# AP Environmental Science Unit 3 Study Guide

# AP Environmental Science Unit 5 Study Guide

## Green Revolution (Industrial Agriculture)

**Green Revolution:** Shifts towards industrial scale farming via mechanization, synthetic fertilization, pesticide use, irrigation, and increased crop varies.

- **Benefits:** Increased yields, decrease world hunger, increase world's carrying capacity, average costs of production fall as output increases, increased profits for farmers, short term increase in land productivity
- **Drawbacks:** Destroys nutrients, excess fertilizer, release of particulate matter, high water need, higher energy demand, soil erosion, pest vulnerability

**Mechanization:** Increased yields and profits but emits GHGs and compacts soil which decreases water holding capacity.

**Synthetic Fertilizers:** Increases yield and profits by directly inputting key nutrients but causes eutrophication and the production of fertilizers releases carbon dioxide.

**Pesticides:** Increases yields and profits but can wash off crops in runoff and harm non-target species in local soils and waters.

**High-Yield Variety Crops:** Hybrid, genetically modified crops are used to produce a higher yield and some are modified to have extra nutrients as well.

**GMOs:** Genetically modified organisms have minimal issues besides the loss of biodiversity as GMOs outcompete native species. GMOs have higher yield, more nutrients, and pest resistance.

## Agricultural Practices

**Monocropping:** Growing only one species of a crop.

- Highly efficient, economical, easy to apply pesticides/fertilizers

- Decreases biodiversity, increases soil erosion, decreases habitat diversity for species in area, prone to pests

**Tilling:** Mixing and breaking up soil to make planting easier, which loosens soil for roots.

- Loss of root structure, organic matter, and topsoil nutrients
- Increased PM in the air and sediments in nearby water.

**Slash and Burn:** Cutting down vegetation and burning it to clear land for agriculture and return nutrients in plants to soil.

- Done by **deforestation:** loss of habitat, biodiversity, carbon dioxide sinks
- Releases carbon dioxide, carbon monoxide, and nitrous oxide; increases PM
- Lowers albedo, making area warmer

**Synthetic Fertilizers:** Puts direct nutrients into the soil without returning organic matter, increasing water capacity, or adding soil decomposers.

- **Leaching:** Water carries excess nutrients into groundwater or into surface waters as runoff.
- Causes eutrophication of surface waters

## Irrigation

*The following is ranked from least to most efficient*

**Furrow Irrigation:** Trench is dug to align crops and filled with water.

**Flood Irrigation:** Floods the entire field, easier but more disruptive to plants.

- Waterlogged soils and drowns the plants

**Spray irrigation:** Groundwater is pumped into spray nozzles

- Expensive because it requires energy for pumps and movement of sprinklers

**Drip Irrigation:** Holes in hose to allow water to slowly drip out

- Avoids waterlogging and conserves water

## Issues with Irrigation

**Waterlogging:** Overwatering can saturate the soil, filling all soil pore space with water.

- Doesn't allow air into pores, so roots can't take in oxygen they need
- Stunts growth or kills crops
- **Solution:** Drip irrigation, soil aeration

**Soil Salinization:** Process of salt building up in a soil over time. Groundwater used for irrigation naturally contains small amounts of salt. However, as the water evaporates, the remaining salt accumulates in the soil, causing dehydration and toxicity.

- **Solution:** Drip irrigation, soil aeration, flushing with fresh water

**Global Human Water Use:** 70% of land is used for agriculture - livestock, irrigation etc. So irrigation causes depletion of aquifers and surface water.

## Aquifers and Groundwater

**Groundwater:** Water stored in pore space of permeable rock layers.

**Aquifers:** Useable groundwater deposits for humans. This is replenished by groundwater recharge (percolating down through soil into aquifer).

> **Unconfined Aquifer:** Water is free to flow in and out, typically near the surface. Recharge quickly.
>
> **Confined Aquifer:** Trapped between impermeable layers, preventing water from easily flowing in or out. Its recharge occurs over a long period, as it takes time for water to infiltrate and replenish it.

