PART IV

SUSTAINING NATURAL RESOURCES

CHAPTER 14

FOOD AND SOIL RESOURCES

Summary

1. Three systems produce the foods for human consumption. Croplands produce mostly grains, about 77% of the world's foods. Rangelands provide meat, about 16% of the world's food. Ocean fisheries supply about 7% of the world's food. We must, however, produce more food for the world's growing population and increase the food available for the one out of every five people who now cannot afford sufficient food.

2. The green revolution uses particular methods to raise crops. Monocultures are developed, bred selectively or genetically engineered, and planted to produce high yields of particular crops. Large amounts of fertilizer, pesticides, and water are used on the crops. Yields of crops are increased through multiple cropping throughout the year. The second green revolution, since 1967, involved the use of fast-growing dwarf varieties of wheat and rice in countries with tropical and subtropical climates. Traditional agriculture practices include interplanting (several crops grown together on the same area of land); polyvarietal cultivation (several varieties of the same crop are grown on the same area of land); agroforestry (crops and trees are grown together); and polyculture (various plants are planted together but mature at different times).

3. Soils are degraded and eroded by water, wind, and people. Soil erosion is primarily caused by flowing water and wind. Human activities such as farming, logging, construction, and off-road vehicles also disturb soil and hasten erosion. In irrigated soil, there is also salt buildup or waterlogging. Today, crops can be planted without disturbing the soil through conservation-tillage, tillage, contour farming, and strip farming. Farmers may also use cover crops to help hold the soil in place. Several crops planted between trees and shrubs, called alley cropping, help preserve soil and its productivity. Windbreaks are used to prevent soil from being blown away. Conservation and fertilization can be used to restore soil fertility, but fertilizing with commercial pesticides brings its own set of problems.

4. Even though food production has levelled off in the last 25 years, the world does still produce enough food to meet the basic nutritional needs of people. However, the food is not evenly distributed throughout the world. The average daily intake of food has increased for people throughout the world since 1961, but at least 15 100 people per day (80% under age 5) die from poverty-related causes. Many of these deaths come from malnutrition or lack of resistance to diseases. Modern agricultural techniques, especially Western farming methods, have a more harmful environmental impact than any other human activity. These methods are extremely energy inefficient, using ten units of energy from fossil fuels to produce one unit of food energy. This kind of waste is unacceptable. In addition, these agricultural methods pollute the environment,

compromise soil (soil erosion and salinization) and water supplies, and produce food that is wasted.

5. Food production can be increased by using crossbreeding techniques on identical or closely related species, or by genetic engineering involving different organisms. Genetic engineering and advanced tissue culture techniques are becoming more common, but many people are concerned about the potential harm such crops may cause. Irrigating more land and cultivating more land are additional solutions, but they may not prove sustainable. Rangelands can be managed more efficiently and at the same time better protect the land, but the primary diet of the Western world (heavy in meat and meat products) needs to be re-evaluated. Overfishing and habitat degradation dominate the marine environment; better management of this food source and protection of the marine environment would ensure continued availability of fish worldwide. Aquaculture is the world's fastest growing type of food production. A more sustainable approach needs to be considered to reduce environmental impacts, both on a national and international scale.

6. More sustainable agricultural systems can be created by reducing resource use and working with nature. We must reduce population growth, reduce poverty, and develop low-input agriculture. Technologies based on ecological knowledge should be used to increase crop production, control pests, and build soil fertility. Such low-input organic farming is friendlier to the environment by reducing carbon dioxide emissions, using less than half the energy that conventional farming demands, providing more habitats for plant and animal species, and improving soil fertility. To shift to such agricultural practices, we need more research on sustainable agriculture and the improvement of human nutrition. We also need to make demonstration projects available to farmers, provide subsidies and foreign aid to encourage organic farming, and offer training programs for farmers, agricultural officials, and agricultural schools and universities.

Key Concepts and Learning Outcomes

After completing this chapter, students should be able to answer the following key questions.

