

ENVIRONMENT

THE SCIENCE BEHIND THE STORIES

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Ch 9

Soil and Agriculture

Part 2: Environmental Issues and the Search for Solutions

PowerPoint® Slides prepared by
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Third Edition

Soil: the foundation for agriculture

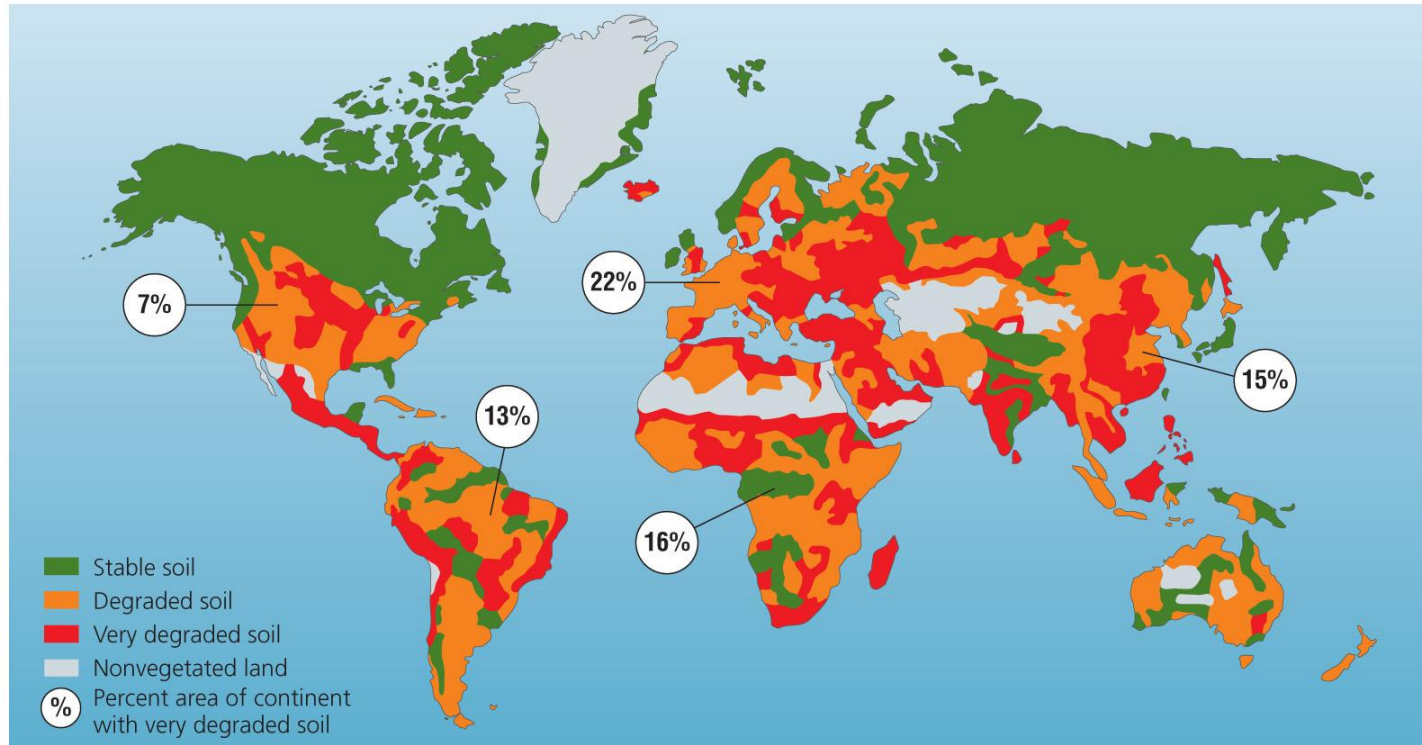
- Land devoted to agriculture covers 38% of Earth's land surface
- **Agriculture** = practice of raising crops and livestock for human use and consumption
- **Cropland** = land used to raise plants for human use
- **Rangeland** or **pasture** = land used for grazing livestock
- **Soil** = a complex plant-supporting system consisting of disintegrated rock, organic matter, water, gases, nutrients, and microorganism
 - It is a renewable resource

Population and consumption degrades soil

- Feeding the world's rising human population requires changing our diet or increasing agricultural production
- *Land suitable for farming is running out*
- We must find ways to improve the efficiency of food production
- *Mismanaged agriculture turns grasslands into deserts; removes forests; diminishes biodiversity; and pollutes soil, air, and water*
 - Fertile soil is blown and washed away