**Saltwater Intrusion:** Excessive pumping near the coast lowers water table pressure, allowing saltwater to be introduced into groundwater.

**Cone of Depression:** Forms when the water table is lowered by heavy pumping, depleting water and drying nearby wells.

## Pesticides

**Broad Spectrum Pesticides:** Power pesticides that target entire groups of species of organisms.

**Herbicide:** Attack completing plant species.

**Fungicide:** Kill fungi.

**Rodenticides:** Kills mice, rats, moles, squirrels, chipmunks.

**Drawbacks of Pesticides:**

- **Non-Target Deats:** Non-target organisms including beneficial predators, pollinators, nitrogen fixers get killed - killing the soil.
- **Bioaccumulation:** Pesticides build up in the food chain to toxic levels for birds, fish, and humans.
- **Resistance:** Pests become resistant to pesticides due to natural selection.
- **Pollution:** Groundwater and aquifer
- **Pesticide Drift:** The pesticides end up everywhere.

**The Pesticide Treadmill:** Pesticide application → Some pests survive and develop resistance → Resistant pests reproduce and spread → Stronger or more pesticides are needed → More pests develop resistance → Cycle repeats

## Meat Production

**Efficiency:** Meat production is inefficient as it takes 20x more land to produce the same amount of calories from meat as from plants.

**Concentrated Animal Feeding Operations (CAFOs):** Animals are **confined** and fed **antibiotics** and nutrient supplements. This uses less land and **improves efficiency**, but it leads to antibiotic resistance, waste disposal, **ethical concerns**, poor nutritional content, and emits **GHGs**.

**Free-Range Grazing:** Open grasslands are used for grazing cattle, which **takes up a lot of space**. Grazing uses **less fossil fuels** and allows land too dry to farm to be used. Overgrazing leaves land exposed to **wind erosion**, leading to desertification. This can also lead to **pollution** of **surface waters**.

## GHGs and Freshwater as They Relate to Agriculture

**Methane:** Livestock enteric fermentation and anaerobic rice cultivation both release methane.

**Nitrous Oxide:** Fertilizers and decay of manure emit nitrous oxide.

**Carbon Dioxide:** Slashing and burning and industrial farming emits carbon dioxide.

**Surface Water:** Agriculture takes too much water for irrigation and runoff of fertilizers/pesticides are polluting the water.

**Groundwater:** Agriculture takes too much for irrigation, fertilizers/pesticides leach into the groundwater, saltwater intrusion, zones of depression.

## Integrated Pest Management

**IPM:** A combination of methods used to control pest species while minimizing disruption to the environment.

> **Prevention**: **Crop rotation** (growing different crops every season), **intercropping** (growing different crops together to enhance resilience), resistant plant varieties, and habitat management to reduce pest risks.
>
> **Cultural & Mechanical Controls**: Mulching, handpicking pests, using traps, and physical barriers like row covers.
>
> **Biological Controls**: Introducing natural predators, parasites, or pathogens to manage pest populations.
>
> **Chemical Controls (Last Resort)**: Targeted, minimal use of pesticides only when necessary to prevent economic damage.

**Drawbacks:** Takes more energy and time, may alter the ecosystem, and doesn't completely eliminate the pests.

## Sustainable Agricultural Practices

**Contour Plowing**: Plow and harvest along the contours of land to prevent erosion

**Windbreaks:** Plant hedgerows around edges of fields to prevent wind erosion

**Perennials:** Do not have to be replanted every year preventing soil disturbance and erosion

**Terracing:** Creating stepped levels on sloped land to reduce erosion and improve water retention

**No-Till Agriculture:** Less erosion and less carbon dioxide emissions *though herbicide use may increase*

**Strip/Intercropping:** Planting two or more crops that work synergistically, improving soil health and restores nutrients

**Crop Rotation:** Reduces specific demands of one crop on soil, prepares solid or next crop, increase nutrient levels

**Green Manure Cover (Cover Crops):** Organic fertilizer from growing plants that are plowed back into the soil to add nutrients and reduce erosion

**Limestone (Calcium Carbonate):** Used to neutralize acidic soil to increase cation exchange capacity.

**Rotational Grazing:** Moving animals between pastures to let grass grow back to reduce erosion and desertification and allow plants to develop deep root systems.

