

## KEY ISSUE 3

# Where Is Agriculture Distributed?

- Agriculture in Developing Regions
- Agriculture in Developed Regions

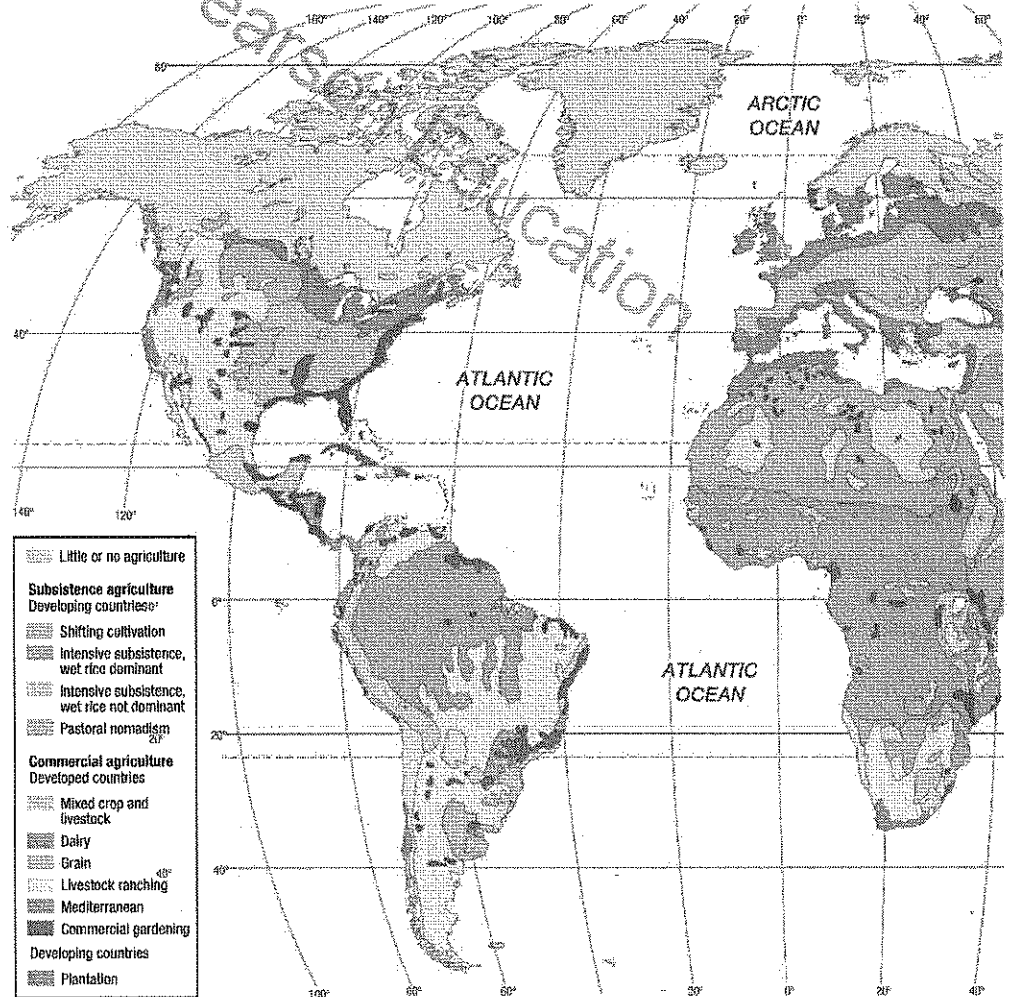
**Learning Outcome 10.3.1**  
Identify the 11 major agricultural regions.

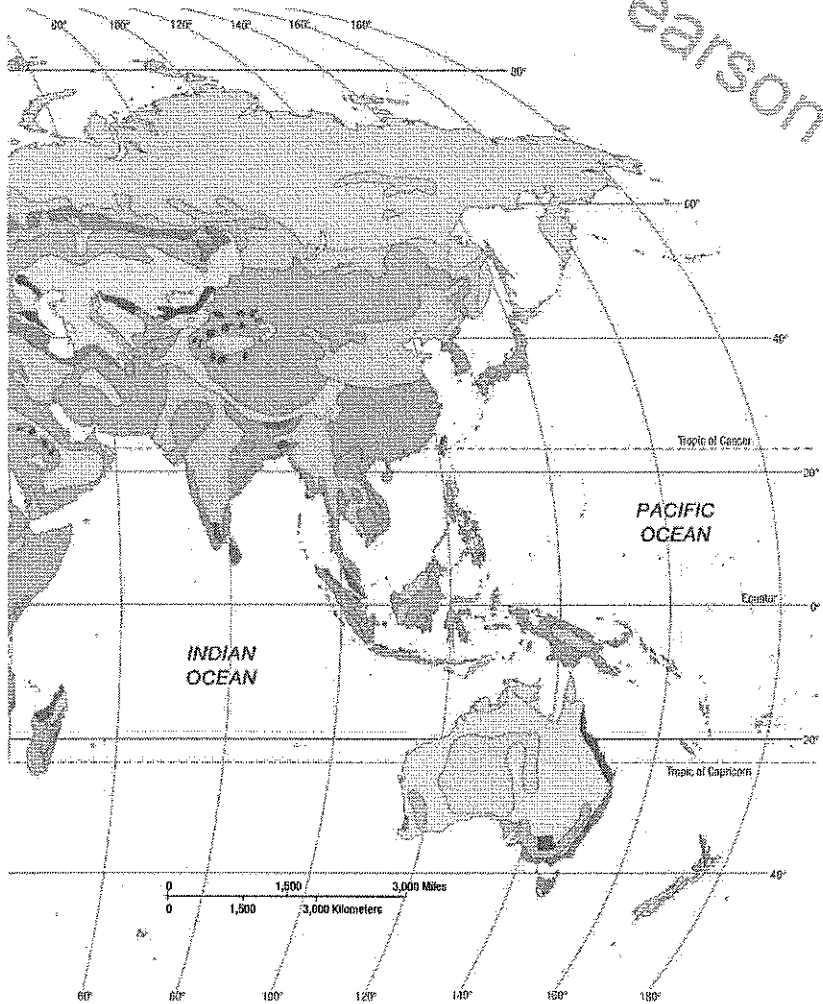
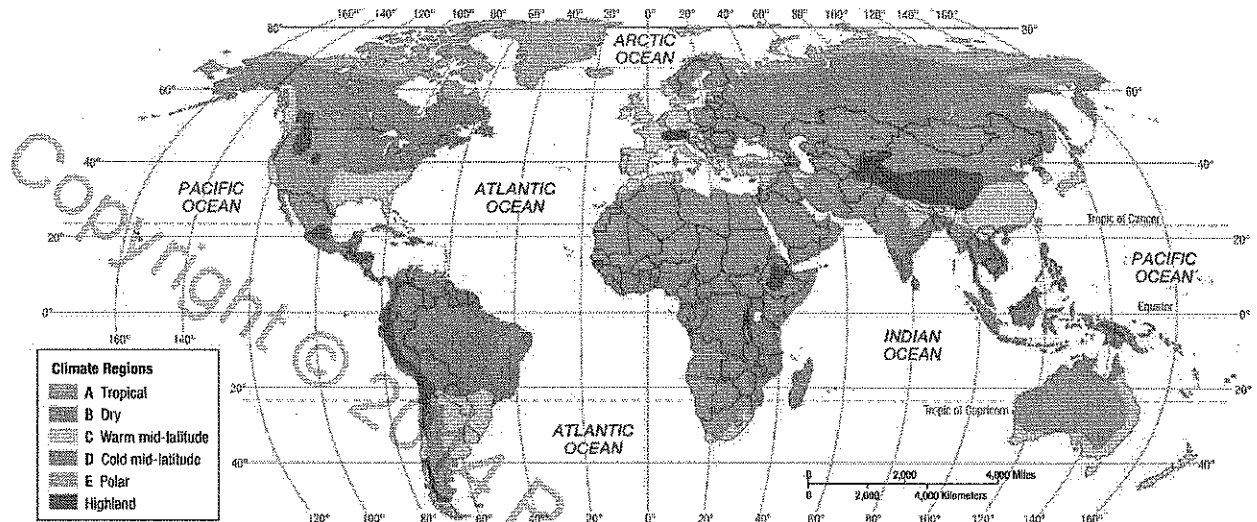
People have been able to practice agriculture in a wide variety of places. The most widely used map of world agricultural regions is based on work done by geographer

Derwent Whittlesey in 1936. Whittlesey identified 11 main agricultural regions, plus an area where agriculture was nonexistent. Whittlesey's 11 regions are divided between 5 that are important in developing countries and 6 that are important in developed countries (Figure 10-18). The 5 agricultural regions that predominate in developing countries are:

- *Pastoral nomadism*—primarily the drylands of Southwest Asia & North Africa, Central Asia, and East Asia
- *Shifting cultivation*—primarily the tropical regions of Latin America, sub-Saharan Africa, and Southeast Asia
- *Intensive subsistence, wet rice dominant*—primarily the large population concentrations of East Asia and South Asia
- *Intensive subsistence, crops other than rice dominant*—primarily the large population concentrations of East Asia and South Asia, where growing rice is difficult

► **FIGURE 10-18 AGRICULTURE AND CLIMATE REGIONS**  
(right) The major agricultural practices of the world can be divided into those that are prevalent in developing countries and those that are prevalent in developed countries (upper right). Climate plays a large role in the practice of agriculture. Figure 1-40 is a more detailed version of the climate map shown here.





• *Plantation*—primarily the tropical and sub-tropical regions of Latin America, sub-Saharan Africa, South Asia, and Southeast Asia

The six agricultural regions that predominate in developed countries are:

- *Mixed crop and livestock*—primarily the U.S. Midwest and central Europe
- *Dairying*—primarily near population clusters in the northeastern United States, southeastern Canada, and northwestern Europe
- *Grain*—primarily the north-central United States, south-central Canada, and Eastern Europe
- *Ranching*—primarily the drylands of western North America, southeastern Latin America, Central Asia, sub-Saharan Africa, and the South Pacific
- *Mediterranean*—primarily lands surrounding the Mediterranean Sea, the western United States, the southern tip of Africa, and Chile
- *Commercial gardening*—primarily the southeastern United States and southeastern Australia

**Pause and Reflect 10.3.1**  
**In which agricultural region do you live?**

## Agriculture in Developing Regions

### Learning Outcome 10.3.2

Explain how pastoral nomadism works in the drylands of developing regions.

In developing countries, most people produce food for their own consumption. Some surplus may be sold to the government or to private firms, but the surplus product is not the farmer's primary purpose and may not even exist some years because of growing conditions. This section considers five agricultural types characteristic of developing countries—pastoral nomadism, shifting cultivation, intensive subsistence with wet rice dominant, intensive subsistence with crops other than rice, and plantation farming.

### AGRICULTURAL REGIONS AND CLIMATE

One factor that contributes to the different types of agriculture in both developed and developing countries is climate. Similarities between the agriculture and climate maps on the previous page are striking. For example, pastoral nomadism is the predominant type of agriculture in Southwest Asia & North Africa, which has a dry climate, whereas shifting cultivation is the predominant type of agriculture in sub-Saharan Africa, which has a tropical climate. Note the division between southeastern China (warm mid-latitude climate, intensive subsistence agriculture with wet rice dominant) and northeastern China (cold mid-latitude climate, intensive subsistence agriculture with wet rice not dominant). In the United States, much of the West is distinguished from the rest of the country according to climate (dry) and agriculture (livestock ranching). Thus, agriculture varies between the drylands and the tropics within developing countries—as well as between the drylands of developing and developed countries.

Because of the problems involved with the concept of environmental determinism, discussed in Chapter 1, geographers are wary of placing too much emphasis on the role

of climate. Cultural preferences discussed in Key Issue 2 also explain agricultural differences in areas of similar climate. Hog production is virtually nonexistent in predominantly Muslim regions because of that religion's taboo against consuming pork products. Wine production is relatively low in Africa and Asia, even where the climate is favorable for growing grapes, because of alcohol avoidance in predominantly non-Christian countries (Figure 4-22).

### PASTORAL NOMADISM

**Pastoral nomadism** is a form of subsistence agriculture based on the herding of domesticated animals. The word *pastoral* refers to sheepherding. It is adapted to dry climates, where planting crops is impossible. Pastoral nomads live primarily in the large belt of arid and semiarid land that includes Central and Southwest Asia and North Africa. The Bedouins of Saudi Arabia and North Africa and the Masai of East Africa are examples of nomadic groups. Only about 15 million people are pastoral nomads, but they sparsely occupy about 20 percent of Earth's land area.

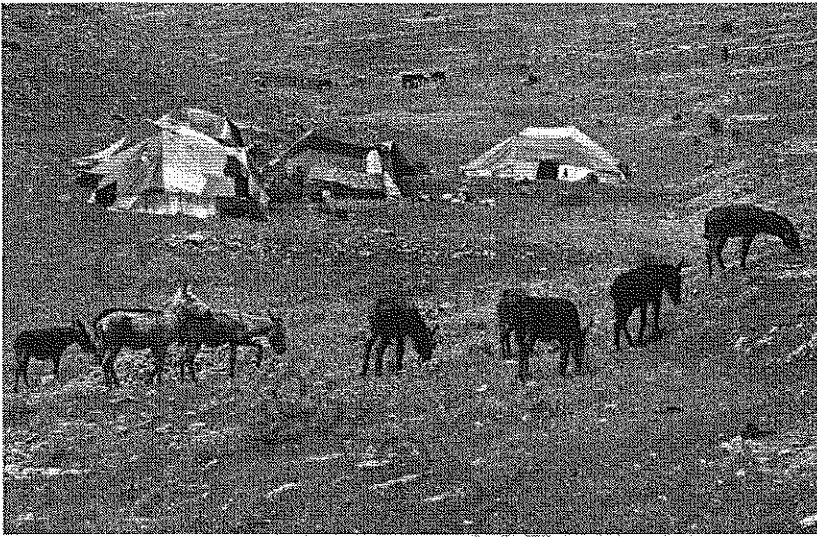
Unlike other subsistence farmers, pastoral nomads depend primarily on animals rather than crops for survival. The animals provide milk, and their skins and hair are used for clothing and tents. Like other subsistence farmers, though, pastoral nomads consume mostly grain rather than meat. To obtain grain, many present-day nomads do raise crops. Their animals are usually not slaughtered, although dead ones may be consumed. To nomads, the size of their herd is both an important measure of power and prestige and their main security during adverse environmental conditions.

Some pastoral nomads obtain grain from sedentary subsistence farmers in exchange for animal products. More often, part of a nomadic group—perhaps the women and children—may plant crops at a fixed location while the rest of the group wanders with the herd. Nomads might hire workers to practice sedentary agriculture in return for grain and protection. Other nomads might sow grain in recently flooded areas and return later in the year to harvest the crop. Yet another strategy is to remain in one place and cultivate the land when rainfall is abundant; then, during periods that are too dry to grow crops, the group can increase the size of the herd and migrate in search of food and water.

▼ FIGURE 10-19 PASTORAL NOMADISM: CHOICE OF ANIMALS Goats are herded in Zantaram, Niger.



**CHOICE OF ANIMALS.** Nomads select the type and number of animals for the herd according to local cultural and physical characteristics. The choice depends on the relative prestige of animals and the ability of species to adapt to a particular climate and vegetation. The camel is the most highly desired animal in North Africa and Southwest Asia, along with sheep and goats. The horse is particularly important in Central Asia.



▲ FIGURE 10-20 PASTORAL NOMADISM: MOVEMENT Normads pitch tents in Turkey.

- Camels are well suited to arid climates because they can go long periods without water, carry heavy baggage, and move rapidly, but they are particularly bothered by flies and sleeping sickness and have a relatively long gestation period—12 months from conception to birth.
- Goats need more water than do camels but are tough and agile and can survive on virtually any vegetation, no matter how poor (Figure 10-19).
- Sheep are relatively slow moving and affected by climatic changes; they require more water than camels and goats and are more selective about which plants they will eat.

The minimum number of animals necessary to support each family adequately varies according to the particular group and animal. The typical nomadic family needs 25 to 60 goats or sheep or 10 to 25 camels.

**MOVEMENTS OF PASTORAL NOMADS.** Pastoral nomads do not wander randomly across the landscape but have a strong sense of territoriality (Figure 10-20). Every group controls a piece of territory and will invade another group's territory only in an emergency or if war is declared. The goal of each group is to control a territory large enough to contain the forage and water needed for survival. The actual amount of land a group controls depends on its wealth and power.

The precise migration patterns evolve from intimate knowledge of the area's physical and cultural characteristics. Groups frequently divide into herding units of five or six families and choose routes based on the most likely water sources during the various seasons of the year. The selection of routes varies in unusually wet or dry years and is influenced by the condition of the animals and the area's political stability.

Some pastoral nomads practice **transhumance**, which is seasonal migration of livestock between mountains and lowland pasture areas. Pasture is grass or other plants grown for feeding grazing animals, as well as land used for

grazing. Sheep or other animals may pasture in alpine meadows in the summer and be herded back down into valleys for winter pasture.