Millions of acres of cropland are lost each year

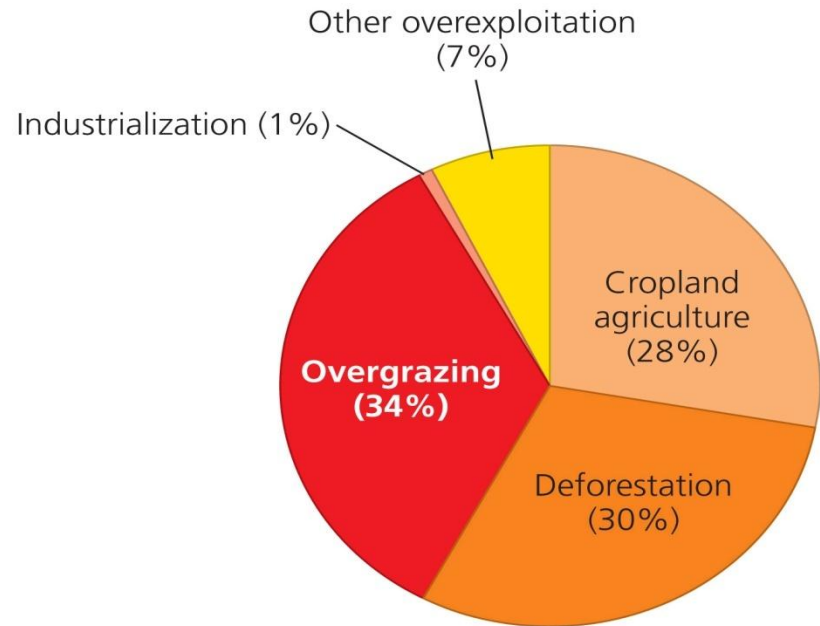
We lose 5-7 million ha (12-17 million acres) of productive cropland annually



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Soil degradation has many causes

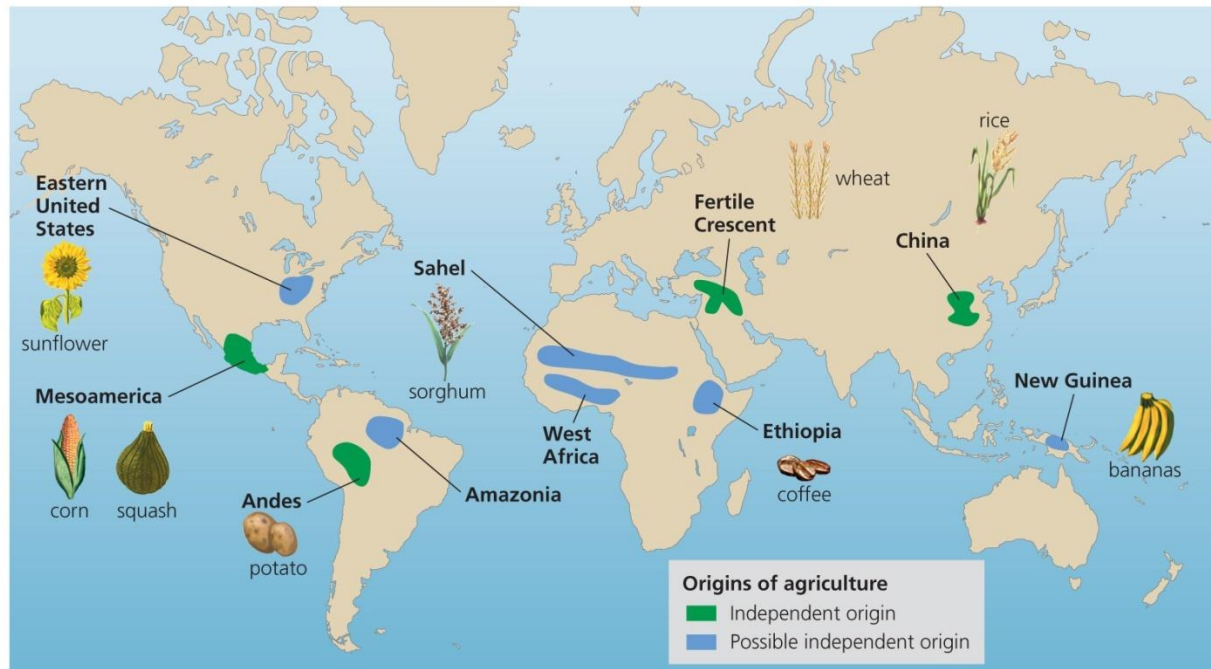
- Soil degradation results *from deforestation, agriculture and overgrazing*
- Over the past 50 years, soil degradation has reduced global grain production by 13%



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Agriculture arose 10,000 years ago

