flow of energy & nutrients
  - Removal of pollutants
- Buffering functions: providing protections from natural hazards, e.g., wetlands against coastal flooding and erosion

Biodiversity

The number or abundance of species in an ecosystem or ecological community

- Species richness: the number of species
- Species evenness: the relative proportion of species
- Species dominance: one of multiple species more common than others
- Keystone species: exerting a stronger community effect disproportionate to their abundance

Geology & Biodiversity

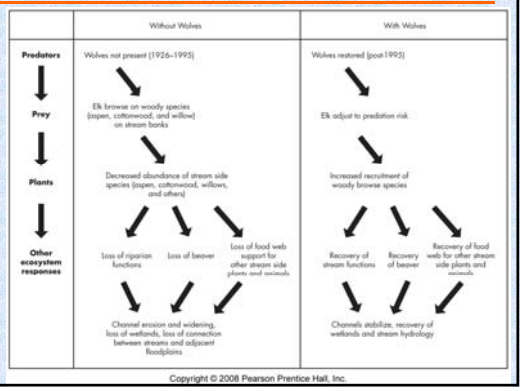
- Geology affects the overall environmental conditions of an ecosystem
  - Changes in topography, e.g., mountain building & slope movement
  - Plate tectonics and ecosystem barrier, e.g., North America & Europe tree diversity vs. mountain range distribution
  - Changes in climate: ice age, glaciation, and global warming
  - Soils development

Keystone Species (1)

- Keystone species: species exert strong community effects disproportionate to their abundance
- Case study: wolf, elk, and mountain stream system in Yellowstone National Park
  - 1960s to mid-1990s: elk overbrowsed the riparian vegetation and affected the stream ecosystem
  - late 1990s: reintroduced wolves that hunted elk and promoted the growth of riparian vegetation, water quality, and stream ecosystem

Keystone Species (2)

Figure 4.5



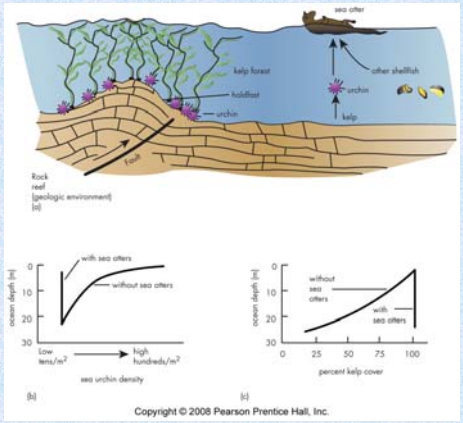
Before

After

Keystone Species (3)

Sea otters, urchins, and kelp

- Kelp forests: three parts – rootlike holdfast, stem (stipe), and blades (leaves)
- Holdfast attached to boulders or the rocky bottom, part of the active geological environment
- Urchins fed on the holdfast of kelp
- Sea otters were restored and fed on urchins, kelp forests were restored



Factors to Increase Biodiversity

- Favored geological environment
  - Moderate amount of disturbance – hazards creating or renewing habitats
  - Harsh environments for certain unique specialized species, increasing biodiversity at regional scale
- Relatively constant environmental conditions, such as T, P, precipitation, and elevation
- Highly modified biologically productive environment

Factors to Reduce Biodiversity

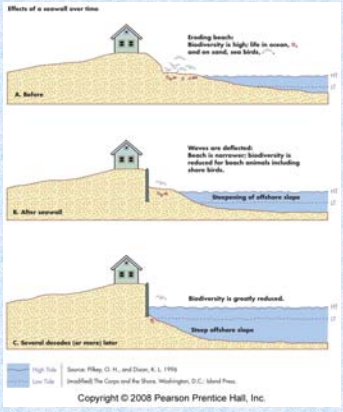
- Extreme geological environment
  - Extreme disturbances damage habitats
  - Limit the number of habitats and ecological niches at a local scale
  - Pollution and other stresses restricting the flow of energy and nutrients
- Fragmentation of ecosystems by land use transformation
- Intrusion of invasive exotic species
- Habitat simplification (engineering structure) or migration barriers

Human Domination

- Human activities exerting dominant community effects
  - Massive land use transformation – urban, agriculture, recreation, and industry development
  - Global climate changes
  - Changes in biogeochemical cycles – O_2, CO_2, energy, and nutrients
  - Most rapid extinction of many species during the last 2000 years

Case Study: Seawalls and Biodiversity

- Seawall construction
  - Beach space narrowed
  - Biodiversity on the beach reduced
  - Waves are deflected
  - Gradient increases of offshore slope



Time Dimension: Human Time vs. Earth Time

- Geological processes on Earth time scale
- Human activities and expectations on human time scale
- Need to operate with an appropriate environmental ethic to prevent degradation
- The Point: Earth will be here long after us

Reduce the Human Footprint

- Human population reduction
- More efficient use of resources
- Better management of our waste
- Better understanding of ecosystems
- The importance of human-dominated ecosystems and other types of ecosystems

Ecological Restoration Kissimmee River

- The process of altering a site or area to reestablish indigenous historical ecosystems
  - Prior to 1940, wide floodplain with diverse wetland plants, wading birds, waterfowl, fish, and other wildlife
  - 1942–1971: 2/3 of the floodplain drained, degraded ecosystem functions and reduction of bird and fish populations
  - 1992: restoration project authorized by Congress
  - 12-km straight channel restored to a meander

Ecological Restoration Everglades

- Since 1900, urban development, much of the Everglades drained
- One of the most valuable wetland ecosystems
  - 11,000 species of plants
  - Hundreds of species of birds, fish, marine mammals
  - 70 threatened or endangered species
- Multilevel partnership restoration project
- Reduction of pollution and removal of invasive exotic species

Important Restoration Aspects

- Hydrologic process: surface water & groundwater
- Soil and rock: Geological conditions (rock and soil type, slope, landscape)
- Vegetation: the cover materials on land and wetland
- Socioeconomic shareholders: interests and start point
- Science: restoration goals and endpoints

Restoration Process & Procedure

TABLE 4.1 Steps and Procedures in Planning and Initiating an Ecological Restoration Project

1. Develop an ecological description of the area to be restored.
2. Provide a clear understanding of the need for the restoration.
3. Define the objectives and goals of the project.
4. Specifically state the procedures that will be used to achieve the restoration.
5. Clearly know the reference ecosystem that the restoration is attempting to reach.
6. Determine how the restored ecosystem will be self-sustaining; that is, provide for flow of energy and cycling of chemicals to ensure long-term self-maintenance of the restored ecosystem and stable linkages to other ecosystems.
7. State the standards of performance during restoration and monitoring following completion.
8. Work with all people (stakeholders) interested in the project from initiation through completion and postproject monitoring.
9. Examine what the potential consequences of the project are likely to be; that is, apply the principle of environmental unity, that everything affects everything else and anticipate what primary, secondary, and tertiary effects may be.

Source: Modified after Society for Ecological Restoration, 2004. The SER international primer on ecological restoration, www.SER.org.

Biological Engineering in Ecological Restoration

- Using vegetation in engineering projects to achieve specific ecological goals
- Designing and constructing certain ecosystems
- Modifying functions of ecosystems