#### THE FUTURE OF PASTORAL NOMADISM.

Agricultural experts once regarded pastoral nomadism as a stage in the evolution of agriculture—between the hunters and gatherers who migrated across Earth's surface in search of food and sedentary farmers who cultivated grain in one place. Because they had domesticated animals but not plants, pastoral nomads were considered more advanced than hunters and gatherers but less advanced than settled farmers.

Pastoral nomadism is now generally recognized as an offshoot of sedentary agriculture, not as a primitive precursor of it. It is simply a practical way of surviving on land that receives too little rain for cultivation of crops. The domestication of animals—the basis for pastoral nomadism—

probably was achieved originally by sedentary farmers, not by nomadic hunters. Pastoral nomads therefore had to be familiar with sedentary farming, and in many cases they practiced it.

Today, pastoral nomadism is a declining form of agriculture, partly a victim of modern technology. Before recent transportation and communications inventions, pastoral nomads played an important role as carriers of goods and information across the sparsely inhabited drylands. They used to be the most powerful inhabitants of the drylands, but now, with modern weapons, national governments can control nomadic population more effectively.

Government efforts to resettle nomads have been particularly vigorous in China, Kazakhstan, and several countries of Southwest Asia, including Israel, Saudi Arabia, and Syria. Nomads are reluctant to cooperate, so these countries have experienced difficulty in trying to force their settlement in collectives and cooperatives. Governments force groups to give up pastoral nomadism because they want the land for other uses. Land that can be irrigated is converted from nomadic to sedentary agriculture. In some instances, the mining and petroleum industries now operate in drylands formerly occupied by pastoral nomads. Some nomads are encouraged to try sedentary agriculture or to work for mining or petroleum companies. Others are still allowed to move about, but only within ranches of fixed boundaries. In the future, pastoral nomadism will be increasingly confined to areas that cannot be irrigated or that lack valuable raw materials.

#### Pause and Reflect 10.3.2

A few trees are growing in the background in Figure 10-19 and none in Figure 10-20. What natural resource needs to be present so that trees can grow?

## SHIFTING CULTIVATION

### Learning Outcome 10.3.3

Explain how shifting cultivation works in the tropics of developing regions.

Shifting cultivation is practiced in much of the world's Tropical, or A, climate regions, which have relatively high temperatures and abundant rainfall. It is practiced by roughly 250 million people across 36 million square kilometers (14 million square miles), especially in the tropical rain forests of Latin America, sub-Saharan Africa, and Southeast Asia.

Two distinctive features of shifting cultivation are:

- Farmers clear land for planting by slashing vegetation and burning the debris (shifting cultivation is sometimes called **slash-and-burn agriculture**).
- Farmers grow crops on a cleared field for only a few years, until soil nutrients are depleted, and then leave it fallow (with nothing planted) for many years so the soil can recover.

People who practice shifting cultivation generally live in small villages and grow food on the surrounding land, which the village controls. Well-recognized boundaries usually separate neighboring villages.

**THE PROCESS OF SHIFTING CULTIVATION.** Each year villagers designate for planting an area surrounding the settlement. Before planting, they must remove the dense vegetation that typically covers tropical land. Using axes, they cut down most of the trees, sparing only those that are economically useful. An efficient strategy is to cut down selected large trees, which bring down smaller trees that may have been weakened by notching. The undergrowth is cleared away with a machete or other long knife. On a windless day the debris is burned under carefully controlled conditions. The rains wash the fresh ashes into the soil, providing needed nutrients (Figure 10-21).

▼ FIGURE 10-21 SHIFTING CULTIVATION: SLASH AND BURN This field in Mozambique is being prepared through slash and burn.



▲ FIGURE 10-22 SHIFTING CULTIVATION: PREPARING THE LAND This field in Côte d'Ivoire is being prepared for planting.

Before planting, the cleared area, known by a variety of names in different regions, including *swidden*, *lading*, *milpa*, *chena*, and *kaingin*, is prepared by hand, perhaps with the help of a simple implement such as a hoe; plows and animals are rarely used (Figure 10-22). The only fertilizer generally available is potash (potassium) from burning the debris when the site is cleared. Little weeding is done the first year that a cleared patch of land is farmed; weeds may be cleared with a hoe in subsequent years.

The cleared land can support crops only briefly, usually three years or less. In many regions, the most productive harvest comes in the second year after burning. Thereafter, soil nutrients are rapidly depleted, and the land becomes too infertile to nourish crops. Rapid weed growth also contributes to the abandonment of a swidden after a few years. When the swidden is no longer fertile, villagers identify a new site and begin clearing it. They leave the old site uncropped for many years, allowing it to become over-run again by natural vegetation. The field is not actually abandoned; the villagers will return to the site someday, perhaps as few as 6 years or as many as 20 years later, to begin the process of clearing the land again. In the meantime, they may still care for fruit-bearing trees on the site.

If a cleared area outside a village is too small to provide food for the population, then some of the people may establish a new village and practice shifting cultivation there. Some farmers may move temporarily to another settlement if the field they are clearing that year is distant.

**CROPS OF SHIFTING CULTIVATION.** The crops grown by each village vary by local custom and taste. The predominant crops include upland rice in Southeast Asia, maize (corn) and manioc (cassava) in South America, and millet and sorghum in Africa. Yams, sugarcane, plantain, and vegetables are also grown in some regions. These crops have originated in one region of shifting cultivation and have diffused to other areas in recent years.

The Kayapo people of Brazil's Amazon tropical rain forest do not arrange crops in the rectangular fields and rows that are familiar to us. They plant in concentric rings. At

first they plant sweet potatoes and yams in the inner area, with corn and rice, manioc, and more yams in successive rings. In subsequent years the inner area of potatoes and yams expands to replace corn and rice. The outermost ring contains plants that require more nutrients, including papaya, banana, pineapple, mango, cotton, and beans. It is here that the leafy crowns of cut trees fall when the field is cleared, and their rotting releases more nutrients into the soil.

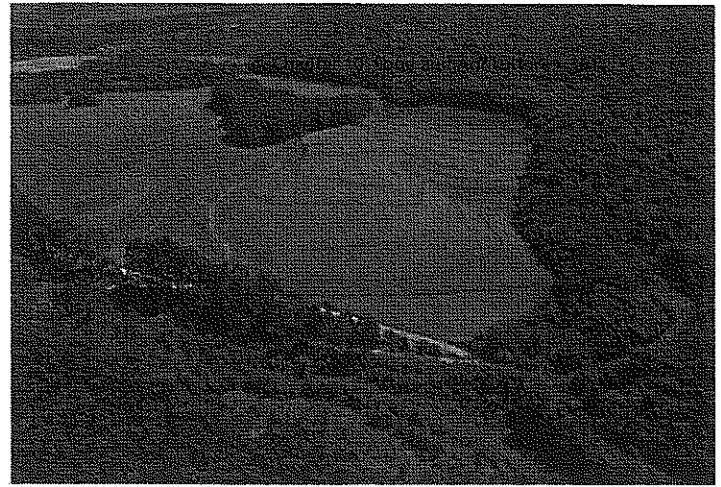
Most families grow only for their own needs, so one swidden may contain a large variety of intermingled crops, which are harvested individually at the best time. In shifting cultivation a "farm field" appears much more chaotic than do fields in developed countries, where a single crop such as corn or wheat may grow over an extensive area. In some cases, families may specialize in a few crops and trade with villagers who have a surplus of others.

**OWNERSHIP AND USE OF LAND IN SHIFTING CULTIVATION.** Traditionally, land was owned by the village as a whole rather than separately by each resident. The chief or ruling council allocated a patch of land to each family and allowed it to retain the output. Individuals may also have had the right to own or protect specific trees surrounding the village. Today, private individuals now own the land in some communities, especially in Latin America.

Shifting cultivation occupies approximately one-fourth of the world's land area, a higher percentage than any other type of agriculture. However, less than 5 percent of the world's people engage in shifting cultivation. The gap between the percentage of people and land area is not surprising because the practice of moving from one field to another every couple years requires more land per person than do other types of agriculture.

**FUTURE OF SHIFTING CULTIVATION.** Land devoted to shifting cultivation is declining in the tropics at a rate of about 75,000 square kilometers (30,000 square miles), or 0.2 percent, per year, according to the United Nations (Figure 10-23). The amount of Earth's surface allocated to tropical rain forests has already been reduced to less than half of its original area, for until recent years the World Bank supported deforestation with loans to finance development schemes that required the clearing of forests. Shifting cultivation is being replaced by logging, cattle ranching, and the cultivation of cash crops. Selling timber to builders and raising beef cattle for fast-food restaurants are more effective development strategies than maintaining shifting cultivation. Developing countries also see shifting cultivation as an inefficient way to grow food in a hungry world. Indeed, compared to other forms of agriculture, shifting cultivation can support only a small population in an area without causing environmental damage.

To its critics, shifting cultivation is at best a preliminary step in economic development. Pioneers use shifting cultivation to clear forests in the tropics and to open land for development where permanent agriculture never existed.



**▲ FIGURE 10-23 DEFORESTATION** The rain forest in Parana, Brazil, once used for shifting cultivation, was cleared plant soybeans.

People unable to find agricultural land elsewhere can migrate to the tropical forests and initially practice shifting cultivation. Critics say it then should be replaced by more sophisticated agricultural techniques that yield more crops per land area. Defenders of shifting cultivation consider it the most environmentally sound approach for the tropics. Practices used in other forms of agriculture, such as applying fertilizers and pesticides and permanently clearing fields, may damage the soil, cause severe erosion, and upset balanced ecosystems.

Large-scale destruction of the rain forests also may contribute to global warming. When large numbers of trees are cut, their burning and decay release large volumes of carbon dioxide. This gas can build up in the atmosphere, acting like the window glass in a greenhouse to trap solar energy in the atmosphere, resulting in the "greenhouse effect," discussed in Chapter 11. Elimination of shifting cultivation could also upset the traditional local diversity of cultures in the tropics. The activities of shifting cultivation are intertwined with other social, religious, political, and various folk customs. A drastic change in the agricultural economy could disrupt other activities of daily life.

As the importance of tropical rain forests to the global environment has become recognized, developing countries have been pressured to restrict further destruction of them. In one innovative strategy, Bolivia agreed to set aside 1.5 million hectares (3.7 million acres) in a forest reserve in exchange for cancellation of \$650 million of its debt to developed countries. Meanwhile, in Brazil's Amazon rain forest, deforestation has increased from 2.7 million hectares (7 million acres) per year during the 1990s to 3.1 million hectares (8 million acres) since 2000.

#### Pause and Reflect 10.3.3

How does rapid population growth in sub-Saharan Africa make it difficult to practice shifting cultivation there?

## INTENSIVE SUBSISTENCE WITH WET RICE DOMINANT

### Learning Outcome 10.3.4

Explain how intensive subsistence farming works in the high population concentrations of developing regions.

Shifting cultivation and pastoral nomadism are forms of subsistence agriculture found in regions of low density. But three-fourths of the world's people live in developing countries, and the form of subsistence agriculture that feeds most of them is **intensive subsistence agriculture**. The term *intensive* implies that farmers must work intensively to subsist on a parcel of land. In densely populated East, South, and Southeast Asia, most farmers practice intensive subsistence agriculture.

**CHARACTERISTICS OF INTENSIVE SUBSISTENCE FARMING.** The typical farm in Asia's intensive subsistence agriculture regions is much smaller than farms elsewhere in the world. Many Asian farmers own several fragmented plots, frequently a result of dividing individual holdings among several children over several centuries. Because the agricultural density—the ratio of farmers to arable land—is so high in parts of East and South Asia, families must produce enough food for their survival from a very small area of land. They do this through careful agricultural practices, refined over thousands of years in response to local environmental and cultural patterns. Most of the work is done by hand or with animals rather than with machines, in part due to abundant labor, but largely from lack of funds to buy equipment.

To maximize food production, intensive subsistence farmers waste virtually no land. Corners of fields and irregularly shaped pieces of land are planted rather than left idle. Paths and roads are kept as narrow as possible to

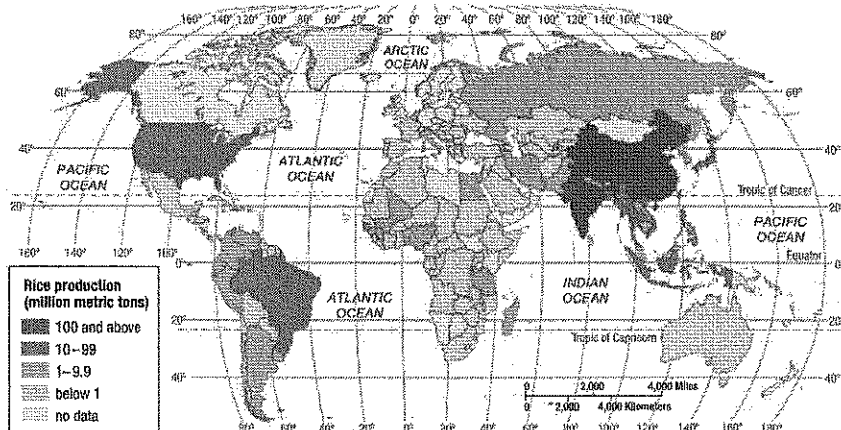


▲ FIGURE 10-25 GROWING RICE: PREPARING THE FIELD Plowing a field with a water buffalo in the Philippines.

minimize the loss of arable land. Livestock are rarely permitted to graze on land that could be used to plant crops, and little grain is grown to feed the animals.

The intensive agriculture region of Asia can be divided between areas where wet rice dominates and areas where it does not (refer to Figure 10-18). The term *wet rice* refers to rice planted on dry land in a nursery and then moved as seedlings to a flooded field to promote growth. Wet rice occupies a relatively small percentage of Asia's agricultural land but is the region's most important source of food. China and India account for nearly 50 percent of the world's rice production, and more than 90 percent is produced in East, South, and Southeast Asia (Figure 10-24). Intensive wet-rice farming is the dominant type of agriculture in southeastern China, East India, and much of Southeast Asia. Successful production of large yields of rice is an elaborate process that is time-consuming and done mostly by hand. The consumers of the rice also perform the work, and all family members, including children, contribute to the effort.

▼ FIGURE 10-24 RICE PRODUCTION China and India produce one-half of the world's rice.



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**CULTIVATION OF WET RICE.** Growing rice involves four principal steps:

- **Field preparation.** A farmer prepares the field for planting, often using a plow drawn by water buffalo or oxen (Figure 10-25). The use of a plow and animal power is one characteristic that distinguishes subsistence agriculture from shifting cultivation.
- **flooding.** The plowed land is then flooded with water (Figure 10-26). The water is collected from rainfall, river overflow, or irrigation. Too much or too little water can



▲ FIGURE 10-26 GROWING RICE: FLOODING THE FIELD Flooded fields in Japan.

damage the crop—a particular problem for farmers in South Asia who depend on monsoon rains, which do not always arrive at the same time each summer. Before planting, dikes and canals are repaired to ensure the right quantity of water in the field. The flooded field is called a **sawah** in the Austronesian language widely spoken in Indonesia, including Java. Europeans and North Americans frequently, but incorrectly, call it a **paddy**, the Malay word for wet rice.

- **Transplanting.** The customary way to plant rice is to grow seedlings on dry land in a nursery and then transplant the seedlings into the flooded field (Figure 10-27). Typically, one-tenth of a sawah is devoted to the cultivation of seedlings. After about a month they are transferred to the rest of the field. Rice plants grow submerged in water for approximately three-fourths of the growing period. Another method of planting rice is to broadcast dry seeds by scattering them through the field, a method used to some extent in South Asia.
- **Harvesting.** Rice plants are harvested by hand, usually with knives (Figure 10-28). To separate the husks, known as **chaff**, from the seeds, the heads are **threshed** by beating them on the ground or treading on them barefoot. The threshed rice is placed in a tray, and the lighter chaff is **winnowed**—that is, allowed to be blown away by the wind. If the rice is to be consumed directly by the farmer, the **hull**, or outer covering, is removed using a mortar and pestle. Rice that is sold commercially is frequently whitened and polished, a process that removes some nutrients but leaves rice more pleasing in appearance and taste to many consumers.

Wet rice is most easily grown on flat land because the plants are submerged in water much of the time. Thus

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▲ FIGURE 10-27 GROWING RICE: TRANSPLANTING PLANTS Transplanting rice by hand in Malaysia.

most wet-rice cultivation takes place in river valleys and deltas. But the pressure of population growth in parts of East Asia has forced expansion of areas under rice cultivation. One method of developing additional land suitable for growing rice is to terrace the hillsides of river valleys.

Land is used even more intensively in parts of Asia by obtaining two harvests per year from one field, a process known as **double cropping**. Double cropping is common in places that have warm winters, such as southern China and Taiwan, but is relatively rare in India, where most areas have dry winters. Normally, double cropping involves alternating between wet rice, grown in the summer when precipitation is higher, and wheat, barley, or another dry crop, grown in the drier winter season. Crops other than rice may be grown in the wet-rice region in the summer on nonirrigated land.

#### Pause and Reflect 10.3.4

Describe the sequence of tasks in wet rice cultivation. How can growing this very labor-intensive crop be cost effective for farmers?

