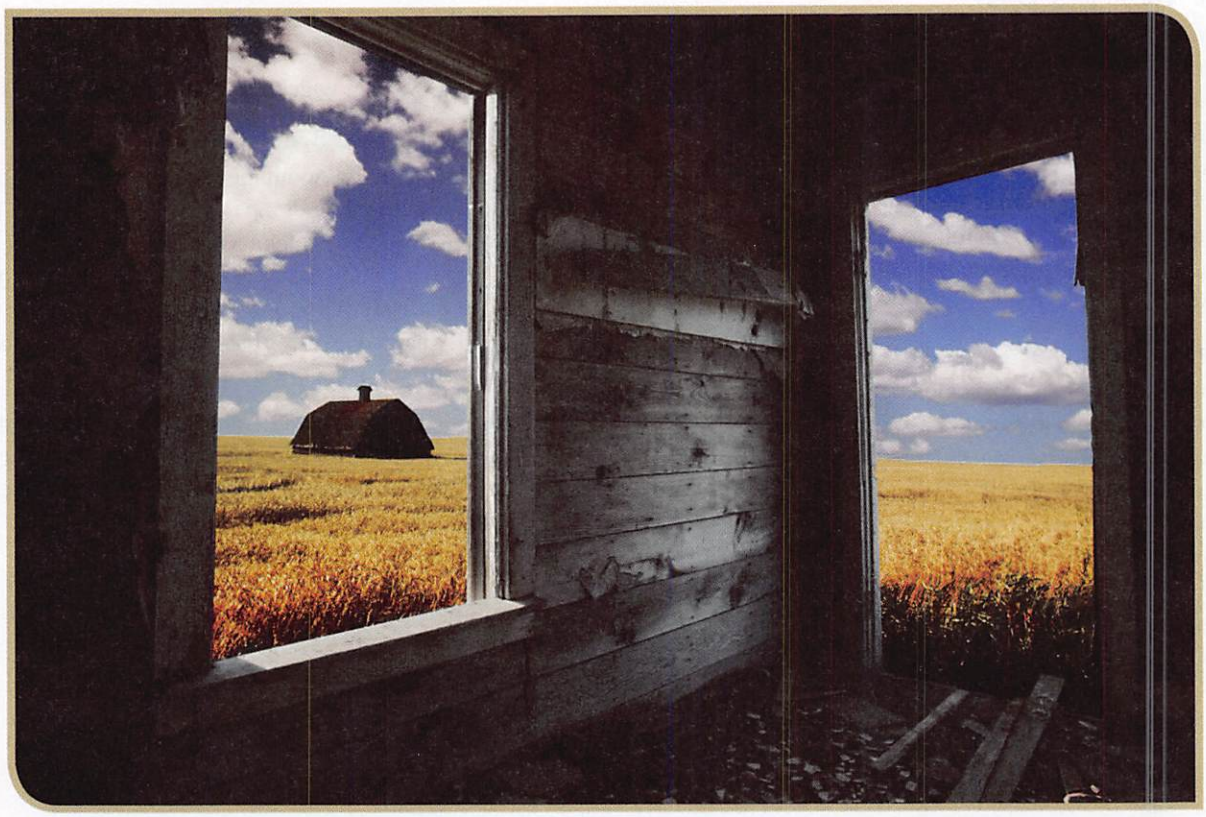
CHAPTER

8

ECONOMIC GEOGRAPHY:

Primary Activities



An abandoned farm house and barn among the vast wheat fields of the Great Plains.

AP Learning Objectives

- Explain the connection between physical geography and agricultural practices.
- Explain the consequences of the Green Revolution on food supply and the environment in the developing world.
- Explain how economic forces influence agricultural practices.
- Describe how the Von Thünen model is used to explain patterns of agricultural production at various scales.
- Explain the interdependence among regions of agricultural production and consumption.
- Explain how agricultural practices have environmental and societal consequences.
- Explain challenges and debates related to the changing nature of contemporary agriculture and food production practices.
- Explain geographic variations in female roles in food production and consumption.

The crop bloomed luxuriantly that summer of 1846. The disaster of the preceding year seemed over, and the potato, the sole sustenance of some 8 million Irish peasants, would again yield the bounty needed. Yet within a week, wrote Father Mathew, "I beheld one wide waste of putrefying vegetation. The wretched people were seated on the fences of their decaying gardens . . . bewailing bitterly the destruction that had left them foodless." Colonel Gore found that "every field was black," and Father O'Sullivan noted that "the fields . . . appeared blasted, withered, blackened, and . . . sprinkled with vitriol. . . ." The potato was irretrievably gone for a second year; famine and pestilence were inevitable.

Within five years, the settlement geography of the most densely populated country in Europe was forever altered. The United States, Canada, and Great Britain received 2 million Irish immigrants, who provided the cheap labor needed for the canals, railroads, and mines that they were creating in a rush to economic development. New patterns of commodity flows were initiated as American maize for the first time found an Anglo-Irish market—as part of Poor Relief—and then entered a wider European market, which had also suffered general crop failure in that bitter year. Within days, a microscopic organism, the cause of the potato blight, had altered the economic and human geography of two continents.

Although the Irish famine of the 1840s was a regional tragedy, it dramatically demonstrated the intricate interrelations among widely separated peoples and places. It demonstrated the fundamental importance of patterns of economic geography and subsistence. Chapters 8, 9, and 10 explore the dynamic economic innovations that are reworking the landscapes of human activities. Food and raw material production still dominate the economies in some parts of the world, but increasingly, people are engaged in activities that involve the processing of raw materials into finished products and the provision of personal, business, and professional services within an increasingly interconnected world economy. Changing patterns of subsistence, livelihood, exchange, and the pursuit of "development" are the focus of economic geography.