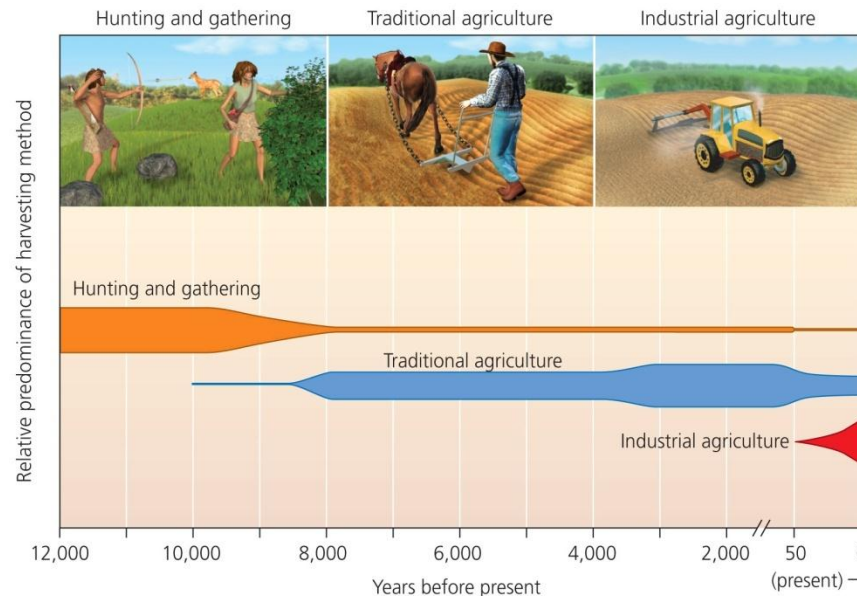
- Agriculture was invented independently by different cultures
- The earliest plant and animal domestication is from the “Fertile Crescent” of the Middle East
 - Wheat, *barley*, rye, *peas*, lentils, *onions*, goats, sheep



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Traditional agriculture

- **Traditional agriculture** = biologically powered agriculture, using human and animal muscle power
 - **Subsistence agriculture** = families produce only enough food for themselves
 - **Intensive agriculture** = produces excess food to sell
 - Uses animals, irrigation and fertilizer, but not *fossil fuels*



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Industrialized agriculture is a recent phenomenon

- **Industrialized agriculture** = using large-scale machinery and fossil fuels to boost yields
 - Also uses pesticides, irrigation and fertilizers
 - **Monocultures** = uniform planting of a single crop
- **Green revolution** = the use of new technology, crop varieties and farming practices introduced to developing countries
 - Increased yields
 - Created new problems and worsened old ones

Chunk and Chew

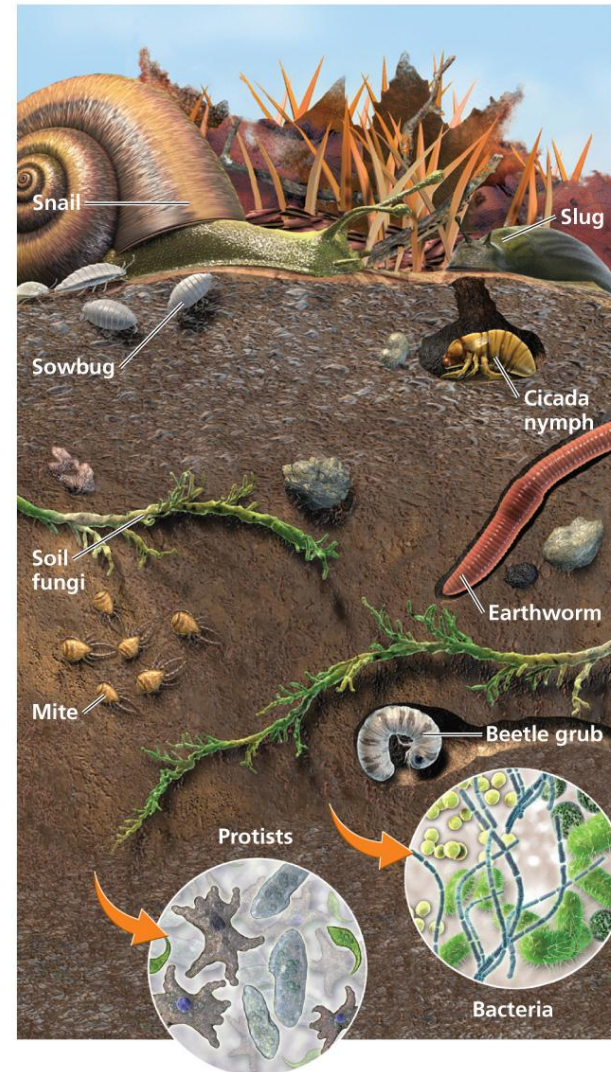
Using the information we just talked about answer the following question with your partner:

In your opinion, what is the greatest cause of increased soil degradation in the past 100 years?

Be ready to share in 1 minute!