14-1 What Systems Provide Us with Food? The Challenges Ahead

A. Food on the planet is produced by croplands, rangelands, and ocean fisheries.
   1. Croplands produce 77% of the world's food.
   2. Rangelands produce meat, which is about 16% of the world's food.
   3. Oceanic fisheries supply 7% of the world's food.
   4. All three systems have increased their food yields since 1950.
   5. Technological advances have increased food production or harvesting.
      a. More sophisticated farming techniques have been developed.
      b. There has been expanded use of inorganic chemical fertilizers, irrigation, and pesticides, and high-yield crops have been developed.
      c. Intense farming methods, such as densely populated feedlots and enclosed breeding and growing pens, and aquaculture ponds or ocean cages have been implemented.
   6. Food to feed the planet must be produced in ever-increasing quantities.
      a. Genetic engineering brings some promise to this endeavour.

b. The planet's net primary productivity is being degraded by human activities.
c. The world's poverty must be reduced so that people can obtain enough food to sustain them.

14-2 How Do Our Food Production Systems Compare with Natural Ecosystems? Simpler and Less Sustainable

A. Agroecosystems are different from natural ecosystems.
1. Natural ecosystems tend to stabilize the soil and keep moisture under plant cover, whereas agroecosystems expose the soil to erosion and moisture loss.
2. Natural ecosystems evolve over time, whereas agroecosystems are designed to promote human choices.
3. Natural systems are driven by solar energy, whereas agroecosystems are driven by fossil fuels.
4. Natural ecosystems undergo succession, whereas agrosystems hold succession at a desired stage.
5. Natural ecosystems display a great deal of structural diversity, whereas agroecosystems tend to be uniform.
6. Natural ecosystems typically contain a great deal of biological diversity, whereas most agroecosystems tend to be simple monocultures.

14-3 What Plants and Animals Feed the World? Our Three Most Important Crops

A. The foods that sustain the world are wheat, rice, and corn. They must be replanted each year.
1. Fourteen plant and eight terrestrial animal species supply 90% of the global intake of calories.
2. More than half the calories come from wheat, rice, and corn.

14-4 What Are the Major Types of Food Production? High-Input and Low-Input Agriculture

A. Industrialized, or high-input, agriculture produces 80% of the world's food, and subsistence agriculture produces 20%.
1. Industrialized agriculture uses much energy, water, fertilizers, and pesticides and is practised on 25% of cropland, mostly in developed countries.
a. Plantation agriculture, a type of industrialized agriculture, is practised primarily in tropical developing countries. Cash crops including bananas, coffee, soybeans, and sugarcane monocultures are grown.
b. Feedlots are another example of industrialized agriculture; they enable rapid production of fattened animals for meat.
2. Traditional agriculture provides about 20% of the food supply and is practised by 42% of the world's people.
a. Traditional subsistence agriculture, typically a single farm, supports one family.
b. Traditional intensive agriculture strives not only to feed the farmer's family but also to produce additional food to sell as income. By using fertilizer, irrigating, etc., a higher yield is possible.

14-5 How Have Green Revolutions Increased Food Production? High-Input Monocultures in Action

A. The green revolution has increased yields in food production per unit of existing cropland.
   1. The following steps describe this revolution:
      a. Key grain crops are selectively bred, or engineered, and grown as monocultures to produce high crop yields.
      b. High yields are sustained by using large amounts of fertilizer, water, and pesticides.
      c. The number of crops grown per year is increased through multiple cropping.
   2. There have been two green revolutions.
      a. The first revolution occurred in developing countries between 1950 and 1970.
      b. The second revolution has occurred since 1967 in developing countries that have enough rain or irrigation capability.
         1) Fast-growing dwarf varieties of rice and wheat, especially for tropical and subtropical climates, have been introduced. Use of pesticides, water, and fertilizers as well as food yields has increased.
         2) Several crops can be planted during one year, increasing food yields further.
   3. These revolutions use machinery and fossil fuels to plant and harvest; high-input green revolution agriculture uses 8% of the world's oil output.