**Legumes:** Consist of nitrogen fixing bacteria on the roots that put nitrogen into the soil.

## Mining

**Mining**: Process of extracting valuable minerals or other geological materials from the Earth

**Ore:** Commercially valuable deposits of mineral that can be used as raw materials

- **High Grade Ore:** Contains high concentration of desired minerals
- **Low Grade Ore:** Contains lower concentration of desired minerals

**Metals:** Elements that can conduct electricity like copper and aluminium

**Reserve:** The known quantity of a resource that can be economically recovered.

**Overburden:** Soil, vegetation, and rocks that are removed to get to an ore deposit.

**Tailings/Slag:** Leftover waste material separated from the valuable metal or minerals within ore

## Surface Mining

**Strip Mining:** Removal of strips of soil and rocks to expose soil, used to mine coal and tar sands.

**Open Pit Mining:** Digging large, terraced holes in the ground to extract copper.

**Mountain Removal:** Use of explosives to level mountains, depositing tailings in nearby regions.

**Placer Mining:** Looking for minerals and metals in river sediments to find diamonds, titanium, and gold.

## Subsurface Mining (Much More Expensive)

1. **Removing Overburden:** The process of removing soil, rock, or other materials that lie above the mineral deposit, to expose the ore.
2. **Loading Ore and Transport:** After the ore is exposed, it is loaded onto trucks, conveyors, or other transport systems for movement to processing facilities.
3. **Crushing and Grinding:** The ore is crushed into smaller pieces and ground into a fine powder to make it easier to extract valuable minerals.
4. **Flotation**: A process used to separate minerals from waste material (gangue) by using chemicals that make the minerals hydrophobic, allowing them to float on the surface for easy removal.

5. **Refining (Smelting):** The process of heating the concentrated ore to a high temperature to extract the metal by removing impurities.
6. **Heap Leaching:** A technique where a solution (usually cyanide for gold or sulfuric acid for copper) is sprayed over a heap of crushed ore to dissolve the target metal, which is then collected.
7. **Dewatering and Impoundment:** After extraction, the mineral slurry is dewatered (water is removed), and the leftover waste, tailings, is stored in impoundments or tailings ponds.
8. **Disposal and Storage of Mine Tailings:** The remaining waste material (tailings) is either stored in containment ponds or disposed of in a controlled manner to minimize environmental impact.

## Environmental Impacts

**Air:** Releases dust, carbon dioxide (from combustion of fossil fuels), sulfur dioxide (from smelting), methane, and causes noise pollution.

**Water:** Disrupts surface water and groundwater flow. Pits can fill with contaminated water.

**Acid Mine Runoff:** Sulfur-containing pyrite (iron sulfide) can react with water to form sulfuric acid, which will decrease the pH of soil. Therefore, mines are often lined with limestone to balance out the pH and clay to help prevent the migration of harmful contaminants into surrounding water.

**Biodiversity Loss:** Habitat destruction, road fragmentation, and poisoning due to exposure of toxins.

**Human Health Impacts:** Respiratory diseases (black lung disease), exposure to toxic chemicals (cyanide), increased risk of cancer, mine collapse, cardiovascular issues.

## Mining Legislation

**Mining Law of 1872:** Allows individuals to recover ores and fuels from federal lands.

**Surface Mining Control and Replacement Act:** Land must be minimally disturbed during coal mining and then reclaimed.

## Overfishing and Aquaculture

**Fishery:** Commercially harvestable population of fish within a particular ecological region.

**Tragedy of Commons:** There is no incentive to protect or replenish fish stocks because fish in the open ocean do not belong to any nation or people. Therefore, there has been a great decline in the fish population (90%).

**Modern Harvesting Methods:** Factory ships to catch and process fish, trawlings/dragnets/long lines, spotter planes.

**Environmental Impacts**: There could be an extinction of the fish species and their habitats. Bycatch can exacerbate this issue by reducing populations of non-target species.