Simply stated, **economic geography** is the study of how people earn their living, how livelihood systems vary from place to place, and how economic activities are spatially interrelated and linked. It applies geography's general concern with spatial variation to the production, exchange, and consumption of goods and services. In reality, of course, we cannot comprehend the totality of the economic pursuits of 7 billion human beings. Instead, economic geographers seek consistencies. They develop generalizations to help understand complex patterns. Studying economic geography reveals the dynamic, interlocking diversity of human activities and the impact of economic activity on all other facets of human life and culture. It reveals the increasing interdependence of differing national and regional economic systems. The potato blight, although it struck one small island, ultimately affected the economies of continents. In like fashion, the exploitation of the natural resources of the United States, the *deindustrialization* of its economy, and the shift to postindustrial service and knowledge activities, are altering the relative wealth of countries, flows of international trade, domestic employment and income patterns, and more (**Figure 8.1**).

Figure 8.1 This oil tanker is part of a world of increasing economic interdependence. Oil is a global commodity, with its price set by global markets.

8.1 The Classification of Economic Activity and Economies

Understanding livelihood patterns is made more difficult by the complex environmental and cultural realities controlling the economic activities of humans. Many production patterns are rooted in the spatially variable circumstances of the *physical environment.* The staple crops of the humid tropics, for example, are not part of the agricultural systems of the midlatitudes; livestock types that thrive in American feedlots or on Western ranges are not adapted to the Arctic tundra or to the margins of the Saharan desert. The unequal distribution of useful petroleum and mineral deposits make some regions wealthy and others dependent. Forestry and fishing depend on still other natural resources that are unequal in occurrence, type, and value.

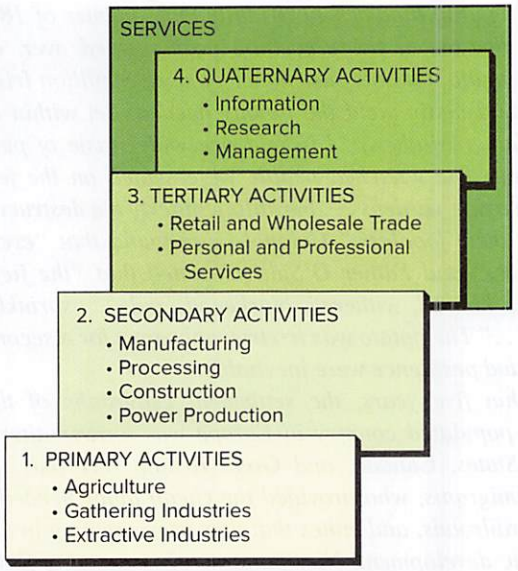
Within the bounds of what is environmentally possible, *cultural considerations* may shape economic decisions. For example, culturally based food preferences rather than environmental limitations may dictate the choice of crops or livestock. Corn (maize) is a preferred grain in Africa and the Americas; wheat in North America, Australia, Argentina, southern Europe, and Ukraine; and rice in much of Asia. Pigs are not raised in Muslim areas, where religious belief prohibits pork consumption.

Level of *technological development* of a culture will affect its recognition of resources or its ability to exploit them. **Technology** refers to the totality of tools and methods available to and used by a culture group in producing items essential to its subsistence and comfort. Preindustrial societies have no knowledge of or need for the iron ore, coal, petroleum, or uranium underlying their hunting, gathering, or gardening grounds. *Political decisions* may encourage or discourage—through subsidies, protective tariffs, or production restrictions—patterns of economic activity. And, ultimately, production is controlled by *economic factors* of demand, whether that demand is expressed through a free-market mechanism, government controls, or the consumption requirements of a single family producing for its own needs.

Categories of Activity

One approach to categorize the world's productive work is to view economic activity as ranged along a continuum of both increasing complexity of product or service and increasing distance from the natural environment. Seen from that perspective, four distinctive stages of economic activities may be distinguished: primary, secondary, tertiary, and quaternary (**Figure 8.2**).

Primary activities are those that harvest or extract something from the Earth. They are at the beginning of the production cycle, where humans are in closest contact with the resources of the environment. Such activities involve basic food and raw material production. Hunting and gathering, grazing, agriculture, fishing, forestry, and mining and quarrying are examples. **Secondary activities** are those that add value to materials by changing their form or combining them into more



AP Figure 8.2 The categories of economic activity.

useful—therefore more valuable—commodities. That processing of raw materials into finished products may range from simple handicraft pottery to the assembly of electronic goods or space vehicles (**Figure 8.3**). Copper smelting, steel making, metalworking, automobile production, food processing, textile and chemical industries—indeed, the full array of *manufacturing and processing industries*—are included in this phase of the production process. Also included are the production of *energy* and the *construction* industry.

Tertiary activities provide *services* to the primary and secondary sectors and *goods* and *services* to businesses and to individuals. The service sector includes wholesale and retail trade, which constitute the vital link between producers and consumers. Business services include accounting, advertising, financial services, insurance, legal services, and real estate. Consumers may use some of these same services, although often from different providers. Examples of consumer service providers include health care, eating and drinking establishments, repair and maintenance providers, and personal service establishments such as hair salons. **Quaternary activities** are a specialized subset of service activities involving research, information, and administration. In advanced economies, competitiveness and productivity are closely tied to the gathering, analysis, and dissemination of information. Generally, economic development brings a dramatic shift in the distribution of economic activity across the categories of economic activity (**Table 8.1**). Industrialization leads to an increase in the secondary sector at the expense of agriculture. Further economic development tends to shift the economic structure toward services such that the world's most advanced economies are now largely **post-industrial information economies.** The United States demonstrates this shift, with just 1 percent of its gross domestic product (GDP) derived from agriculture and more than three-fourths from service activities. Still, primary activities are essential to all human life and are dominant globally on a land area basis.