Soil as an ecosystem

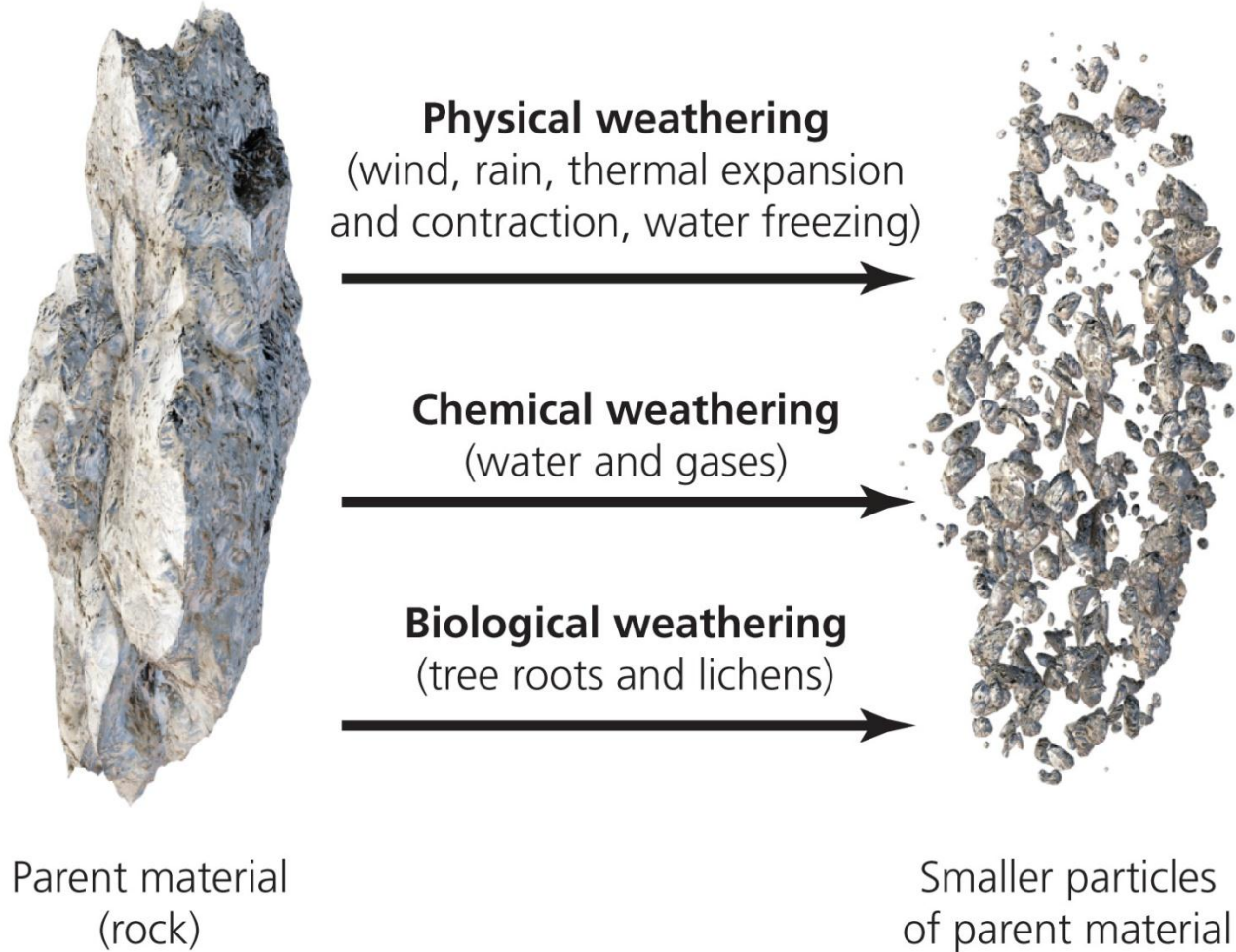
- *Soil consists of mineral matter, organic matter, air, and water*
 - Dead and living microorganisms, and decaying material
 - Bacteria, algae, earthworms, insects, mammals, amphibians, and reptiles



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Since soil is composed of living and non-living matter, it is considered an ecosystem

Weathering produces soil



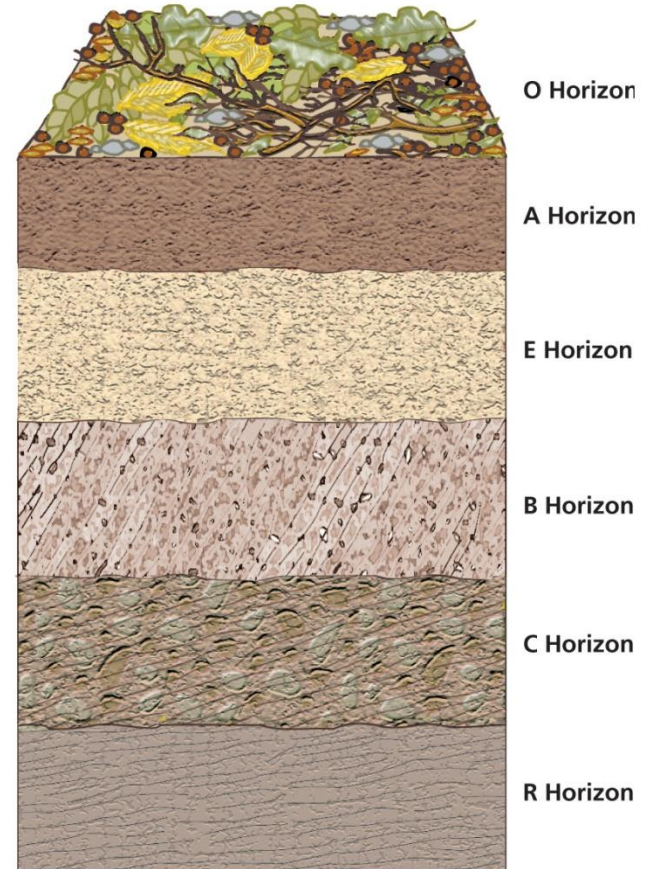
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Other processes affect soil formation

