Chapter 12: Effects of Agriculture on the Environment
How Agriculture Changes the Environment
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• Major environmental problems associated with Ag
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  - Off-site pollution of other ecosystems, of soil, water and air
How Agriculture Changes the Environment
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• Major environmental problems cont.
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• Major environmental problems cont.
  – Deforestation
How Agriculture Changes the Environment

• Major environmental problems cont.
  – Deforestation
  – Desertification
How Agriculture Changes the Environment

- Major environmental problems cont.
  - Deforestation
  - Desertification
  - Degradation of aquifers
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  – Deforestation
  – Desertification
  – Degradation of aquifers
  – Salinization of soil ("Salting")
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  - Salinization of soil ("Salting")
  - Accumulation of toxic organic compounds
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- Major environmental problems cont.
  - Deforestation
  - Desertification
  - Degradation of aquifers
  - Salinization of soil (“Salting”)
  - Accumulation of toxic organic compounds
  - Loss of biodiversity
The Plow Puzzle
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- Plows – the physical disturbance of soil using large farm “implements” that are dragged through the soil either by “work animals” or machines
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- Plows – the physical disturbance of soil using large farm “implements” that are dragged through the soil either by “work animals” or machines.
- They shape the land for efficient planting, but they destroy the soil structure thus making it more prone to erosion and loss of fertility.
Plows

- These devices reach at least 14 inches below the soil surface - some go much deeper. Imagine the amount of energy required to pull such devices through the soil…. 

Sunday, April 14, 13
Horizons

O Horizon is mostly organic materials, including decomposed or decomposing leaves and twigs. This horizon is often brown or black.

A Horizon is composed of both mineral and organic materials. The color is often light black to brown. Leaching—the process of dissolving, washing, or draining earth materials by percolation of groundwater or other liquids—occurs in the A horizon and moves clay and other materials, such as iron and calcium, to the B horizon.

E Horizon is composed of light-colored materials resulting from leaching of clay, calcium, magnesium, and iron to lower horizons. The A and E horizons together constitute the zone of leaching.

B Horizon is enriched in clay, iron oxides, silica, carbonate, or other material leached from overlying horizons. This horizon is known as the zone of accumulation.

C Horizon is composed of partially altered (weathered) parent material; rock is shown here, but the material could also be alluvial in nature, such as river gravels, in other environments. This horizon may be stained red with iron oxides.

R Unweathered (unaltered) parent material. (Not shown)
Our Eroding Soil
Our Eroding Soil

- When land has been cleared of its natural vegetation, the soil begins to lose its fertility
  - Erosion is tied to the loss of particles that help maintain presence of plant nutrients
Our Eroding Soil

• When land has been cleared of its natural vegetation, the soil begins to lose its fertility
  – Erosion is tied to the loss of particles that help maintain presence of plant nutrients
• Became a national issue in the US in the 1930s
  – Intense plowing + drought
  – Loosened soil blew away during the “Dust Bowl” years
Erosion on Cropland by Year (Billions of Tons)

1982: 3.00
1987: 2.50
1992: 2.00
1997: 1.50
2001: 1.00
2003: 0.50

- **Sheet & Rill Erosion**: Red
- **Wind Erosion**: Yellow

Cropland includes cultivated and non-cultivated cropland.
Our Eroding Soil
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  – After plowing soil becomes exposed to rain and wind effects
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• When original vegetation ("canopy cover") is cleared soil changes
Our Eroding Soil

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  – Deep rooted grasses had held soil in place
  – After plowing soil becomes exposed to rain and wind effects

• When original vegetation ("canopy cover") is cleared soil changes
  – Soil exposed to sunlight speeds the rate of decomposition
Our Eroding Soil
Our Eroding Soil

• Traditionally declines in soil fertility were treated using organic fertilizers
Our Eroding Soil

• Traditionally declines in soil fertility were treated using organic fertilizers
  – Animal manures, worm castings
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• In the 20th century crop production increased
  – Chemical fertilizers
Our Eroding Soil

- Traditionally declines in soil fertility were treated using organic fertilizers
  - Animal manures, worm castings
- In the 20th century crop production increased
  - Chemical fertilizers
  - Adding nitrogen and phosphorous to the soil was easily achieved
• Since WWII mechanized farming has seriously damaged land
  – > 1 billion hectares
  – In US 1/3 of topsoil has been lost (washed to sea)
  – This is the result of massive disturbances to the soil by plowing and use of heavy farm equipment in concert with natural weathering
Where Does Eroded Soil Go?
Where Does Eroded Soil Go?