Figure 8.3 These fattened cattle outside a meat packing plant in Colorado are products of *primary production*. The slaughter and processing of these cattle into various beef cuts, hamburger, and beef by-products such as dog food and fertilizer is a *secondary activity*.

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The term *industry*—in addition to its common meaning as a branch of manufacturing activity—is frequently employed as a substitute, identical in meaning to *activity,* as a designation of these categories of economic enterprise. That is, we can speak of the steel, or automobile, or textile "industry," with all the impressions of factories, mills, raw materials, and products each type of enterprise implies. But with equal logic, we can refer in a more generalized way to the "entertainment" or the "travel" industry or, in the present context, to "primary," "secondary," and "service" industries.

These categories of production and service activities help us see an underlying structure to the nearly infinite variety of things people do to earn a living and to sustain themselves. But by themselves, they tell us little about the organization of the larger economy of which the individual worker or establishment is a part. For that broader organizational understanding, we look to *systems* rather than *components* of economies.

Types of Economic Systems

Broadly viewed, economies fall into one of three major types of systems: *subsistence, commercial,* or *planned.* None of these economic systems is "pure." That is, none exists in isolation in an increasingly interdependent world. Each, however, displays certain underlying characteristics based on its distinctive forms of resource management and economic control.

In a **subsistence economy,** goods and services are created for the use of the producers and their kinship groups. Therefore, there is little exchange of goods and only limited need for markets. In the **market (commercial) economies** that have become dominant in nearly all parts of the world, producers or their agents, in theory, freely market their goods and services, the laws of supply and demand determine price and quantity, and market competition is the primary force that shapes production decisions and distributions. In the extreme form of **planned economies** associated with communist societies, producers or their agents disposed of goods and services through government agencies that controlled both supply and price. The quantities produced and the locational patterns of production were strictly programmed by central planning departments.

With a few exceptions—such as Cuba and North Korea—rigidly planned economies no longer exist in their classical form; they have been modified or dismantled in favor of free market structures or only partially retained in a lesser degree

Table 8.1

Stage of Economic Development and the Structure of Economic Activity

	Value Added as Percentage of GDP, 2016[1]		
Country/Category	**Agriculture**	**Manufacturing**	**Services**
Least Developed			
Central African Republic	43	7	41
Mali	42	5	40
Newly Industrialized			
Malaysia	9	22	53
Thailand	8	27	56
Industrial			
Czech Republic	3	27	60
South Korea	2	29	59
Postindustrial			
Australia	3	7	73
United States	1	12	79

Source: *The World Bank,* Open Database, *2018. Values do not add to 100 percent due to mining, construction, and utilities*
[1]Some values are from earlier years where 2016 data was missing.

of economic control associated with governmental supervision or ownership of selected sectors of increasingly market-oriented economies. Nevertheless, their landscape evidence lives on in formerly communist societies, such as the former Soviet Union and its satellite bloc countries. The physical structures, patterns of production, and regional interdependencies they imposed continue to influence the economic decisions of successor societies.

In actuality, few people are members of only one of these systems. A farmer in India may produce rice and vegetables privately for the family's consumption but also save some of the produce to sell. In addition, members of the family may market cloth or other handicrafts they make. With the money derived from those sales, the Indian peasant is able to buy, among other things, clothes for the family, tools, and fuel. Thus, that Indian farmer is a member of at least two systems: subsistence and commercial.

In the United States, government controls or subsidies on the production of various types of goods and services (such as growing corn, producing alcohol, constructing and operating nuclear power plants, and engaging in licensed personal and professional services) mean that the country does not have a purely market economy. To a limited extent, its citizens participate in a controlled and planned environment, as well as in a free-market environment. Many African, Asian, and Latin American market economies have been decisively shaped by government or international development and monetary agency policies that encourage the production of export commodities rather than food for domestic markets. Other developing countries promote through import restrictions and currency manipulation the development of their own industrial capacity. Example after example would show that "free" markets depend upon institutions and government controls.

No matter what economic system prevails, transportation is a key variable. No advanced economy can flourish without a well-connected transport network. Subsistence societies—or subsistence areas of developing countries—are characterized by their isolation from regional and world trade routes (**Figure 8.4**). That isolation restricts their progression to more advanced forms of economic structure.

Inevitably, spatial patterns of economic activities and systems are subject to change. For example, the commercial economies of Western European countries are being restructured by both increased free market competition and supranational regulation under the World Trade Organization (WTO) and the European Union (EU; see Chapter 12 for more on this topic). The countries of Latin America, Africa, Asia, and the Middle East that traditionally were dominated by subsistence economies are now benefiting from technology transfer and integration into expanding global production and exchange patterns. For example, the phenomenal growth of the Chinese economy is rewriting the map of economic activity and shifting the global balance of economic power. Economic globalization increases linkages among distant regions and spreads wealth more widely, but also undermines the stability of established production locations. In short, the creative destruction of capitalism produces results that vary widely from place to place.