▼ FIGURE 10-28 GROWING RICE: HARVESTING Harvesting rice by hand in Thailand.





## INTENSIVE SUBSISTENCE WITH WET RICE NOT DOMINANT

### Learning Outcome 10.3.5

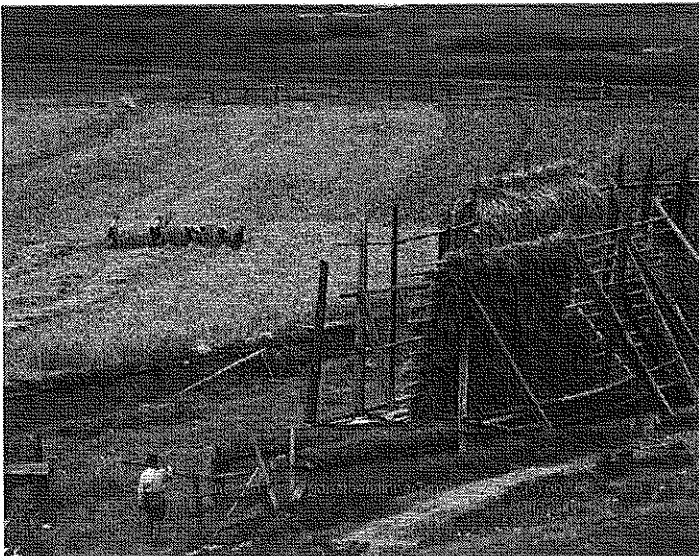
Describe reasons for growing crops other than wet rice in intensive subsistence regions.

Climate prevents farmers from growing wet rice in portions of Asia, especially where summer precipitation levels are too low and winters are too harsh (refer to Figure 10-18). Agriculture in much of the interior of India and northeastern China is devoted to crops other than wet rice. Wheat is the most important crop, followed by barley (Figure 10-29). Various other grains and legumes are grown for household consumption, including millet, oats, corn, sorghum, and soybeans. In addition, some crops are grown in order to be sold for cash, such as cotton, flax, hemp, and tobacco.

Aside from what is grown, this region shares most of the characteristics of intensive subsistence agriculture with the wet-rice region. Land is used intensively and worked primarily by human power, with the assistance of some hand implements and animals. In milder parts of the region where wet rice does not dominate, more than one harvest can be obtained some years through skilled use of **crop rotation**, which is the practice of rotating use of different fields from crop to crop each year to avoid exhausting the soil. In colder climates, wheat or another crop is planted in the spring and harvested in the fall, but no crops can be sown through the winter.

Since the Communist Revolution in 1949, private individuals have owned little agricultural land in China. Instead, the Communist government organized agricultural producer communes, which typically consisted of several villages of several hundred people each. By combining

▼ FIGURE 10-29 CHINA BARLEY FIELDS Hillsides are terraced to create flat fields.



▲ FIGURE 10-30 CHINA COMMUNE A commune in Changsha, China.

several small fields into a single large unit, China's government hoped to promote agricultural efficiency; scarce equipment and animals and larger improvement projects, such as flood control, water storage, and terracing, could be shared (Figure 10-30). In reality, productivity did not increase as much as the government had expected because people worked less efficiently for the commune than when working for themselves.

China has therefore dismantled the agricultural communes. The communes still hold legal title to agricultural land, but villagers sign contracts that entitle them to farm portions of the land as private individuals. Chinese farmers may sell to others the right to use the land and to pass on the right to their children. Reorganization has been difficult because irrigation systems, equipment, and other infrastructure were developed to serve large communal farms rather than small individually managed ones, which cannot afford to operate and maintain the machinery. But production has increased greatly.

## PLANTATION FARMING

The types of agriculture in developing countries discussed so far are considered subsistence agriculture because the principal purpose is production of food for consumption by the farmer's family. Plantation farming is a form of commercial agriculture found in developing countries. A **plantation** is a large commercial farm in a developing country that specializes in one or two crops.

Most plantations are located in the tropics and subtropics, especially in Latin America, Africa, and Asia (Figure 10-31). Although generally situated in developing countries, plantations are often owned or operated by Europeans or North Americans, and they grow crops for sale primarily to developed countries. Crops are normally processed at the plantation before being shipped because processed goods are less bulky and are therefore cheaper to ship the long distances to the North American and European markets.

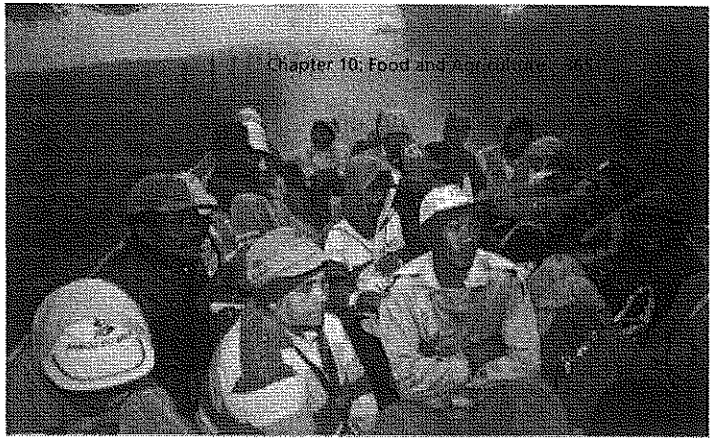
Among the most important crops grown on plantations are cotton, sugarcane, coffee, rubber, and tobacco (Figure 10-32). Also produced in large quantities are cocoa, jute, bananas, tea, coconuts, and palm oil. Latin American



▲ FIGURE 10-31 COFFEE PLANTATION This plantation is in Minas Gerais, Brazil.

plantations are most likely to grow coffee, sugarcane, and bananas, whereas Asian plantations may provide rubber and palm oil. Crops such as tobacco, cotton, and sugarcane, which can be planted only once a year, are less likely to be grown on large plantations today than in the past.

Because plantations are usually situated in sparsely settled locations, they must import workers and provide them with food, housing, and social services (Figure 10-33).



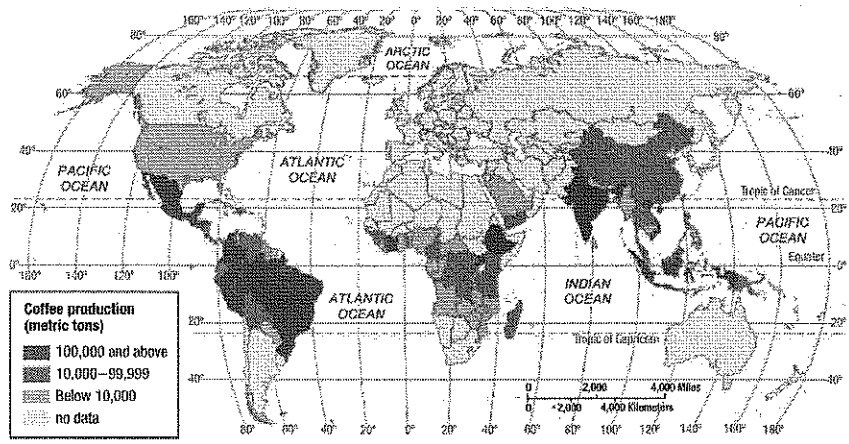
▲ FIGURE 10-33 PLANTATION WORKERS Temporary laborers are transported to a coffee plantation in Minas Gerais, Brazil.

Plantation managers try to spread the work as evenly as possible throughout the year to make full use of the large labor force. Where the climate permits, more than one crop is planted and harvested annually. Rubber tree plantations try to spread the task of tapping the trees throughout the year.

Until the Civil War, plantations were important in the U.S. South, where the principal crop was cotton, followed by tobacco and sugarcane. Demand for cotton increased dramatically after the establishment of textile factories in England at the start of the Industrial Revolution in the late eighteenth century. Cotton production was stimulated by the improvement of the cotton gin by Eli Whitney in 1793 and the development of new varieties of cotton that were hardier and easier to pick. Slaves brought from Africa performed most of the labor until the abolition of slavery and the defeat of the South in the Civil War. Thereafter, plantations declined in the United States; they were subdivided and either sold to individual farmers or worked by tenant farmers.

**Pause and Reflect 10.3.5**  
 What foods do you consume that are grown on plantations?

▼ FIGURE 10-32 COFFEE BEAN PRODUCTION One-third of the world's coffee beans are grown in Brazil.



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## Agriculture in Developed Regions

### Learning Outcome 10.3.6

Describe how mixed crop and livestock farming works.

Commercial agriculture in developed countries can be divided into six main types: mixed crop and livestock farming, dairy farming, commercial gardening and fruit farming, grain farming, Mediterranean agriculture, and livestock ranching. Each type is predominant in distinctive regions within developed countries, depending largely on climate. Commercial agriculture is also becoming increasingly important in many developing countries.

In commercial farming, farmers grow crops and raise animals primarily for sale off the farm rather than for their own consumption. Agricultural products are not sold directly to consumers but to food-processing companies. Large processors, such as General Mills and Kraft, typically sign contracts with commercial farmers to buy their grain, chickens, cattle, and other output. Farmers may have contracts to sell sugar beets to sugar refineries, potatoes to distilleries, and oranges to manufacturers of concentrated juices.

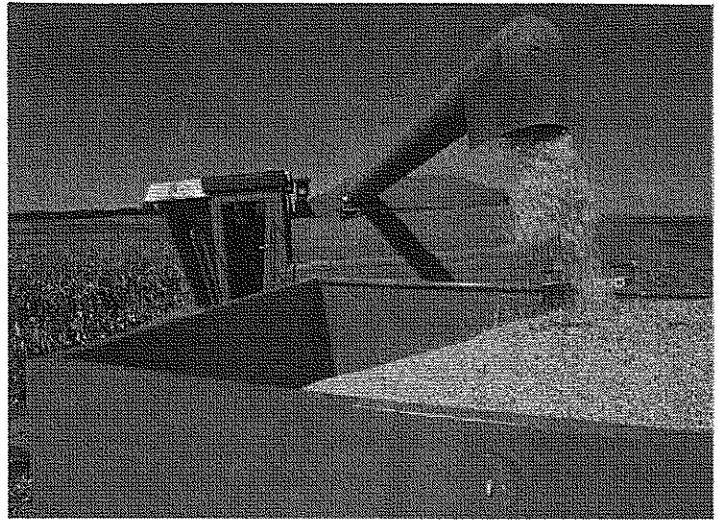
Commercial farming is closely tied to other businesses. The system of commercial farming found in developed countries has been called **agribusiness** because the family farm is not an isolated activity but is integrated into a large food-production industry. Commercial farmers make heavy use of modern communications and information technology to stay in touch and keep track of prices, yields, and expenditures.

Although farmers account for less than 2 percent of the U.S. labor force, around 20 percent of U.S. laborers work in food production and services related to agribusiness—food processing, packaging, storing, distributing, and retailing. Agribusiness encompasses such diverse enterprises as tractor manufacturing, fertilizer production, and seed distribution. Although most farms are owned by individual families, many other aspects of agribusiness are controlled by large corporations.

### MIXED CROP AND LIVESTOCK FARMING

Mixed crop and livestock farming is the most common form of commercial agriculture in the United States west of the Appalachians and east of 98° west longitude and in much of Europe from France to Russia (refer to Figure 10-18).

**INTEGRATION OF CROPS AND LIVESTOCK.** The most distinctive characteristic of mixed crop and livestock farming is the integration of crops and livestock (Figure 10-35). Most of the crops are fed to animals rather than consumed directly by humans. In turn, the livestock



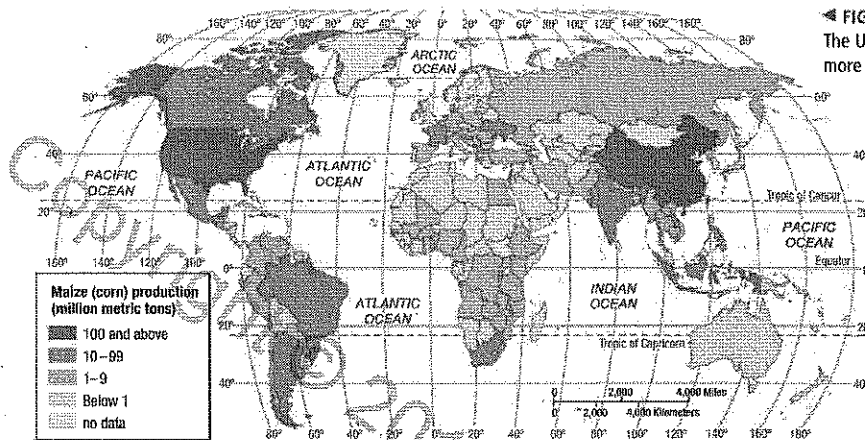
▲ FIGURE 10-34 MIXED CROP AND LIVESTOCK Harvesting corn in Iowa.

supply manure to improve soil fertility to grow more crops. A typical mixed crop and livestock farm devotes nearly all land area to growing crops but derives more than three-fourths of its income from the sale of animal products, such as beef, milk, and eggs. In the United States pigs are often bred directly on the farms, whereas cattle may be brought in to be fattened on corn.

Mixing crops and livestock permits farmers to distribute the workload more evenly through the year. Fields require less attention in the winter than in the spring, when crops are planted, and in the fall, when they are harvested. Meanwhile, livestock require year-long attention. A mix of crops and livestock also reduces seasonal variations in income; most income from crops comes during the harvest season, but livestock products can be sold throughout the year.

In the United States, corn (maize) is the crop most frequently planted in the mixed crop and livestock region because it generates higher yields per area than do other crops (Figure 10-35). Some of the corn is consumed by people as oil, margarine, and other food products, but most is fed to pigs and cattle. The most important mixed crop and livestock farming region in the United States—extending from Ohio to the Dakotas, with its center in Iowa—is frequently called the **Corn Belt** because around half of the cropland is planted in corn. Soybeans have become the second-most-important crop in the U.S. mixed commercial farming region. Like corn, soybeans are mostly used to make animal feed. Tofu (made from soybean milk) is a major food source, especially for people in China and Japan. Soybean oil is widely used in U.S. foods, as a hidden ingredient.

**CROP ROTATION.** Mixed crop and livestock farming typically involves crop rotation. The farm is divided into a number of fields, and each field is planted on a planned cycle, often of several years. The crop planted changes from one year to the next, typically going through a cycle of two or more crops, and perhaps a year of fallow before the cycle is repeated. Crop rotation helps maintain the fertility of a field because various crops deplete the soil of



◀ FIGURE 10-35 MAIZE (CORN) PRODUCTION  
The United States produces nearly 40 percent and China more than 20 percent of the world total.

certain nutrients but restore others. Crop rotation contrasts with shifting cultivation, in which nutrients depleted from a field are restored only by leaving the field fallow (uncropped) for many years. With shifting cultivation, in any given year, crops cannot be planted in most of an area's fields, so overall production is much lower than in mixed commercial farming.

A two-field crop-rotation system was developed in Northern Europe as early as the fifth century. A cereal grain, such as oats, wheat, rye, or barley, was planted in Field A one year, while Field B was left fallow. The following year, Field B was planted, and Field A was left fallow, and so forth. Beginning in the eighth century, a three-field system was introduced. The first field was planted with a winter cereal, the second was planted with a spring cereal, and the third was left fallow. As a result, each field yielded four harvests every six years, compared to three every six years under the two-field system.

A four-field system was introduced in Europe during the eighteenth century. The first year, the farmer could plant a root crop (such as turnips) in Field A, a cereal in Field B, a "rest" crop (such as clover, which helps restore the field) in Field C, and a cereal in Field D. The second year, the farmer might select a cereal for Field A, a rest crop for Field B, a cereal for Field C, and a root for Field D. The rotation would continue for two more years before the cycle would start again. Each field thus passed through a cycle of four crops—root, cereal, rest crop, and another cereal.

Cereals such as wheat and barley were sold for flour and beer production, and straw (the stalks remaining after the heads of wheat are threshed) was retained for animal bedding. Root crops such as turnips were fed to the animals during the winter. Clover and other rest crops were used for cattle grazing and for restoring nitrogen to the soil.

#### Pause and Reflect 10.3.6

What are the principal differences between harvesting of maize in the United States (Figure 10-34) and harvesting of rice in Thailand (Figure 10-28)?

## COMMERCIAL GARDENING AND FRUIT FARMING

Commercial gardening and fruit farming is the predominant type of agriculture in the southeastern United States. The region has a long growing season and humid climate, and it is accessible to the large markets of New York, Philadelphia, Washington, and other eastern U.S. urban areas. The type of agriculture practiced in this region is frequently called *truck farming*, from the Middle English word *truck*, meaning "bartering" or "exchange of commodities." Truck farms grow many of the fruits and vegetables that consumers in developed countries demand, such as apples, asparagus, cherries, lettuce, mushrooms, and tomatoes. Some of these fruits and vegetables are sold fresh to consumers, but most are sold to large processors for canning or freezing.

Truck farms are highly efficient large-scale operations that take full advantage of machines at every stage of the growing process. Truck farmers are willing to experiment with new varieties, seeds, fertilizers, and other inputs to maximize efficiency. Labor costs are kept down by hiring migrant farm workers, some of whom are undocumented immigrants from Mexico who work for very low wages. Farms tend to specialize in a few crops, and a handful of farms may dominate national output of some fruits and vegetables.