- A lot of it travels down streams and rivers
Where Does Eroded Soil Go?

• A lot of it travels down streams and rivers
  – Deposited at their mouths
Where Does Eroded Soil Go?

• A lot of it travels down streams and rivers
  – Deposited at their mouths
  – Fills in water ways
Where Does Eroded Soil Go?

• A lot of it travels down streams and rivers
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  – Fills in water ways
  – Damages fisheries and coral reefs
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  - Enrichment of waters, eutrophication
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• Sedimentation has chemical effects
  – Enrichment of waters, eutrophication
  – Transport of toxic chemical pesticides
Making Soils Sustainable
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• Soil forms continuously
  – But very slowly
  – 1mm of soil formation takes 10-40 years
Making Soils Sustainable

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  – But very slowly
  – 1mm of soil formation takes 10-40 years
• To be truly sustainable soil lost should equal amount of new soil produced
Contour Plowing
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- Land is plowed perpendicular to the slopes and as horizontally as possible to the “contour” of the land horizontally.
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• Benefits:
Contour Plowing

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• Benefits:
  – One of the most effective ways to reduce soil erosion
Contour Plowing

- Land is plowed perpendicular to the slopes and as horizontally as possible to the “contour” of the land horizontally.
- Benefits:
  - One of the most effective ways to reduce soil erosion
  - Also uses less fuel and time
No-Till Agriculture
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- Land is not plowed, but using herbicides and integrated pest management controls weeds
No-Till Agriculture

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  - The goal is to suppress and control weeds, but not eliminate them at the expense of soil conservation
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  – The goal is to suppress and control weeds, but not eliminate them at the expense of soil conservation
  – Additional benefit is that it reduces the release of $\text{CO}_2$ accelerated soil decomposition
Controlling Pests
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- Pests are undesirable:
  - Competitors, parasites, and predators
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• In agriculture pests are mainly
  – Insects, nematodes, bacterial and viral diseases, weeds and vertebrates.
• Loss can be large
  – Estimated at 1/3 of potential harvest and 1/10 of the harvested crop
Controlling Pests
Controlling Pests

• Because a farm is maintained in a very early stage of ecological succession and enriched by fertilizers and water
  – It is a good place for crops
  – AND early-successional plants (weeds)
Controlling Pests

• Because a farm is maintained in a very early stage of ecological succession and enriched by fertilizers and water
  – It is a good place for crops
  – AND early-successional plants (weeds)
• Weeds compete for all resources
  – Light, water, nutrients, and space to grow.
  Weed are also early successional plants as well!
The History of Pesticides
The History of Pesticides

• Pre-Industrial Revolution methods
The History of Pesticides

- Pre-Industrial Revolution methods
  - Slash and burn agriculture
The History of Pesticides

• Pre-Industrial Revolution methods
  – Slash and burn agriculture
  – Planting aromatic herbs that repel insects
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• Modern science-based agriculture
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  – Search for chemicals that would reduce abundance of pests
The History of Pesticides

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  – Slash and burn agriculture
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• Modern science-based agriculture
  – Search for chemicals that would reduce abundance of pests
  – The first, like arsenic, were toxic to all life
    • Killed both pests and beneficial organisms
The History of Pesticides
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- Second stage began in the 1930s
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  - Petroleum based sprays and natural plant chemicals (e.g., nicotine)
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The History of Pesticides

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  - Petroleum based sprays and natural plant chemicals (e.g., nicotine)
- Third stage was the development of artificial organic compounds
  - DDT, broad-spectrum
  - Aldrin and dieldrin used to control termites
    - Toxic to humans and has been found in breast milk
The History of Pesticides
The History of Pesticides

- Forth stage is a return to biological and ecological knowledge.
The History of Pesticides

• Forth stage is a return to biological and ecological knowledge.