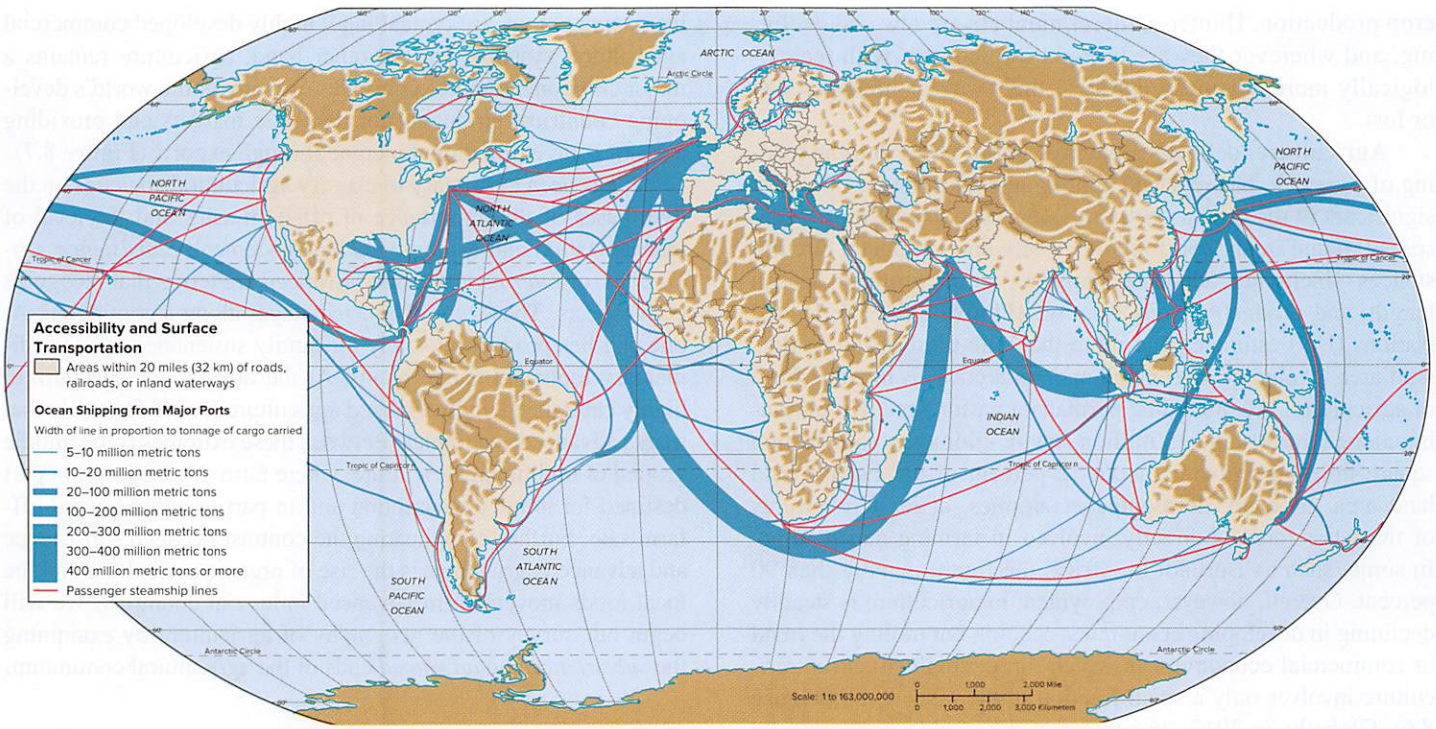

Figure 8.4 Patterns of surface transportation and accessibility. Accessibility is a key measure of economic development and of the degree to which a world region can participate in interconnected market activities. Isolated areas of countries with advanced economies suffer a price disadvantage because of high transportation costs. Lack of accessibility in subsistence economic areas slows their modernization and hinders their participation in the world market.

Source: Allen, Paul, Student Atlas of World Geography, *McGraw-Hill.*

In the remainder of this chapter, we will center our attention on the primary industries. In Chapter 9, we will consider the secondary and service sectors of the economy.

8.2 Primary Activities: Agriculture

Humankind's basic economic concern is producing or securing sufficient food resources to meet daily energy requirements and normal nutritional needs. Those supplies may be acquired directly, through hunting, gathering, farming, or fishing, or indirectly, through performance of other primary, secondary, or service sector endeavors that yield sufficient income to obtain needed daily sustenance. Statistics from the Food and Agriculture Organization (FAO) at the United Nations show that in 2010, 2.6 billion people or 38 percent of the world's population depended on agriculture, hunting, fishing, and forestry for their livelihoods.

Since the 1960s, neo-Malthusians (see Chapter 4) have revived Thomas Robert Malthus's fears that the world's steadily increasing population would exceed food supplies. Instead, although global population has tripled since 1950, the total number of undernourished people has dropped since 1990. The FAO has set the minimum daily requirement for caloric intake at 2,350 per person. By that measure, annual food supplies are more than sufficient to meet world needs. That is, if total food resources were evenly distributed, everyone would have access to amounts sufficient for adequate daily nourishment. In reality, however, about 800 million people or 11 percent of the world's population are inadequately supplied with food and nutrients. This stark contradiction between sufficient worldwide food supplies and widespread malnutrition reflects, among other reasons, inequalities in national and personal incomes; lack of access to fertile soils, credit, and education; local climatic conditions or catastrophes; and lack of transportation and storage facilities. By mid-century, the increasingly interconnected world population will expand to a projected 9.8 billion, and concerns with individual states' food supplies will inevitably remain a persistent international issue. World and regional issues of food security are explored in Chapter 10.

