Tilling: disturbing the soil

Topic 5.4 examines damage from tilling, slash-and-burn farming and fertilizer use. Tillage turns or loosens soil to prepare a seedbed, mix materials into the soil or control weeds. Its benefits can come with longer-term costs.

1. FOLLOW THE EFFECTS OF REPEATED DISTURBANCE

Breaks soil aggregates →	Particles become easier to detach →	Wind and water erode topsoil
Buries or removes protective residue →	Bare soil receives raindrop impact →	Runoff transports sediment off-site
Disrupts soil habitat and organic matter →	Soil structure and water storage suffer →	Long-term soil productivity can fall

An aggregate is a cluster of soil particles held together. Effects vary with soil type, slope, rainfall, tillage intensity and the amount of cover retained.

2. EROSION IS NOT THE SAME AS LOSS OF FERTILITY

Erosion is the physical removal and transport of soil. It can reduce fertility because topsoil contains organic matter and nutrients. Soil fertility can also decline without erosion, for example when harvest removes nutrients faster than they are replaced. Downstream sediment reduces water clarity and can bury aquatic habitat.

3. EXTENSION: PROTECT SOIL WHILE PRODUCING FOOD

Reduced tillage limits disturbance; retained crop residue and cover crops shield soil from wind and rain. Living roots and organic matter help maintain structure and water infiltration. These practices work together: simply stopping plowing does not remove every soil or nutrient-management problem.

Soil structure and erosion mechanisms: USDA NRCS, Minimizing Soil Disturbance.
Cover, roots and reduced tillage: USDA NRCS, Soil Health on Cropland.

Scope: College Board AP Environmental Science CED, Topic 5.4, p. 98.

Slash-and-burn: a short-term boost

Vegetation is cut, dried and burned to clear a field. Ash returns some mineral nutrients to the surface and can temporarily raise soil pH and fertility. Burning is not a way to create a permanent supply of nutrients.

1. WHAT HAPPENS AFTER CLEARING?

CUT + BURN

Vegetation is removed.

→

ASH + CROPS

Some nutrients become available.

→

CONTINUED USE

Harvest and losses can lower fertility.

Some nutrients are lost during burning; others are removed in harvested crops or lost through erosion and leaching. Without vegetation protecting the ground, heavy rain can wash away ash and topsoil. The duration of useful crop production depends on local conditions and management.

2. DAMAGE EXTENDS BEYOND THE FIELD

Clearing forest removes habitat and reduces standing biomass. Burning releases CO_2 that had been stored in plants; smoke also carries particles and other pollutants. Fires can escape into nearby vegetation. Regrowth can take up carbon again, but it does not instantly restore the former forest, its carbon stocks or its ecological communities.

3. DISTINGUISH ROTATION FROM PERMANENT CLEARING

In shifting cultivation, a cropped plot is left fallow so vegetation can regrow before it is used again. A sufficiently long fallow can help restore soil fertility. Shortened fallows or repeated burning before recovery can degrade the land. Traditional long-fallow systems are not the same as permanent forest conversion; impacts depend on the recovery interval, area cleared and local ecosystem.

Ash, nutrients and fallow cycles: FAO, Changes in shifting cultivation in Africa.
Habitat and carbon effects: NASA Earth Observatory, Tropical Deforestation.

Scope: College Board AP Environmental Science CED, Topic 5.4, p. 98.

Fertilizers: track where nutrients go

Fertilizers supply nutrients needed for crop growth. Problems arise when nutrients escape uptake and move into water or air. Both manufactured fertilizers and manure can cause nutrient pollution when poorly managed.

1. FROM FIELD TO LOW-OXYGEN WATER

Runoff delivers excess nitrogen and phosphorus → Algae grow; biomass later dies → Decomposition uses dissolved O_2

Eutrophication is nutrient enrichment of water. When enrichment drives excessive growth, the resulting organic matter supports decomposers whose respiration can deplete dissolved oxygen. Hypoxia (low oxygen) can stress or kill fish and other aquatic animals.

Avoid the shortcut "fertilizer directly uses up oxygen." The biological response links nutrient addition to oxygen loss; not every nutrient input produces a severe bloom.

2. TWO OTHER PATHWAYS: BELOW GROUND AND INTO AIR

Leaching carries dissolved nutrients downward with percolating water; nitrate can reach groundwater. This differs from runoff moving over the land surface. Adding nitrogen to agricultural soils can also increase microbial production of nitrous oxide, N_2O, a greenhouse gas. Nitrogen pollution is therefore not only a surface-water problem.

3. EXTENSION: MATCH THE RESPONSE TO THE LOSS

Use soil testing and crop needs to guide nutrient rates, timing, placement and application methods. Cover crops can take up leftover nutrients; vegetated buffers can intercept some runoff and sediment. These measures reduce losses but cannot capture everything. More fertilizer is not automatically better, especially when another factor limits crop growth.

Nutrient sources and loss reduction: EPA, Sources and Solutions: Agriculture.
Blooms, oxygen and groundwater: EPA, Basic Information on Nutrient Pollution.
Nitrogen additions and agricultural emissions: EPA, Nitrous Oxide Emissions.

Scope: College Board AP Environmental Science CED, Topic 5.4, p. 98.