14-6 What Is the State of Agriculture in Canada? Good News and Bad News

A. Agriculture is important in the Canadian economy, but there are environmental costs and emerging threats
   1. Numbers of farms are decreasing, but the size of farms is increasing.
   2. Only 7% of Canada's land is suitable for farming.
   3. About 83% of the farmland is in the Prairie provinces; Ontario and Quebec combined have 13%.
   4. Environmental impacts of farming include soil erosion, water pollution, pesticide use, and habitat disruption.
   5. Bovine spongiform encephalopathy (BSE), or mad cow disease, was detected in 2003.
   6. Avian influenza is a potential threat.
   7. Biotechnology is still controversial.

14-7 What Growing Techniques Are Used in Traditional Agriculture? Low-Input Agrodiversity in Action

A. Growing techniques in traditional agriculture are used to make yields more productive.
   1. Interplanting involves growing several crops on the same plot of land.
      a. In polyvarietal cultivation, several varieties of the same crop are planted on a plot.
      b. Intercropping involves growing two or more different crops on the same plot at the same time.
      c. In agroforestry, or alley cropping, crops and trees are grown together.
      d. Polyculture involves planting together many different crops that mature at various times.
         1) Polyculture requires less fertilizer and water because the root systems are at different levels.

2) The soil is protected from wind and water erosion because crops are growing year-round.
3) Multiple habitats support natural predators of crop-eating insects, so less insecticide is needed.
4) There are fewer weeds and less need for herbicides.
5) With several crops, bad weather will not destroy every one of them.
6) Low-input polyculture produces higher crop yields than high-input monoculture.

2. Tassas, small pits with added manure and planted following periodic rains, have tripled yields on at least 100 000 hectares of unproductive land in some African countries.

14-8 Why Are Croplands Degrading? Missing Organics

A. Harvesting removes biomass that would otherwise re-enrich the soil.
1. All food comes from the soil: the base of life.
2. Preserving the world's topsoil is the key to producing enough food to feed the world's growing population.
3. Land degradation occurs when natural or human-induced processes decrease the future ability of land to support crops, livestock, or wild species.
   a. Plowed croplands to which no fertilizer is added are compromised by the most basic of farming activities: the harvest.
   b. When the crop biomass is taken away, so are the inorganic nutrients that the plants have extracted from the soil.
   c. Over repeated harvests the soil's nutrient content, or fertility, becomes impaired.
   d. The soil's organic component goes largely unreplenished, which impairs its cohesiveness and ability to retain moisture.
   e. The result is a dry, unproductive soil that is susceptible to erosion.
4. With only marginal croplands still uncultivated, we no longer have the luxury of "moving on."

14-9 What Causes Soil Erosion? The Big Three

A. Soil erosion is caused by water, wind, and people.
1. Land degradation occurs when the future ability of the land to support crops, livestock, or wild species is decreased.
2. There are two harmful effects of soil erosion:
   a. loss of soil fertility, and
   b. sediment pollution in water bodies.
3. Soil is a renewable resource unless eroded faster than it can form.

14-10 How Serious Is Global Soil Erosion? Mostly Bad News

A. A joint UN and World Resources Institute report estimates that topsoil is eroding faster than it is being replenished on 38% of the world's cropland.
1. Worldwide erosion causes $375 billion damage per year.

14-11 What Is Desertification, and How Serious Is It? Decreasing Land Productivity

A. Desertification occurs when production falls by 10% or more though a combination of natural causes (drought) and human activities. It may be moderate, severe, or very severe; but only in extreme cases does it lead to a desert.
   1. Prolonged droughts can't be controlled, but the consequences can be reduced by reducing overgrazing, deforestation, and destructive forms of planting, irrigation, and mining.
   2. Restoration of these areas includes planting trees and grasses to anchor soil and hold water.