Before there was farming, *hunting* and *gathering* were the universal forms of primary production. These preagricultural pursuits are now practiced by at most a few thousand people worldwide, primarily in isolated and remote pockets within the low latitudes and among the sparse populations of very high latitudes. The interior of New Guinea, rugged areas of interior Southeast Asia, diminishing segments of the Amazon rain forest, and a few districts of tropical Africa and northern Australia still contain such preagricultural people. Much of the Arctic region, of course, is ill suited for any form of food

crop production. Hunter-gatherer numbers are few and declining, and wherever they are brought into contact with technologically more advanced cultures, their way of life is eroded or lost.

Agriculture, defined as the growing of crops and the tending of livestock, has replaced hunting and gathering as the most significant of the primary activities. It is spatially the most widespread, found in all world regions where environmental circumstances—including adequate moisture, good growing season length, and productive soils—permit (**Figure 8.5**). The United Nations (UN) estimates that more than one-third of the world's land area (excluding Greenland and Antarctica) is in some form of agricultural use, including permanent pastureland. Crop farming alone covers some 15 million square kilometers (5.8 million square miles) worldwide, about 12 percent of the Earth's total land area. In many developing economies, at least two-thirds of the labor force is directly involved in farming and herding. In some, such as Burundi in Africa, the figure is more than 90 percent. Overall, however, employment in agriculture is steadily declining in developing economies, echoing but trailing the trend in commercial economies, in which direct employment in agriculture involves only a small fraction of the labor force (**Figure 8.6**). Globally, in 2017, 26 percent of the world's economically active population worked in agriculture. In the United States, just 2 percent of workers were in agriculture and in the United Kingdom, it was just 1 percent. Indeed, a declining number or proportion of farm workers, along with farm consolidation and increasing output, are typical in all highly developed commercial agricultural systems. On the other hand, agriculture remains a major component in the economies of many of the world's developing countries, producing for domestic markets and providing a major source of national income through exports (**Figure 8.7**).

It has been customary to classify agricultural societies on the twin bases of the importance of off-farm sales and the level of mechanization and technological advancement. *Subsistence, traditional* (or *intermediate*), and *advanced* are terms that recognize both aspects. These are recognized stages along a continuum. At one end lies production solely for family sustenance, using rudimentary tools and native plants. At the other is the specialized, highly capitalized, industrialized agriculture for off-farm sale that marks advanced economies. Between these extremes is the middle ground of traditional agriculture, where farm production is in part destined for home consumption and in part oriented toward off-farm sale. Further complicating the contrast between subsistence and advanced agriculture is the rise of organic agriculture and the local foods movement in advanced industrial countries. We will begin our survey of the geography of agriculture by examining the *subsistence* and *advanced* ends of the agricultural continuum.

Subsistence Agriculture

By definition, a *subsistence* economic system involves nearly total self-sufficiency on the part of its members. Production for exchange is minimal, and any exchange is noncommercial;

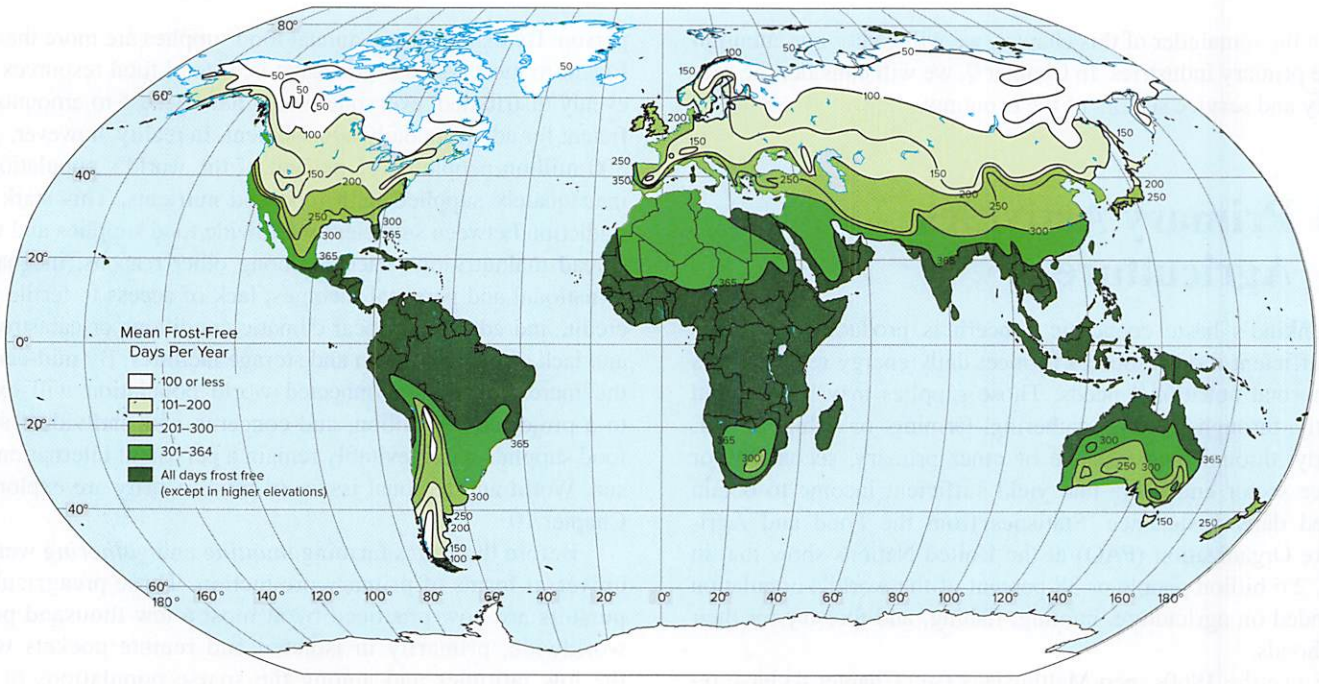

Figure 8.5 Average length of growing season. The number of frost-free days is an important environmental control on agriculture, as is the availability of precipitation sufficient in amount and reliability for crop production. Because agriculture is not usually practicable with less than a 90-day growing season, large parts of Russia and Canada have only limited cropping potential. Except where irrigation water is available, arid regions are similarly outside of the margins of regular crop production.