- **Erosion** = the dislodging and movement of soil by wind or water
 - Occurs when vegetation is absent
- Biological *activity includes deposition, decomposition, and accumulation of organic matter*
 - **Humus** = a dark, spongy, crumbly mass of material formed by partial decomposition

A soil profile consists of horizons

- **Horizon** = each layer of soil
- **Soil profile** = the cross-section of soil as a whole
- Up to six major horizons may occur in a soil profile
 - **Topsoil** = inorganic and organic material most nutritive for plants
 - **Leaching** = dissolved particles move down through horizons



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Soil Profile

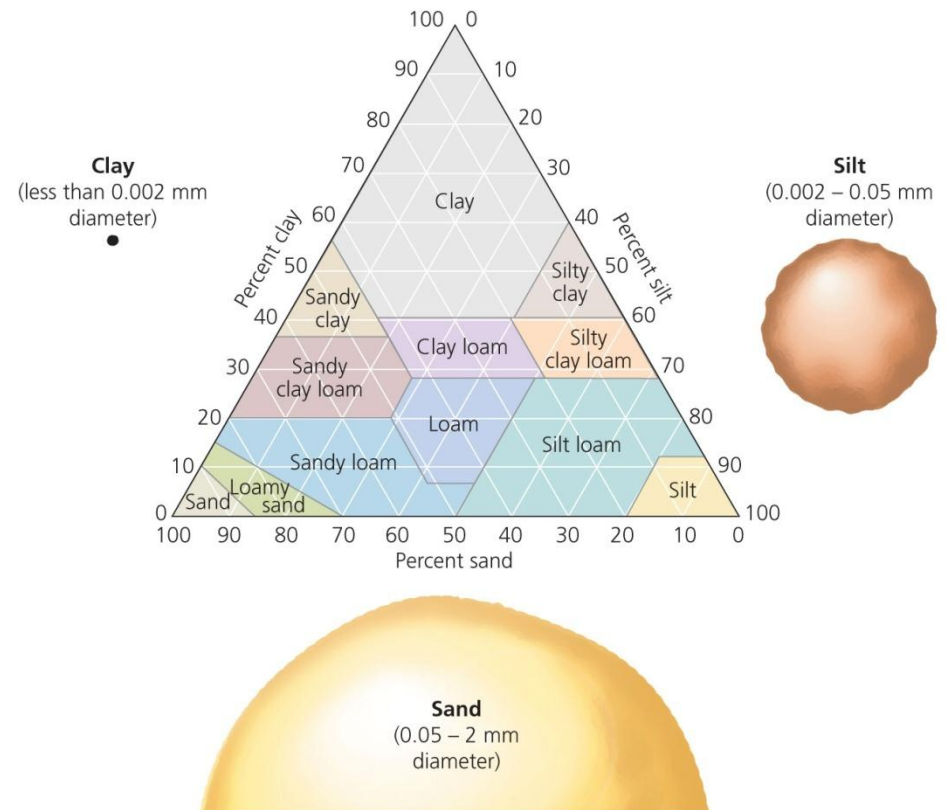
- The uppermost layer (the O horizon, or little layer) consists mostly of **organic matter deposited by organisms**.
- Below is lies the A horizon, or **topsoil**, consisting of some organic material mixed with mineral components.
- **Minerals and organic matter** tend to leach out of the E horizon down in the B horizon, or subsoil, where they accumulate.
- The C horizon consists largely of **weathered parent material** unaltered or only slightly altered by the processes of soil formation.
- The C horizon may overlie an R horizon of **pure parent material**.

Soils are characterized in many ways

- Soils are classified based on color, texture, structure, and pH
- **Soil color** = indicates its composition and fertility
 - Black or dark brown = rich in organic matter
 - Pale gray or white = indicates leaching
- **Soil texture** = determined by the size of particles
 - From smallest to largest = clay, silt, sand
 - **Loam** = soil with an even mixture of the three
 - Influences how easy it is to cultivate and let air and water travel through the soil

Soil texture classification

Silty soils with medium-size pores, or loamy soils with mixtures of pore sizes are best for plant growth and crop agriculture



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Soil structure and pH

- **Soil structure** = a measure of soil's "clumpiness"
 - Large clumps can discourage plant roots
 - Repeated tilling compacts soil, decreasing its water-absorbing capabilities
 - **Plowpan** = a hard layer resulting from repeated plowing that resists water infiltration and root penetration
- **Soil pH** = influences a soil's ability to support plant growth
 - Soils that are too acidic or basic can kill plants

Fact or Fiction

Choose the one that is TRUE, hold up your fingers based on your answer choice:

Which layer contains a lot of humus and is also known as topsoil?