14-12 How Do Excess Salts and Water Degrade Soils? Crop Losses from Too Much Salt and Water

A. Loss of crop productivity can result from repeated irrigation, which produces salt buildup or water logging of plant crops.
   1. Forty percent of the world's food is produced on one-fifth of the world's irrigated cropland.
   2. Salts left behind after repeated irrigation may remain in the topsoil. This is called salinization.
   3. Salinization has reduced yields on 10% of the world's cropland.
   4. Waterlogging occurs when saline water (from irrigation) envelops the deep roots of plants. This saline water accumulates underground and raises the water table.

14-13 How Can We Maintain and Restore Soil Fertility? Conservation and Fertilizers

A. Soil fertility can be maintained best through soil conservation. The next best thing is to restore some of the nutrients by the use of fertilizers.
   1. Organic fertilizer can be used to restore lost plant nutrients. There are several types.
      a. Animal manure improves soil structure, adds nitrogen, and stimulates soil bacteria and fungi.
         1) The U.S. Department of Agriculture researchers are evaluating the value of burnt chicken wastes that are rich in phosphorus.
      b. Green manure consists of freshly cut or growing green vegetation plowed into the soil to increase organic matter and humus.
      c. Compost, an organic fertilizer, is formed when microorganisms in the soil break down leaves, food wastes, paper, and wood into organic matter.
      d. Compost from the mushroom industry can be used as fertilizer.
         1) It retains moisture and nutrients in the soil.
         2) One application lasts all year; other fertilizers have to be applied every few weeks.
   2. Crop rotation involves planting different crops to replenish the soil, especially if a previous crop has depleted the soil of certain nutrients.

14-14 Can Inorganic Fertilizers Save the Soil? A Partial Solution

A. Many farmers (especially in developed countries) rely on commercial inorganic fertilizers.
   1. There are advantages and disadvantages to the use of inorganic fertilizers (Figure 14-11).
   2. Commercial inorganic fertilizers contain nitrogen, phosphorus, and potassium.

B. Used with organic fertilizers, they can maintain or enhance soil fertility.

14-15 How Can Conservation Tillage Reduce Soil Erosion? Do Not Disturb the Soil

A. To reduce soil erosion, farmers must eliminate plowing and tilling and keep the soil covered with vegetation.
   1. Conventional-tillage farming means plowing in the fall and leaving the soil bare all winter, which makes it vulnerable to wind and erosion.
   2. Conservation-tillage farming disturbs the soil as little as possible during planting.
      a. Minimum-tillage farming allows the soil to rest over the winter. The subsurface soil is broken up and loosened, but the topsoil is not turned.
      b. No-till farming uses special machines to inject seeds, fertilizers, and herbicides into thin slits which are then smoothed over.
      c. By 2011, about 72% of Canadian farmers practised conservation tillage, reducing erosion and improving income.

14-16 What Other Methods Can Reduce Soil Erosion? Several Tried and True Methods

A. Additional methods to reduce soil erosion include the following.
   1. Terrace the land into a series of broad, nearly level terraces that run along the contour of the land. This method holds water for crops and reduces runoff.
   2. Use contour farming, which involves plowing and crop planting in rows across the slope of the land, not up and down. Each row acts as a small dam.
   3. Use strip cropping by alternating row crops (corn or cotton) with a cover crop (grass or legume) that completely covers the soil. Runoff is caught by the cover crop.
   4. Leave crop residues on the land after harvest.
   5. Plant cover crops like rye or alfalfa after harvest.
   6. Use alley cropping or agroforestry and plant several crops together in strips or alleys between trees or shrubs, which may provide fruit or fuelwood.
      a. The shade of the trees and shrubs reduces evaporation and helps retain soil moisture.
      b. Fruit, fuelwood, and trimming can be used as mulch.
   7. Use windbreaks or shelterbelts of trees to reduce wind erosion, help retain soil moisture, provide fuelwood, and support bird and insect habitats.

