MILLER/SPOOLMAN

LIVING IN THE ENVIRONMENT

17TH

Chapter 12

Food, Soil, and Pest Management

Core Case Study: Organic Agriculture Is on the Rise

- **Organic agriculture**
  - Crops grown without using synthetic pesticides, synthetic inorganic fertilizers, or genetically engineered seeds
  - Animals grown without using antibiotics or synthetic hormones
  - U.S. in 2008: .6% cropland; 3.5% food sales
  - Europe, Australia and New Zealand much higher

Industrialized Agriculture vs. Organic Agriculture

Industrialized Agriculture

Uses synthetic inorganic fertilizers and sewage sludge to supply plant nutrients

Makes use of synthetic chemical pesticides

Uses conventional and genetically modified seeds

Depends on nonrenewable fossil fuels (mostly oil and natural gas)

Produces significant air and water pollution and greenhouse gases

Is globally export-oriented

Uses antibiotics and growth hormones to produce meat and meat products

Organic Agriculture

Emphasizes prevention of soil erosion and the use of organic fertilizers such as animal manure and compost, but no sewage sludge to help replace lost plant nutrients

Employs crop rotation and biological pest control

Uses no genetically modified seeds

Reduces fossil fuel use and increases use of renewable energy such as solar and wind power for generating electricity

Produces less air and water pollution and greenhouse gases

Is regionally and locally oriented

Uses no antibiotics or growth hormones to produce meat and meat products

Fig. 12-1, p. 277

Industrialized Agriculture

Uses synthetic inorganic fertilizers and sewage sludge to supply plant nutrients

Makes use of synthetic chemical pesticides

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Fig. 12-1a, p. 277

Organic Agriculture

- Emphasizes prevention of soil erosion and the use of organic fertilizers such as animal manure and compost, but no sewage sludge to help replace lost plant nutrients
- Employs crop rotation and biological pest control
- Uses no genetically modified seeds
- Reduces fossil fuel use and increases use of renewable energy such as solar and wind power for generating electricity
- Produces less air and water pollution and greenhouse gases
- Is regionally and locally oriented
- Uses no antibiotics or growth hormones to produce meat and meat products

Fig. 12-1b, p. 277

12-1 What Is Food Security and Why Is It Difficult to Attain?

- ***Concept 12-1A*** *Many people in less-developed countries have health problems from not getting enough food, while many people in more-developed countries have health problems from eating too much food.*

- ***Concept 12-1B*** *The greatest obstacles to providing enough food for everyone are poverty, political upheaval, corruption, war, and the harmful environmental effects of food production.*

Many People Have Health Problems Because They Do Not Get Enough to Eat

- **Food security**
  - All or most people in a country have daily access to enough nutritious food to lead active and healthy lives

- **Food insecurity**
  - Chronic hunger and poor nutrition
  - Root cause: poverty
  - Political upheaval, war, corruption, bad weather

Starving Children in Sudan Collect Ants

Fig. 12-2, p. 279

Many People Suffer from Chronic Hunger and Malnutrition (1)

- **Macronutrients**
  - Carbohydrates
  - Proteins
  - Fats
- **Micronutrients**
  - Vitamins
  - Minerals

Key Nutrients for a Healthy Human Life

Table 12-1 Key Nutrients for a Healthy Human Life

Nutrient	Food Source	Function
Proteins	Animals and some plants	Help to build and repair body tissues
Carbohydrates	Wheat, corn, and rice	Provide short-term energy
Lipids (oils and fats)	Animal fats, nuts, oils	Help to build membrane tissues and create hormones

Many People Suffer from Chronic Hunger and Malnutrition (2)

- **Chronic undernutrition**, hunger
- **Chronic malnutrition**
- 1 in 6 people in less-developed countries is chronically undernourished or malnourished
- **Famine**
  - Drought, flooding, war, other catastrophes

World Hunger

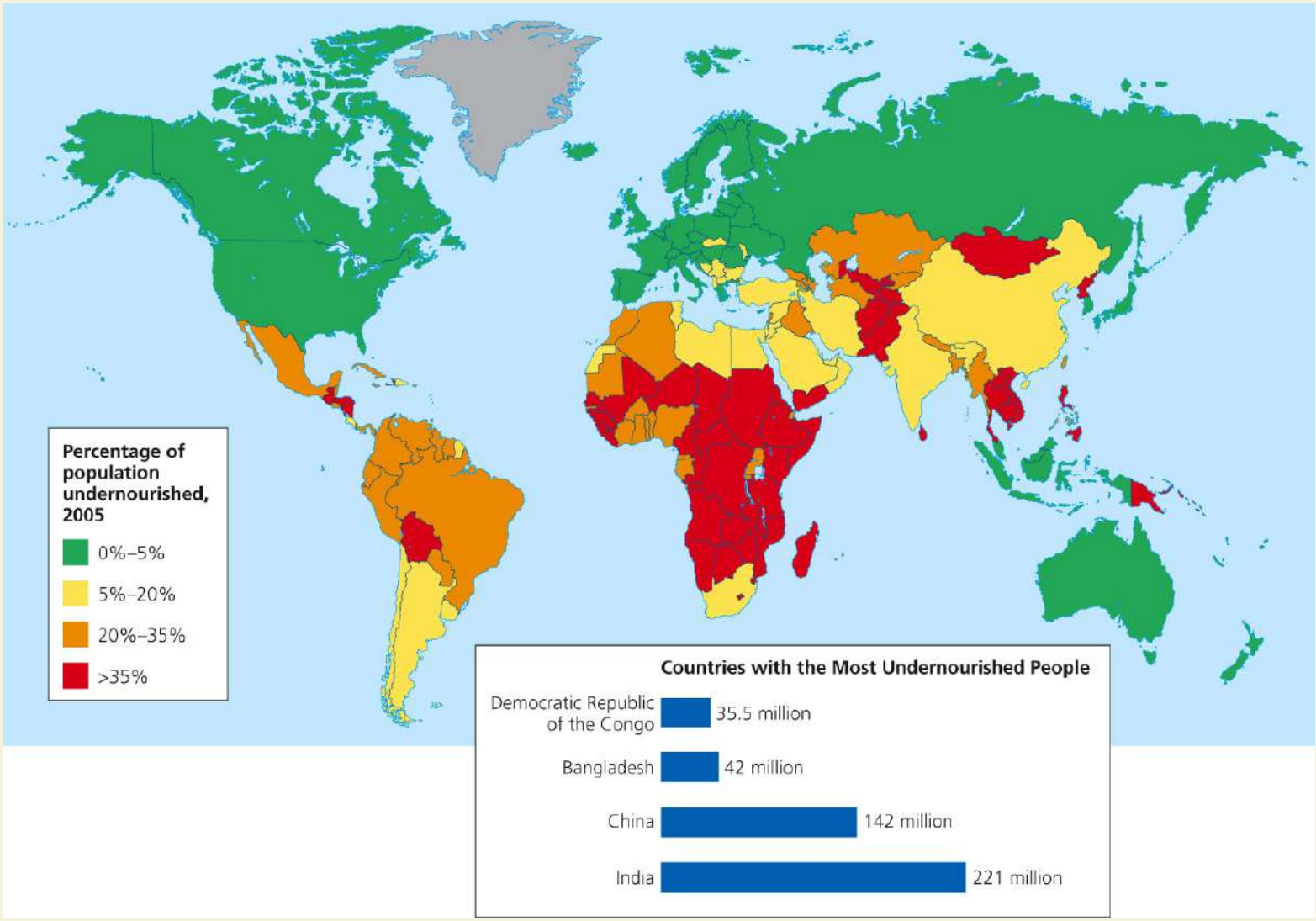


Figure 15, Supplement 8

Many People Do No Get Enough Vitamins and Minerals

- Most often vitamin and mineral deficiencies in people in less-developed countries
- Iron
- Vitamin A
- Iodine
- Golden rice

Woman with Goiter in Bangladesh

Fig. 12-3, p. 280

Many People Have Health Problems from Eating Too Much

- **Overnutrition**
  - Excess body fat from too many calories and not enough exercise

- Similar health problems to those who are underfed
  - Lower life expectancy
  - Greater susceptibility to disease and illness
  - Lower productivity and life quality

12-2 How Is Food Produced?

- ***Concept 12-2*** *We have used high-input industrialized agriculture and lower-input traditional methods to greatly increase supplies of food.*

Food Production Has Increased Dramatically

- Three systems produce most of our food
  - Croplands: 77% on 11% world's land area
  - Rangelands, pastures, and feedlots: 16% on 29% of world's land area
  - Aquaculture: 7%
- Importance of wheat, rice, and corn
- Tremendous increase in global food production

Industrialized Crop Production Relies on High-Input Monocultures

- **Industrialized agriculture, high-input agriculture**

- Goal is to steadily increase crop yield
  - **Plantation agriculture**: cash crops
    - Primarily in less-developed countries
  - Increased use of greenhouses to raise crops

Heavy Equipment Used to Harvest Wheat in the United States

Fig. 12-4, p. 281

Plantation Agriculture: Oil Palms on Borneo in Malaysia

5, p. 281

Case Study: Hydroponics: Growing Crops without Soil

- **Hydroponics**: growing plants in nutrient-rich water solutions rather than soil
  - Grow indoors almost anywhere, year-round
  - Grow in dense urban areas
  - Recycle water and fertilizers
  - Little or no need for pesticides
  - No soil erosion
  - Takes money to establish
  - Help make the transition to more sustainable agriculture

Hydroponic Salad Greens

Fig. 12-6, p. 282

Traditional Agriculture Often Relies on Low-Input Polycultures (1)

- **Traditional subsistence agriculture**
  - Human labor and draft animals for family food
- **Traditional intensive agriculture**
  - Higher yields through use of manure and water

Traditional Agriculture Often Relies on Low-Input Polycultures (2)

- **Polyculture**
  - Benefits over monoculture

- **Slash-and-burn agriculture**
  - Subsistence agriculture in tropical forests
  - Clear and burn a small plot
  - Grow many crops that mature at different times
  - Reduced soil erosion
  - Less need for fertilizer and water

Science Focus: Soil Is the Base of Life on Land (1)

- Soil composition
  - Eroded rock
  - Mineral nutrients
  - Decaying organic matter
  - Water
  - Air
  - Microscopic decomposers

Science Focus: Soil Is the Base of Life on Land (2)

- Layers (horizons) of mature soils
  - O horizon: leaf litter
  - A horizon: topsoil
  - B horizon: subsoil
  - C horizon: parent material, often bedrock