• Biological control - the use of predators and parasites to control pests
  – The use of *Bacillus thuringiensis* (BT) is the most widely used BioInsecticide
  – Predatory insects such as ladybugs, or parasitic wasps
  – Proven safe and effective
The History of Pesticides
The History of Pesticides

- Other biological control agents
The History of Pesticides

- Other biological control agents
  - Sex pheromones (chemicals released to attract opposite sex) used as bait in traps to interrupt reproductive cycle
Bacterial disease of insects sprayed from aircraft

Parasitic wasps are released; females lay eggs in caterpillars; wasp larvae feed on caterpillars

Other predators of insect pests
Integrated Pest Management
Integrated Pest Management

- Fifth stage
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- Fifth stage
- IPM uses a combination of methods
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  - Biological control
  - Chemical pesticides
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  - Chemical pesticides
  - Methods of planting crops (mixed fields)
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  - Economically makes sense
Integrated Pest Management

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- IPM uses a combination of methods
  - Biological control
  - Chemical pesticides
  - Methods of planting crops (mixed fields)
- Goal can be control, but never complete elimination of pests
  - Economically makes sense
  - Does less damage to ecosystem, soil, water and air
Integrated Pest Management

• No-till or low-till agriculture another feature of IPM
  – Helps build levels of natural enemies of pests
Control of oriental fruit moth done by parasitic wasp.
Monitoring Pesticides in the Environment
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• World pesticide use exceeds 2.5 billion kg
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  - US use exceeds 680 million kg
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• Once applied may decompose in place or be carried by wind and water
  – Breakdown products can also be toxic
  – Eventually fully decompose but can take a long time
Genetically Modified Crops
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- Three methods
Genetically Modified Crops

• Three methods
  – 1. Faster and more efficient development of new hybrids
Genetically Modified Crops

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  - 2. Introduction of the “terminator gene”
Genetically Modified Crops

- Three methods
  - 1. Faster and more efficient development of new hybrids
  - 2. Introduction of the “terminator gene”
  - 3. Transfer of genetic properties from widely divergent kinds of life (fish genes to Strawberries or tomatoes)
New Hybrids
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• Concern that genetic modification may produce
New Hybrids

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  – “superhybrids”
New Hybrids

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• Concern that genetic modification may produce
  – “superhybrids”
  – Could become pest or transfer genes to closely related weeds
The Terminator Gene
The Terminator Gene

- Makes seeds from a crop sterile
The Terminator Gene

• Makes seeds from a crop sterile
  – Done for environmental and economic reasons
The Terminator Gene

• Makes seeds from a crop sterile
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  – Prevents a gmo from spreading
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• Critics note
The Terminator Gene

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  – Prevents a gmo from spreading
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• Critics note
  – Farmer’s in poor nations must be able to grow next years crops from their own seeds
Transfer of Genes
Transfer of Genes

- Genes transfer from one major life form to another
Transfer of Genes

• Genes transfer from one major life form to another
  – Most likely to have negative and undesirable impacts
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  – Most likely to have negative and undesirable impacts

• E.g. *Bacillus thuringiensis*
  – Produce toxin that kills caterpillars
  – Gene identified and transferred to corn
  – Engineered corn now produces its own pesticide
Transfer of Genes
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• Bt plants thought to be a constructive step in pest control
Transfer of Genes

• Bt plants thought to be a constructive step in pest control
  – No longer need to spray pesticide
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• Bt plants produce toxin in all cells
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• Bt plants produce toxin in all cells
  – Even in pollen that can spread
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  - No longer need to spray pesticide
- Bt plants produce toxin in all cells
  - Even in pollen that can spread
  - Monarch butterflies that eat pollen may die
Transfer of Genes

• Much concern worldwide about the political, social and environmental effects of genetic modification of crops.
Grazing on Rangelands
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• Almost half of the Earth's land area is used as rangeland
  – 30% of Earth’s land area is arid rangeland
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• Arid rangeland easily damaged especially in time of drought
Grazing on Rangelands

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  – 30% of Earth’s land area is arid rangeland
• Arid rangeland easily damaged especially in time of drought
• Streams and rivers also damaged
  – Trampling banks and fecal matter
Traditional and Industrial Use of Grazing and Rangelands
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• In modern industrialized agriculture
Traditional and Industrial Use of Grazing and Rangelands

• In modern industrialized agriculture
  – Cattle initially raised on open range
Traditional and Industrial Use of Grazing and Rangelands

• In modern industrialized agriculture
  – Cattle initially raised on open range
  – Then transport to feed lots
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  – Cattle initially raised on open range
  – Then transport to feed lots
  – Major impact is local pollution from manure
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• Traditional herding practices
Traditional and Industrial Use of Grazing and Rangelands

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• Traditional herding practices
  – Damage land through overgrazing
Traditional and Industrial Use of Grazing and Rangelands

• In modern industrialized agriculture
  – Cattle initially raised on open range
  – Then transport to feed lots
  – Major impact is local pollution from manure