14-17 How Much Has Food Production Increased? Impressive Gains Nullified by Population Growth

A. The amount of food produced per person is affected by both food production and population growth.
   1. Total world grain production has steadily increased since 1961.
   2. Population growth since 1961 has caused the per capita grain production to level off.
   3. Enough food is produced to meet the basic nutritional needs of every person on Earth.
   4. One out of nine people in developing countries is not getting enough to eat because food is not distributed equally among the world's people.
   5. This occurs because of differences in soil, climate, political and economic power, and average per capita income.
   6. The root causes of hunger and malnutrition are and will continue to be poverty and inequality. Other factors are war, corruption, and tariffs and subsidies that make it hard for poor people to acquire the food they produce.

14-18 How Serious Are Undernutrition and Malnutrition? Some Progress

A. Some people cannot grow or buy enough food to meet their basic energy needs, and others do not get enough protein and other key nutrients.
B. People need fairly large amounts of macronutrients (protein, carbohydrates, and fats) and smaller amounts of micronutrients (vitamins such as A, C, and E) and minerals (iron, iodine, and calcium).
   1. Chronic undernutrition is suffered by those who can't grow or buy enough food. Children in this group may have stunted growth, mental retardation, and be susceptible to infectious diseases.
   2. Malnutrition results from insufficient protein and other key nutrients.
      a. About one in nine people in developing countries are chronically undernourished, with an estimate of 6 million children under the age of 5 dying prematurely from poverty, undernutrition, malnutrition, and increased susceptibility to normally nonfatal diseases.
   3. UNICEF studies show that one-half to two-thirds of these deaths could be prevented by
      a. immunizing children against childhood diseases;
      b. encouraging breast feeding;
      c. preventing dehydration from diarrhea by giving a mixture of sugar and salt in a glass of water;
      d. giving children vitamin A capsules twice per year to prevent blindness;
      e. providing family planning services for spacing children; and
      f. increasing education for women, emphasizing nutrition, water sterilization, and childcare.
   4. The diet of many people in developed countries is insufficient to promote good health.

14-19 How Serious Are Micronutrient Deficiencies? Important but Limited Progress

A. WHO states that about one in three people suffer from a deficiency of one or more of the following: vitamin A, iron, and iodine.
   1. Blindness due to vitamin A deficiency occurs in 250 000 children under 6 each year, and up to 80% die within a year.
   2. Golden rice has a gene spliced into it to enrich beta-carotene, but poorly nourished people can't convert beta-carotene into vitamin A.
   3. Iron is needed to prevent anaemia, and iodine is needed for proper thyroid functioning and the prevention of brain damage and goiter.
   4. Iodine deficiency can stunt growth, affect mental ability, and cause the formation of goiter.

14-20 How Serious Is Overnutrition? Bad and Getting Worse

A. Overnutrition is when food intake exceeds energy needs and results in body fat. Too little exercise, too many calories, or both cause overnutrition.
   1. Both overnutrition and undernutrition lead to similar health problems: lower life expectancy, greater susceptibility to disease and illness, and lower productivity and life quality.
   2. After smoking, overnutrition is the second leading cause of preventable death.
   3. In developed countries, one of every seven adults suffers from overnutrition.

4. About 60% of adult Canadians are overweight, and 24% are obese.

14-21 What Are the Environmental Effects of Producing Food? Agriculture Is Number One

A. The most harmful environmental impact caused by human activity is modern agriculture.
   1. Modern agriculture negatively impacts air, soil, water, and biodiversity.
   2. Harmful environmental effects that limit food production include soil erosion, salt buildup and waterlogging, water deficits and droughts, and loss of wild species that provide genetic resources.
   3. Up to 30% of the world's cropland has been degraded, and 17% seriously degraded.
   4. Soil degradation is limiting food production in India and China.