**Aquaculture**: Farming of aquatic organisms, such as fish, shellfish, and plants, in controlled environments for commercial purposes.

- **Fish Farming:** Man-made tanks and enclosures used to catch catfish, tilapia, salmon, etc.
- **Mariculture:** Marine organisms are kept in open ocean enclosure or sweater tanks used to farm flounder, shellfish, and seaweed.

**Drawbacks of Aquaculture:**

- **Contamination:** Fish feces and waste feed contamination.
- **Disease:** Increased spread of disease and parasites like sea lice to native populations because of high fish density.
- **Loss of Biodiversity:** Large farmed fish escape and outcompete or breed with natives.
- **Habitat Loss:** Destruction of natural habitat and ecosystem due to farming.

**Integrated Multirptoihc Acqualcutre:** Sustainable approach that combines different species at various trophic levels, such as fish, shellfish, and plants, in a single system. The waste produced by one species is used as nutrients for another, promoting a balanced ecosystem and reducing environmental impact while increasing overall productivity.

## Forestry

**Forest:** Land dominated by trees and other woody vegetation.

**Types of Forests:** Natural, semi-natural, and plantation forests.

**Ecosystem Services of Forests:**

- **Provisioning Service:** Forests supply resources like timber, fuelwood, fruits, and medicinal plants.
- **Regulating Service:** Forests regulate the climate by absorbing carbon dioxide (carbon sequestration) and helping to mitigate climate change.
- **Cultural Service:** Forests provide recreational spaces, spiritual value, and opportunities for education and research.
- **Supporting Service:** Forests maintain biodiversity by providing habitats for a variety of species and supporting nutrient cycling.

**Carbon Sequestration:** Forests absorb and store carbon dioxide from the atmosphere.

**Cooling Effect of Trees:** Trees reduce ambient temperatures by providing shade and releasing moisture through transpiration, acting as natural air conditioners.

**Clear Cutting:** Removing all or almost all the trees in an area. This is easiest and most economical, but causes soil erosion, increases soil temperature, increases turbidity of water, and causes flooding.

**Tree Plantations:** Areas where the same tree species are repeatedly planted, grown, and harvested. This lowers biodiversity, as all the trees are the same species and age.

**Selective Cutting:** Removal individual trees or small groups of trees while leaving the majority of the forest intact. This method promotes the replanting of shade-tolerant species, reduces erosion, and minimizes biodiversity loss, though it may still require the construction of logging roads.

**Slash and Burn:** Clearing up land for agriculture by cutting trees and burning them, releasing carbon doxie, nitrous oxide, and water vapor into the atmosphere.

**Importance of Sustainable Forest Management:** Forests provide employment for 14 million people, wood is the primary source of renewable energy, and they offer other benefits such as carbon sequestration, biodiversity preservation, and watershed protection.

**Sustainable Logging Practices:**

- **Recycle:** Use recycled wood or old wood products without recycling
- **Selective Cutting:** Only cut what you need
- **Reforestation:** Replanting trees in areas that have been deforested
- **Integrated Pest Management:** Selectively removing diseased trees to prevent spread of infection through the entire forest.

**Fire Suppression:** Putting out all natural forest fires as soon as they start; however, this leads to more dry biomass build up making future fires worse. Rather, close monitoring can prevent fire damage and prevent worse fires in the future.

**Prescribed Burning:** When there's a lot of dead biomass, it may be necessary to burn it as this is a fuel for future fires. Burning dead biomass improves soil quality, prevents fires, and recycles nutrients.

## Urbanization

**Urbanization:** Removing natural vegetation to convert natural landscape to city.

**Impervious Surfaces:** Impermeable surfaces like concrete, asphalt, and cement don't allow water to infiltrate into the ground. This prevents groundwater recharge and increases runoff.

**Increased Carbon Dioxide Emissions:** Cement production, machinery, deforestation, landfills, vehicle emissions all emit carbon dioxide into the atmosphere.