Soil Formation and Generalized Soil Profile

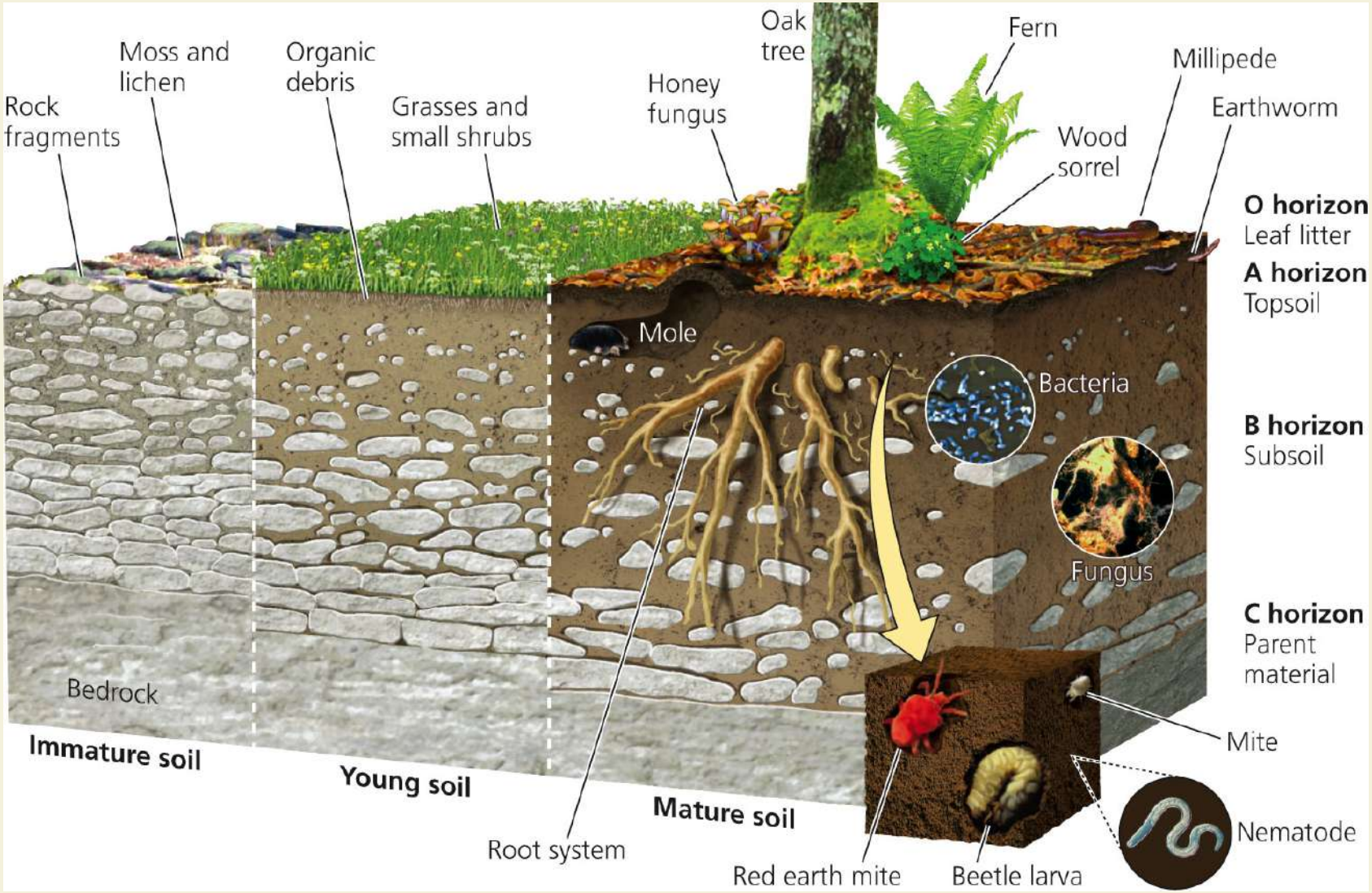


Fig. 12-A, p. 284

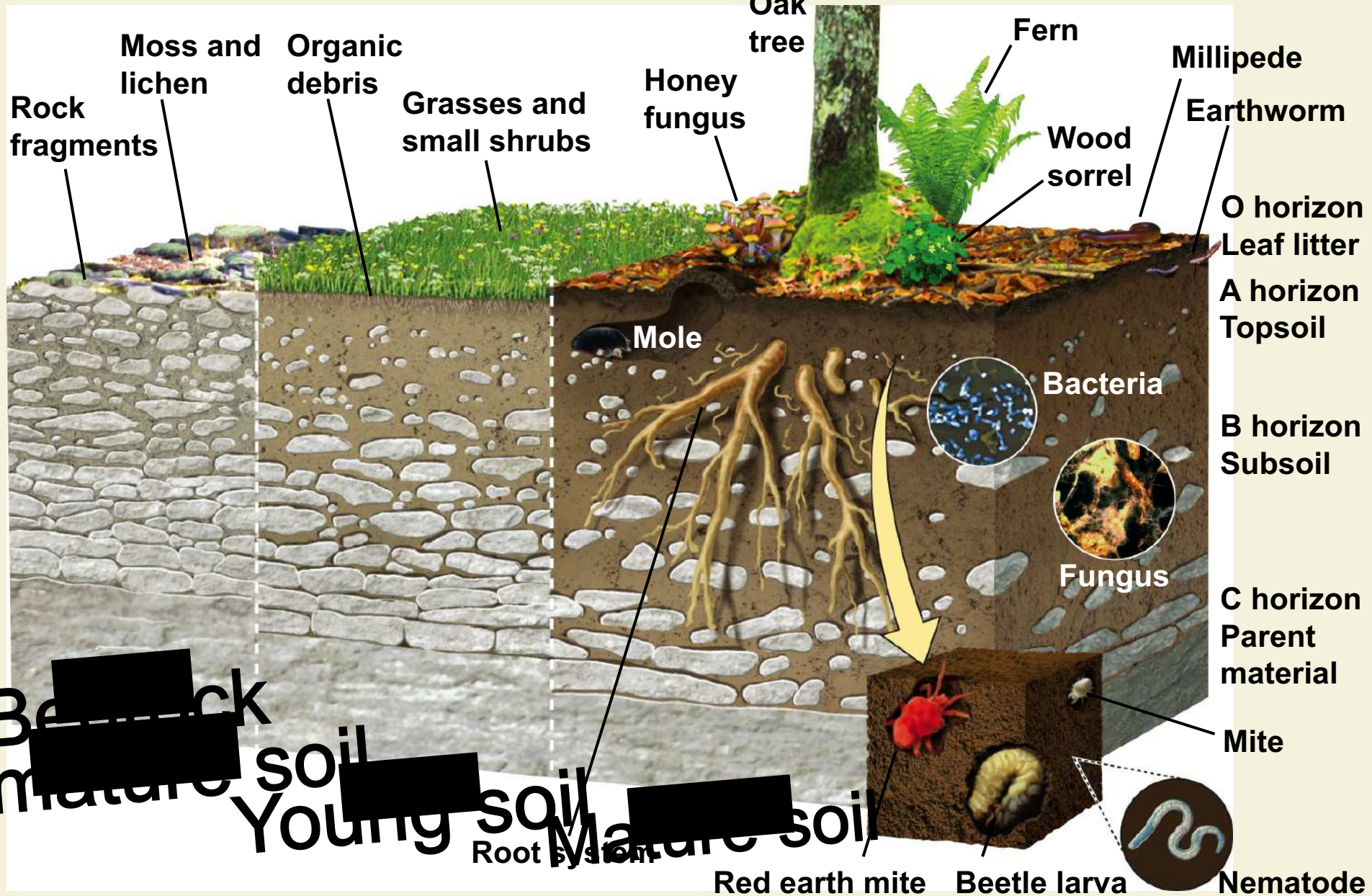

Oak tree
Fern
Millipede
Moss and lichen
Organic debris
Honey fungus
Earthworm
Rock fragments
Grasses and small shrubs
Wood sorrel
O horizon
Leaf litter
A horizon
Topsoil
Mole
Bacteria
B horizon
Subsoil
Fungus
C horizon
Parent material
Mite
Young soil
Root system
Mature soil
Red earth mite
Beetle larva
Nematode

Fig. 12-A, p. 284

A Closer Look at Industrialized Crop Production

- **Green Revolution**: increase crop yields
  1. Monocultures of high-yield key crops
     - Rice, wheat, and corn
  2. Large amounts of fertilizers, pesticides, water
  3. Multiple cropping

- Second Green Revolution
  - Fast growing dwarf varieties

- World grain has tripled in production

Global Outlook: Total Worldwide Grain Production (Wheat, Corn, and Rice)

Fig. 12-7, p. 285

Fig. 12-7a, p. 285

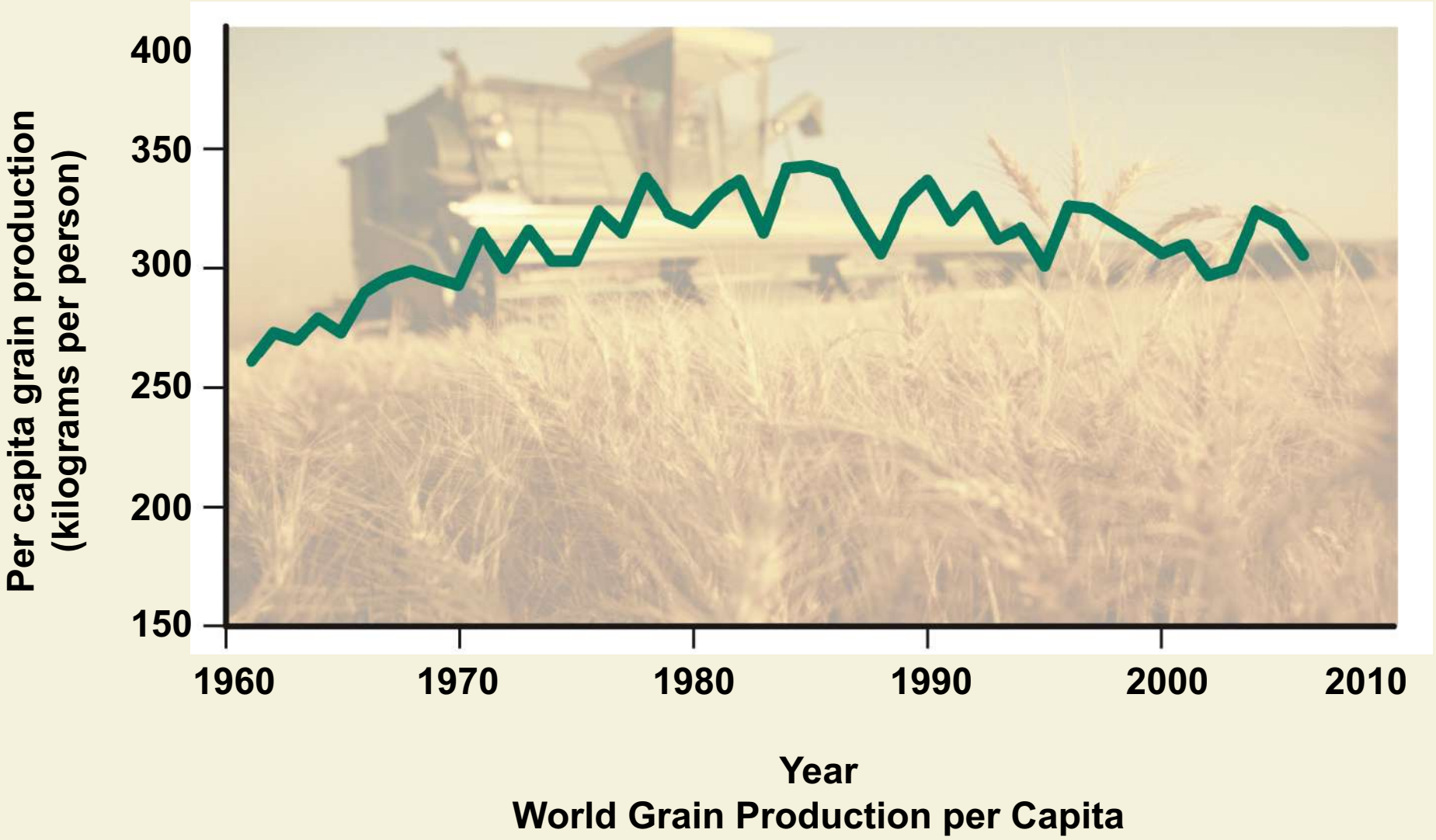


Fig. 12-7b, p. 285

Case Study: Industrialized Food Production in the United States

- Agribusiness
  - Average farmer feeds 129 people
  - Annual sales greater than auto, steel, and housing combined
- Food production: very efficient
  - Americans spend 10% of income on food
- Hidden costs of subsidies and costs of pollution and environmental degradation

