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Soil and Agriculture

Chapter Objectives

This chapter will help you:

Explain the importance of soils to agriculture

Describe the impacts of agriculture on soils

Outline major developments in the history of agriculture

Delineate the fundamentals of soil science, including soil formation and soil properties

Analyze the types and causes of soil erosion and land degradation

Explain the principles of soil conservation and provide solutions to soil erosion and land degradation

Summarize major policy approaches for addressing soil conservation

Lecture Outline

I. Central Case: Iowa's Farmers Practice No-Till Agriculture

A. Repeated cycles of plowing and planting since farmers first settled the region have diminished the soil's productivity.

B. Turning the earth by tilling (plowing, disking, harrowing, or chiseling) aerates the soil and works weeds and old crop residue into the soil to nourish it. But, tilling also leaves the surface bare, allowing wind and water to erode away precious topsoil.

C. The conventional practice of tilling the soil after harvests instead turned to **no-till** farming--rather than plowing after each harvest, crop residues were left atop their fields, keeping the soil covered with plant material at all times.

D. After three years the no-till fields produced as much corn as the conventional fields, while requiring less time and money.

E. By enhancing soil conditions and reducing erosion, no-till techniques are benefiting Iowa's people and environment as well, cutting down on pollution in its air, waterways, and ecosystems.

F. Similar effects are being felt elsewhere in the world where no-till methods are being applied.

II. Soil: The Foundation for Agriculture

A. As population and consumption increase, soils are being degraded.

1. **Agriculture** is the practice of raising crops and livestock for human use and consumption.
2. We obtain most of our food and fiber from **cropland**, land used to raise plants for human use.
3. **Rangeland**, or pasture, is the land used for grazing livestock.
4. **Soil** is a complex system of disintegrated rock, organic matter, water, gases, nutrients, and microorganisms.
5. Throughout the world, especially in drier regions, it has gotten more difficult to raise crops and graze livestock as soils have deteriorated in quality and declined in productivity—a process termed **soil degradation**.

B. Agriculture began 10,000 years ago.

1. Our ancestors began intentionally planting seeds from plants whose produce was most desirable, called *selective breeding*.
2. People followed the same process of selective breeding with animals, creating livestock from wild species.
3. Once our ancestors learned to cultivate crops and raise animals, they began to settle in more permanent camps and villages.
4. **Traditional agriculture** needed human and animal muscle power, hand tools, and simple machines.

C. Industrialize agriculture dominates today.

1. The industrial revolution introduced large-scale fossil fuel combustion and mechanization, enabling farmers to replace horses and oxen with faster and more powerful means of cultivating, harvesting, transporting, and processing crops; this is called **industrial agriculture.**
2. For maximum efficiency, the new agriculture required the uniform planting of a single crop, or **monoculture.**
3. The **green revolution** applied technology to boost crop yields in developing nations.

III. Soil as a System

A. Soil formation is a slow process.

1. **Parent material** is the base geological material in a location. It may be composed of lava or volcanic ash, rock or sediment deposited by glaciers, wind-blown dunes, or sediments deposited by rivers, in lakes, or in the ocean.
2. **Bedrock** is the continuous mass of solid rock that makes up Earth's crust.
3. The **weathering** of parent material is the first step in the formation of soil. This is the physical, chemical, and/or biological process that converts large rock particles into smaller particles.
4. Weathering and the accumulation and transformation of organic matter are the key processes of soil formation, and these are influenced by five factors: climate, organisms, topography, parent material, and time.

B. A soil profile consists of layers known as horizons.

1. Each layer of soil is termed a **horizon**, and the cross-section as a whole, from surface to bedrock, is known as a **soil profile**.
2. Minerals are generally transported downward in the soil as a result of **leaching**, the process whereby solid particles suspended or dissolved in liquid are transported to another location.
3. A crucial horizon for agriculture and ecosystems is the A horizon, or **topsoil**.
4. The O and A horizons are home to most of the countless organisms that give life to soil.
5. Topsoil is vital for agriculture, but agriculture practiced unsustainably over time will deplete organic matter.

C. Soils differ in color, texture, structure, and pH.

1. Soil scientists classify soils—and farmers judge their quality for farming—based largely on properties such as color, texture, structure, and pH.
2. To a scientist or a farmer, the color of soil can indicate its composition and sometimes its fertility.
3. Soil texture is determined by the size of particles.
    a. **Clay** consists of particles less than 0.002 mm in diameter, **silt** of particles 0.002–0.05 mm, and **sand** of particles 0.05–2 mm.
    b. Soil with an even mixture of the three particle sizes is known as **loam**.
4. Soil structure is a measure of the ―clumpiness‖ of soil.
5. Plants can die in soils that are too acidic or alkaline, whereas moderate variation influences the availability of nutrients for plants' roots.