A form of truck farming called specialty farming has spread to New England, among other places. Farmers are profitably growing crops that have limited but increasing demand among affluent consumers, such as asparagus, peppers, mushrooms, strawberries, and nursery plants. Specialty farming represents a profitable alternative for New England farmers at a time when dairy farming is declining because of relatively high operating costs and low milk prices.

## DAIRY FARMING

### Learning Outcome 10.3.7

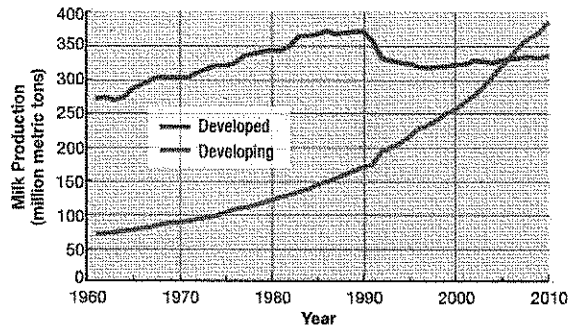
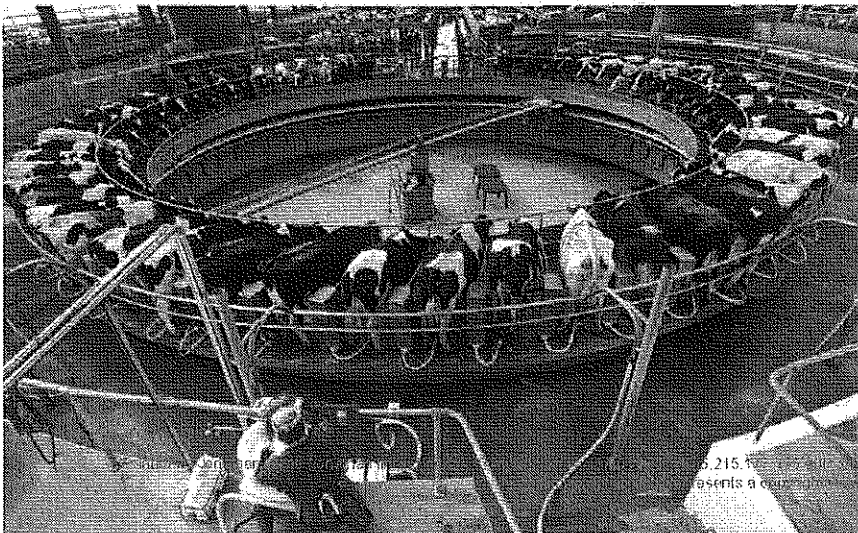
Describe how dairy farming and commercial gardening work.

Dairy farming is the most important commercial agriculture practiced on farms near the large urban areas of the north-eastern United States, southeastern Canada, and north-western Europe (Figure 10-36). Dairying has also become an important type of farming in South and East Asia. Traditionally, fresh milk was rarely consumed except directly on the farm or in nearby villages. With the rapid growth of cities in developed countries during the nineteenth century, demand for the sale of milk to urban residents increased. Rising incomes permitted urban residents to buy milk products, which were once considered luxuries.

**REGIONAL DISTRIBUTION OF DAIRYING.** For most of the twentieth century, the world's milk production was clustered in a handful of developed countries. However, the share of the world's dairy farming conducted in developing countries has risen dramatically, from 26 percent in 1980 to 53 percent in 2010 (Figure 10-37). In the twenty-first century, India has become the world's largest milk producer, ahead of the United States, the traditional leader, and China and Pakistan are now third and fourth largest (Figure 10-38).

In developed countries, dairying is the most important type of commercial agriculture in the first ring outside large cities because of transportation factors. Dairy farms must be closer to their market than other types of farms because their products are highly perishable. The ring surrounding a city from which milk can be supplied without spoiling is known as the **milkshed**. Improvements in transportation have permitted dairying to be undertaken farther from the market. Until the 1840s, when railroads were first

▼ FIGURE 10-36 DAIRY FARM Many cows are milked simultaneously at this dairy farm in Wiltshire, England.



▲ FIGURE 10-37 CHANGING MILK PRODUCTION  
Developing countries now produce more milk than developed countries.

used for transporting dairy products, milksheds rarely had a radius beyond 50 kilometers (30 miles). Today, refrigerated railcars and trucks enable farmers to ship milk more than 500 kilometers (300 miles). As a result, nearly every farm in the northeastern United States and northwestern Europe is within the milkshed of at least one urban area.

Dairy farmers, like other commercial farmers, usually do not sell their products directly to consumers. Instead, they generally sell milk to wholesalers, who distribute it in turn to retailers. Retailers then sell milk to consumers in shops or at home. Farmers also sell milk to butter and cheese manufacturers.

In general, the farther the farm is from large urban concentrations, the smaller is the percentage of output devoted to fresh milk. Farms located farther from consumers are more likely to sell their output to processors that make butter, cheese, or dried, evaporated, and condensed milk. The reason is that these products keep fresh longer than milk does and therefore can be safely shipped from remote farms.

Countries likewise tend to specialize in certain products. New Zealand, the world's largest per capita producer of dairy products, devotes about 5 percent to liquid milk, compared to more than 50 percent in the United Kingdom.

New Zealand farmers do not sell much liquid milk because the country is too far from North America and northwestern Europe, the two largest relatively wealthy population concentrations.

**CHALLENGES FOR DAIRY FARMERS.** Like other commercial farmers, dairy farmers face economic difficulties because of declining revenues and rising costs. Dairy farmers who have quit farming most often cite lack of profitability and excessive workload as reasons for getting out of the business. Distinctive features of dairy farming have exacerbated the economic difficulties:

- **Labor intensive.** Cows must be milked twice a day, every day; although the actual milking can be done by machines, dairy farming nonetheless requires constant attention throughout the year.

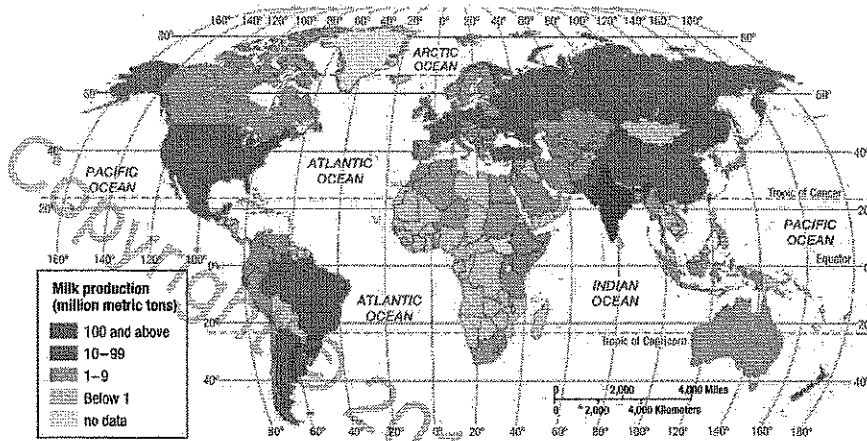


FIGURE 10-38 MILK PRODUCTION India has replaced the United States as the world's leading milk producer.

- Winter feed. Dairy farmers face the expense of feeding the cows in the winter, when they may be unable to graze on grass. In northwestern Europe and in the northeastern United States, farmers generally purchase hay or grain for winter feed. In the western part of the U.S. dairy region, crops are more likely to be grown in the summer and stored for winter feed on the same farm.

**Pause and Reflect 10.3.7**  
Look on the label of your milk carton. How far away from you is the dairy?

## CONTEMPORARY GEOGRAPHIC TOOLS Protecting Farmland

Loss of farmland to urban growth is especially severe at the edge of the string of large metropolitan areas along the East Coast of the United States. Some of the most threatened agricultural land lies in Maryland, a small state where two major cities—Washington and Baltimore—have coalesced into a continuous built-up area (see Chapter 13). In Maryland, a geographic information system (GIS) was used to identify which farms should be preserved.

Maps generated through GIS were essential in identifying agricultural land to protect because the most appropriate farms to preserve were not necessarily those with the highest-quality soil. Why should the state and nonprofit organizations spend scarce funds to preserve “prime” farmland that is nowhere near the path of urban sprawl? Conversely, why purchase an expensive, isolated farm already totally surrounded by residential developments, when the same amount of money could buy several large contiguous farms that effectively blocked urban sprawl elsewhere?

To identify the “best” lands to protect, GIS consultants produced

a series of soil quality, environmental, and economic maps that were combined into a single composite map (Figure 10-39). The map shows that 4 percent of the state's farmland had prime soils, significant environmental features, and high projected population growth, and 25 percent had two of the three factors.

Maryland officials are making use of the results of the GIS as part of an overall strategy to minimize sprawl. For example, state highway money is allocated to improving roads in existing built-up areas rather than extending new roads through important conservation areas.

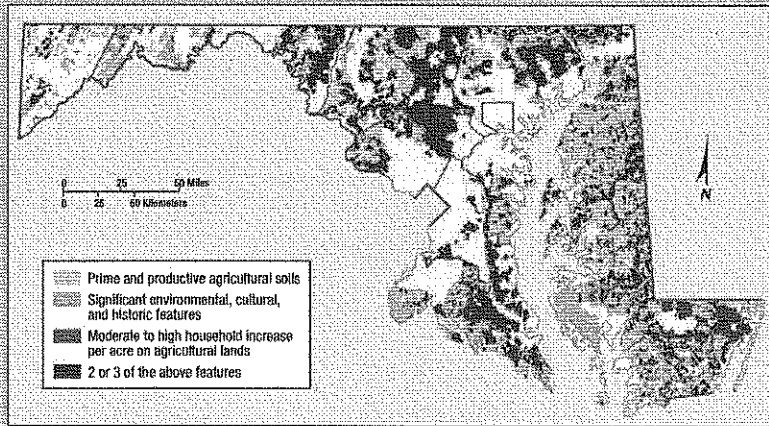


FIGURE 10-39 PROTECTING FARMLAND IN MARYLAND Prime farmland is typically flat and well-drained. Significant environmental features included water quality, flood control, species habitats, historic sites, and especially attractive scenery.

## GRAIN FARMING

### Learning Outcome 10.3.8

Describe how grain and Mediterranean farming work.

Some form of grain is the major crop on most farms. Grain is the seed from various grasses, such as wheat, corn, oats, barley, rice, millet, and others. Commercial grain agriculture is distinguished from mixed crop and livestock farming because crops on a grain farm are grown primarily for consumption by humans rather than by livestock. Farms in developing countries also grow crops for human consumption, but the output is directly consumed by the farmers. Commercial grain farms sell their output to manufacturers of food products, such as breakfast cereals and breads.

The most important crop grown is wheat, used to make bread flour. Wheat generally can be sold for a higher price than other grains, such as rye, oats, and barley, and it has more uses as human food. It can be stored relatively easily without spoiling and can be transported a long distance. Because wheat has a relatively high value per unit weight, it can be shipped profitably from remote farms to markets.

As was the case with milk production, the share of world production of wheat in developing countries has increased rapidly. Much of this increased production results from growth in large-scale commercial agriculture. Developing countries accounted for more than one-half of world wheat production in 2010, compared to only one-fourth in 1960. The United States is by far the largest producer of wheat among developed countries, but it now ranks third among all countries, behind China and India (Figure 10-40). China has been the world leader since 1983, and India has been second since 1999.

Large-scale grain production, like other commercial farming ventures in developed countries, is heavily mechanized, conducted on large farms, and oriented to consumer preferences. The McCormick reaper (a machine that

cuts grain standing in the field), invented in the 1830s, first permitted large-scale wheat production. Today the combine machine performs in one operation the three tasks of reaping, threshing, and cleaning.

Unlike work on a mixed crop and livestock farm, the effort required to grow wheat is not uniform throughout the year. Some individuals or firms may therefore have two sets of fields—one in the spring wheat belt and one in the winter wheat belt. Because the planting and harvesting in the two regions occur at different times of the year, the workload can be distributed throughout the year. In addition, the same machinery can be used in the two regions, thus spreading the cost of the expensive equipment. Combine harvesting contractors start working in Oklahoma in early summer and work their way northward.

Commercial grain farms are generally located in regions that are too dry for mixed crop and livestock agriculture. Within North America, large-scale grain production is concentrated in three areas:

- The winter wheat belt through Kansas, Colorado, and Oklahoma. The winter wheat crop is planted in the autumn and develops a strong root system before growth stops for the winter. The wheat survives the winter, especially if it is insulated beneath a snow blanket, and is ripe by the beginning of summer.
- The spring wheat belt through the Dakotas, Montana, and southern Saskatchewan in Canada. Winters are usually too severe for winter wheat in this region, so spring wheat is planted in the spring and harvested in the late summer.
- The Palouse region of Washington State. Wheat comprises a smaller percentage of agricultural output than in the other two wheat-growing regions. The Palouse is also an important source of legumes; for example, 80 percent of U.S. lentils are grown in the region.

Wheat's significance extends beyond the amount of land or number of people involved in growing it. Unlike other agricultural products, wheat is grown to a

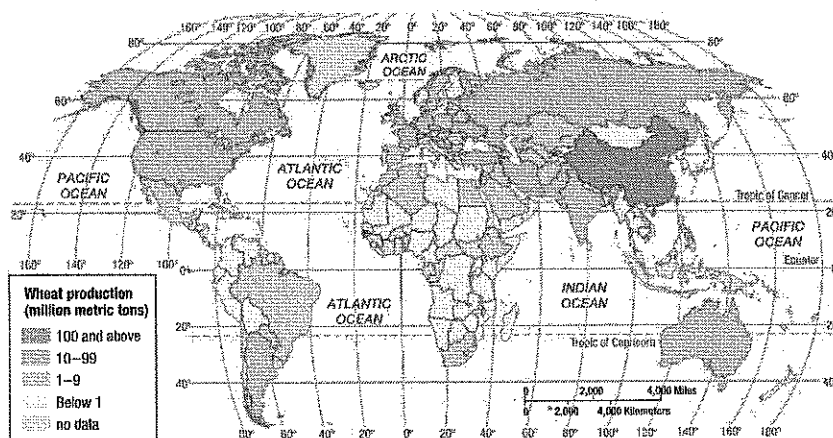
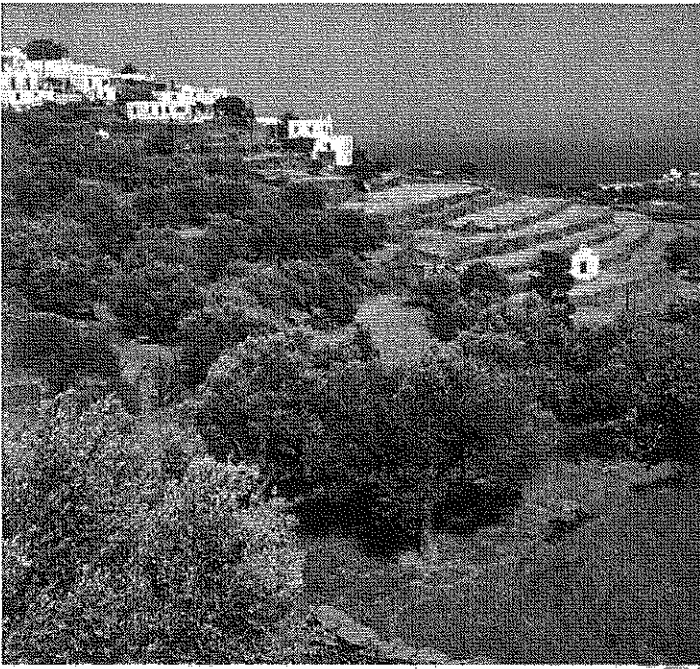


FIGURE 10-40 WHEAT PRODUCTION  
China and India are the leading wheat producers, followed by the United States.



▲ **FIGURE 10-41 MEDITERRANEAN AGRICULTURE** Nearly all olives are produced in countries that border the Mediterranean Sea or have similar climates, including Sifnos, Greece.

considerable extent for international trade, and it is the world's leading export crop. The United States and Canada account for about half of the world's wheat exports; consequently, the North American prairies are accurately called the world's "breadbasket." The ability to provide food for many people elsewhere in the world is a major source of economic and political strength for these two countries.

## MEDITERRANEAN AGRICULTURE

Mediterranean agriculture exists primarily on the lands that border the Mediterranean Sea in Southern Europe, North Africa, and western Asia (Figure 10-41). Farmers in California, central Chile, the southwestern part of South Africa, and southwestern Australia practice Mediterranean agriculture as well.

These Mediterranean areas share a similar physical environment (refer to Figures 10-18 and 10-40). Every Mediterranean area borders a sea, and most are on west coasts of continents (except for some lands surrounding the Mediterranean Sea). Prevailing sea winds provide moisture and moderate the winter temperatures. Summers are hot and dry, but sea breezes provide some relief. The land is very hilly, and mountains frequently plunge directly to the sea, leaving very narrow strips of flat land along the coast.