Crossbreeding and Genetic Engineering Produce New Crop/Livestock Varieties (1)

- First gene revolution
  - Cross-breeding through artificial selection
    - Slow process
    - Amazing results

- Genetic engineering = second gene revolution
  - Alter organism's DNA
  - Genetic modified organisms (GMOs): transgenic organisms

Crossbreeding and Genetic Engineering Produce New Crop/Livestock Varieties (2)

- Age of Genetic Engineering: developing crops that are resistant to
  - Heat and cold
  - Herbicides
  - Insect pests
  - Parasites
  - Viral diseases
  - Drought
  - Salty or acidic soil

- Promise and potential perils

Meat Production and Consumption Have Grown Steadily

- Animals for meat raised in
  - Pastures and rangelands
  - Feedlots

- Meat production increased fourfold between 1961 and 2007
  - Increased demand for grain
  - Demand is expected to go higher

Industrialized Meat Production

Fig. 12-8, p. 287

Fish and Shellfish Production Have Increased Dramatically

- Fishing with fleets depletes fisheries and uses many resources

- **Aquaculture**, blue revolution
  - World's fastest-growing type of food production
  - Dominated by operations that raise herbivorous species

World Seafood Production, Including Both Wild Catch and Aquaculture

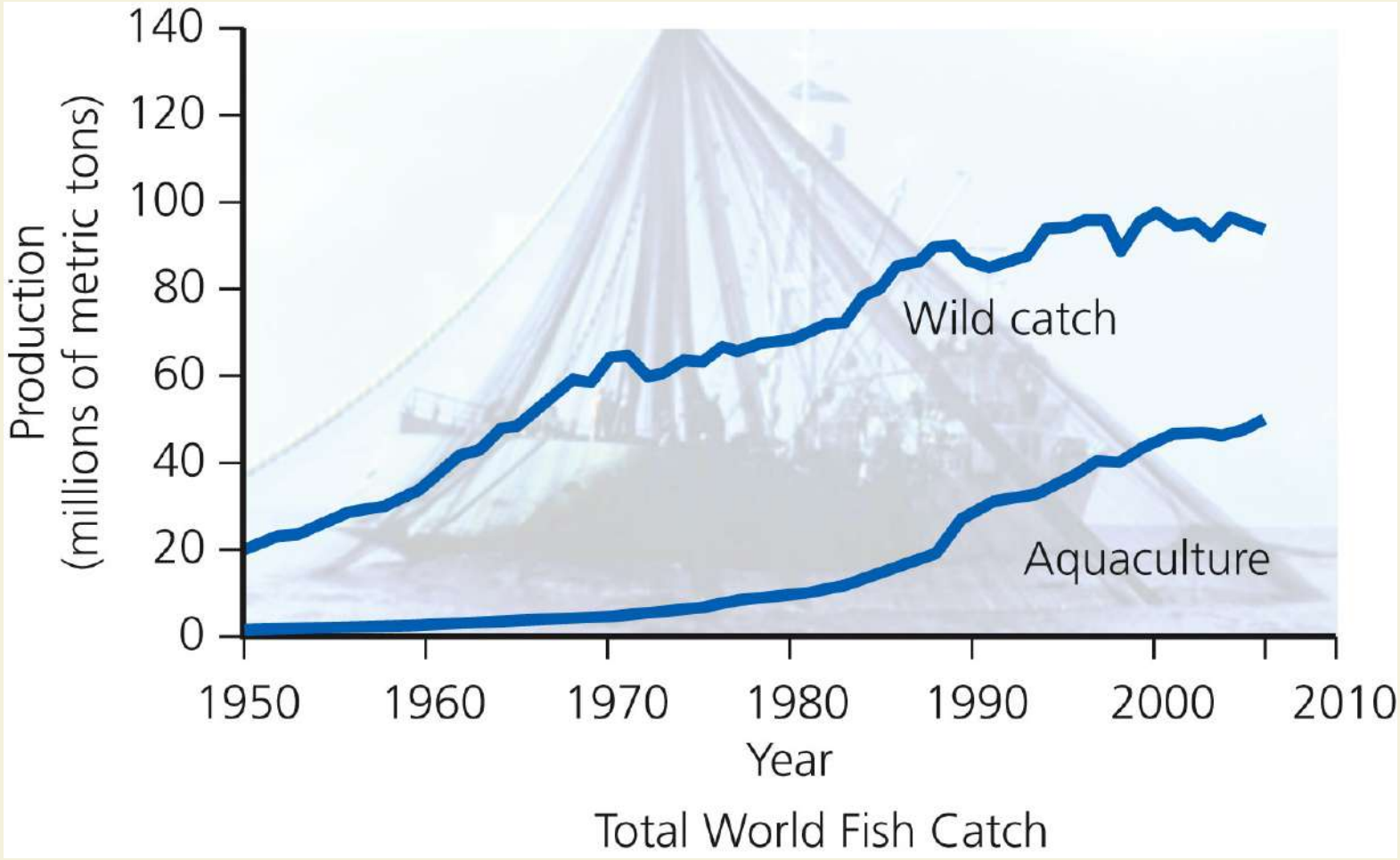
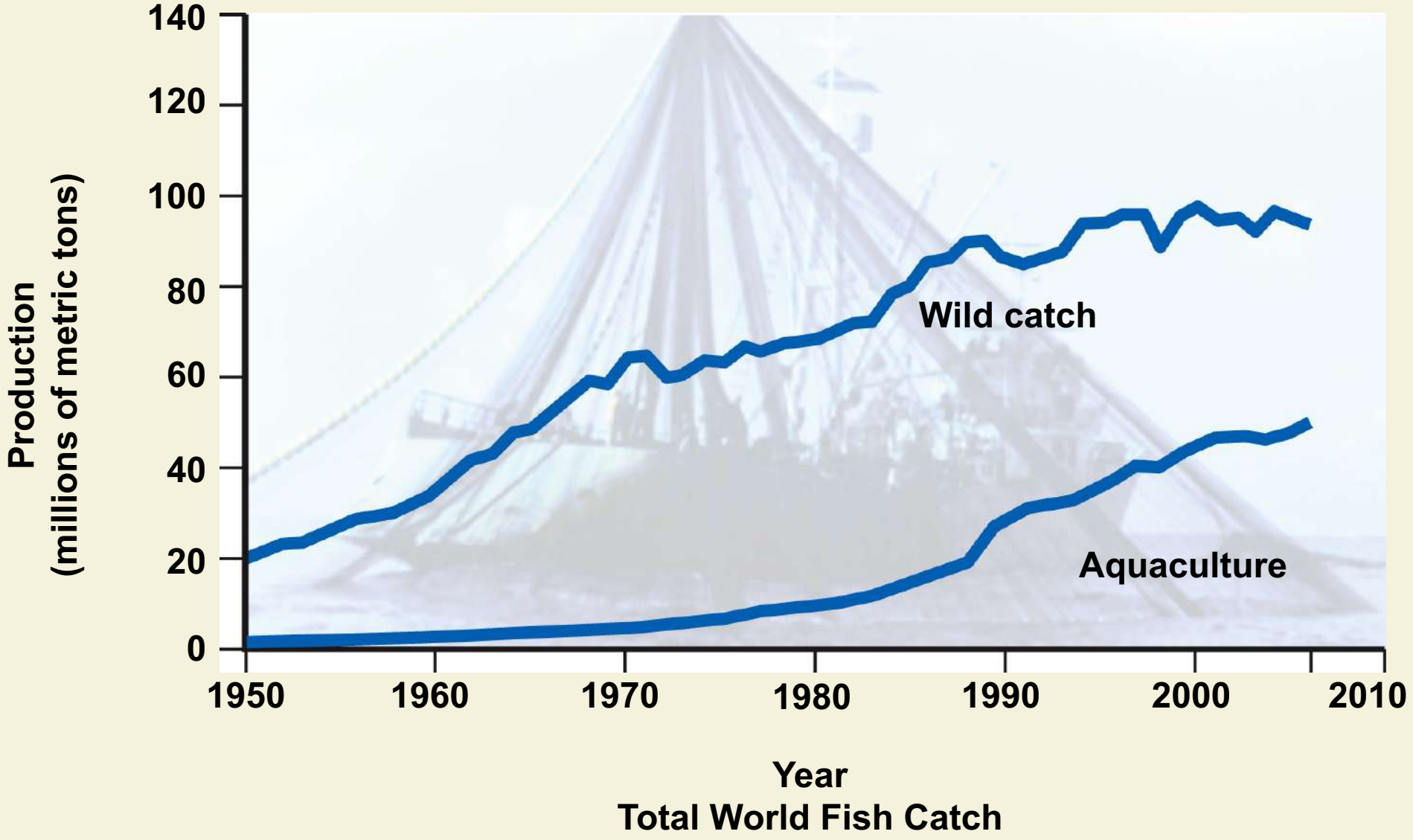


Fig. 12-9, p. 287



Total World Fish Catch

Fig. 12-9, p. 287

Industrialized Food Production Requires Huge Inputs of Energy

- Mostly nonrenewable energy – oil and natural gas
  - Farm machinery
  - Irrigate crops
  - Produce pesticides (petrochemicals)
  - Commercial inorganic fertilizers
  - Process and transport food
  - 19% of total fossil fuel energy use in U.S.
  - U.S. food travels an average of 2,400 kilometers

12-3 What Environmental Problems Arise from Food Production?