• Traditional herding practices
  – Damage land through overgrazing
  – Impact varies depending on density relative to rainfall and soil fertility
Biogeography of Agricultural Animals
Biogeography of Agricultural Animals

• Everyplace people have dispersed they have bought animals w/ them
Biogeography of Agricultural Animals

• Everyplace people have dispersed they have bought animals w/ them
  – Pre-industrial and throughout western civilization
Biogeography of Agricultural Animals

• Everyplace people have dispersed they have bought animals with them
  – Pre-industrial and throughout western civilization
• Environmental effects of introductions
Biogeography of Agricultural Animals

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• Environmental effects of introductions
  – Native vegetation may be greatly reduced and threatened w/ extinction
Biogeography of Agricultural Animals

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  – Pre-industrial and throughout western civilization

• Environmental effects of introductions
  – Native vegetation may be greatly reduced and threatened w/ extinction
  – Introduced animals may compete w/ native herbivores, threatening them w/ extinction as well
Carrying Capacity of Grazing Lands
Carrying Capacity of Grazing Lands

• Carrying capacity-
Carrying Capacity of Grazing Lands

• Carrying capacity-
  – the maximum number of species per unit area that can persist w/o decreasing the ability of that population or its ecosystem to maintain that density in the future.
Carrying Capacity of Grazing Lands

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  – the maximum number of species per unit area that can persist w/o decreasing the ability of that population or its ecosystem to maintain that density in the future.

• When the carrying capacity is exceeded, the land is overgrazed. (sometimes poor grazing practices can lead to problems even though the number of animals may have been small).
Carrying Capacity of Grazing Lands
Carrying Capacity of Grazing Lands

• Overgrazing
Carrying Capacity of Grazing Lands

• Overgrazing
  – Slows the growth of vegetation
Carrying Capacity of Grazing Lands

- Overgrazing
  - Slows the growth of vegetation
  - Reduces the diversity of plant species
Carrying Capacity of Grazing Lands

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Carrying Capacity of Grazing Lands

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  - Slows the growth of vegetation
  - Reduces the diversity of plant species
  - Leads to dominance by plant species that are relatively undesirable to the cattle
  - Hastens loss of soil by erosion
  - Subject the land to further damage from trampling
Desertification
Desertification

- Deserts occur naturally where there is too little water for substantial plant growth.
Desertification

• Deserts occur naturally where there is too little water for substantial plant growth.
  – The warmer the climate the greater the rainfall needed to convert an area from desert to non-desert
Desertification

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  – The warmer the climate the greater the rainfall needed to convert an area from desert to non-desert
  – The crucial factor is available water in the soil for plant use
Desertification

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  - The warmer the climate the greater the rainfall needed to convert an area from desert to non-desert
  - The crucial factor is available water in the soil for plant use
  - Factors that destroy the ability of a soil to store water can create a desert
Desertification
Desertification

• Earth has five natural warm desert regions
Desertification

- Earth has five natural warm desert regions
  - Primarily between 15° and 30° north and south of the equator
Desertification

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  – Primarily between $15^\circ$ and $30^\circ$ north and south of the equator
• Based on climate 1/3 of Earth’s land area should be desert
Desertification

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- Based on climate 1/3 of Earth’s land area should be desert
  - 43% of land is desert
Desertification

• **Earth has five natural warm desert regions**
  – Primarily between 15° and 30° north and south of the equator

• **Based on climate 1/3 of Earth’s land area should be desert**
  – 43% of land is desert
  – Additional area due to human activities
Desertification
Desertification

- Desertification – the deterioration of land in arid, semiarid, and dry sub humid areas due to changes in climate and human activities.
Desertification

- Desertification – the deterioration of land in arid, semiarid, and dry sub humid areas due to changes in climate and human activities.
- Serious problem that affects 1/6 of world population (1 billion people)
What Causes Deserts
What Causes Deserts

- The leading cause of desertification are bad farming practices.
What Causes Deserts

• The leading cause of desertification are bad farming practices.
  – Failure to use contour plowing
What Causes Deserts

• The leading cause of desertification are bad farming practices.
  – Failure to use contour plowing
  – To much farming
What Causes Deserts

• The leading cause of desertification are bad farming practices.
  – Failure to use contour plowing
  – To much farming
  – Overgrazing
What Causes Deserts

• The leading cause of desertification are bad farming practices.
  – Failure to use contour plowing
  – To much farming
  – Overgrazing
  – Conversion of rangelands to croplands in marginal areas
What Causes Deserts