Farmers derive a smaller percentage of income from animal products in the Mediterranean region than in the mixed crop and livestock region. Livestock production is hindered during the summer by the lack of water and good grazing land. Some farmers living along the Mediterranean

Sea traditionally used transhumance to raise animals, although the practice is now less common. Under transhumance, animals—primarily sheep and goats—are kept on the coastal plains in the winter and transferred to the hills in the summer.

Most crops in Mediterranean lands are grown for human consumption rather than for animal feed. **Horticulture**—which is the growing of fruits, vegetables, and flowers—and tree crops form the commercial base of Mediterranean farming. A combination of local physical and cultural characteristics determines which crops are grown in each area. The hilly landscape encourages farmers to plant a variety of crops within one farming area.

In the lands bordering the Mediterranean Sea, the two most important cash crops are olives and grapes. Two-thirds of the world's wine is produced in countries that border the Mediterranean, especially Italy, France, and Spain. Mediterranean agricultural regions elsewhere in the world produce most of the remaining one-third (refer to Figure 4-22). The lands near the Mediterranean Sea are also responsible for a large percentage of the world's supply of olives, an important source of cooking oil. Despite the importance of olives and grapes to commercial farms bordering the Mediterranean Sea, approximately half of the land is devoted to growing cereals, especially wheat for pasta and bread. As in the U.S. winter wheat belt, the seeds are sown in the fall and harvested in early summer. After cultivation, cash crops are planted on some of the land, and the remainder of the land is left fallow for a year or two to conserve moisture in the soil.

Cereals occupy a much lower percentage of the cultivated land in California than in other Mediterranean climates. Instead, a large portion of California farmland is devoted to fruit and vegetable horticulture, which supplies a large portion of the citrus fruits, tree nuts, and deciduous fruits consumed in the United States. Horticulture is practiced in other Mediterranean climates, but not to the extent found in California. The rapid growth of urban areas in California, especially Los Angeles, has converted high-quality agricultural land into housing developments. Thus far, the loss of farmland has been offset by the expansion of agriculture into arid lands. However, farming in drylands requires massive irrigation to provide water. In the future, California agriculture may face stiffer competition for the Southwest's increasingly scarce water supply.

### Pause and Reflect 10.3.8

At least 1 million metric tons of wine are produced in eight countries (Argentina, Australia, China, France, Italy, South Africa, Spain, and the United States). Referring to Figures 4-22 and 10-18, which one of the eight countries does not appear to have Mediterranean agriculture?



## LIVESTOCK RANCHING

### Learning Outcome 10.3.9

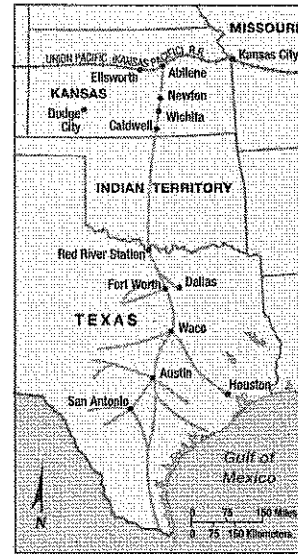
Describe how livestock ranching works.

**Ranching** is the commercial grazing of livestock over an extensive area (Figure 10-42). This form of agriculture is adapted to semiarid or arid land and is practiced in developed countries where the vegetation is too sparse and the soil too poor to support crops.

**CATTLE RANCHING IN THE UNITED STATES.** The importance of ranching in the United States extends beyond the people who choose this form of commercial farming. Its prominence in popular culture, especially in Hollywood films and television, has not only helped to draw attention to this form of commercial farming but has also served to illustrate, albeit in sometimes romanticized ways, the crucial role that ranching played in the history and settlement of areas of the United States. Cattle ranching in Texas, as glamorized in popular culture, did actually dominate commercial agriculture, but only for a short period—from 1867 to 1885.

Cattle ranching expanded in the United States during the 1860s because of the demand for beef in East Coast cities. If they could get their cattle to Chicago, ranchers were paid \$30 to \$40 per head, compared to only \$3 or \$4 per head in Texas. Once in Chicago, the cattle could be slaughtered and processed by meat-packing companies and shipped in packages to consumers in the East. To reach Chicago, cattle were driven on hoof by cowboys over trails from Texas to the nearest railhead. There the cattle were driven into cattle cars for the rest of their journey. The western terminus of the rail line reached Abilene, Kansas, in 1867. Wichita, Caldwell, Dodge City, and other towns in Kansas took their turns as the main destination for cattle

▼ FIGURE 10-42 RANCHING Cattle on a west Texas ranch are rounded up for shipping.



▲ FIGURE 10-43 CHISHOLM TRAIL The Chisholm Trail was used to move cattle from Texas to railroad stations in Kansas during the 1860s and 1870s.

driven north on trails from Texas. The most famous route from Texas northward to the rail line was the Chisholm Trail, which began near Brownsville at the Mexican border and extended northward through Texas (Figure 10-43).

Cattle ranching declined in importance during the 1880s, after it came into conflict with sedentary agriculture. Most early U.S. ranchers adhered to "the Code of the West," although the system had no official legal status. Under the code, ranchers had range rights—that is, their cattle could graze on any open land and had access to scarce water sources and grasslands. The early cattle ranchers in the West owned little land, only cattle. The U.S. government, which owned most of the land used for open grazing, began to sell it to farmers to grow crops, leaving

cattle ranchers with no legal claim to it. For a few years the ranchers tried to drive out the farmers by cutting fences and then illegally erecting their own fences on public land, and "range wars" flared. The farmers' most potent weapon proved to be barbed wire, first commercially produced in 1873. The farmers eventually won the battle, and ranchers were compelled to buy or lease land to accommodate their cattle. Large cattle ranches were established, primarily on land that was too dry to support crops. Ironically, 60 percent of cattle grazing today takes place on land leased from the U.S. government.

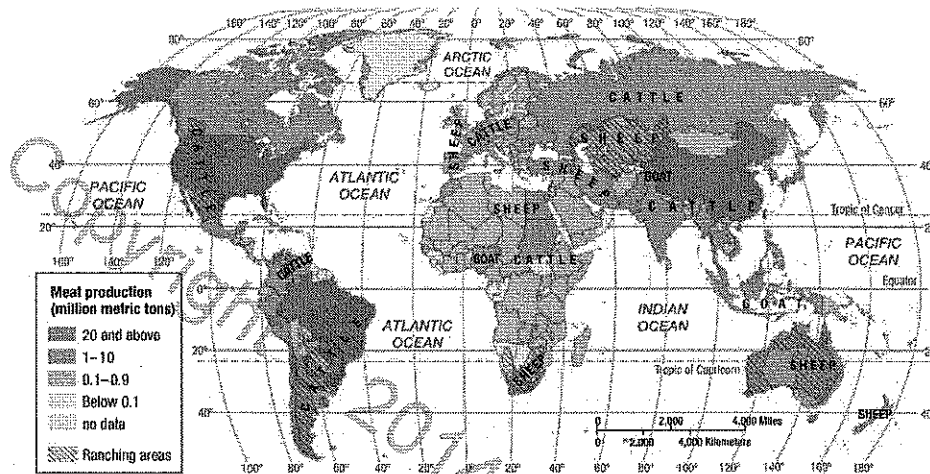


FIGURE 10-44 MEAT PRODUCTION  
China is now the world's largest meat producer.

With the spread of irrigation techniques and hardier crops, land in the United States has been converted from ranching to crop growing. Ranching generates lower income per area of land, although it has lower operating costs. Cattle are still raised on ranches but are frequently sent for fattening to farms or to local feed lots along major railroad and highway routes rather than directly to meat processors.

#### COMMERCIAL RANCHING IN OTHER REGIONS.

Commercial ranching is conducted in several developed countries besides the United States and, increasingly, in developing countries. The interior of Australia was opened for grazing in the nineteenth century, although sheep are more common there than cattle. Ranching is rare in Europe, except in Spain and Portugal. In South America, a large portion of the pampas of Argentina, southern Brazil, and Uruguay is devoted to grazing cattle and sheep. The cattle industry grew rapidly in Argentina in part because the land devoted to ranching was relatively accessible to the ocean, making it possible for meat to be transported to overseas markets.

As with other forms of commercial agriculture, the growth in ranching has been in developing countries. China is the leading producer of meat, ahead of the United States, and Brazil is third (Figure 10-44). China passed the United States as the world's leading meat producer in 1990 and now produces twice as much. Developed countries were responsible for only one-third of world meat production in 2010, compared to two-thirds in 1980.

Ranching has followed similar stages around the world. First was the herding of animals over open ranges, in a semi-nomadic style. Then ranching was transformed into fixed

farming by dividing the open land into ranches. When many of the farms converted to growing crops, ranching was confined to the drier lands. To survive, the remaining ranches experimented with new methods of breeding and sources of water and feed. Ranching has become part of the meat-processing industry rather than an economic activity carried out on isolated farms. In this way, commercial ranching differs from pastoral nomadism, the form of animal herding practiced in less developed regions.

#### Pause and Reflect 10.3.9

What are the two most important ranched animals, according to Figure 10-45?

#### CHECK-IN: KEY ISSUE 3

##### Where Is Agriculture Distributed?

- ✓ Agriculture can be divided into 11 major regions, including 5 in developing regions and 6 in developed regions.
- ✓ In developing regions, pastoral nomadism is prevalent in drylands, shifting cultivation in tropical forests, and intensive subsistence in regions with high population concentrations.
- ✓ In developed regions, mixed crop and livestock is the most common form of agriculture. Dairy, commercial gardening, grain, Mediterranean, and livestock ranching are also important.

## KEY ISSUE 4

## Why Do Farmers Face Economic Difficulties?

- Challenges for Farmers in Developing Countries
- Challenges for Farmers in Developed Countries
- Strategies to Increase the World's Food Supply
- Sustainable Agriculture

### Learning Outcome 10.4.1

Describe the impact of population growth and trade on farming in developing countries.

Commercial farmers in developed countries and subsistence farmers in developing countries face comparable challenges. Farmers in both developing and developed countries have difficulty generating enough income to continue farming. The underlying reasons, though, are different. Commercial farmers can produce a surplus of food, whereas many subsistence farmers are barely able to produce enough food to survive.

## Challenges for Farmers in Developing Countries

Two issues discussed in earlier chapters influence the choice of crops planted by subsistence farmers in developing countries:

- Subsistence farmers must feed an increasing number of people because of rapid population growth in developing countries (discussed in Chapter 2).
- Farmers who have traditionally practiced subsistence farming are pressured to grow food for export instead of for direct consumption due to the adoption of the international trade approach to development (discussed in Chapter 9).

### SUBSISTENCE FARMING AND POPULATION GROWTH

Population growth influences the distribution of types of subsistence farming, according to economist Ester Boserup. It compels subsistence farmers to consider new farming approaches that produce enough food to take care of the additional people.

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For hundreds if not thousands of years, subsistence farming in developing countries yielded enough food for people living in rural villages to survive, assuming that no drought, flood, or other natural disaster occurred. Suddenly in the late twentieth century, developing countries needed to provide enough food for a rapidly increasing population as well as for the growing number of urban residents who cannot grow their own food. According to Boserup, subsistence farmers increase the supply of food through intensification of production, achieved in two ways:

- New farming methods are adopted. Plows replace axes and sticks. More weeding is done, more manure is applied, more terraces are carved out of hillsides, and more irrigation ditches are dug (Figure 10-45). The additional labor needed to perform these operations comes from the population growth. The farmland yields more food per area of land, but with the growing population, output per person remains about the same.
- Land is left fallow for shorter periods. This expands the amount of land area devoted to growing crops at any given time. Boserup identified five basic stages in the intensification of farmland:
  - Forest fallow. Fields are cleared and utilized for up to 2 years and left fallow for more than 20 years, long enough for the forest to grow back.
  - Bush fallow. Fields are cleared and utilized for up to 8 years and left fallow for up to 10 years, long enough for small trees and bushes to grow back.

▼ FIGURE 10-45 INTENSIVE FARMING METHODS Hillsides in Radi, Bhutan, are terraced into fields for intensive planting of rice.



- **Short fallow.** Fields are cleared and utilized for perhaps 2 years (Boserup was uncertain) and left fallow for up to 2 years, long enough for wild grasses to grow back.
- **Annual cropping.** Fields are used every year and rotated between legumes and roots.
- **Multi-cropping.** Fields are used several times a year and never left fallow.

Contrast shifting cultivation, practiced in regions of low population density, such as sub-Saharan Africa, with intensive subsistence agriculture, practiced in regions of high population density, such as East Asia. Under shifting cultivation, cleared fields are utilized for a couple years and then left fallow for 20 years or more. This type of agriculture supports a small population living at low density. As the number of people living in an area increases (that is, as the population density increases) and more food must be grown, fields will be left fallow for shorter periods of time. Eventually, farmers achieve the very intensive use of farmland characteristic of areas of high population density.

## SUBSISTENCE FARMING AND INTERNATIONAL TRADE

To expand production, subsistence farmers need higher-yield seeds, fertilizer, pesticides, and machinery. Some needed supplies can be secured by trading food with urban dwellers. For many African and Asian countries, though, the main way to obtain agricultural supplies is to import them from other countries. However, subsistence farmers lack the money to buy agricultural equipment and materials from developed countries.

To generate the funds they need to buy agricultural supplies, developing countries must produce something they can sell in developed countries. The developing countries sell some manufactured goods (see Chapter 11), but most raise funds through the sale of crops in developed countries. Consumers in developed countries are willing to pay high prices for fruits and vegetables that would otherwise be out of season or for crops such as coffee and tea that cannot be grown in developed countries because of the climate.

In a developing country such as Kenya, families may divide by gender between traditional subsistence agriculture and contributing to international trade. Women practice most of the subsistence agriculture—that is, growing food for their families to consume—in addition to the tasks of cooking, cleaning, and carrying water from wells. Men may work for wages, either growing crops for export or at jobs in distant cities. Because men in Kenya frequently do not share the wages with their families, many women try to generate income for the household by making clothes, jewelry, baked goods, and other objects for sale in local markets.

The sale of export crops brings a developing country foreign currency, a portion of which can be used to buy agricultural supplies. But governments in developing countries face a dilemma: The more land that is devoted to growing export crops, the less that is available to grow crops for domestic consumption. Rather than help to increase productivity, the funds generated through the sale of export crops may be needed to feed the people who switched from subsistence farming to growing export crops.

### Pause and Reflect 10.4.1

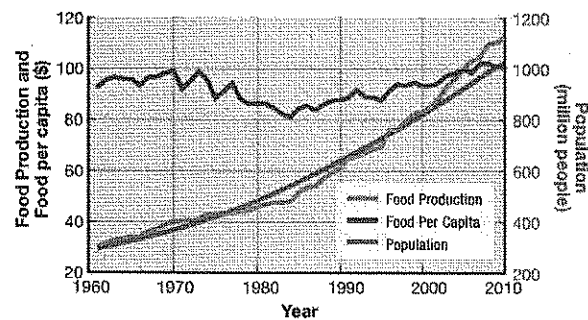
What is an example of a product available in supermarkets in the United States that was exported from a developing country?

## AFRICA'S FOOD-SUPPLY STRUGGLE

Sub-Saharan Africa is struggling to keep food production ahead of population growth. Since 1961, food production has increased substantially in sub-Saharan Africa, but so has population (Figure 10-46). As a result, food production per capita has changed little in a half-century.

The threat of famine is particularly severe in the Horn of Africa and the Sahel. Traditionally, this region supported limited agriculture. With rapid population growth, farmers overplanted, and herd size increased beyond the capacity of the land to support the animals. Animals overgrazed the limited vegetation and clustered at scarce water sources.

Government policies have aggravated the food-shortage crisis. To make food affordable for urban residents, governments keep agricultural prices low. Constrained by price controls, farmers are unable to sell their commodities at a profit and therefore have little incentive to increase production.



▲ FIGURE 10-46 POPULATION AND FOOD IN AFRICA Food production is increasing at about the same rate as population in Africa. As a result, food production per capita is staying about the same.

## DRUG CROPS

### Learning Outcome 10.4.2

Understand distinctive challenges for developing countries to increase food supply.

The export crops grown in some developing countries, especially in Latin America and Asia, are those that can be converted to drugs. Cocaine and heroin, the two leading, especially dangerous drugs, are abused by 16 to 17 million people each, and marijuana, the most popular drug, is estimated to be used by 140 million worldwide:

- Cocaine is derived from coca leaf, most of which is grown in Colombia or the neighboring countries Peru and Bolivia. Most consumers are located in developed countries, especially in North America. The principal shipping route is from Colombia by sea to Mexico or other Central American countries and then by land through Mexico to the United States (Figure 10-47).
- Heroin is derived from raw opium gum, which is produced by the opium poppy plant. Afghanistan is the source of nearly 90 percent of the world's opium; most of the remainder is grown in Myanmar (Burma) and Laos. Most traffic flows from Afghanistan through Iran, Turkey, and the Balkans to Western Europe, where the largest numbers of the world's users live. A second route goes through Central Asia to Russia (Figure 10-48).
- Marijuana, produced from the *Cannabis sativa* plant, is cultivated widely around the world. The overwhelming majority of the marijuana that reaches the United States is grown in Mexico. Cultivation of *C. sativa* is not thought to be expanding worldwide, whereas cultivation of opium poppies and coca leaf are.