- ***Concept 12-3*** *Food production in the future may be limited by its serious environmental impacts, including soil erosion and degradation, desertification, water and air pollution, greenhouse gas emissions, and degradation and destruction of biodiversity.*

Producing Food Has Major Environmental Impacts

- Harmful effects of agriculture on
  - Biodiversity
  - Soil
  - Water
  - Air
  - Human health

Natural Capital Degradation: Food Production

Natural Capital Degradation

Food Production

Biodiversity Loss

Loss and degradation of grasslands, forests, and wetlands in cultivated areas

Fish kills from pesticide runoff

Killing wild predators to protect livestock

Loss of genetic diversity of wild crop strains replaced by monoculture strains

Soil

Erosion

Loss of fertility

Salinization

Waterlogging

Desertification

Increased acidity

Water

Water waste

Aquifer depletion

Increased runoff, sediment pollution, and flooding from cleared land

Pollution from pesticides and fertilizers

Algal blooms and fish kills in lakes and rivers caused by runoff of fertilizers and agricultural wastes

Air Pollution

Emissions of greenhouse gas CO_2 from fossil fuel use

Emissions of greenhouse gas N_2O from use of inorganic fertilizers

Emissions of greenhouse gas methane (CH_4) by cattle (mostly belching)

Other air pollutants from fossil fuel use and pesticide sprays

Human Health

Nitrates in drinking water (blue baby)

Pesticide residues in drinking water, food, and air

Contamination of drinking and swimming water from livestock wastes

Bacterial contamination of meat

Fig. 12-10, p. 289

Natural Capital Degradation

Food Production

Biodiversity Loss

Loss and degradation of grasslands, forests, and wetlands in cultivated areas

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Fig. 12-10, p. 289

Topsoil Erosion Is a Serious Problem in Parts of the World

- **Soil erosion**
  - Movement of soil by wind and water
  - Natural causes
  - Human causes

- Two major harmful effects of soil erosion
  - Loss of soil fertility
  - Water pollution

Topsoil Erosion on a Farm in Tennessee

Fig. 12-11, p. 289

Natural Capital Degradation: Gully Erosion in Bolivia

Fig. 12-12, p. 290

Wind Removes Topsoil in Dry Areas

Fig. 12-13, p. 290

Natural Capital Degradation: Global Soil Erosion

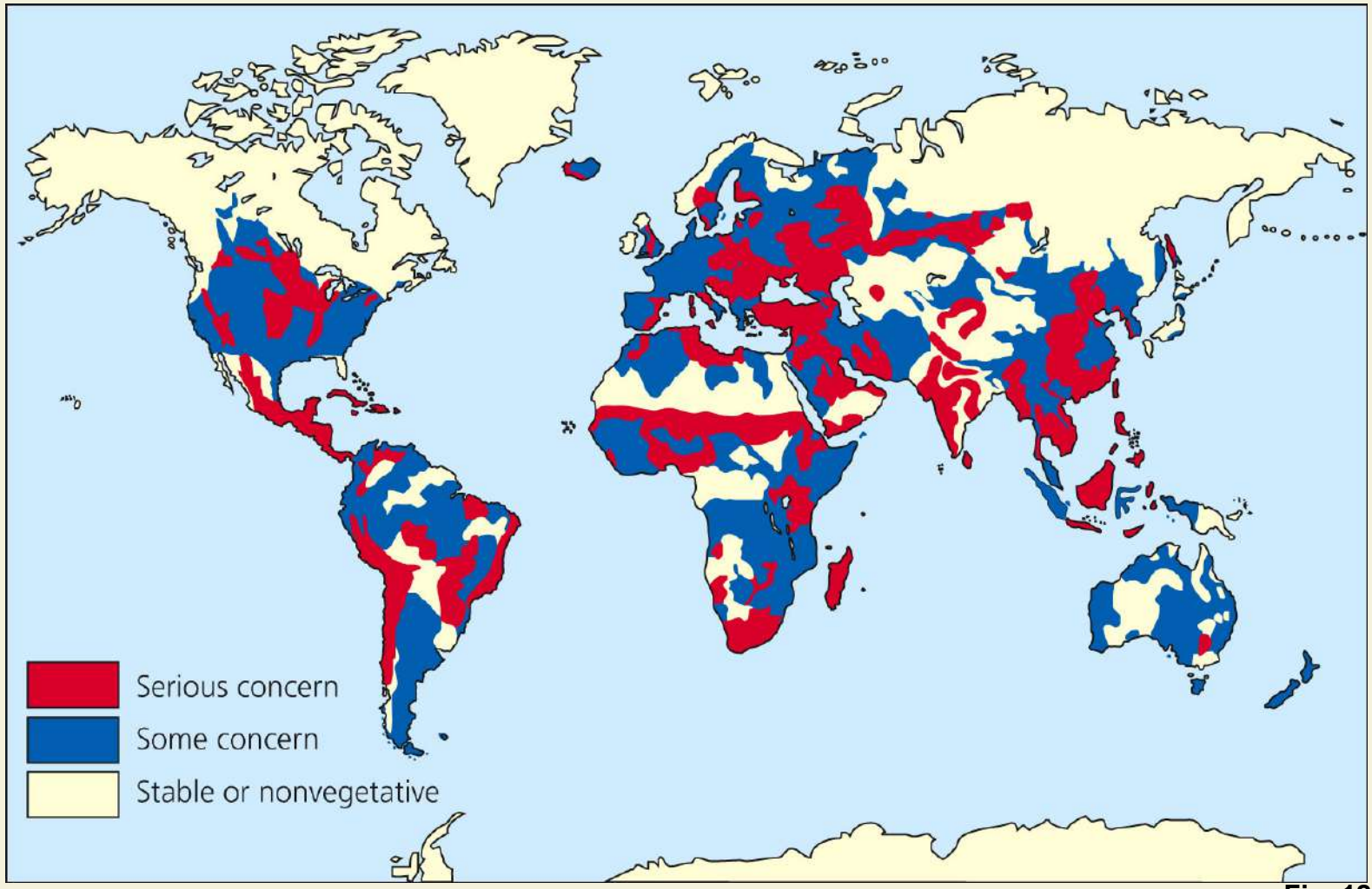


Fig. 12-14, p. 291

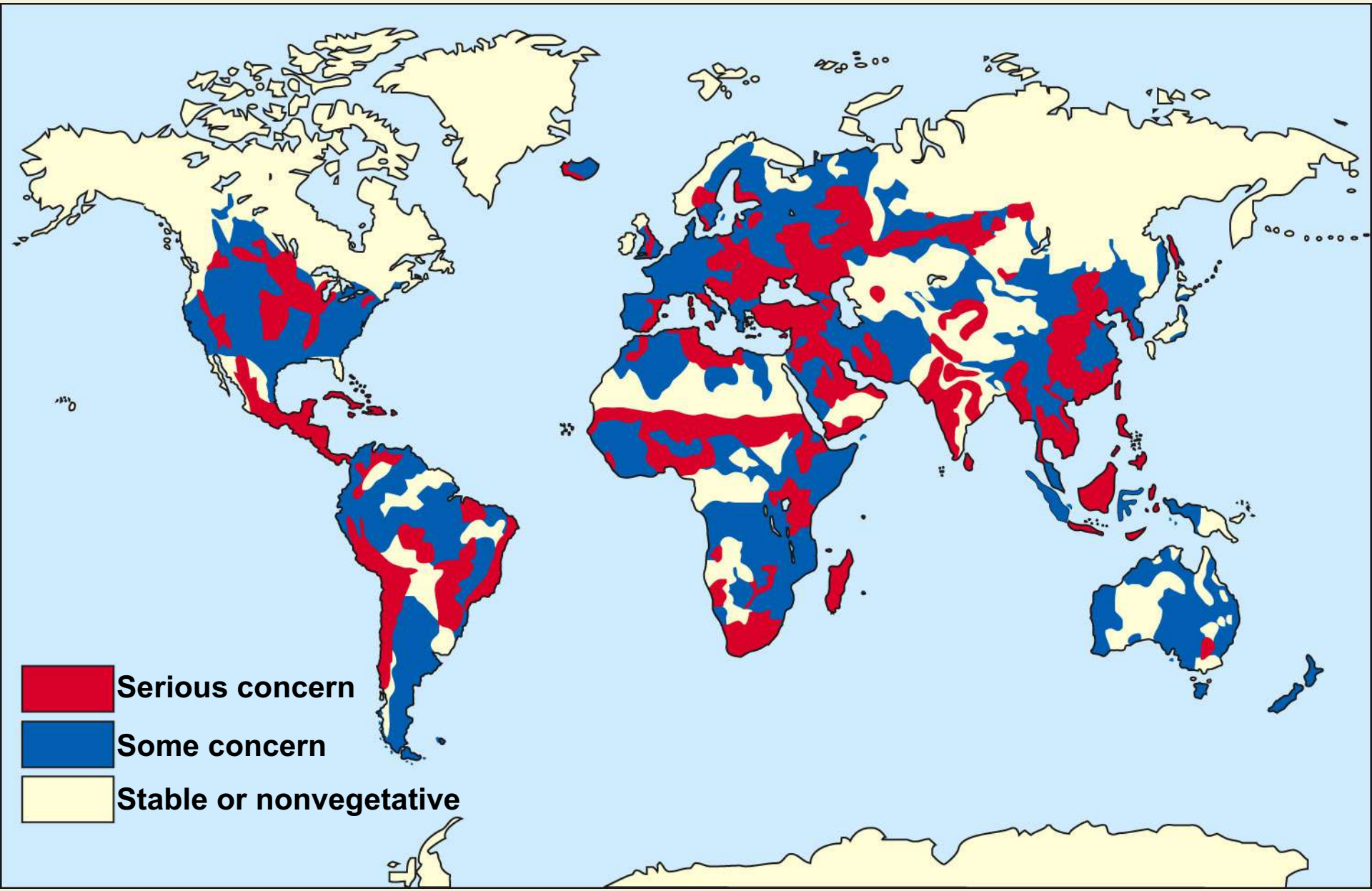
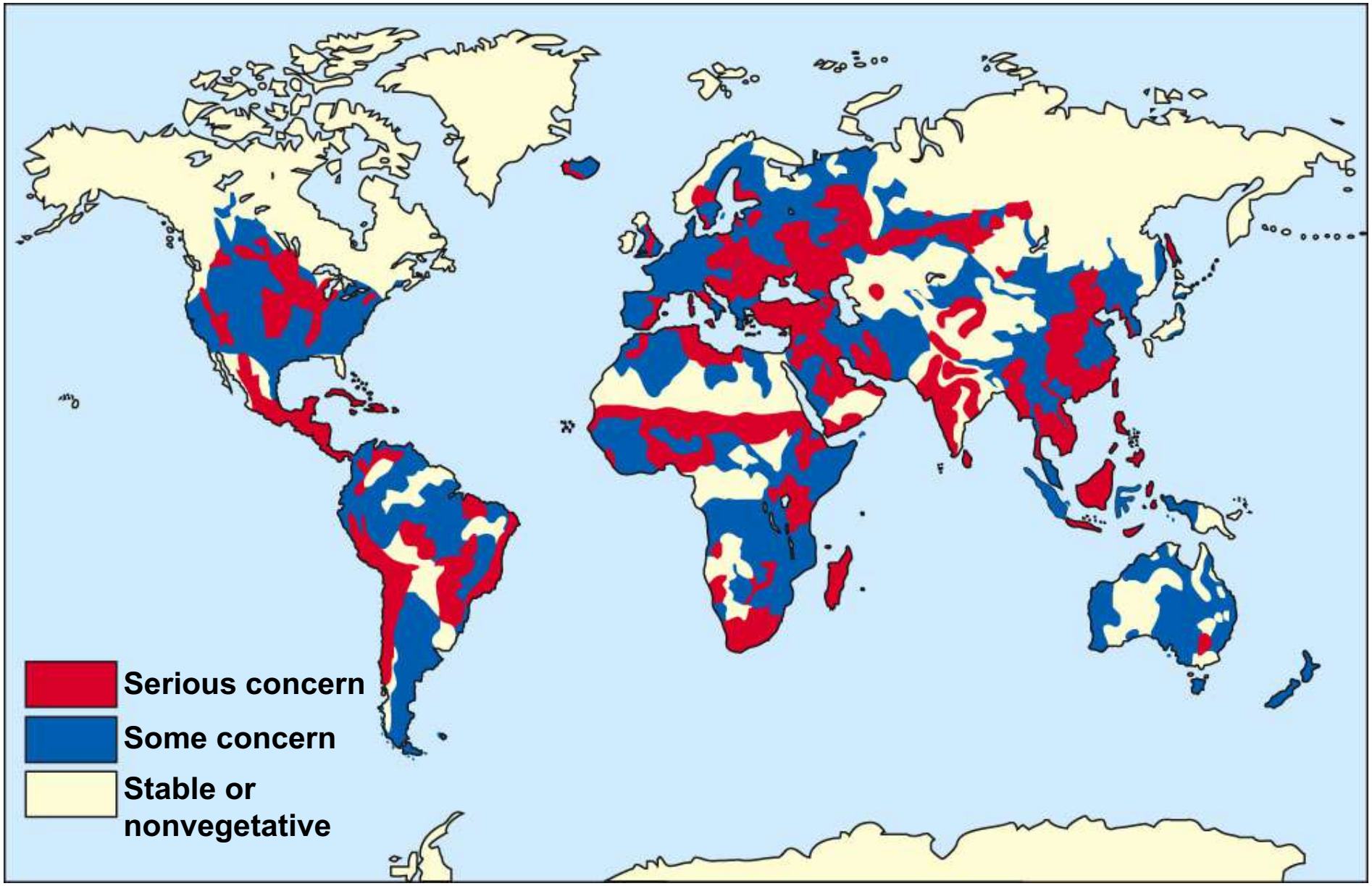