1. A horizon
2. B Horizon
3. O Horizon
4. Z Horizon

Regional differences in soils affect agriculture

- Rainforests have high primary productivity, but the nutrients are in plants, not the soil
 - Rain leaches minerals and nutrients deeper into the soil, reducing their accessibility to roots
 - *Swidden agriculture* = cultivation of a plot for a few years and then letting it regrow into forest
- Temperate grasslands have lower rainfall and less nutrient leaching



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Erosion degrades ecosystems and agriculture

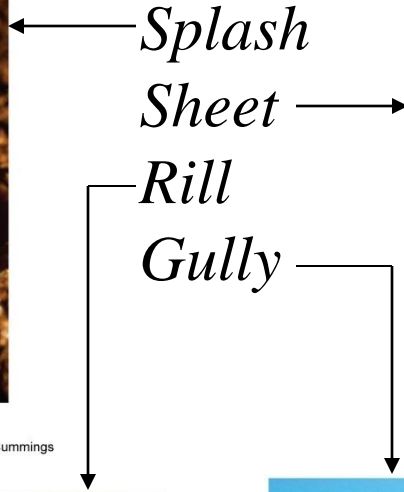
- *Deposition = the arrival of eroded material at its new location*
- Flowing water deposits sediment in river valleys and deltas
 - Floodplains are excellent for farming
- *Erosion is a problem because it occurs faster than new soil is formed*
- Erosion increases through: excessive tilling, overgrazing, and clearing forests

Various types of soil erosion



(a) Splash erosion

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(b) Sheet erosion

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(c) Rill erosion

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(d) Gully erosion

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Soil erosion is a global problem

- *Humans are the primary cause of erosion*
 - It is occurring at unnaturally high rates
- In Africa, erosion over the next 40 years could reduce crop yields by half
 - Coupled with rapid population growth, some observers describe the future of agriculture as a crisis situation



Chunk and Chew

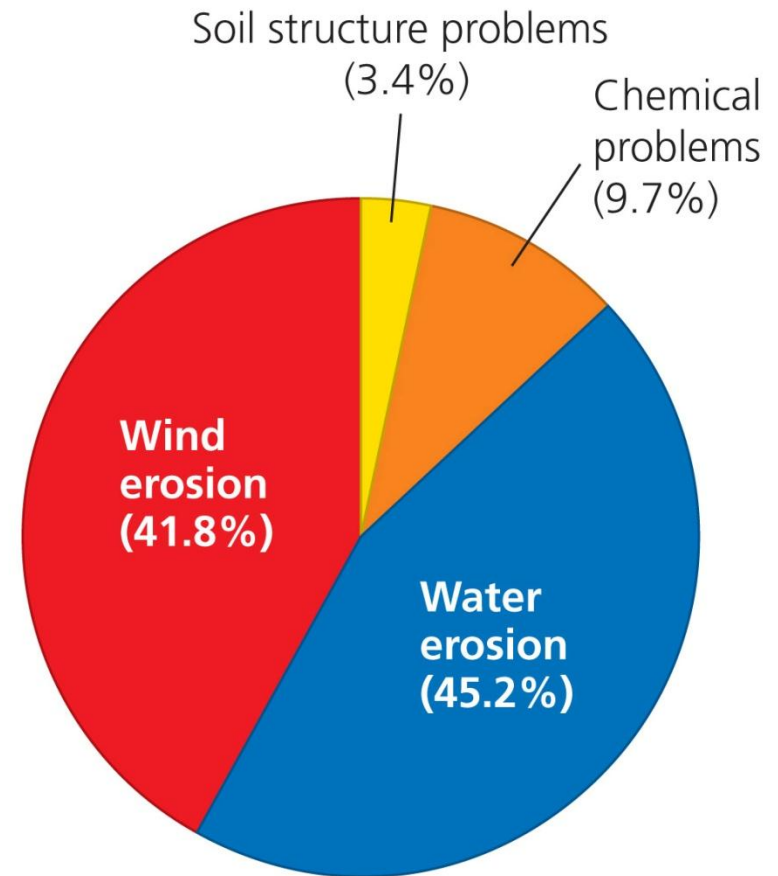
- Using the information we just talked about answer the following question with your partner:

Why is increased erosion a problem?

Be prepared to share your answer in 1 minute.