14-22 What Is the Gene Revolution? From Crossbreeding to Mixing Genes in a New Way

A. Crossbreeding, which mixes the genes of a single or a closely related species, and genetic engineering, which mixes genes of different organisms, can be used to increase yields of crops.
   1. Crossbreeding involves a process that takes more than 15 years. The varieties are often useful only for a few years; then pests and diseases reduce the value of the new varieties.
   2. Genetic engineering, which splices a gene from one species into the DNA of another species, is creating improved strains of crops and livestock animals.
      a. This process can take half as much time as traditional methods to develop a new crop.
      b. It cuts costs.
      c. It allows for all kinds of potential product development.
      d. More than two-thirds of food products on U.S. shelves contain ingredients made from genetically engineered crops.
      e. Scientists are experimenting with cell cultures to produce a variety of food and medical products in fermentation tanks or bioreactors.
   3. There are legal and genetic complications from genetically modified crops.
      a. Percy Schmeiser, a canola farmer in Saskatchewan, was sued by Monsanto Canada.
      b. He gathered the seeds of genetically modified canola plants that invaded his fields.
      c. The Supreme Court said he deprived Monsanto the benefits of its technology.
   4. Suicide seeds are being developed that only produce sterile plants.
      a. Canada, with a majority of other countries, has a moratorium on the testing of "suicide seeds."
      b. The United States did not agree to the moratorium.

14-23 How Safe Are Genetically Modified Foods? Saviour or Frankenfood?

A. There as much controversy over the safety of genetically modified crops with respect to human health and ecosystems.
   1. The Ecological Society of America has recommended more caution in releasing genetically engineered organisms into the environment.

2. Several scientists feel that genetic engineering of food is based on two faulty assumptions: that world hunger is caused by a global shortage of food, and that genetic engineering is the only and best way to increase food production.
3. GMFs are labelled in Japan, Europe, South Korea, Canada, Australia, and New Zealand. Canada has a voluntary labelling system.
4. The U.S. Department of Agriculture has opposed such labelling.

14-24 Can We Continue Expanding the Green Revolution? Maybe, Maybe Not

A. The green revolution may not be expandable indefinitely.
   1. Green revolution crop varieties require huge amounts of fertilizer and water.
   2. The costs of these crops are too high for subsistence farmers in developing countries.
   3. There is a limit to the yield that can be produced by increasing fertilizers, water, and pesticides.
   4. As environmental effects take place, crop yields in some areas may well begin decreasing.
   5. Comparisons of yields are based on old and new monoculture varieties, rather than between new varieties and higher-yielding polyculture cropping systems.
   6. Seeds used throughout the world are fairly uniform, and this increases the vulnerability of the crops to pests, diseases, and harsh weather.

14-25 Will People Try New Foods? Changing Eating Habits Is Difficult

A. People do not adopt new foods easily, and most will reject insects as a protein source.
   1. Possibilities of new foods include winged bean from SE Asia, black ant larvae from Mexico, giant water bugs in Thailand, emperor moth caterpillars in South Africa, etc.
   2. The above-mentioned protein sources are four times as protein-rich as beef, fish, or eggs.
   3. Polycultures of perennial crops may also be a way to decrease tilling of the soil, reduce energy use, save water, and reduce soil erosion and water pollution.

14-26 Is Irrigating More Land the Answer? A Limited Solution

A. Irrigated land per person has decreased since 1978. This is partly explained by the rapid rise of the world population, depletion of underground aquifers, inefficient use of irrigation water, and salt buildup in soil.

14-27 Is Cultivating More Land the Answer? Another Limited Solution

A. Theoretically, the world's cropland could be more than doubled by clearing tropical forests and irrigating arid land.
B. Cultivation of such land is unlikely to be sustainable.
C. Significant expansion of cropland is unlikely over the next few decades because of poor soils, limited water, high costs, and harmful environmental effects.

14-28 Can We Grow More Food in Urban Areas? Some Untapped Potential

A. People in urban areas should grow more of their own food (in backyards, in rooftop and balcony gardens, etc.).
B. Growing food in urban areas reduces stresses on soil and biodiversity in nonurban areas.

C. Urban soil needs to be checked for traces of toxic pollutants such as lead and mercury.

14-29 How Much Food Is Wasted? Way Too Much

A. The FAO estimates that as much as 70% of the food produced in the world is wasted through spoilage, inefficient processing or preparation, and plate waste.