Fig. 12-14, p. 291



Stepped Art

Fig. 12-14, p. 291

Drought and Human Activities Are Degrading Drylands

- **Desertification**
  - Moderate
  - Severe
  - Very severe
- Human agriculture accelerates desertification
- Effect of global warming on desertification

Severe Desertification

Fig. 12-15, p. 291

Natural Capital Degradation: Desertification of Arid and Semiarid Lands

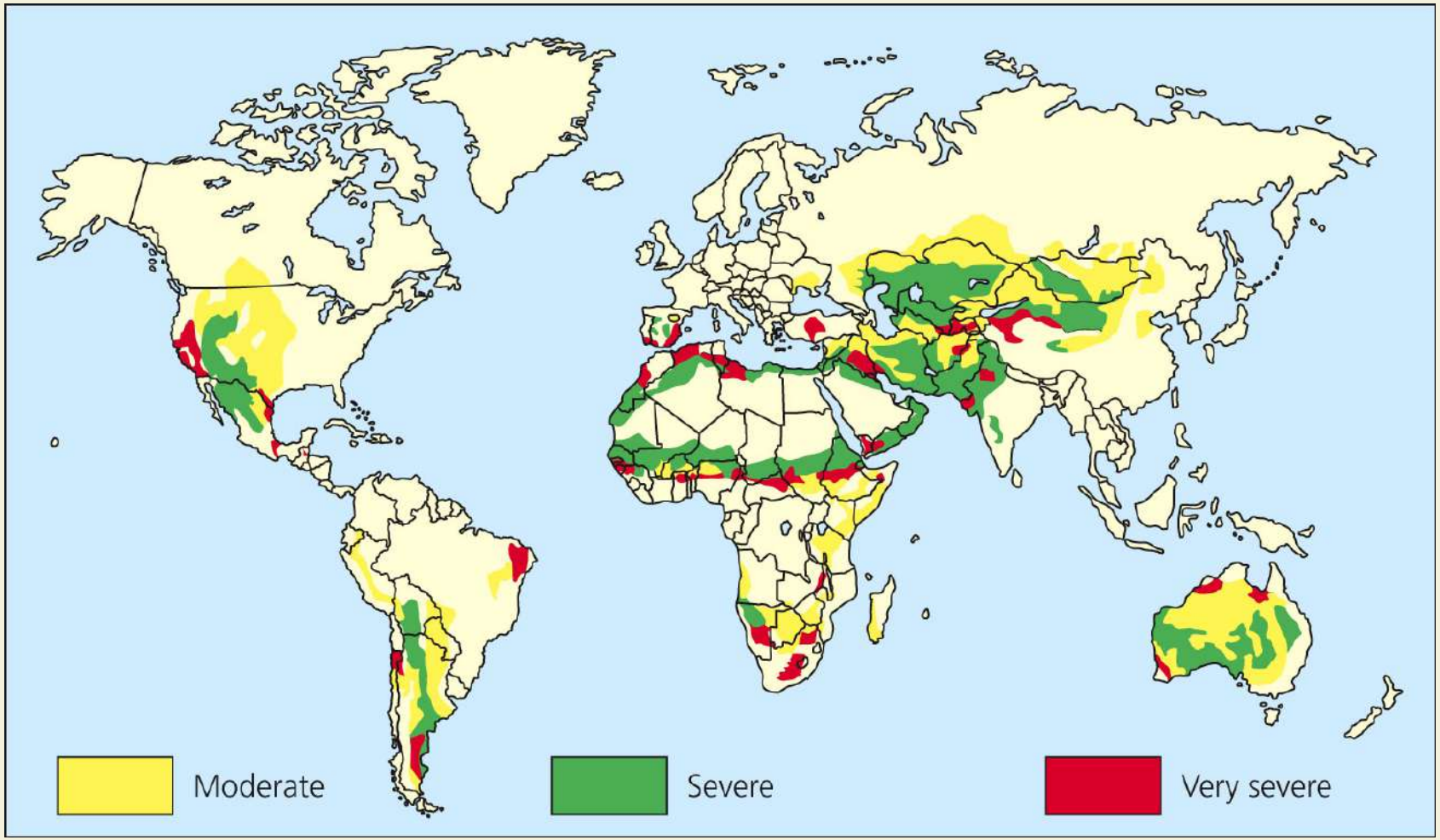


Fig. 12-16, p. 292

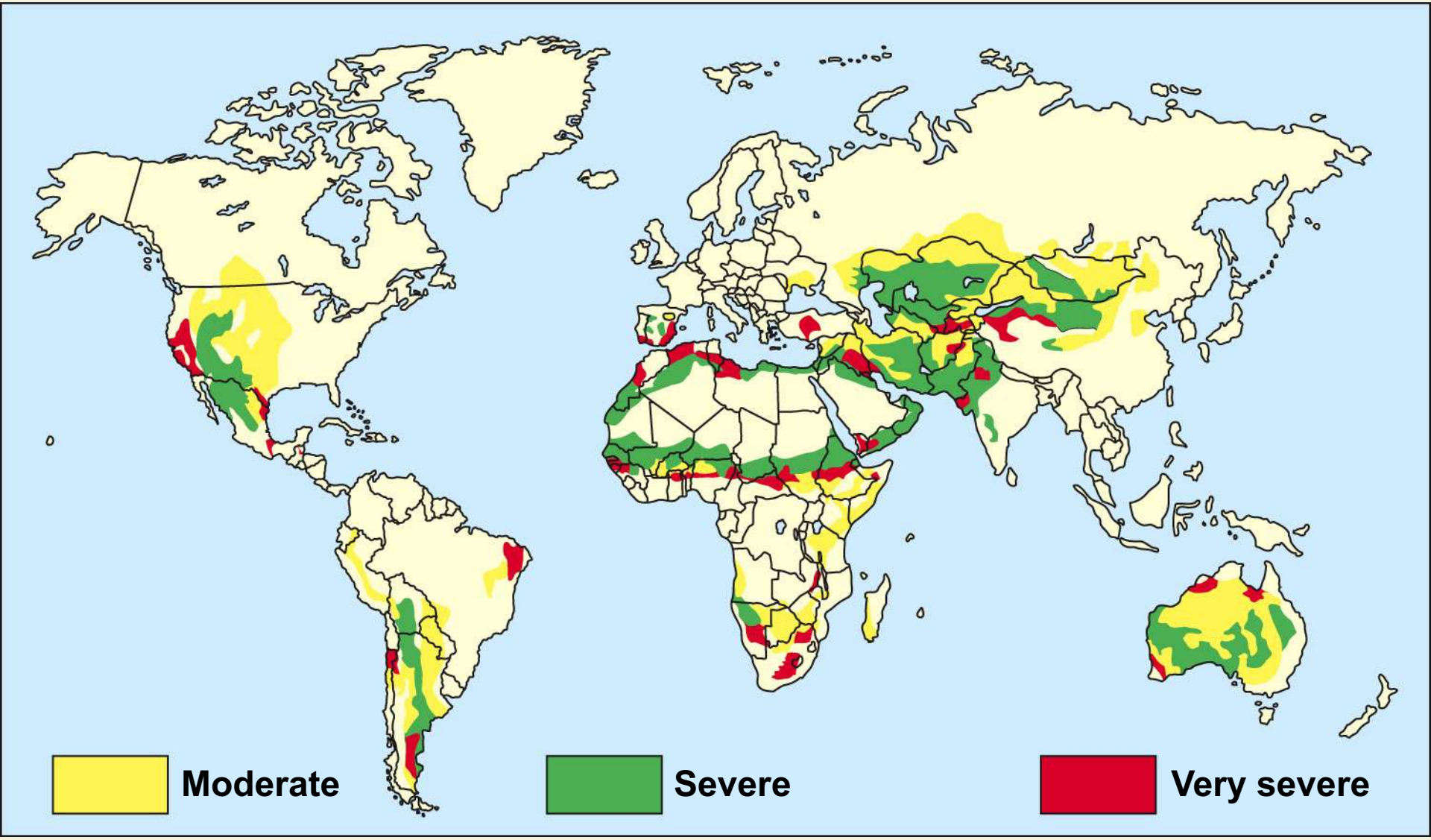


Fig. 12-16, p. 292

Excessive Irrigation Has Serious Consequences

- **Salinization**
  - Gradual accumulation of salts in the soil from irrigation water
  - Lowers crop yields and can even kill plants
  - Affects 10% of world croplands

- **Waterlogging**
  - Irrigation water gradually raises water table
  - Can prevent roots from getting oxygen
  - Affects 10% of world croplands