Source: Wayne M. Wendland.

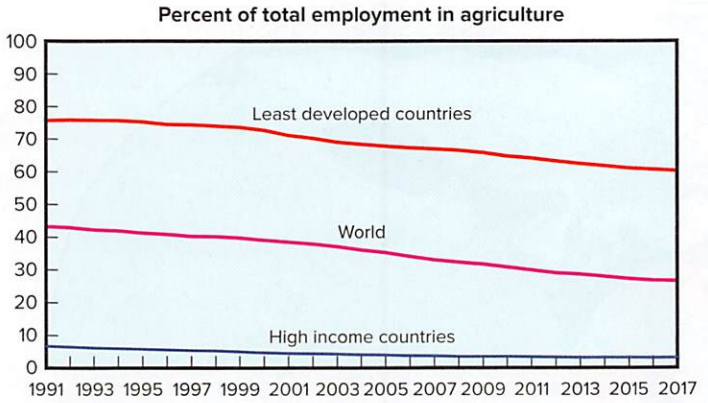

Figure 8.6 In economies worldwide, the percentage of the labor force in agriculture has been steadily declining—and is projected to decrease to even lower levels. Still, large differences remain between the world's high income countries and the least developed countries.

Sources: World Bank, Open Database, 2018.

each family or close-knit social group relies on itself for its food and other most essential requirements. Farming for the immediate needs of the family is, even today, the predominant occupation of humankind. In most of Africa, South and East Asia, and much of Latin America, a large percentage of people are primarily concerned with feeding themselves from their own land and livestock.

Two chief types of subsistence agriculture may be recognized: *extensive* and *intensive*. The essential contrast between them is yield per unit of land area and, therefore, the population that can be supported. **Extensive subsistence agriculture** involves large areas of land and minimal labor input per hectare. Both production per land unit and population densities are low. **Intensive subsistence agriculture** involves the cultivation of small landholdings through the expenditure of great amounts of labor per acre. Yields per unit area and population densities are both high (**Figure 8.8**).

Extensive Subsistence Agriculture

Of the several types of *extensive subsistence* agriculture, two are of particular interest: nomadic herding and shifting cultivation.

Nomadic herding, the wandering yet controlled movement of livestock solely dependent on natural forage, is the most extensive type of land-use system (Figure 8.8). That is, it requires the greatest amount of land area per person sustained. Over large portions of semiarid and desert areas of Asia, in certain highland zones, and on the fringes of and within the Sahara, a relatively small number of people graze animals for consumption by the herder group, not for market sale. Sheep, goats, and camels are most common, while cattle, horses, and yaks are locally important. The reindeer of Lapland were formerly part of the same system.

Whatever the animals involved, their common characteristics are hardiness, mobility, and an ability to subsist on sparse forage. The animals provide a variety of products: milk, cheese, blood, and meat for food; hair and wool for clothing; skins for clothing and shelter; and excrement for fuel. For the herder, the animals represent primary subsistence, savings, and insurance against an uncertain future. Nomadic movement is tied to sparse

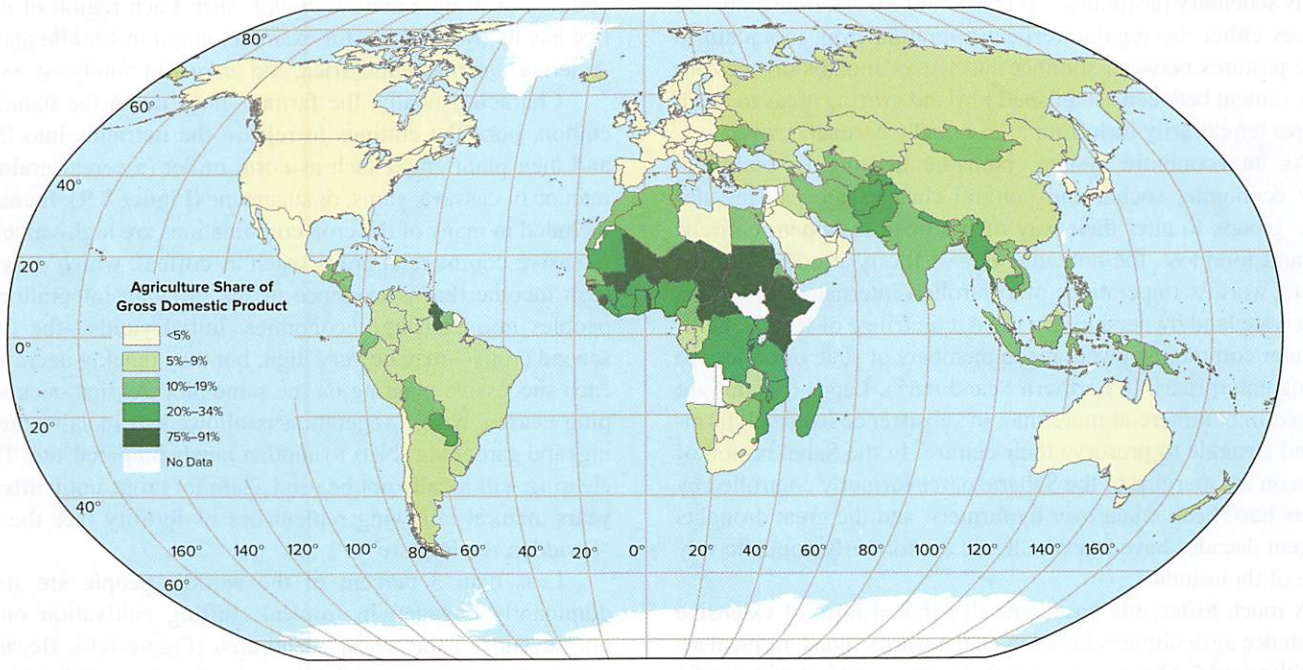

Figure 8.7 Share of agriculture in GDP, 2016. Agriculture makes the largest percentage contributions to GDP in the world's least developed countries.