**Coastal Cities:** Population growth in coastal cities can lead to **saltwater intrusion** due to **excessive groundwater withdrawal**, lowering water table pressure and allowing saltwater to seep into the groundwater. Sea level rise can contaminate fresh groundwater with salt.

**Suburban Area:** A residential zone near a city, typically with lower population density and more green space than urban areas.

**Urban Sprawl:** Uncontrolled expansion of urban areas into surrounding rural land, leading to low-density development, increased automobile dependence, and the spread of infrastructure. *People start developing suburbs around the urban center.*

- Population decline in the city → Decrease in tax revenue → Reduced funding for public services and infrastructure → Lower quality of life in the city → People and businesses move to suburban areas → Further population decline → Further decrease in tax revenue.
- Expanded highway systems make travel easier and increase driving.

**Solutions to Urban Sprawl:**

- **Urban Growth Boundaries:** Zoning laws set by cities preventing developing beyond a certain boundary.
- **Public Transport and Walkability:** Make cities like this to attract people to stay.
- **Mixed Land Use:** Residential, business, and entertainment buildings all located in the same area of the city, enabling walkability and sense of place.

## Urban Runoff

**Effects of Urban Runoff:** Decreased infiltration and groundwater recharge, rain washes pollutants into storm drains and into local surface waters.

- **Salt:** Damages plants and insects
- **Sediments:** Increased turbidity of water, which decreases the photosynthesis of algae
- **Fertilizers:** Cause eutrophication
- **Oil:** Suffocate fish and kills aquatic insects

**Permeable Pavement:** Allows storm water to infiltrate and recharge groundwater, decreasing runoff and amount of pollutants carried into storm drains. But, this is much more expensive.

**Rain Garden:** Small garden in urban areas that reduces runoff by allowing water to soak into the soil, lowers flood risk, creates habitat for pollinators, and stores carbon dioxide.

**Promote Public Transit:** More cars leads to more pollutants and more impervious surfaces, so public transit would decrease urban runoff and pollutants on the road.

**Building Vertically:** Decreasing the amount of impervious surfaces, decreasing urban runoff.

**Green Roofs:** Rooftop gardens that decrease runoff, sequesters carbon, filters and absorbs air pollutants.

## Ecological Footprint

**Ecological Footprint:** Measure of how much a person consumes, expressed in area of land (gha). People use land for food, raw materials, housing, waste, and electricity production.

- Ecological footprint can be also expressed as the number of earths required if the entire world consumed the same resources as given individual or group.
- The current average US footprint is 5.1 earths.

**Carbon Footprint:** Measured in tons of carbon dioxide produced per year.

**Factors That Impact Ecological Footprint: Increases vs. Decreases:**

| Factors that Increase Ecological Footprint ⬆️🌍 | Factors that Decrease Ecological Footprint 🌱 |
|---|---|
| High consumption of fossil fuels (cars, coal) 🚗⛽ | Using renewable energy sources (solar, wind, hydroelectric) 🌞💨 |
| High meat consumption (especially beef and lamb) 🍖 | Eating a plant-based or low-impact diet 🥦🍎 |
| Excessive use of single-use plastics 🛍️ | Recycling and using reusable products ♻️ |
| Overconsumption of water 💧 | Water conservation (low-flow fixtures, rainwater harvesting) 🌧️💦 |
| Deforestation and land conversion 🌳➡️🏙️ | Reforestation and sustainable land management 🌱🌳 |
| High levels of waste generation 🗑️ | Reducing, reusing, and recycling materials 🔄 |
| Dependence on non-sustainable agriculture 🚜 | Supporting organic or sustainable farming practices 🌾🌿 |
| Large, energy-inefficient homes 🏠💡 | Living in smaller, energy-efficient homes or apartments 🏡⚡ |
| Frequent air travel ✈️ | Using public transportation or walking/cycling 🚶🚲 |
| Overfishing and resource depletion 🐟 | Sustainable fishing practices and resource management 🐠 |

**Overshoot Day:** Marks the day when humanity has used all the biological resources that Earth regenerates during the entire year.