Natural Capital Degradation: Severe Salinization on Heavily Irrigated Land

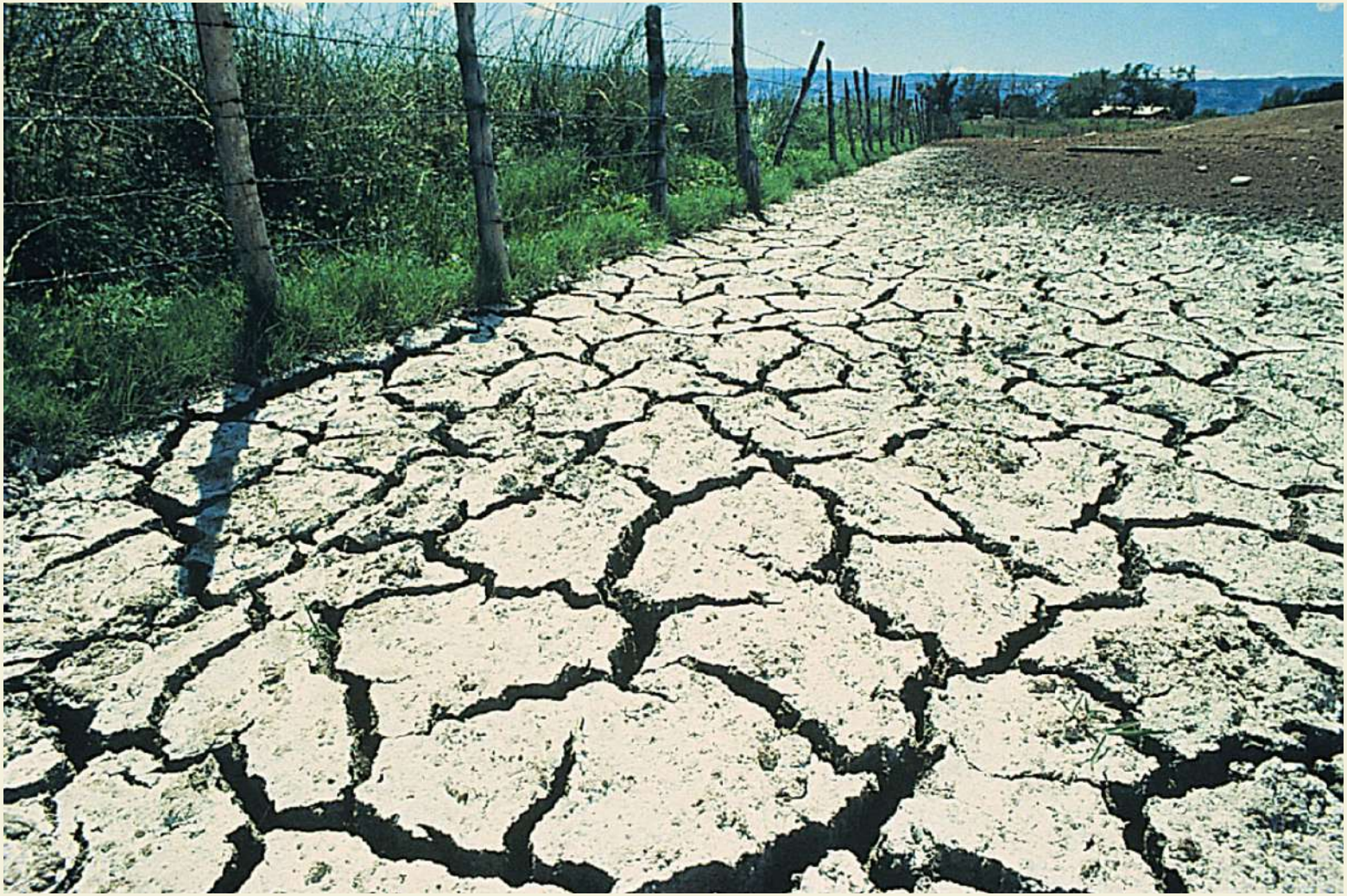


Fig. 12-17, p. 292

Agriculture Contributes to Air Pollution and Projected Climate Change

- Clearing and burning of forests for croplands
- One-fourth of all human-generated greenhouse gases
- Livestock contributes 18% of gases: methane in cow belches
  - Grass-fed better than feedlots

Food and Biofuel Production Systems Have Caused Major Biodiversity Losses

- Biodiversity threatened when
  - Forest and grasslands are replaced with croplands – tropical forests
- Agrobiodiversity threatened when
  - Human-engineered monocultures are used
- Importance of seed banks
  - Newest: underground vault in the Norwegian Arctic

Genetic Engineering Could Solve Some Problems but Create Others

- Pros
- Cons

Trade-Offs: Genetically Modified Crops and Foods

Trade-Offs

Genetically Modified Crops and Foods

Advantages		Disadvantages
Need less fertilizer		Unpredictable genetic and ecological effects
Need less water		Harmful toxins and new allergens in food
More resistant to insects, disease, frost, and drought		No increase in yields
Grow faster		More pesticide-resistant insects and herbicide-resistant weeds
May need less pesticides or tolerate higher levels of herbicides		Could disrupt seed market
May reduce energy needs		Lower genetic diversity

Fig. 12-18, p. 294

Trade-Offs

Genetically Modified Crops and Foods

Advantages

Need less fertilizer

Need less water

More resistant to insects, disease, frost, and drought

Grow faster

May need less pesticides or tolerate higher levels of herbicides

May reduce energy needs

Disadvantages

Unpredictable genetic and ecological effects

Harmful toxins and new allergens in food

No increase in yields

More pesticide-resistant insects and herbicide-resistant weeds

Could disrupt seed market

Lower genetic diversity

Fig. 12-18, p. 294

There Are Limits to Expanding the Green Revolutions

- Usually require large inputs of fertilizer, pesticides, and water
  - Often too expensive for many farmers

- Can we expand the green revolution by
  - Irrigating more cropland?
  - Improving the efficiency of irrigation?
  - Cultivating more land? Marginal land?
  - Using GMOs?
  - Multicropping?

Industrialized Meat Production Has Harmful Environmental Consequences

- Advantages
- Disadvantages

Trade-Offs: Animal Feedlots

Trade-Offs

Animal Feedlots

Advantages	Disadvantages
Increased meat production	Large inputs of grain, fish meal, water, and fossil fuels
Higher profits	Greenhouse gas (CO_2 and CH_4) emissions
Less land use	
Reduced overgrazing	Concentration of animal wastes that can pollute water
Reduced soil erosion	Use of antibiotics can increase genetic resistance to microbes in humans
Protection of biodiversity	

Fig. 12-19, p. 295

Trade-Offs

Animal Feedlots

Advantages

Increased meat production

Higher profits

Less land use

Reduced overgrazing

Reduced soil erosion

Protection of biodiversity

Disadvantages

Large inputs of grain, fish meal, water, and fossil fuels

Greenhouse gas (CO_2 and CH_4) emissions

Concentration of animal wastes that can pollute water

Use of antibiotics can increase genetic resistance to microbes in humans

Fig. 12-19, p. 295

Producing Fish through Aquaculture Can Harm Aquatic Ecosystems

- Advantages
- Disadvantages

Trade-Offs: Aquaculture

Trade-Offs

Aquaculture

Advantages	Disadvantages
High efficiency	Large inputs of land, feed, and water
High yield	Large waste output
Reduced over-harvesting of fisheries	Loss of mangrove forests and estuaries
Low fuel use	Some species fed with grain, fish meal, or fish oil
High profits	Dense populations vulnerable to disease

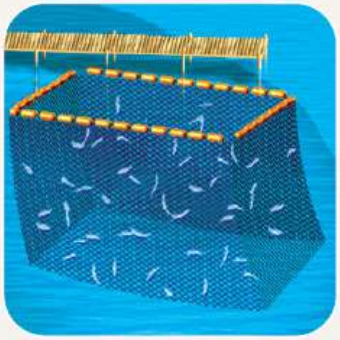


Fig. 12-20, p. 296

Trade-Offs

Aquaculture

Advantages

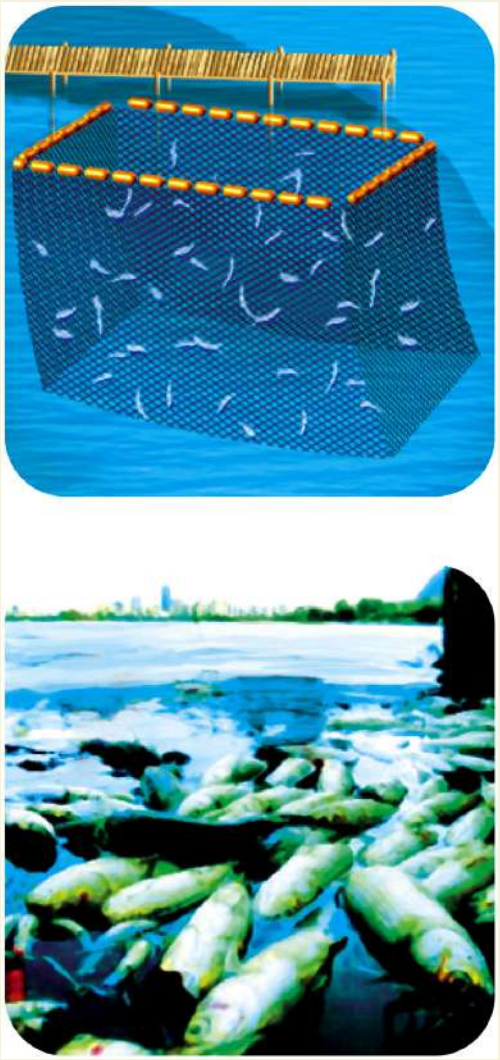
High efficiency

High yield

Reduced over-harvesting of fisheries

Low fuel use

High profits



Disadvantages

Large inputs of land, feed, and water

Large waste output

Loss of mangrove forests and estuaries

Some species fed with grain, fish meal, or fish oil

Dense populations vulnerable to disease

Fig. 12-20, p. 296

12-4 How Can We Protect Crops from Pests More Sustainably?

- ***Concept 12-4*** *We can sharply cut pesticide use without decreasing crop yields by using a mix of cultivation techniques, biological pest controls, and small amounts of selected chemical pesticides as a last resort (integrated pest management).*

Nature Controls the Populations of Most Pests

- What is a **pest**?
  - Interferes with human welfare
- Natural enemies—predators, parasites, disease organisms—control pests
  - In natural ecosystems
  - In many polyculture agroecosystems
- What will happen if we kill the pests?

Natural Capital: Spiders are Important Insect Predators

Fig. 12-21, p. 297

We Use Pesticides to Try to Control Pest Populations (1)

- **Pesticides**
  - Insecticides
  - Herbicides
  - Fungicides
  - Rodenticides

- Herbivores overcome plant defenses through natural selection: coevolution

We Use Pesticides to Try to Control Pest Populations (2)

- First-generation pesticides
  - Borrowed from plants
- Second-generation pesticides
  - Lab produced: DDT and others
  - Benefits versus harm
- Broad-spectrum and narrow-spectrum agents
- Persistence varies

Individuals Matter: Rachel Carson

- Biologist
- *Silent Spring*
- Potential threats of uncontrolled use of pesticides

Rachel Carson, Biologist

Fig. 12-B, p. 298

Modern Synthetic Pesticides Have Several Advantages

- Save human lives
- Increases food supplies and profits for farmers
- Work quickly
- For many, health risks are very low relative to benefits
- New pest control methods: safer and more effective

Modern Synthetic Pesticides Have Several Disadvantages (1)

- Accelerate rate of genetic resistance in pests
- Expensive for farmers
- Some insecticides kill natural predators and parasites that help control the pest population
- Pollution in the environment
- Some harm wildlife
- Some are human health hazards

Pesticide Use Has Not Reduced U.S. Crop Losses to Pests

- David Pimentel: Pesticide use has not reduced U.S. crop loss to pests
  - 1942-1997: crop losses from insects increased from 7% to 13%, even with 10x increase in pesticide use
  - High environmental, health, and social costs with use
  - Use alternative pest management practices

- Pesticide industry disputes these findings

Trade-Offs: Conventional Chemical Pesticides

Trade-Offs

Conventional Chemical Pesticides

Advantages

Save lives

Increase food supplies

Profitable

Work fast

Safe if used properly

Disadvantages

Promote genetic resistance

Kill natural pest enemies

Pollute the environment

Can harm wildlife and people

Are expensive for farmers

Fig. 12-22, p. 299

Trade-Offs

Conventional Chemical Pesticides

Advantages

Save lives

Increase food supplies

Profitable

Work fast

Safe if used properly

Disadvantages

Promote genetic resistance

Kill natural pest enemies

Pollute the environment

Can harm wildlife and people

Are expensive for farmers

Fig. 12-22, p. 299

What Can You Do? Reducing Exposure to Pesticides

Fig. 12-23, p. 300

Case Study: Ecological Surprises: The Law of Unintended Consequences

- 1955: Dieldrin sprayed to control mosquitoes
- Malaria was controlled
- Dieldrin didn’t leave the food chain
- Domino effect of the spraying
- Happy ending

Laws and Treaties Can Help to Protect Us from the Harmful Effects of Pesticides

- U.S. federal agencies and laws
  - EPA, USDA, FDA
  - Fungicide and Rodenticide Act, 1947
  - Food Quality Protection Act, 1996

- Effects of active and inactive pesticide ingredients are poorly documented
  - U.S. exports many banned pesticides

- Circle of poison

There Are Alternatives to Using Pesticides (1)