### Pause and Reflect 10.4.2

Why does most consumption of cocaine and heroin occur in developed countries?



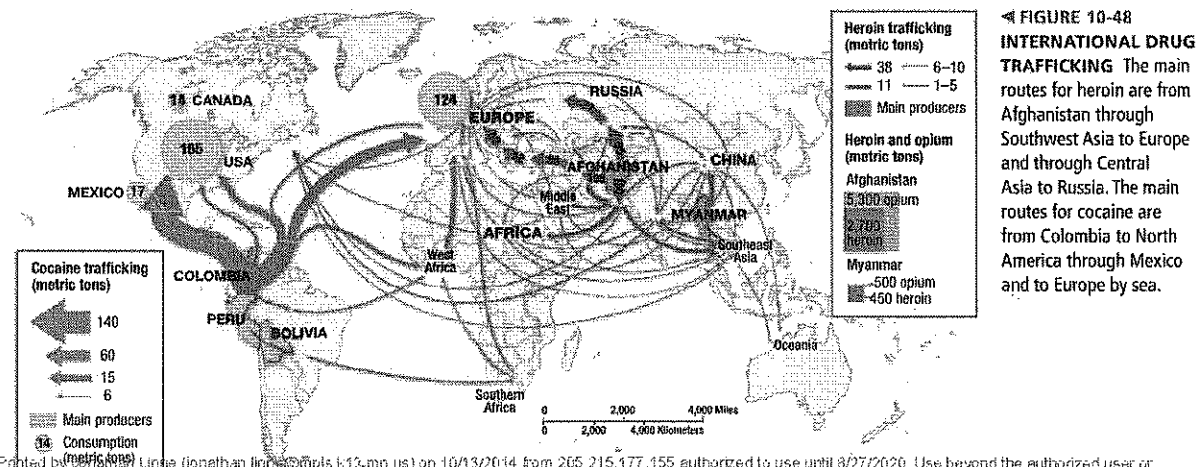
▲ FIGURE 10-47 POPPY FIELD Afghanistan is the leading producer of poppies, which are cultivated for opium production.

## FOOD PRICES

The greatest challenge to world food supply in the twenty-first century has been food prices rather than food supply. Food prices more than doubled between 2006 and 2008, and they have remained at record high levels since then (Figure 10-49). The UN attributes the record high food prices to four factors:

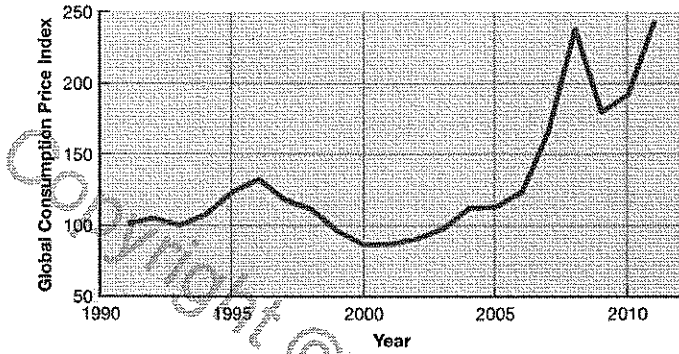
- Poor weather, especially in major crop-growing regions of the South Pacific and North America
- Higher demand, especially in China and India
- Smaller growth in productivity, especially without major new “miracle” breakthroughs
- Use of crops as biofuels instead of food, especially in Latin America

On the other side of the coin, record high food prices have stimulated record high prices for prime agricultural land. Adjusting for inflation, the price of farmland in Iowa doubled from around \$2,500 per acre in 2000 to \$5,000 in 2010.



◀ FIGURE 10-48 INTERNATIONAL DRUG TRAFFICKING The main routes for heroin are from Afghanistan through Southwest Asia to Europe and through Central Asia to Russia. The main routes for cocaine are from Colombia to North America through Mexico and to Europe by sea.

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▲ FIGURE 10-49 FOOD PRICE INDEX Worldwide food prices rose rapidly between 2006 and 2008 and have remained high since then.

## SUSTAINABILITY AND INEQUALITY IN OUR GLOBAL VILLAGE

### Asian Carp and Chicago's Economy

The growth of aquaculture has led to the farming of nonnative species. One example is the Asian carp, which were imported to the United States in the 1970s to stock a fish farm in Arkansas. Flooding allowed the carp to escape the farm and enter U.S. waterways. Fast-growing and voracious eaters, Asian carp can grow to over 45 kilograms (100 pounds) (Figure 10-50). Once in the waterways, the extremely aggressive Asian carp have competed successfully with native fish for food and habitat, and they have even attacked people fishing in small boats. Asian carp have traveled up the Mississippi and Illinois rivers, and they now constitute 97 percent of the fish in these rivers. Now the Asian carp threaten to reach the Great Lakes.

The most likely point of entry into the Great Lakes for the Asian carp is through Chicago-area waterways. To connect Lake Michigan and the rest of the Great Lakes with the inland waterways of the United States, canals were constructed during the

nineteenth century. The U.S. Army Corps of Engineers has installed electric barriers to try to keep the Asian carp from traveling through the canals to Lake Michigan. However, in the long run, the only effective way to keep the carp out of the Great Lakes is to shut the canals. However, the canals play a major role in the economy of the Chicago area and the

United States as a whole. Barges carry petroleum, coal, and other important raw materials from domestic and international sources to factories. Shutting the canals could devastate the region's economy; estimates of the impact on Chicago's economy range from \$70 million to \$235 million per year.



▲ FIGURE 10-50 ASIAN CARP Asian carp are in the Illinois River and threaten to reach the Great Lakes through Chicago-area canals.

## Challenges for Farmers in Developed Countries

### Learning Outcome 10.4.3

Explain the impact of overproduction and market access on farming in developed countries.

Commercial farmers in developed countries are in some ways victims of their own success. Having figured out how to produce large quantities of food, they face low prices for their output. Government subsidies help prop up farm income, but many believe that the future health of commercial farming depends on embracing more sustainable practices.

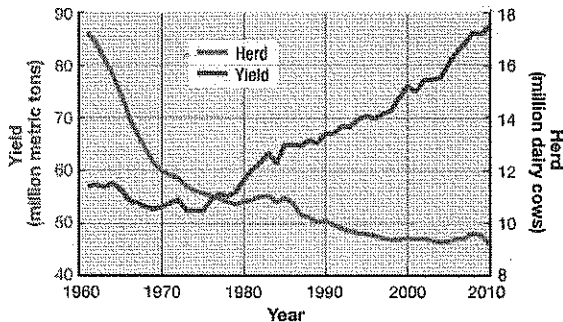
### OVERPRODUCTION IN COMMERCIAL FARMING

Commercial farmers suffer from low incomes because they are capable of producing much more food than is demanded by consumers in developed countries. A surplus of food can be produced because of widespread adoption of efficient agricultural practices. New seeds, fertilizers, pesticides, mechanical equipment, and management practices have enabled farmers to obtain greatly increased yields per area of land.

The experience of dairy farming in the United States demonstrates the growth in productivity. The number of dairy cows in the United States decreased from 10.8 million to 9.1 million between 1980 and 2010. But milk production increased from 58 to 87 million metric tons. Thus, yield per cow increased 78 percent during this 30-year period, from 5.37 to 9.56 metric tons per cow (Figure 10-51).

Although the food supply has increased in developed countries, demand has remained constant because the market for most products is already saturated. In developed countries, consumption of a particular commodity may not change significantly if the price changes. Americans, for example, do not switch from Wheaties to Corn

▼ FIGURE 10-51 U.S. DAIRY PRODUCTIVITY The amount of milk produced per cow has increased rapidly in the United States, especially since the 1980s.



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Flakes if the price of corn falls more rapidly than does the price of wheat. Demand is also stagnant for most agricultural products in developed countries because of low population growth.

The U.S. government has three policies that are supposed to address the problem of excess productive capacity:

- Farmers are encouraged to avoid producing crops that are in excess supply. Because soil erosion is a constant threat, the government encourages planting fallow crops, such as clover, to restore nutrients to the soil and to help hold the soil in place. These crops can be used for hay or forage for pigs, or to produce seeds for sale.
- The government pays farmers when certain commodity prices are low. The government sets a target price for a commodity and pays farmers the difference between the price they receive in the market and the target price set by the government as a fair level for the commodity. The target prices are calculated to give farmers the same price for the commodity today as in the past, when compared to other consumer goods and services.
- The government buys surplus production and sells or donates it to foreign governments. In addition, low-income Americans receive food stamps in part to stimulate their purchase of additional food.

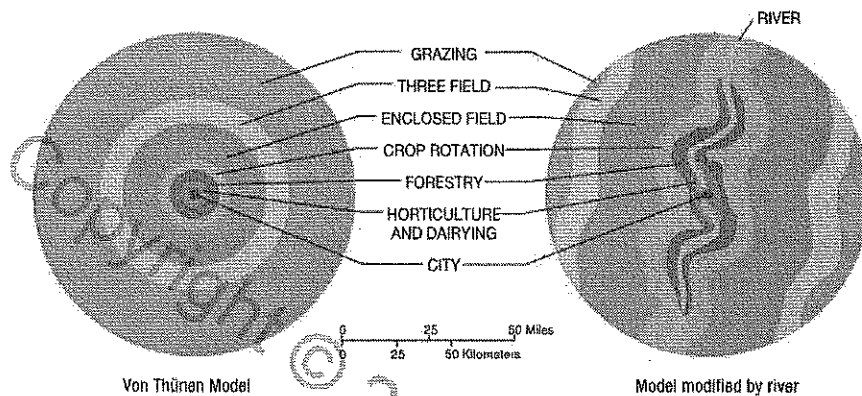
The United States has averaged about \$20 billion a year on farm subsidies in recent years. Annual spending varies considerably from one year to the next. Subsidy payments are lower in years when market prices rise and production is down, typically as a result of poor weather conditions in the United States or political problems in other countries. Farming in Europe is subsidized even more than in the United States. More farmers receive subsidies in Europe, and they receive more than American farmers. The high subsidies are a legacy of a long-standing commitment by the European Union to maintain agriculture in its member states, especially in France. Supporters point to the preservation of rural village life in parts of Europe, while critics charge that Europeans pay needlessly high prices for food as a result of the subsidies.

Government policies in developed countries point out a fundamental irony in worldwide agricultural patterns: In developed regions such as North America and Europe, farmers are encouraged to grow less food, whereas developing countries struggle to increase food production to match the rate of growth in the population.

### IMPORTANCE OF ACCESS TO MARKETS

Because the purpose of commercial farming is to sell produce off the farm, the distance from the farm to the market influences the farmer's choice of crop to plant. Geographers use the von Thünen model to help explain the importance of proximity to market in the choice of crops on commercial farms.

Johann Heinrich von Thünen, an estate owner in northern Germany, first proposed the model in 1826, in



▲ FIGURE 10-52 **VON THÜNEN MODEL** (left) According to the von Thünen model, in the absence of topographic factors, different types of farming are conducted at different distances from a city, depending on the cost of transportation and the value of the product. (right) von Thünen recognized that his model would be modified by site factors, such as a river, in this sketch, which changes the accessibility of different land parcels to the market center. Agricultural uses that seek highly accessible locations need to locate nearer the river.

a book titled *The Isolated State* (Figure 10-52). According to this model, which geographers later modified, a commercial farmer initially considers which crops to cultivate and which animals to raise based on market location. In choosing an enterprise, the farmer compares two costs: the cost of the land and the cost of transporting products to market.

Von Thünen based his general model of the spatial arrangement of different crops on his experience as the owner of a large estate in northern Germany during the early nineteenth century. He found that specific crops were grown in different rings around the cities in the area:

- **First ring.** Market-oriented gardens and milk producers were located in the first ring out from the cities. These products are expensive to deliver and must reach the market quickly because they are perishable.
- **Second ring.** The next ring out from the cities contained wood lots, where timber was cut for construction and fuel; closeness to market is important for this commodity because of its weight.
- **Third ring.** The next ring was used for various crops and for pasture; the specific commodity was rotated from one year to the next.
- **Fourth ring.** The outermost ring was devoted exclusively to animal grazing, which requires lots of space.

The model assumed that all land in a study area had similar site characteristics and was of uniform quality, although von Thünen recognized that the model could vary according to topography and other distinctive physical conditions. For example, a river might modify the shape of

the rings because transportation costs change when products are shipped by water routes rather than over roads. The model also failed to consider that social customs and government policies influence the attractiveness of plants and animals for a commercial farmer.

Although von Thünen developed the model for a small region with a single market center, the model is also applicable on a national or global scale. Farmers in relatively remote locations who wish to sell their output in

the major markets of Western Europe and North America, for example, are less likely to grow highly perishable and bulky products.

The following example illustrates the influence of transportation cost on the profitability of growing wheat:

- Gross profit from sale of wheat grown on 1 hectare of land not including transportation costs:
  - a. Wheat can be sold for \$250 per metric ton.
  - b. Yield per hectare of wheat is 4 tons.
  - c. Gross profit is \$1,000 per hectare (\$250 per ton  $\times$  4 tons).
- Net profit from sale of wheat grown on 1 hectare of land *including* transportation costs:
  - a. Cost of transporting 4 tons of wheat to market is \$0.10 per kilometer.
  - b. Net profit from the sale of 4 tons of wheat grown on a farm located 1,000 kilometers from the market is \$900 (\$1,000 gross profit – \$100 for 1,000 kilometers of transport costs).
  - c. Net profit from sale of 1,000 kilograms of wheat grown on a farm located 10,000 kilometers from the market is \$0 (\$1,000 gross profit – \$1,000 for 10,000 kilometers of transport costs).

This example shows that a farmer would make a profit by growing wheat on land located less than 10,000 kilometers from the market. Beyond 10,000 kilometers, wheat is not profitable because the cost of transporting it exceeds the gross profit. These calculations demonstrate that farms located closer to market tend to select crops with higher transportation costs per hectare of output, whereas more distant farms are more likely to select crops that can be transported less expensively.

#### Pause and Reflect 10.4.3

If the price of wheat dropped to \$200 per ton, what would be the maximum distance that the wheat could be profitably shipped?



## Strategies to Increase the World's Food Supply

### Learning Outcome 10.4.4

Explain the contribution of expanding exports and farmland to world food supply.

Whereas developed countries often produce more food than they need, many developing countries struggle to produce enough to feed their rapidly growing populations. Four strategies are being employed to distribute food to everyone in the world:

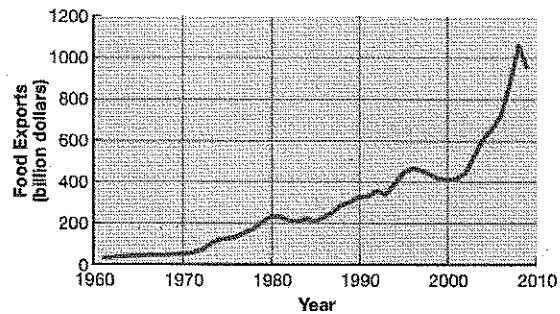
- Increasing exports from countries with surpluses
- Expanding the land area used for agriculture
- Expanding fishing
- Increasing the productivity of land now used for agriculture

Challenges underlie each of these strategies.

### INCREASING EXPORTS FROM COUNTRIES WITH SURPLUSES

Trade in food has increased rapidly, especially since 2000, exceeding \$1 billion for the first time in 2008 (Figure 10-53). On a global scale, agricultural products are moving primarily from the Western Hemisphere to the Eastern Hemisphere. Latin America, led by Brazil and Argentina, is the by far the leading region for export of agricultural products; North America, Southeast Asia, and the South Pacific are the other major exporting regions (Figure 10-54).

Prior to the 1980s, the only major food importing regions were Europe, East Asia, and the former Soviet Union. Historically, European countries used their colonies as suppliers of food; after they became independent countries, the former colonies sold food to Europe. Joining East

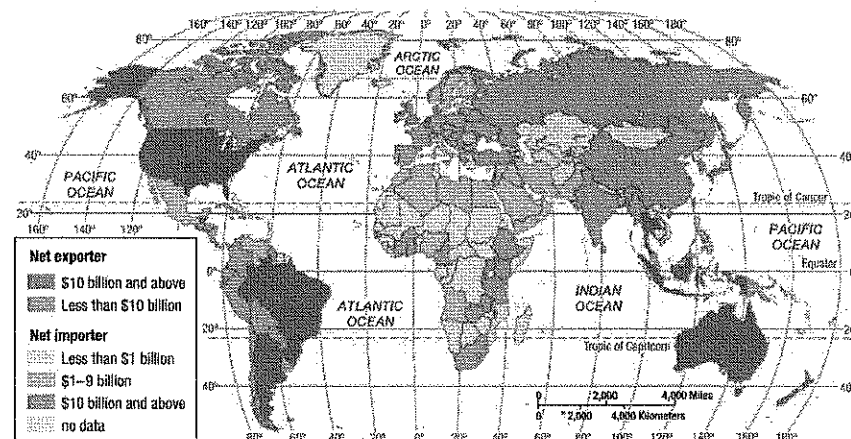


▲ FIGURE 10-53 GROWTH IN AGRICULTURAL EXPORTS Agricultural trade increased from \$400 billion in 2000 to \$1 trillion in 2010.