Desertification

- ***Desertification*** = a loss of more than 10% productivity
 - Erosion, soil compaction, forest removal, overgrazing, salinization, climate change, depletion of water sources
- Most prone areas = arid and semiarid lands
- Desertification affects 1/3 of the planet's land area
 - In over 100 countries



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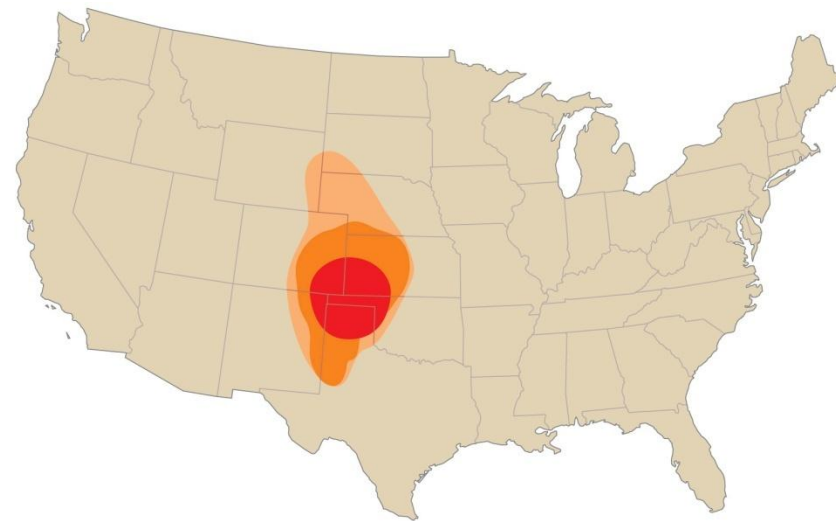
The Dust Bowl

- In the late 19th and early 20th centuries, settlers arrived in Oklahoma, Texas, Kansas, New Mexico and Colorado
- Grew wheat, grazed cattle
 - Removed vegetation
- A drought in the 1930s made conditions worse
- Thousands of farmers left their land and had to rely on governmental help



(a) Kansas dust storm, 1930s

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(b) Dust Bowl region

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The Soil Conservation Service

- Started in 1935, the Service works with farmers to develop conservation plans for farms
 - *Assess the land*
 - Prepare an integrated plan
 - *Work closely with landowners*
 - Implement conservation measures
- **Conservation districts** = districts operate with federal direction, authorization, and funding, but are organized by the states

Protecting soil: crop rotation and contour farming

- **Crop Rotation** = *alternating the crops grown field from one season or year to the next,*
 - Cover crops protect soil when main crops aren't planted
 - Wheat or corn and soybeans
- **Contour Farming** = *plowing furrows sideways across a hillside, perpendicular to its slope, to prevent rills and gullies*



(a) Crop rotation

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(b) Contour farming

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Protecting soil: terracing and intercropping

- ***Terracing*** = level platforms are cut into steep hillsides, sometimes with raised edges
 - A “staircase” to contain water
- ***Intercropping*** = planting different types of crops in alternating bands or other spatially mixed arrangements
 - Increases ground cover



(c) Terracing

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(d) Intercropping

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Protecting soil: shelterbelts and reduced tillage

- *Shelterbelts or Windbreaks* = rows of trees or other tall, perennial plants that are planted along the edges of fields to slow the wind
 - Alley cropping = shelterbelts + intercropping
- *Reduced Tillage* = furrows are cut in the soil, a seed is dropped in and the furrow is closed
 - **No-till farming** disturbs the soil even less



(e) Shelterbelts

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(f) No-till farming

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Irrigation: boosted productivity, but problems, too

- ***Irrigation*** = *Artificially providing water to support agriculture*
 - Unproductive regions become farmland
- Waterlogging = over-irrigated soils
 - Water suffocates roots
- ***Salinization*** = *the buildup of salts in surface soil layers*
 - Worse in arid areas

Salinization inhibits production of 20% of all irrigated cropland, costing more than \$11 billion/year



(a) Conventional irrigation

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Salinization prevention

- It is easier and cheaper to prevent salinization than fix it
- Do not plant water-guzzling crops in sensitive areas
- Irrigate with low-salt water
- *Irrigate efficiently, supplying only water that the crop requires*
 - **Drip irrigation** targets water directly to plants



(b) Center-pivot irrigation, aerial view

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(c) Drip irrigation

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Fact or Fiction

Which is the best agricultural practices for a hilly terrain?

1. Crop Rotation
2. Intercropping
3. Terracing
4. Shelterbelts

Fertilizers boost yields but cause problems

- **Fertilizer** = substances that contain essential nutrients
- **Inorganic fertilizers** = mined or synthetically manufactured mineral supplements
- **Organic fertilizers** = the remains or wastes of organisms
 - manure, crop residues, fresh vegetation
 - **Compost** = produced when decomposers break down organic matter



(a)

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← Applying synthetic fertilizer, vs. Planting rye, a “green manure” →