- Fool the pest
  - Crop rotation; changing planting times
- Provide homes for pest enemies
  - Polyculture
- Implant genetic resistance – genetic engineering
- Bring in natural enemies
  - Predators, parasites, diseases

There Are Alternatives to Using Pesticides (2)

- Use insect perfumes
  - pheromones
- Bring in hormones
  - Interfere with pest life cycle
- Alternative methods of weed control
  - Crop rotation, cover crops, mulches

Solutions: An Example of Genetic Engineering to Reduce Pest Damage

Fig. 12-24, p. 302

Natural Capital: Biological Pest Control

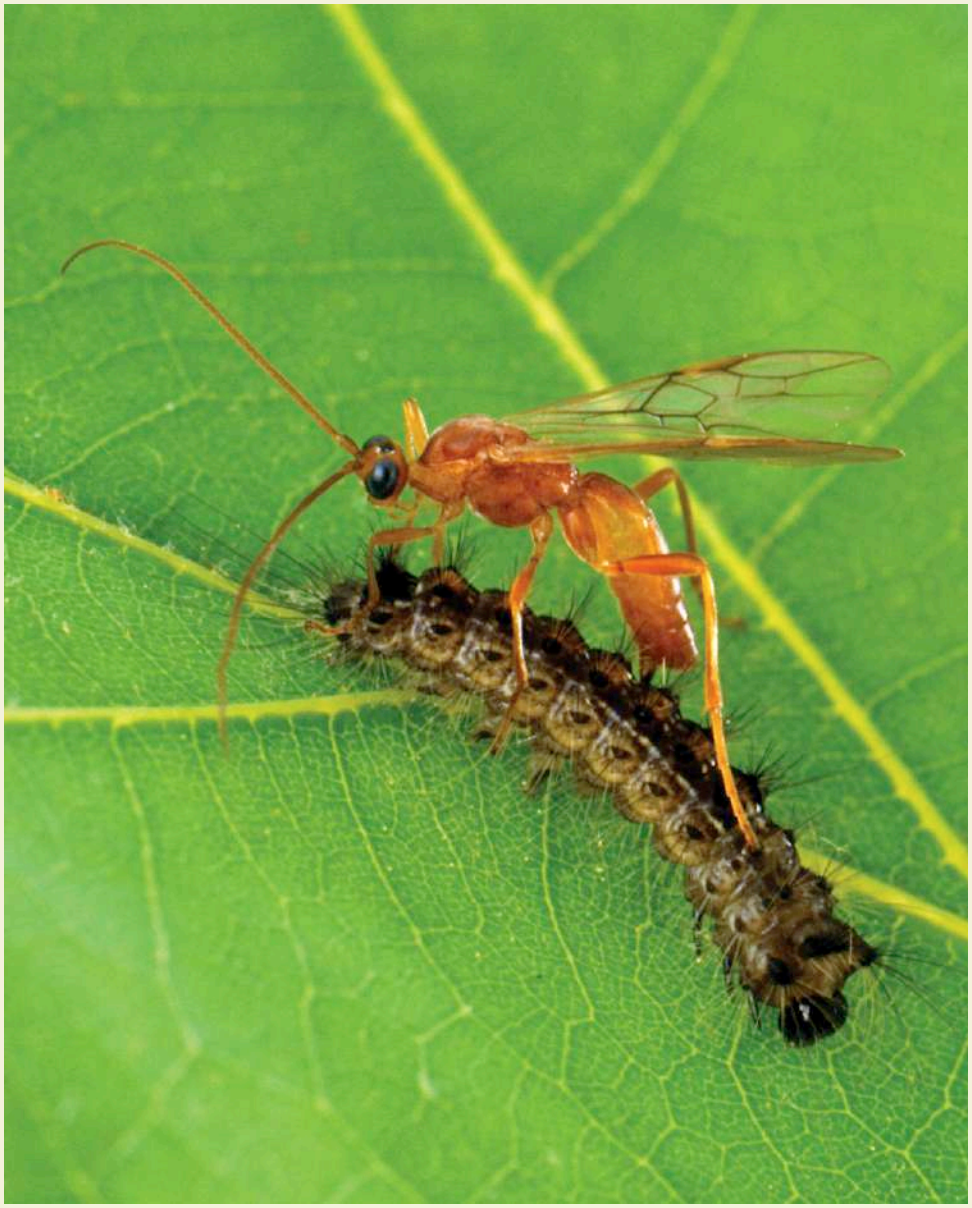


Fig. 12-25, p. 302

Integrated Pest Management Is a Component of Sustainable Agriculture

- **Integrated pest management (IPM)**
  - Coordinate: cultivation, biological controls, and chemical tools to reduce crop damage to an economically tolerable level
  - Reduces pollution and pesticide costs

- Disadvantages
  - Requires expert knowledge
  - High initial costs
  - Government opposition

12-5 How Can We Improve Food Security?

- ***Concept 12-5*** *We can improve food security by creating programs to reduce poverty and chronic malnutrition, relying more on locally grown food, and cutting food waste.*

Use Government Policies to Improve Food Production and Security

- Control prices to make food affordable
- Provide subsidies to farmers
- Let the marketplace decide—
  - Working in New Zealand and Brazil

Other Government and Private Programs are Increasing Food Security

- Immunizing children against childhood diseases
- Encourage breast-feeding
- Prevent dehydration in infants and children
- Provide family planning services
- Increase education for women

- One-half to one-third of nutrition-related deaths in children can be prevented for $5-10 per year

12-6 How Can We Produce Food More Sustainably?

- ***Concept 12-6*** *More sustainable food production will require using resources more efficiently, sharply decreasing the harmful environmental effects of industrialized food production, and eliminating government subsidies that promote such harmful impacts.*

Reduce Soil Erosion

- **Soil conservation**, some methods
  - Terracing
  - Contour planting
  - Strip cropping with cover crop
  - Alley cropping, agroforestry
  - Windbreaks or shelterbelts
  - Conservation-tillage farming
    - No-till
    - Minimum tillage

- Identify erosion hotspots

Soil Conservation: Terracing

Fig. 12-26, p. 305

Soil Conservation: Contour Planting and Strip Cropping

Fig. 12-27, p. 305

Soil Conservation: Alley Cropping

Fig. 12-28, p. 305

Soil Conservation: Windbreaks

Fig. 12-29, p. 306

Case Study: Soil Erosion in the United States—Learning from the Past

- What happened in the Dust Bowl in the 1930s?
- Migrations to the East, West, and Midwest
- 1935: Soil Erosion Act
- More soil conservation needed

Natural Capital Degradation: The Dust Bowl of the Great Plains, U.S.

Fig. 12-30, p. 307

Fig. 12-30, p. 307

Restore Soil Fertility

- **Organic fertilizer**
  - **Animal manure**
  - **Green manure**
  - **Compost**
- **Manufactured inorganic fertilizer**
  - Nitrogen, phosphorus, calcium
- Crop rotation

Reduce Soil Salinization and Desertification

- Soil salinization
  - Prevention
  - Clean-up

- Desertification, reduce
  - Population growth
  - Overgrazing
  - Deforestation
  - Destructive forms of planting, irrigation, and mining

Solutions: Soil Salinization

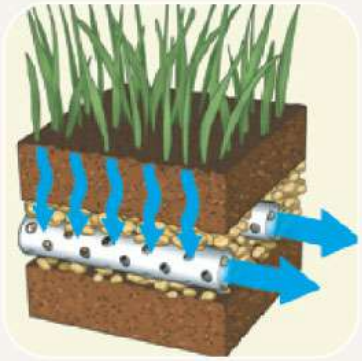
Solutions

Soil Salinization

Prevention

Reduce irrigation

Switch to salt-tolerant crops



Cleanup

Flush soil (expensive and wastes water)

Stop growing crops for 2–5 years

Install underground drainage systems (expensive)

Fig. 12-31, p. 308

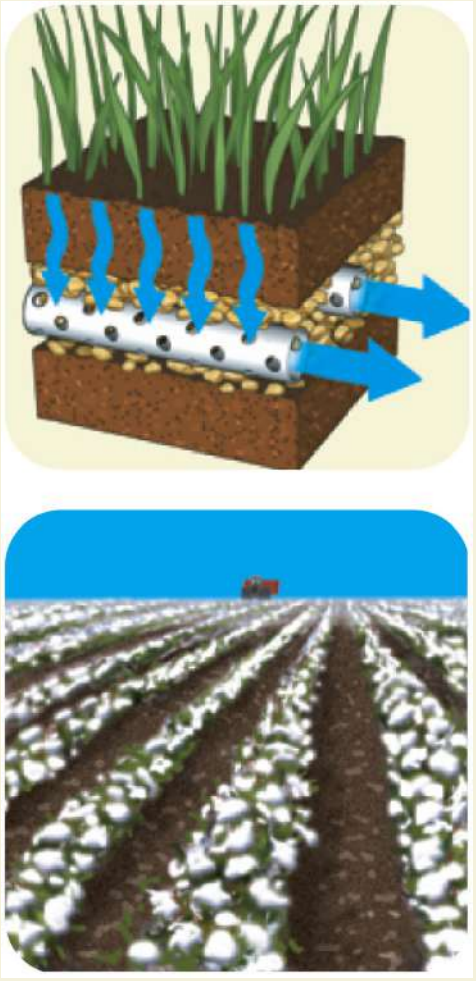
Solutions

Soil Salinization

Prevention

Reduce irrigation

Switch to salt-tolerant crops



Cleanup

Flush soil (expensive and wastes water)

Stop growing crops for 2–5 years

Install underground drainage systems (expensive)

Fig. 12-31, p. 308

Practice More Sustainable Aquaculture

- Open-ocean aquaculture
  - Choose herbivorous fish

- Polyculture

Solutions: More Sustainable Aquaculture

Fig. 12-32, p. 308

Case Study: Raising Salmon in an Artificial Ecosystem

- Cooke Aquaculture in the Bay of Fundy, New Brunswick, Canada

- Mimic a natural system with 3 species:
  - Salmon in cages
  - Shellfish in socks filter waste
  - Kelp uses some of added nutrients

Produce Meat More Efficiently and Humanely

- Shift to more grain-efficient forms of protein
- Beef from rangelands and pastures, not feedlots
- Develop meat substitutes; eat less meat