D. Cation exchange is vital for plant growth.

1. Plants gain many nutrients through a process called *cation exchange*.

a. *Cation exchange capacity* expresses a soil's ability to hold cations (preventing them from leaching and thus making them available to plants) and is a useful measure of soil fertility.

E. Regional differences in soil traits can affect agriculture.

IV. Land Degredation and Soil Conservation

1. **Land degradation** is a general deterioration of land that diminishes its productivity and biodiversity, impairs the functioning of its ecosystems, and reduces the ecosystem services that the land offers.

A. Erosion can degrade ecosystems and agriculture.

1. **Erosion** is the removal of material from one place and its transport toward another via wind or water.

2. Erosion can occur in several ways, including wind erosion and four principal kinds of water erosion (splash, sheet, rill, and gully).

3. To prevent erosion in vulnerable locations, we can erect a variety of physical barriers that capture soil.

B. Soil erosion is a global problem.

C. Desertification reduces productivity of arid lands.

1. **Desertification** is a loss of more than 10% productivity due to soil erosion, soil compaction, forest removal, overgrazing**,** drought, salinization**,** climate change, depletion of water sources, and so on.

D. The Dust Bowl was a monumental event in the United States.

1. Large-scale cultivation of the southern Great Plains of the United States, combined with a drought in the 1930s, led to dust storms, destroying the land and affecting human health in the **Dust Bowl**.

E. The Soil Conservation Service pioneered measures to slow soil degradation.

1. **Conservation districts** within each county promoted soil-conservation practices.

2. In 1994, the SCS was renamed the **Natural Resources Conservation Service**, and its responsibilities were expanded to include water quality protection and pollution control.

F. Soil conservation efforts are thriving internationally.

G. Farmers can protect soil against degradation in various ways.

1. **Crop rotation** is the practice of alternating the kind of crop grown in a particular field from one season or year to the next.
2. **Contour farming** consists of plowing furrows sideways across a hillside, perpendicular to its slope and following the natural contours of the land, to help prevent formation of rills and gullies.
3. **Terracing** transforms slopes into series of steps like a staircase, enabling farmers to cultivate hilly land without losing huge amounts of soil to water erosion.
4. The planting of different types of crops in alternating bands or other spatially mixed arrangements is called **intercropping.**
5. **Shelterbelts** are rows of trees or other tall plants that are planted along the edges of fields to break the wind.
6. **Conservation tillage** describes an array of approaches that reduce the amount of tilling relative to conventional farming.

H. Erosion-control practices protect and restore plant cover.

I. Irrigation boosts productivity, but can damage soil.

1. Crops that require a great deal of water can be grown with **irrigation,** artificial provision of water.
2. Soils too saturated with water may experience **waterlogging**, which damages both soil and roots.
3. A more frequent problem is **salinization**, the buildup of salts in surface soil layers.

J. Salinization is easier to prevent than to correct.

K. Fertilizers boost crop yields but can be overapplied.

1. Nutrient depletion creates a need for **fertilizers** containing nutrients.
2. **Inorganic fertilizers** are mined or synthetically manufactured mineral supplements.
3. **Organic fertilizers** consist of the remains or wastes of organisms and include animal manure, crop residues, fresh vegetation (*green manure),* and *compost*, a mixture produced when decomposers break down organic matter, including food and crop waste, in a controlled environment.

L. Grazing practices can contribute to soil degradation.

1. When too many livestock eat too much of the plant cover, impeding plant regrowth and preventing the replacement of biomass, the result is **overgrazing**.

V. Agricultural Policy

A. Some policies worsen land degradation.

B. Wetlands have been drained for farming.

1. Many of our crops grow on the sites of former *wetlands*—swamps, marshes, bogs, and river floodplains—that people drained and filled in.

2. Under the *Wetlands Reserve Program*, the U.S. government offers payments to landowners who protect, restore, or enhance wetland areas on their property.

C. A number of U.S. and international programs promote soil conservation.

1. The **Conservation Reserve Program**, established in the 1985 farm bill, pays farmers to stop cultivating highly erodible cropland and instead place it in conservation reserves planted with grasses and trees.

2. Internationally, the United Nations promotes soil conservation and sustainable agriculture through a variety of programs led by the Food and Agriculture Organization (FAO).

VI. Conclusion

A. Many policies in the United States and worldwide have been quite successful in reducing erosion.

B. Many challenges remain; better technologies and wider adoption of soil conservation techniques are needed to avoid a food crisis.

Key Terms

agriculture
bedrock
clay
conservation districts
Conservation Reserve Program
conservation tillage
contour farming
crop rotation
cropland
desertification
Dust Bowl
erosion
fertilizer
green revolution
horizon
industrial agriculture
inorganic fertilizers
intercropping
irrigation
land degredation
leaching
loam
monoculture
Natural Resources Conservation Service
no-till
organic fertilizers
overgrazing
parent material
rangeland
salinization
sand

shelterbelts
silt
soil
soil degradation
soil profile
terracing
topsoil
traditional agriculture
waterlogging
weathering