- The leading cause of desertification are bad farming practices.
  - Failure to use contour plowing
  - Too much farming
  - Overgrazing
  - Conversion of rangelands to croplands in marginal areas
  - Poor forestry practices
What Causes Deserts
What Causes Deserts

• Desert like areas can be created anywhere by poisoning of the soil
What Causes Deserts

• Desert like areas can be created anywhere by poisoning of the soil
  – World wide chemicals account for 12% of soil degradation
What Causes Deserts

- Desert like areas can be created anywhere by poisoning of the soil
  - World wide chemicals account for 12% of soil degradation
  - Irrigation in arid lands can cause salts to build up to toxic levels
Preventing Desertification
Preventing Desertification

- First step is detection of symptoms
Preventing Desertification

• First step is detection of symptoms
  – Lowering of water table
Preventing Desertification

• First step is detection of symptoms
  – Lowering of water table
  – Increase in the salt content of soil
Preventing Desertification

• First step is detection of symptoms
  – Lowering of water table
  – Increase in the salt content of soil
  – Reduced surface water
Preventing Desertification

• First step is detection of symptoms
  – Lowering of water table
  – Increase in the salt content of soil
  – Reduced surface water
  – Increased soil erosion
Preventing Desertification

• First step is detection of symptoms
  – Lowering of water table
  – Increase in the salt content of soil
  – Reduced surface water
  – Increased soil erosion
  – Loss of native vegetation
Preventing Desertification

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  – Lowering of water table
  – Increase in the salt content of soil
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• Achieved by monitoring
Preventing Desertification
Preventing Desertification

• Next step
Preventing Desertification

• Next step
  – Proper methods of soil conservation, forest management and irrigation
Preventing Desertification

• Next step
  – Proper methods of soil conservation, forest management and irrigation
• Good soil conservation includes
Preventing Desertification

• Next step
  – Proper methods of soil conservation, forest management and irrigation

• Good soil conservation includes
  – Use of wind breaks
Preventing Desertification

• Next step
  – Proper methods of soil conservation, forest management and irrigation

• Good soil conservation includes
  – Use of wind breaks
  – Reforestation
Does Farming Change the Biosphere?
Does Farming Change the Biosphere?

- 1st Agriculture changes land cover
Does Farming Change the Biosphere?

• 1st Agriculture changes land cover
  – Resulting in changes in reflected light
Does Farming Change the Biosphere?

- 1st Agriculture changes land cover
  - Resulting in changes in reflected light
  - The evaporation of water
Does Farming Change the Biosphere?

- 1st Agriculture changes land cover
  - Resulting in changes in reflected light
  - The evaporation of water
  - The roughness of the surface
Does Farming Change the Biosphere?

• 1st Agriculture changes land cover
  – Resulting in changes in reflected light
  – The evaporation of water
  – The roughness of the surface
  – Rate of exchange of chemical compounds
Does Farming Change the Biosphere?

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• 2\textsuperscript{nd} Modern ag increases carbon dioxide
Does Farming Change the Biosphere?

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• 2nd Modern ag increases carbon dioxide
  – Major user of fossil fuels
Does Farming Change the Biosphere?

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  - Resulting in changes in reflected light
  - The evaporation of water
  - The roughness of the surface
  - Rate of exchange of chemical compounds

- 2nd Modern ag increases carbon dioxide
  - Major user of fossil fuels
  - Clearing land speeds decomposition
Does Farming Change the Biosphere?
Does Farming Change the Biosphere?

- 3rd Affect climate through fires
Does Farming Change the Biosphere?

- 3rd Affect climate through fires
  - Associated w/ clearing land
Does Farming Change the Biosphere?

• 3\textsuperscript{rd} Affect climate through fires
  – Associated w/ clearing land
  – Add small particulates to the atmosphere
Does Farming Change the Biosphere?

• 3rd Affect climate through fires
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• 4th Artificial production of nitrogen
Does Farming Change the Biosphere?

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• 4th Artificial production of nitrogen
  – Alters biogeochemical cycle
Does Farming Change the Biosphere?

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• 5th Affects species diversity
Does Farming Change the Biosphere?

- **3rd** Affect climate through fires
  - Associated w/ clearing land
  - Add small particulates to the atmosphere
- **4th** Artificial production of nitrogen
  - Alters biogeochemical cycle
- **5th** Affects species diversity
  - Reduces diversity and increases # of endangered species