Efficiency of Converting Grain into Animal Protein

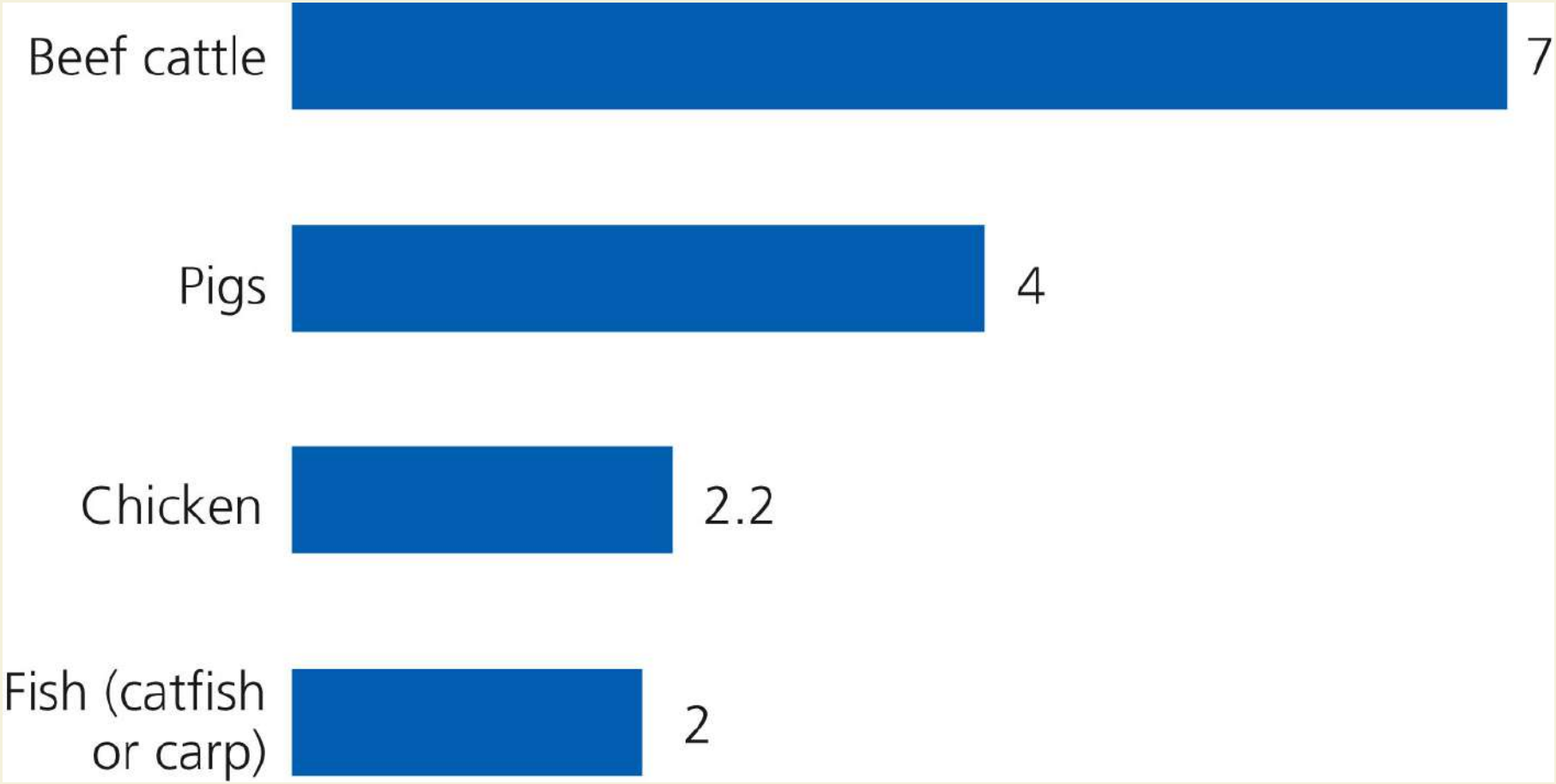


Fig. 12-33, p. 309

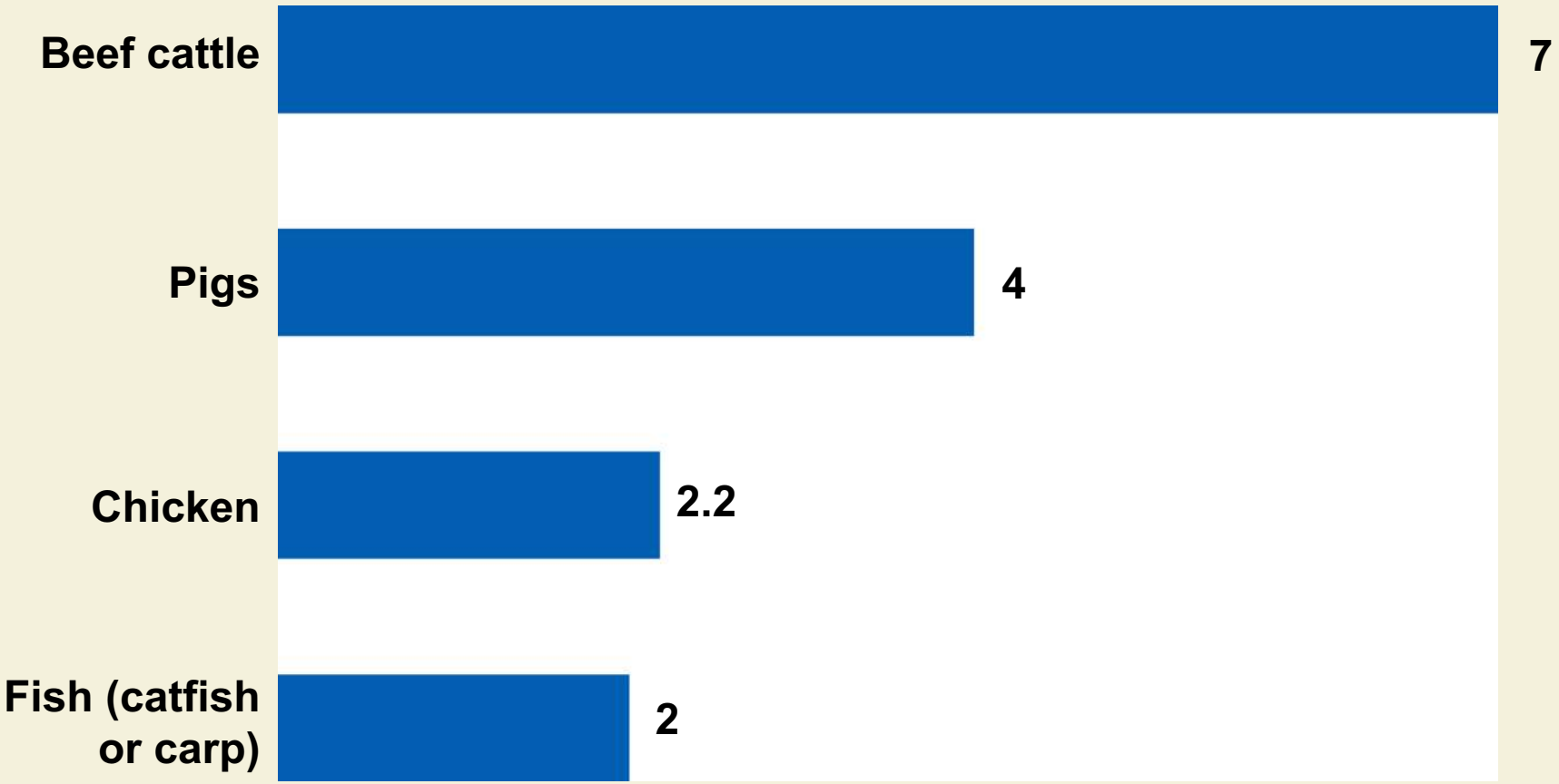


Fig. 12-33, p. 309

Shift to More Sustainable Agriculture (1)

- Sustainable agriculture uses fewer inputs, creates less pollution, and contributes less to global warming

- Organic farming
  - Many benefits
  - Requires more labor

Shift to More Sustainable Agriculture (2)

- Strategies for more sustainable agriculture
  - Research on organic agriculture with human nutrition in mind
  - Show farmers how organic agricultural systems work
  - Subsidies and foreign aid
  - Training programs; college curricula
  - Encourage hydroponics
  - Greater use of alternative energy

Solutions: More Sustainable Organic Agriculture

Solutions

More Sustainable Agriculture

More

- High-yield polyculture
- Organic fertilizers
- Biological pest control
- Integrated pest management
- Efficient irrigation
- Perennial crops
- Crop rotation
- Water-efficient crops
- Soil conservation
- Subsidies for sustainable farming

Less

- Soil erosion
- Soil salinization
- Water pollution
- Aquifer depletion
- Overgrazing
- Overfishing
- Loss of biodiversity and agrobiodiversity
- Fossil fuel use
- Greenhouse gas emissions
- Subsidies for unsustainable farming

Fig. 12-34, p. 310

Solutions

More Sustainable Agriculture

More

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Fig. 12-34, p. 310

Solutions: Organic Farming

Solutions

Organic Farming

- Improves soil fertility
- Reduces soil erosion
- Retains more water in soil during drought years
- Uses about 30% less energy per unit of yield
- Lowers CO_2 emissions
- Reduces water pollution by recycling livestock wastes
- Eliminates pollution from pesticides
- Increases biodiversity above and below ground
- Benefits wildlife such as birds and bats

Fig. 12-35, p. 311

Solutions

Organic Farming

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Fig. 12-35, p. 311

Science Barge: Prototype of Sustainable Urban Farm in Yonkers, New York

Fig. 12-36, p. 311

Science Focus: Sustainable Polycultures of Perennial Crops

- Polycultures of perennial crops

- Wes Jackson: natural systems agriculture benefits
  - No need to plow soil and replant each year
  - Reduces soil erosion and water pollution
  - Deeper roots – less irrigation needed
  - Less fertilizer and pesticides needed

Comparison of the Roots between an Annual Plant and a Perennial Plant

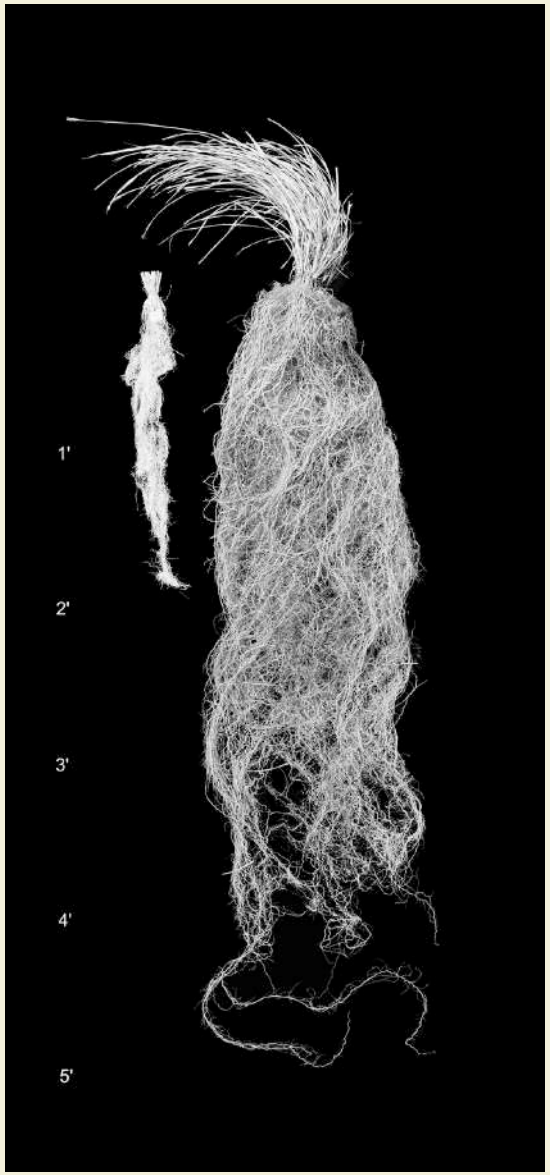

Fig. 12-C, p. 312

Buy Locally Grown Food, Grow More Food Locally, and Cut Food Waste

- Supports local economies
- Reduces environmental impact on food production
- Community-supported agriculture

What Can You Do? Sustainable Organic Agriculture

Fig. 12-37, p. 313

Three Big Ideas

1. More than 1 billion people have health problems because they do not get enough to eat and 1.1 billion people face health problems from eating too much.

2. Modern industrialized agriculture has a greater harmful impact on the environment than any other human activity.

Three Big Ideas

3. More sustainable forms of food production will greatly reduce the harmful environmental impacts of current systems while increasing food security.