Asia as net food importers were Southwest Asia and North Africa during the 1970s, South Asia and sub-Saharan Africa during the 1980s, and Central Asia in 2008. Food production was unable to keep up with rapid population growth in these regions, and as they embraced the international trade path of development, agriculture was increasingly devoted to growing export crops for sale in developed countries. Japan is by far the leading importer of food, followed by the United Kingdom, China, and Russia.

In response to the increasing global demand for food imports, the United States passed Public Law 480, the Agricultural Trade and Assistance Act of 1954 (referred to as P.L.-480). Title I of the act provided for the sale of grain at low interest rates, and Title II gave grants to needy groups of people. The United States remains the world's leading exporter of grain, including nearly one-half of the world's maize exports. But the overall share of exports accounted for by the United States has declined rapidly, from 18 to 19 percent of the world total in the 1970s to 10 to 11 percent in the twenty-first century. Agricultural exports from the United States have continued to increase rapidly, but developing regions—especially Latin America and Southeast Asia—have had more rapid increases.

▼ FIGURE 10-54 TRADE IN AGRICULTURAL PRODUCTS The principal flow of agriculture in the world is from the Western Hemisphere to Europe and Asia.



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### EXPANDING AGRICULTURAL LAND

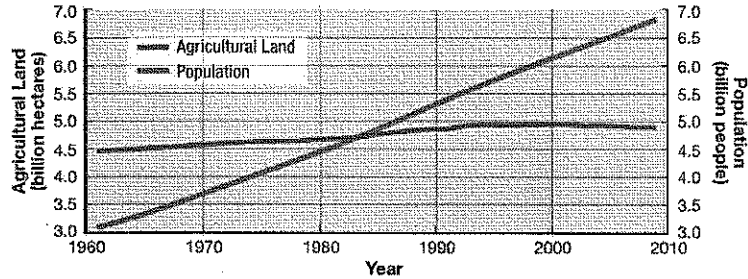
Historically, world food production has increased primarily by expanding the amount of land devoted to agriculture. When the world's population began to increase more rapidly in the late eighteenth and early nineteenth centuries, during the Industrial Revolution, pioneers could migrate to uninhabited territory and cultivate the land. Sparsely inhabited land suitable for agriculture was available in western North America, central Russia, and Argentina's

pampas.

Two centuries ago, people believed that good agricultural land would always be available for willing pioneers. Today few scientists believe that further expansion of agricultural land can feed the growing world population. At first glance, new agricultural land appears to be available because only 11 percent of the world's land area is currently cultivated. However, in recent decades, population has increased much more rapidly than agricultural land (Figure 10-55).

In some regions, farmland is abandoned for lack of water. Especially in semiarid regions, human actions are causing land to deteriorate to a desertlike condition, a process called **desertification** (or, more precisely, semiarid land degradation). Semiarid lands that can support only a handful of pastoral nomads are overused because of rapid population growth. Excessive crop planting, animal grazing, and tree cutting exhaust the soil's nutrients and preclude agriculture. The Earth Policy Institute estimates that 2 billion hectares (5 million acres) of land have been degraded around the world (Figure 10-56). Overgrazing is thought to be responsible for 34 percent of the total, deforestation for 30 percent, and agricultural use for 28 percent. The UN estimates that desertification removes 27 million hectares (70 million acres) of land from agricultural production each year, an area roughly equivalent to Colorado.

Excessive water threatens other agricultural areas, especially drier lands that receive water from human-built irrigation systems. If the irrigated land has inadequate drainage, the underground water level rises to the point where roots become waterlogged. The UN estimates that 10 percent of all irrigated land is waterlogged, mostly in Asia and South America. If the water is salty, it can damage plants. The ancient civilization of Mesopotamia may have collapsed in part because of waterlogging and excessive salinity in its agricultural lands near the Tigris and Euphrates rivers.

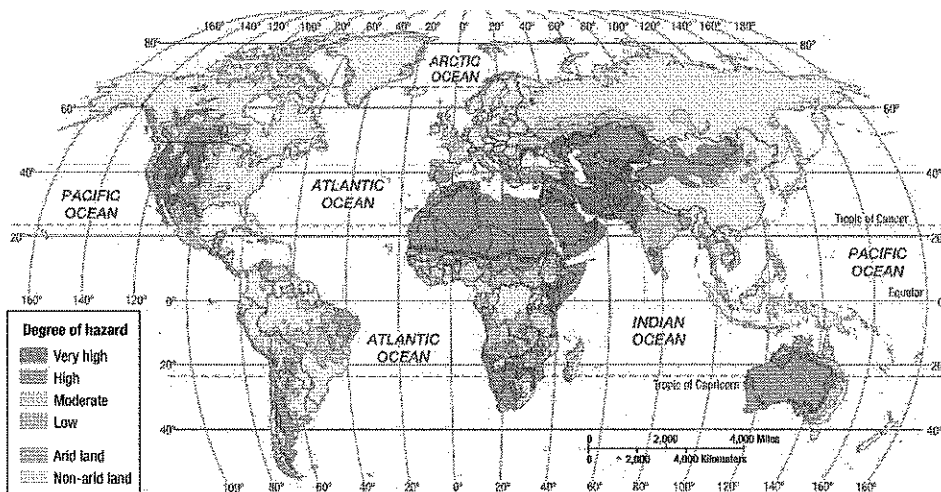


▲ FIGURE 10-55 AGRICULTURAL LAND AND POPULATION GROWTH Land devoted to agriculture has remained virtually unchanged since 1990, whereas population has increased by more than 50 percent.

Urbanization can also contribute to reducing agricultural land. As urban areas grow in population and land area, farms on the periphery are replaced by homes, roads, shops, and other urban land uses. In North America, farms outside urban areas are left idle until the speculators who own them can sell them at a profit to builders and developers, who convert the land to urban uses. A serious problem in the United States has been the loss of 200,000 hectares (500,000 acres) of the most productive farmland, known as **prime agricultural land**, as urban areas sprawl into the surrounding countryside (see the Contemporary Geographic Tools feature).

Pause and Reflect 10.4.4

By Itself, GIS can't rank the relative importance of the various factors in protecting farmland. Policymakers and the public must make these value judgments. Do you think that prime soils, significant environmental features, and high population growth should be valued the same or differently in deciding which farmland to protect?



◀ FIGURE 10-56 DESERTIFICATION (SEMIARID LAND DEGRADATION) The most severe problems are in northern Africa, central Australia, and the southwestern parts of Africa, Asia, North America, and South America.

## EXPANDING FISHING

### Learning Outcome 10.4.5

Describe the contribution of fishing to world food supply.

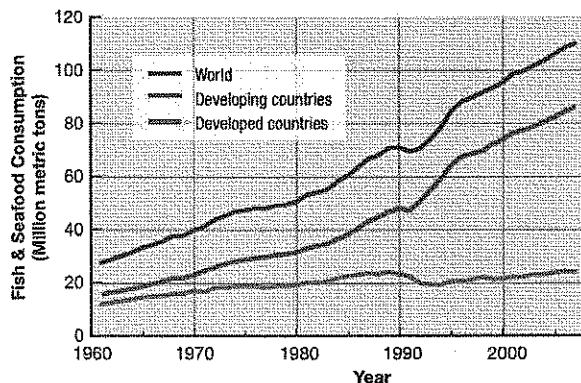
A third alternative for increasing the world's food supply is to expand fishing. The agriculture discussed thus far in this chapter is land based. At first glance, increased use of food from the sea is attractive. Oceans are vast, covering nearly three-fourths of Earth's surface and lying near most population concentrations. Historically the sea has provided only a small percentage of the world food supply.

Food acquired from Earth's waters includes fish, crustaceans (such as shrimp and crabs), mollusks (such as clams and oysters), and aquatic plants (such as watercress). Water-based food is acquired in two ways:

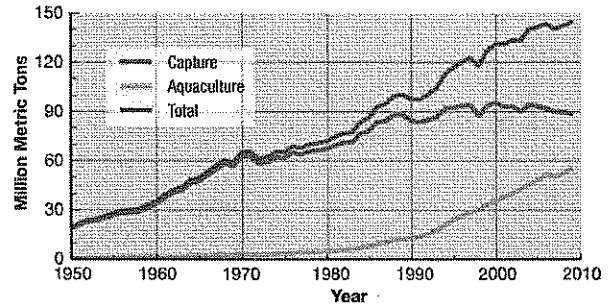
- Fishing, which is the capture of wild fish and other seafood living in the waters.
- Aquaculture, or aquafarming, which is the cultivation of seafood under controlled conditions. (See the Sustainability and Inequality in Our Global Village feature.)

**FISH CONSUMPTION.** Human consumption of fish and seafood has increased from 27 million metric tons in 1960 to 110 million metric tons in 2010 (Figure 10-57). Developing countries are responsible for five-sixths of the increase. Fish consumption has increased more rapidly than population growth. During the past half-century, per capita consumption of fish has nearly doubled in both developed and developing countries, from 17 kcal per person per day in 1960 to 30 kcal per person per day in 2010. Still, fish and seafood account for only 1 percent of all calories consumed by humans (refer to Figure 10-13).

▼ FIGURE 10-57 GROWTH IN HUMAN CONSUMPTION OF FISH Human consumption of fish has increased in both developed and developing regions.



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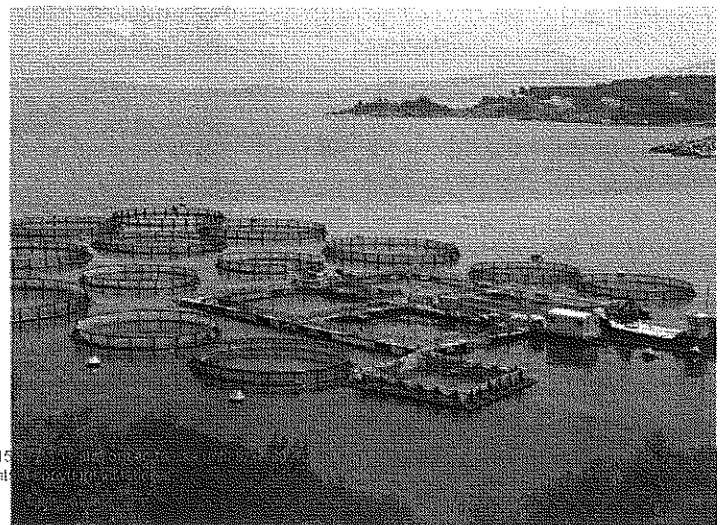


▲ FIGURE 10-58 GROWTH IN FISH PRODUCTION Increased fish production has come primarily from aquaculture rather than wild capture of fish.

**FISH PRODUCTION.** During the past half-century, global fish production has increased from approximately 36 to 145 million metric tons (Figure 10-58). The growth results entirely from expansion of aquaculture (Figure 10-59). The capture of wild fish in the oceans and lakes has stagnated since the 1990s, despite population growth and increased demand to consume fish. The reason that production is higher than human consumption is that a large portion of the fish that is caught is converted to fish meal and fed to poultry and hogs. Only two-thirds of the fish caught from the ocean is consumed directly by humans.

The world's oceans are divided into 18 major fishing regions, including seven each in the Atlantic and Pacific oceans, three in the Indian Ocean, and the Mediterranean (Figure 10-60). Fishing is also conducted in inland waterways, such as lakes and rivers. The areas with the largest yields are the Pacific Northwest and Asia's inland waterways. China is responsible for one-third of the world's yield of fish (Figure 10-61). The other leading countries are naturally those with extensive ocean boundaries, such as Chile, Indonesia, and Peru.

▼ FIGURE 10-59 AQUACULTURE Fish are raised inside the containers at this fish farm in Corfu, Greece.



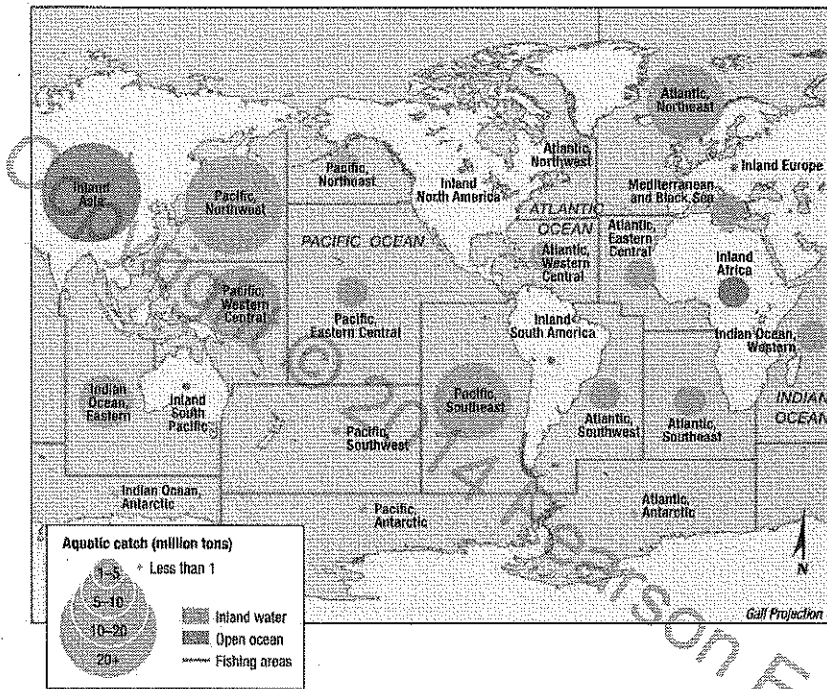


FIGURE 10-60 MAJOR FISHING REGIONS  
The largest yields are in the Pacific and Asia.

**OVERFISHING.** Hope grew during the mid-twentieth century that increased fish consumption could meet the needs of a rapidly growing global population. However, the population of some fish species declined because they were harvested faster than they could reproduce. Overfishing has been particularly acute in the North Atlantic and Pacific oceans. Because of overfishing, the population of large predatory fish, such as tuna and swordfish, has declined by 90 percent in the past half-century. The UN estimates that one-quarter of fish stocks

have been overfished and one-half fully exploited, leaving only one-fourth underfished. Consequently, the total world fish catch has remained relatively constant since the 1980s, despite population growth.

**Pause and Reflect 10.4.5**

Should Chicago's canals be shut to protect the Great Lakes from Asian carp? Why or why not?

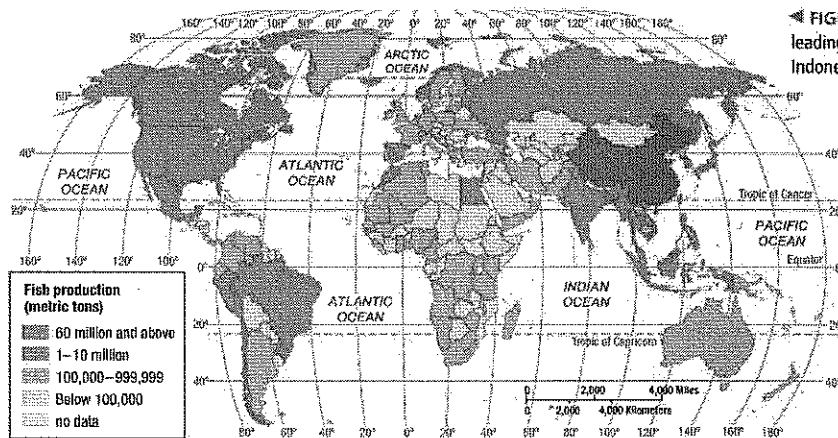


FIGURE 10-61 FISH PRODUCTION China is the leading fishing country, followed by Chile, Peru, and Indonesia.

## INCREASING PRODUCTIVITY

### Learning Outcome 10.4.6

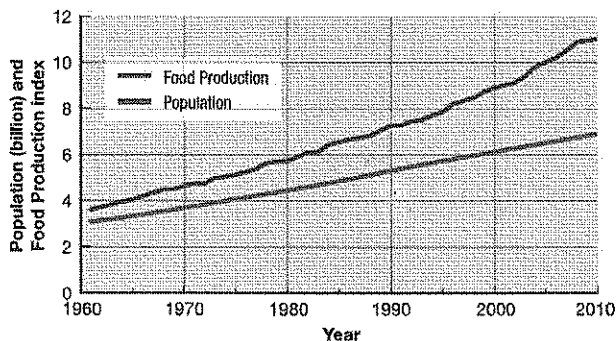
Describe the contribution of higher productivity to world food supply.

Population grew at the fastest rate in human history during the second half of the twentieth century, as discussed in Chapter 2. Many experts forecast massive global famine, but these dire predictions did not come true. Instead, new agricultural practices have permitted farmers worldwide to achieve much greater yields from the same amount of land. Worldwide, obtaining more food from the same amount of land has been the leading source of increasing the food supply.