Source: The World Bank, Open Database, 2018.

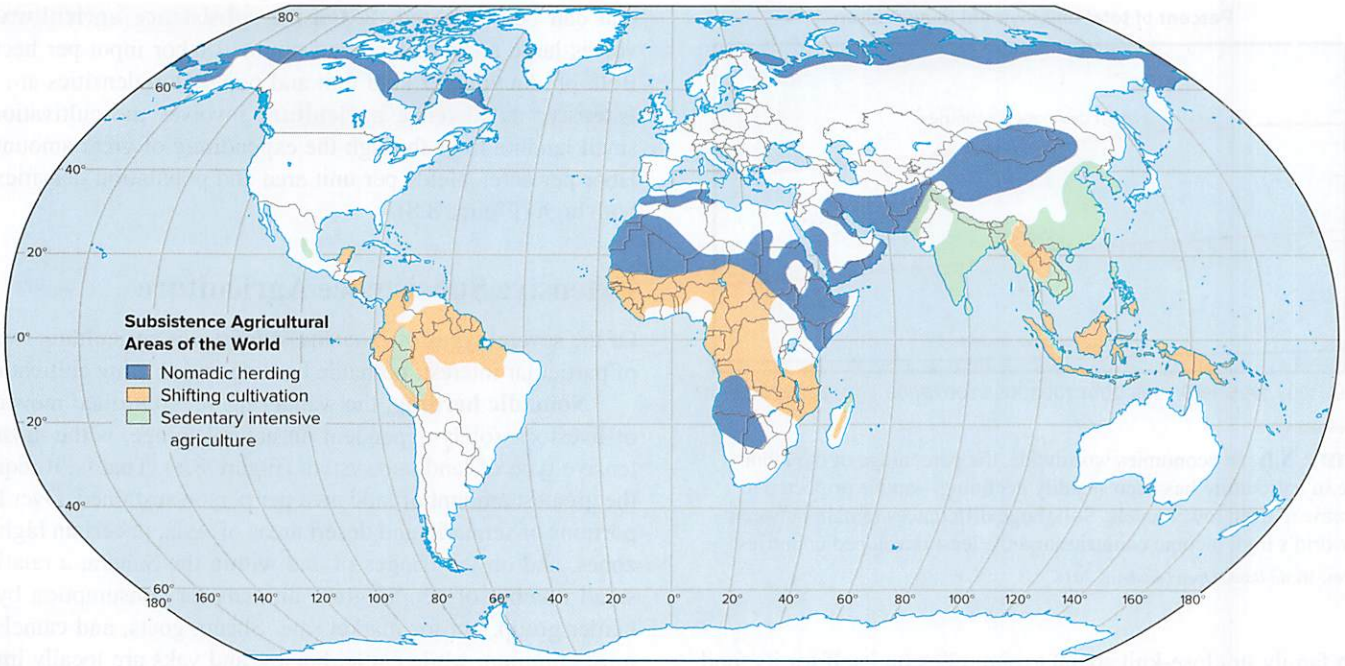

Figure 8.8 Nomadic herding, supporting relatively few people, was the age-old way of life in the dry or cold regions of the world. Shifting or swidden agriculture maintains soil fertility by tested traditional practices in tropical wet and wet-and-dry climates. Large parts of Asia support millions of people engaged in sedentary intensive cultivation, with rice and wheat the chief crops.

and seasonal rainfall or to cold temperatures and to the varying appearance and exhaustion of forage. Extended stays in a given location are neither desirable nor possible. *Transhumance* is a special form of seasonal movement of livestock to exploit specific locally varying pasture conditions. Used by permanently or seasonally sedentary pastoralists and pastoral farmers, transhumance involves either the regular vertical migration from mountain to valley pastures between summer and winter months or horizontal movement between established lowland grazing areas to reach pastures temporarily lush from monsoonal (seasonal) rains.

As an economic system, nomadic herding is declining. Many economic, social, and cultural changes are causing nomadic groups to alter their way of life or to disappear entirely. First and foremost, the nomadic way of life is at odds with the modern world's imperatives of controlled international borders and private land ownership. On the Arctic fringe of Russia, herders under communism were made members of state or collective herding enterprises. In northern Scandinavia, Lapps (Saami) are engaged in commercial more than in subsistence livestock farming and struggle to preserve their culture. In the Sahel region of Africa on the margins of the Sahara, oases formerly controlled by herders have been taken over by farmers, and the great droughts of recent decades have forever altered the formerly nomadic way of life of thousands.