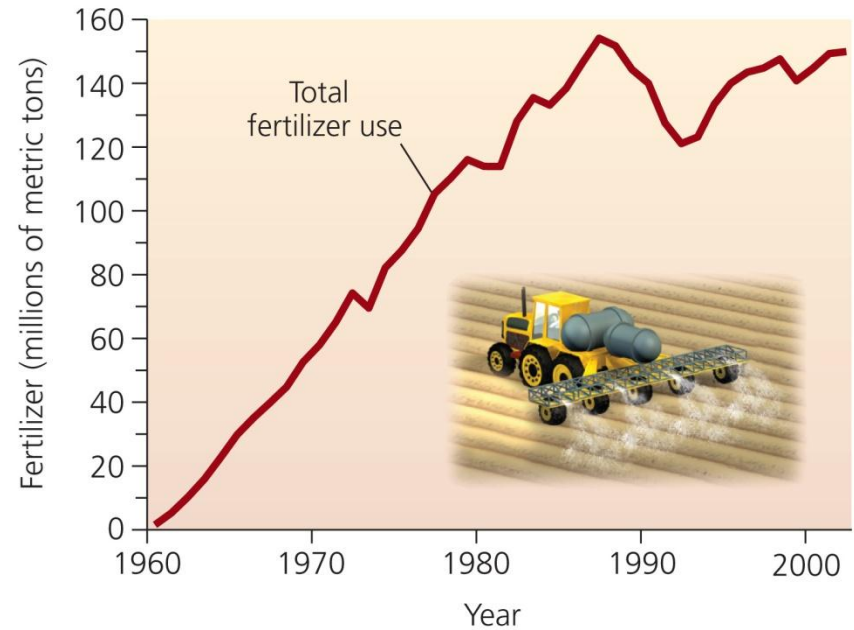


(b)

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Overapplication of Fertilizer

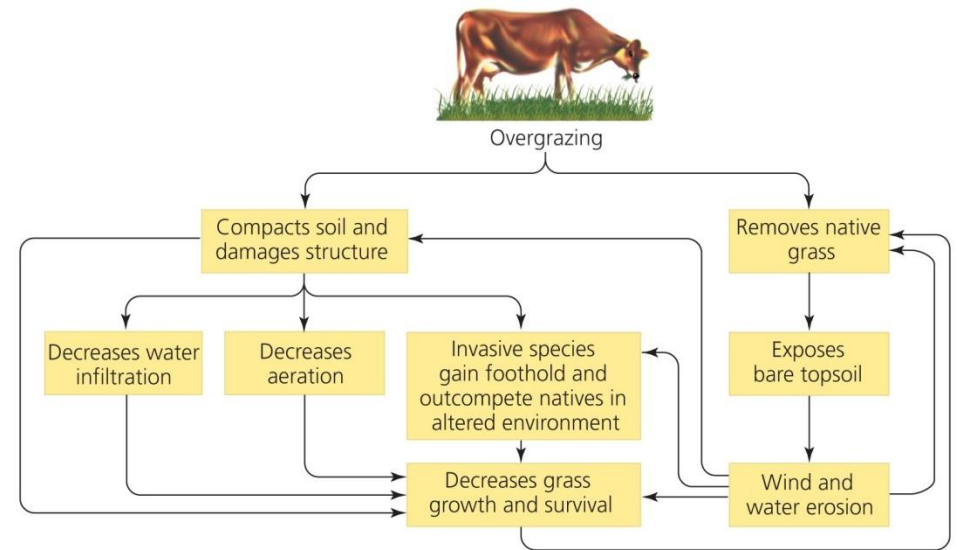
- Inorganic fertilizer use has skyrocketed
- *Overapplying fertilizer can ruin the soil and severely pollute several areas*
- Runoff causes eutrophication in nearby water systems
- *Nitrates leach through soil and contaminate groundwater*
- Nitrates can also volatilize (evaporate) into the air



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Overgrazing causes soil degradation

- **Overgrazing** = too many animals eat too much of the plant cover
 - Impedes plant regrowth
- *A leading cause of soil degradation*
- Government subsidies provide few incentives to protect rangeland



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70% of the world's rangeland is classified as degraded

U.S. programs promote soil conservation

- *Food Security Act of 1985: Farmers that adopt soil conservation plan receive price supports and other benefits*
- *Conservation Reserve Program (1985)*
 - *Farmers are paid to place highly erodible land into conservation reserves*
 - *Trees and grasses are planted instead of crops*
 - *Saves 771 million tons of topsoil per year*
 - *Generates income for farmers*
 - *Provides habitat for native wildlife*

Federal Agricultural Improvement Act (1996)

- *Known as the Freedom to Farm Act*
 - Aimed to reduce subsidies and government influence over farm products
 - *Created the Environmental Quality Incentive Program and Natural Resource Conservation Foundation*
 - Promotes and pays for conservation practices in agriculture
- Low-Input Sustainable Agriculture Program (1998)
 - Provides funding for sustainable agricultural practices for individual farmers

Chunk and Chew

Using the information we just talked about answer the following question with your partner:

What problems could excess fertilizers cause to the ecosystems surrounding cropland?

Be prepared to share your answer in 1 minute