14-30 How Are Rangelands Used to Produce Meat? Grass and Shrubs for Livestock

A. Much of the world's rangeland is used to raise livestock.
   1. Moderate levels of grazing encourage plant diversity.
   2. Overgrazing and undergrazing need to be prevented.

14-31 Is Producing More Meat the Answer? More Protein at the Expense of the Environment

A. Meat and meat products are good sources of protein.
   1. Some predict increases in meat production may come from densely populated feedlots that presently account for much of the world's beef, pork, and poultry production.
   2. Meat-based diets have health and environmental consequences.
      a. Meat produces large amounts of animal waste that pollutes the environment.
      b. Livestock production has an enormous impact on grain use and on the world's catch of fish (one-third of the world's fish catch is used to feed livestock).

14-32 What Are the Effects of Overgrazing? Eroding Soil and Fewer Livestock

A. Overgrazing can lead to soil erosion and limit livestock production.
   1. It lowers the net primary productivity of grassland vegetation.
   2. It reduces grass cover.
   3. It exposes soil to erosion by wind and water.
   4. It compacts the soil.
   5. It enhances the invasion of land by woody shrubs and prickly pear cactus and limits livestock production.

14-33 How Can Rangelands Be Managed More Sustainably to Produce More Meat? Control and Restore

A. The most widely used method for more sustainable rangeland management is to control the number of grazing animals and the time any given area is grazed. This can be difficult to do.
   1. Livestock tend to aggregate around natural water sources known as riparian zones.
      a. Riparian areas can be fenced off to prevent damage.
      b. Livestock can be moved regularly.
   2. Locating waterholes, water tanks, and salt blocks at strategic places can also help.
   3. Several methods for the removal of unwanted invader plants can be used, such as herbicide spraying, mechanical removal, or controlled burning.
   4. It is less expensive is to have controlled, short-term trampling by large numbers of livestock than to replant with native grass seeds.

14-34 How Can We Produce Meat More Sustainably? Shifting Our Meat Priorities

A. We can reduce the environmental impacts of meat production by shifting from less grain-efficient forms of animal protein (beef and pork) to more grain-efficient forms (poultry and farmed fish).
   1. Many rangelands are not suitable for growing crops-, so reducing livestock in these areas would not free up much land for growing grain to feed people.
   2. Others argue that we can achieve a wholesome diet based on little or no meat, that consumption of meat has serious environmental impacts, and that overconsumption of meat has negative health impacts.

14-35 Where Do We Get the Fish and Shellfish We Eat? Ocean and Freshwater Ecosystems and Fish Farms

A. Fisheries are the third major food-producing system.
   1. About 51% of the annual commercial catch of fish and shellfish comes from the ocean.
   2. The rest comes from the use of aquaculture to raise marine and freshwater fish in ponds and underwater cages.
   3. Fish and shellfish provide about 7% of the global food supply and are the primary source of animal protein for about 1 billion people, primarily in developing countries.

14-36 How Are Fish and Shellfish Harvested? Hunt and Gather as Much as You Can

A. Commercial marine fishing is an industry that uses high-tech methods to locate and harvest fish and shellfish.
   1. Trawler fishing is used to catch fish and shellfish that live on, or near, the ocean floor.
      a. This type of fishing involves dragging funnel-shaped, weighted nets along the bottom.
      b. It often destroys bottom habitats and catches and kills other species such as seals and endangered or threatened species of sea turtles.
   2. Purse-seine fishing catches surface-living species (e.g., tuna, mackerel, anchovies, and herring).
      a. Once a school of fish is located, a large net is used to surround the school and draw the net closed like a purse string.
      b. This method has killed large numbers of dolphins.
   3. Longlining involves putting out lines up to 80 miles long with thousands of hooks.
      a. This method, used for open-ocean fish such as tuna, shark, and swordfish, also catches sea turtles, birds, pilot whales, and dolphins.
   4. Drift-net fishing can lead to overfishing of the desired species and may trap and kill large numbers of unwanted fish and marine mammals. A UN ban on drift nets longer than 2.5 kilometres in international waters has sharply reduced the use of this technique, but increased the use of longlines.
   5. Commercial fish catches have levelled off since 1982.