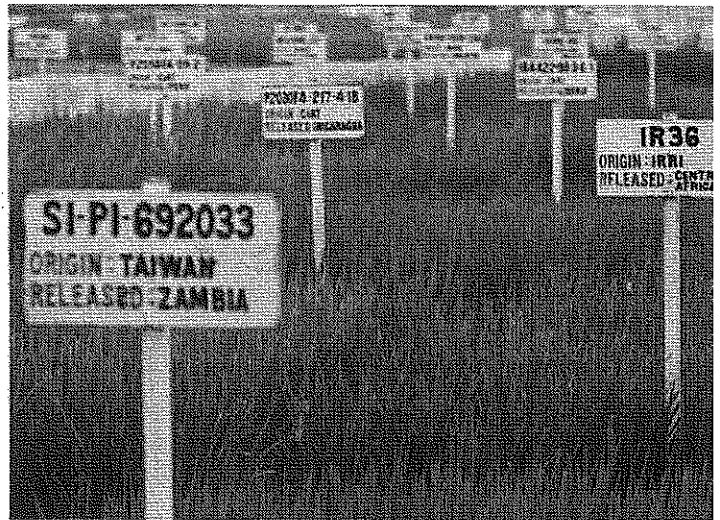
**THE GREEN REVOLUTION.** The invention and rapid diffusion of more productive agricultural techniques during the 1970s and 1980s is called the **green revolution**. The green revolution involves two main practices: the introduction of new higher-yield seeds and the expanded use of fertilizers. Because of the green revolution, agricultural productivity at a global scale has increased faster than population growth (Figure 10-62).

Scientists began an intensive series of experiments during the 1950s to develop a higher-yield form of wheat. A decade later, the “miracle wheat seed” was ready. Shorter and stiffer than traditional breeds, the new wheat was less sensitive to variation in day length, responded better to fertilizers, and matured faster. The Rockefeller and Ford foundations sponsored many of the studies, and the program’s director, Dr. Norman Borlaug, won the Nobel Peace Prize in 1970. The International Rice Research Institute, established in the Philippines by the Rockefeller and Ford foundations, worked to create a miracle rice seed (Figure 10-63). During the 1960s, their scientists introduced a hybrid of Indonesian rice and Taiwan dwarf rice that was hardier and that increased yields. More recently, scientists have developed new high-yield maize (corn).

▼ FIGURE 10-62 POPULATION AND FOOD PRODUCTION World population has increased less rapidly than food production.



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▲ FIGURE 10-63 INTERNATIONAL RICE RESEARCH INSTITUTE, HOME OF THE GREEN REVOLUTION “Miracle” high-yield seeds have been produced through laboratory experiments at the International Rice Research Institute (IRRI). The IRRI is testing rice varieties in the Philippines.

The new miracle seeds were diffused rapidly around the world. India’s wheat production, for example, more than doubled in five years. After importing 10 million tons of wheat annually in the mid-1960s, India had a surplus of several million tons by 1971. Other Asian and Latin American countries recorded similar productivity increases. The green revolution was largely responsible for preventing a food crisis in these regions during the 1970s and 1980s. But will these scientific breakthroughs continue in the twenty-first century?

To take full advantage of the new miracle seeds, farmers must use more fertilizer and machinery. Farmers have known for thousands of years that application of manure, bones, and ashes somehow increases, or at least maintains, the fertility of the land. Not until the nineteenth century did scientists identify nitrogen, phosphorus, and potassium (potash) as the critical elements in these substances that improve fertility. Today these three elements form the basis for fertilizers—products that farmers apply to their fields to enrich the soil by restoring lost nutrients.

Nitrogen, the most important fertilizer, is a ubiquitous substance. China is the leading producer of nitrogen fertilizer. Europeans most commonly produce a fertilizer known as urea, which contains 46 percent nitrogen. In North America, nitrogen is available as ammonia gas, which is 82 percent nitrogen but more awkward than urea to transport and store. Both urea and ammonia gas combine nitrogen and hydrogen. The problem is that the cheapest way to produce both types of nitrogen-based fertilizers is to obtain hydrogen from natural gas or petroleum. As fossil fuel prices increase, so do the prices for nitrogen-based fertilizers, which then become too expensive for many farmers in developing countries. In contrast to nitrogen, phosphorus and potash reserves are not distributed uniformly across Earth’s surface. Phosphate rock reserves are clustered in China, Morocco, and the United States. Proven potash reserves are concentrated in Canada, Russia, and Ukraine.

Farmers need tractors, irrigation pumps, and other machinery to make the most effective use of the new miracle seeds. In developing countries, farmers cannot afford such equipment and cannot, in view of high energy costs, buy fuel to operate the equipment. To maintain the green revolution, governments in developing countries must allocate scarce funds to subsidize the cost of seeds, fertilizers, and machinery.

**GENETICALLY MODIFIED FOODS.** Farmers have been manipulating crops and livestock for thousands of years. The very nature of agriculture is to deliberately manipulate nature. Humans control selective reproduction of plants and animals in order to produce a larger number of stronger, hardier survivors. Beginning in the nineteenth century, the science of genetics expanded understanding of how to manipulate plants and animals to secure dominance of the most favorable traits. However, genetic modification (GM), which became widespread in the late twentieth century, marks a sharp break with the agricultural practices of the past several thousand years. Under GM, the genetic composition of an organism is not merely studied, it is actually altered; GM involves mixing genetic material of two or more species that would not otherwise mix in nature.

Worldwide, 160 million hectares—10 percent of all farmland—were devoted to genetically modified crops in 2010; 77 percent of the world's soybeans, 49 percent of cotton, and 26 percent of maize were genetically modified in 2010. GM is especially widespread in the United States: 94 percent of soybeans, 90 percent of cotton, and 88 percent of maize; usage increased rapidly during the first decade of the twenty-first century (Figure 10-64). Three-fourths of the processed food that Americans consume has at least one GM ingredient. North America was responsible for one-half of the world's genetically modified foods, and developing countries—especially in Latin America—were responsible for the other one-half.

The United States has urged sub-Saharan African countries to increase their food supply in part through increased use of GM of crops and livestock. Africans are divided on whether to accept genetically modified organisms. The

positives of GM are higher yields, increased nutrition, and more resistance to pests. Genetically modified foods are also better tasting, at least to some palates. Despite these benefits, opposition to GM is strong in Africa for several reasons:

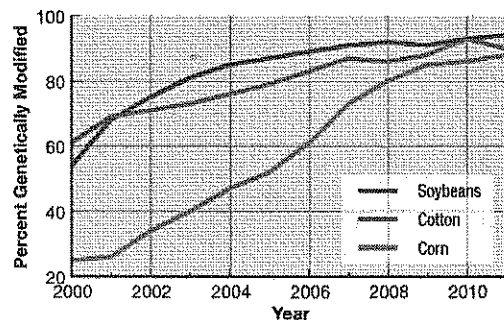
- **Health problems.** Consuming large quantities of genetically modified foods may reduce the effectiveness of antibiotics and could destroy long-standing ecological balances in local agriculture.
- **Export problems.** European countries, the main markets for Africa's agricultural exports, require genetically modified foods to be labeled. Europeans are especially strongly opposed to GM because they believe genetically modified food is not as nutritious as food from traditionally bred crops and livestock. Because European consumers shun genetically modified food, African farmers fear that if they are no longer able to certify their exports as being not genetically modified, European customers will stop buying them (Figure 10-65).
- **Increased dependence on the United States.** U.S.-based transnational corporations, such as Monsanto, manufacture most of the GM seeds. Africans fear that the biotech companies could—and would—introduce a so-called "terminator" gene in the GM seeds to prevent farmers from replanting them after harvest and require them to continue to purchase seeds year after year from the transnational corporations.

"We don't want to create a habit of using genetically modified maize that the country cannot maintain," explained Mozambique's prime minister. If agriculture is regarded as a way of life, not just a food production business, GM represents for many Africans an unhealthy level of dependency on developed countries.

**Pause and Reflect 10.4.6**

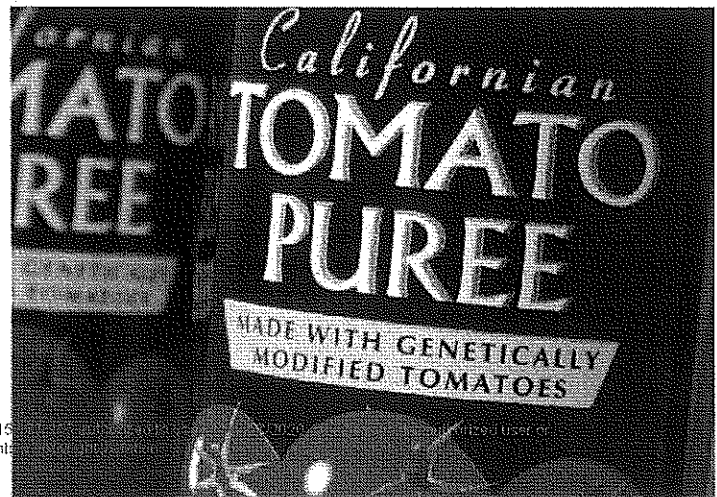
What are the benefits and drawbacks for sub-Saharan Africa to plant more genetically modified crops?

▼ **FIGURE 10-64 GENETICALLY MODIFIED CROPS IN THE UNITED STATES** Approximately 90 percent of major crops in the United States are genetically modified.



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▼ **FIGURE 10-65 GENETICALLY MODIFIED FOOD** Genetically modified food is widespread in the United States but shunned by most consumers in Europe.



## Sustainable Agriculture

### Learning Outcome 10.4.7

Describe the role of sustainable agriculture in world food supply.

Some commercial farmers are converting their operations to **sustainable agriculture**, agricultural practices that preserve and enhance environmental quality. Farmers practicing sustainable agriculture typically generate lower revenues than do conventional farmers, but they also have lower costs.

An increasingly popular form of sustainable agriculture is organic farming. Worldwide, the UN classified 37 million hectares (75 million acres), or 0.6 percent of farmland, as organic in 2009. Australia was the leader, with 12 million of the hectares, or 32 percent of the worldwide total (Figure 10-66). Argentina accounted for 12 percent of the worldwide total, and the United States, China, and Brazil for 5 percent each. Three principal practices distinguish sustainable agriculture (and, at its best, organic farming) from conventional agriculture:

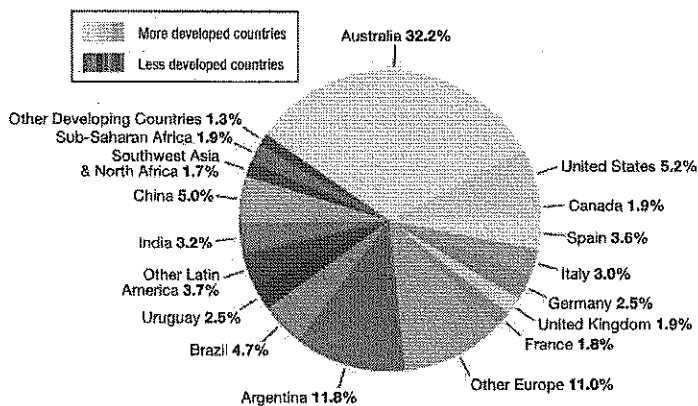
- Sensitive land management
- Limited use of chemicals
- Better integration of crops and livestock

### SENSITIVE LAND MANAGEMENT

Sustainable agriculture protects soil in part through **ridge tillage**, which is a system of planting crops on ridge tops. Crops are planted on 10- to 20-centimeter (4- to 8-inch) ridges that are formed during cultivation or after harvest. A crop is planted on the same ridges, in the same rows, year after year. Ridge tillage is attractive for two main reasons: lower production costs and greater soil conservation.

Production costs are lower with ridge tillage in part because it requires less investment in tractors and

▼ FIGURE 10-66 DISTRIBUTION OF ORGANIC FARMING Australia accounts for nearly one-third of the world's organic farming.



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other machinery than conventional planting. An area that would be prepared for planting under conventional farming with three to five tractors can be prepared for ridge tillage with only one or two tractors. The primary tillage tool is a row-crop cultivator that can form ridges. There is no need for a plow, or a field cultivator, or a 300-horsepower four-wheel-drive tractor. With ridge tillage, the space between rows needs to match the distance between wheels of the machinery. If 75 centimeters (30 inches) are left between rows, tractor tires will typically be on 150-centimeter (60-inch) centers and combine wheels on 300-centimeter (120-inch) centers. Wheel spacers are available from most manufacturers to fit the required spacing.

Ridge tillage features a minimum of soil disturbance from harvest to the next planting. A compaction-free zone is created under each ridge and in some row middles. Keeping the trafficked area separate from the crop-growing area improves soil properties. Over several years, the soil will tend to have increased organic matter, greater water-holding capacity, and more earthworms. The channels left by earthworms and decaying roots enhance drainage.

Ridge tillage compares favorably with conventional farming for yields while lowering the cost of production. Although more labor intensive than other systems, it is profitable on a per-acre basis. In Iowa, for example, ridge tillage has gained favor for production of organic and herbicide-free soybeans, which sell for more than regular soybeans.

### LIMITED USE OF CHEMICALS

In conventional agriculture, seeds are often genetically modified to survive when herbicides and insecticides are sprayed on fields to kill weeds and insects. These are known as "Roundup Ready" seeds because their creator, Monsanto, sells its weed killers under the brand name Roundup. Roundup Ready seeds were planted in 90 percent of all soybean fields and 70 percent of all cotton and maize (corn) fields in the United States in 2010. In addition to the adverse impacts of herbicides on soil and water quality, widespread use of Roundup Ready seeds is causing some weeds to become resistant to herbicides.

Sustainable agriculture, on the other hand, involves application of limited if any herbicides to control weeds. In principle, farmers can control weeds without chemicals, although doing so requires additional time and expense that few farmers can afford. Researchers have found that combining mechanical weed control with some chemicals yields higher returns per acre than relying solely on one of the two methods.

Ridge tillage also promotes decreased use of chemicals, which can be applied only to the ridges and not the entire field. Combining herbicide banding—which applies chemicals in narrow bands over crop rows—with cultivating may be the best option for many farmers.

## INTEGRATED CROP AND LIVESTOCK

Mixed crop and livestock is a common form of farming in the United States, as discussed earlier in the chapter. But many farmers in the mixed crop and livestock region actually choose to only grow crops or raise more animals than the crops they grow can feed. They sell their crops off the farm or purchase feed for their animals from outside suppliers. Sustainable agriculture attempts to integrate the growing of crops and the raising of livestock as much as possible at the level of the individual farm. Animals consume crops grown on the farm and are not confined to small pens.

Integration of crops and livestock reflects a return to the historical practice of mixed crop and livestock farming, in which growing crops and raising animals were regarded as complementary activities on the farm. This was the common practice for centuries, until the mid-1900s, when technology, government policy, and economics encouraged farmers to become more specialized.

Sustainable agriculture is sensitive to the complexities of biological and economic interdependencies between crops and livestock:

- **Number of livestock.** The correct number, as well as the distribution, of livestock for an area is determined based on the landscape and forage sources. Prolonged concentration of livestock in a specific location can result in permanent loss of vegetative cover, so a farmer needs to move the animals to reduce overuse in some areas. Growing row crops on the more level land while confining pastures to steeper slopes will reduce soil erosion, so it may be necessary to tolerate some loss of vegetation in specific locations.
- **Animal confinement.** The moral and ethical debate over animal welfare is particularly intense regarding confined livestock production systems (Figure 10-67). Confining livestock leads to surface and ground water pollution, particularly where the density of animals is high. Expensive waste management facilities are a necessary cost of confined production systems. If animals are not confined, manure can contribute to soil fertility. However, quality of life in nearby communities may be adversely affected by the smell.
- **Management of extreme weather conditions.** Herd size may need to be reduced during periods of short- and long-term drought. On the other hand, livestock can buffer the negative impacts of low rainfall periods by consuming crops that in conventional farming would be left as failures. Especially in Mediterranean climates such as California's, properly managed grazing significantly reduces fire hazards by reducing fuel buildup in grasslands and brushlands.
- **Flexible feeding and marketing.** Flexibility in feeding livestock and sending livestock to market can help cushion farmers against trade and price fluctuations and, in conjunction with cropping operations, make more efficient use of farm labor. Feed costs are the largest single variable cost in any livestock operation. Most of the feed



FIGURE 10-67 (TOP) CONVENTIONAL VERSUS (BOTTOM) ORGANIC FARMING Chickens are not penned up in cages on an organic farm.

may come from other enterprises on a ranch, though some is usually purchased off the farm. Feed costs can be kept to a minimum by monitoring animal condition and performance and understanding seasonal variations in feed and forage quality on the farm.

### Pause and Reflect 10.4.7

Are you willing to pay more for food that is organically produced? Why or why not?

### CHECK-IN: KEY ISSUE 4

#### Why Do Farmers Face Economic Difficulties?

- ✓ Farmers in developing countries face challenges of meeting the needs of rapid population growth and growing food for export.
- ✓ Farmers in developed countries face challenges of overproduction and access to markets.
- ✓ Four strategies for increasing the world's food supplies include increasing exports, expanding agricultural land, expanding fishing, and increasing productivity of land.
- ✓ Sustainable agriculture involves sensitive land management, limited use of chemicals, and better integration of crops and livestock.