14-37 How Are Overfishing and Habitat Degradation Affecting Fish Harvests? Dropping Yields

A. The world's commercially valuable marine fish are already being overfished.
   1. Few fish have been left to provide breeding stock.

2. Commercial extinction means that it is not profitable to hunt a particular species that has almost been eradicated by overfishing.
3. Canada's fish stocks are being depleted, especially the East Coast fishery and the West Coast salmon fishery.

14-38 Should Governments Continue Subsidizing Fishing Fleets? Too Many Boats Chasing Too Few Fish

A. Government subsidies, price controls, low-interest loans, and grants for fishing gear are major causes of overfishing.
B. Continuing to subsidize excess fishing allows some fishers to keep their jobs and boats a little longer, while making less and less money, until the fishery collapses.
C. Some of the money should be shifted to buying up some fishing boats and retraining the crews.

14-39 What Is Aquaculture? Feedlots of the Sea

A. Aquaculture is the process of raising fish and shellfish for food like crops, rather than harvesting them in the seas and inland waters.
   1. In fish farming, fish (e.g., salmon and carp) are cultivated in marine cages, ponds, or lakes, and harvested at a particular size.
   2. In fish ranching, anadromous species, such as salmon, are kept in fenced-in areas during the time they live in saltwater. They are then released, and harvested as they return to spawn in freshwater.
   3. The advantages and disadvantages of aquaculture are listed in Figure 14-29.
   4. Use of aquaculture to grow single-celled cyanobacteria such as *Spirulina* has been proposed. (*Spirulina* is 70% protein)
   5. The intensive raising of large, carnivorous fish could deplete smaller fish species used for fish meal, and could result in the collapse of both the ocean fishing and the aquaculture industry.

14-40 What Is the State of Aquaculture in Canada? Healthy, but Not Problem-Free

A. In Canada, aquaculture us growing by 10 to15% per year.
   1. The most common species is salmon, followed by mussels, oysters, trout, and steelhead.
      a. Farmed salmon are fed pellets made from small fish. This practice may cause
         1) a depletion of small fish stocks, and
         2) an increase in PCB and dioxin concentrations in salmon.
      b. Potential health and ecological effects could be avoided if salmon were fed canola oil.
   2. Fish farming can also have a variety of other impacts on wild fish populations, including transmission of disease from captive stocks; escapes of non-native fish from fish farms; and water quality issues such as excess wastes, antibiotics, and pesticides that build up in the waters and bottom sediment surrounding fish farms.

14-41 What Is More Sustainable Agriculture? Learn from Nature

A. There are three main ways to reduce hunger, malnutrition, and the harmful effects of agriculture.
   1. Slow population growth.

2. Reduce poverty.
3. Develop and phase in systems of more sustainable, or low-input, agriculture (organic farming), relying on the following practices:
   a. perennial polyculture rather than raising annual crops
   b. use of manure and tilled-in crop residues to build and maintain soil fertility
   c. very judicious use of pesticides so that pests have less chance of becoming pesticide-resistant
4. In 2002, agricultural scientists reported on a 21-year study that compared organic and conventional farming methods. It showed that there are a number of advantages to low-input organic farming.
   a. Low-input farming uses up to 56% less energy per unit of yield.
   b. It improves soil health and fertility.
   c. More habitats are provided for wild plant and animal species.

14-42 How Can We Make the Transition to More Sustainable Agriculture? Get Serious

A. Four major strategies have been suggested to help farmers make the transition to more sustainable agriculture.
   1. Increase research on sustainable agriculture and improving human nutrition.
   2. Set up demonstration projects throughout each country for farmers.
   3. Provide subsidies and increased foreign aid to encourage its use.
   4. Establish training programs in sustainable agriculture for farmers and government agricultural officials; encourage the creation of college curricula in this area.
   5. The goal is to feed the world's people, sustain the world's natural capital, and live off the natural income it provides.