A much differently based and distributed form of extensive subsistence agriculture is found in all the warm, moist, tropical areas of the world. There, many people engage in a kind of nomadic farming. Once put into agricultural use, the soils of those areas rapidly lose many of their nutrients (in hot, wet climates, organic matter rapidly decomposes and heavy rains and groundwater dissolve and *leach* the nutrients from the soil). After several harvests, the soils are depleted and the farmers move on. In a sense, the farmers rotate fields rather than crops to maintain soil productivity. This type of **shifting cultivation** has a number of names, the most common of which are *swidden* (an English localism for "burned clearing") and *slash-and-burn.* Each region of its practice has its own name—for example, *milpa* in Middle and South America, *chitemene* in Africa, and *ladang* in Southeast Asia.

Characteristically, the farmers hack down the natural vegetation, burn the cuttings to release the nutrients into the soil, and then plant crops such as corn, millet (a cereal grain), rice, manioc or cassava, yams, or sugarcane (**Figure 8.9**). Increasingly included in many of the crop combinations are high-value, labor-intensive commercial crops (such as coffee), which provide the cash income that is evidence of the growing integration of all peoples into exchange economies. Initial yields—the first and second crops—may be very high, but they quickly decrease with each successive planting on the same plot. As that occurs, cropping ceases, native vegetation is allowed to reclaim the clearing, and gardening shifts to another newly prepared site. The first clearing will ideally not be used again for crops until, after many years, natural fallowing replenishes its fertility (see the feature "Swidden Agriculture").

Less than 3 percent of the world's people are still predominantly engaged in tropical shifting cultivation on about one-seventh of the world's land area (Figure 8.8). Because the essential characteristic of the system is the intermittent cultivation of the land, each family requires a total area equivalent to the garden plot in current use, plus all land left fallow for regeneration. Population densities are traditionally low, for much land

(a)

(b)

Figure 8.9 Swidden agriculture in Liberia, Africa. First, the vegetation is cut and burned (*a*). Then, the field is planted (*b*). Stumps and trees left in the clearing will remain after the burn.

(a, b) ©Albert Swingle

is needed to support few people. Here as elsewhere, however, population density must be considered a relative term. In actuality, although crude (arithmetic) density is low, people per unit area of *cultivated* land may be high.

Shifting cultivation is one of the oldest and most widely spread agricultural systems of the world. It is found on the islands of Borneo, New Guinea, and Sumatra but is now retained only in small parts of the uplands of Southeast Asia in Vietnam, Thailand, Myanmar, and the Philippines. Nearly the whole of inland Central and West Africa, Brazil's Amazon basin, and large portions of Central America were engaged in this type of extensive subsistence agriculture.

It may be argued that shifting cultivation is an ingenious, highly efficient cultural adaptation where land is abundant in relation to population. Shifting cultivation generally involves *polyculture,* the production of many different types of crops in a single field. Polyculture reduces vulnerability to pests and diseases and spreads the harvests through the year to provide food security. Polyculture keeps the soil covered by vegetation, reducing the potential for soil erosion. Traditional shifting cultivation has many advantages over commercial agriculture: no chemical fertilizers, herbicides, or pesticides are used and energy is provided by humans or draft animals rather than fossil fuels. Nonetheless, as population densities increase, the system becomes less viable. The basic change, as noted in Chapter 4, is that land is no longer abundant in relation to population in many of the less-developed wet, tropical countries. Their growing populations have cleared and settled the forestlands formerly only intermittently used in swidden cultivation. The **Boserup thesis,** proposed by the economist Ester Boserup, is based on the observation that population increases necessitate increased inputs of labor and technology to compensate for reductions in the natural yields of swidden farming. It holds that population growth forces an increased use of technology in farming and—in a reversal of the Malthusian idea that the supply of food is fixed or only slowly expandable—triggers the switch from extensive to intensive subsistence agriculture, which sharply increases food production.

Intensive Subsistence Systems

Intensive subsistence agriculture is particularly important in the densely populated areas of Asia as shown in Figure 8.8. As a descriptive term, *intensive subsistence* is no longer fully applicable to changing practices in which subsistence and commercial agriculture are increasingly combined. Although families may still be fed primarily with the produce of their individual plots, the exchange of farm commodities within the system is considerable. Production of food for sale in rapidly growing urban markets is increasingly vital for the rural economies of subsistence farming areas and for the sustenance of the growing proportion of national and regional populations no longer themselves engaged in farming. Nevertheless, hundreds of millions of Indians, Chinese, Pakistanis, Bangladeshis, and Indonesians plus further millions in other Asian, African, and Latin American countries remain small-plot, mainly subsistence producers of rice, wheat, corn, millet, or pulses (peas, beans, and other legumes). Most live in monsoon Asia, and we will devote our attention to that area.

Intensive subsistence farmers are concentrated in such major river valleys and deltas as the Ganges and the Chang Jiang (Yangtze) and in smaller valleys close to coasts—level areas with fertile alluvial soils. These warm, moist districts are well suited to the production of rice, a crop that under ideal conditions can provide large amounts of food per unit of land. Rice cultivation requires a great deal of time and attention, for planting rice shoots by hand in standing fresh water is a tedious art (**Figure 8.10**). In the cooler and drier portions of Asia, wheat is grown intensively, along with millet and, less commonly, upland rice.

Figure 8.10 Transplanting rice seedlings requires hard manual labor. The newly flooded diked fields, previously plowed and fertilized, will have their water level maintained until the grain is ripe. This photograph was taken in Vietnam. The scene is repeated wherever subsistence wet-rice agriculture is practiced.

Rice is known to have been cultivated in parts of China and India for more than 7,000 years. Today, wet, or lowland, rice is the mainstay of subsistence agriculture and diets of populations from Sri Lanka and India to Taiwan, Japan, and Korea. It is grown on more than 80 percent of the planted area in Bangladesh, Thailand, and Malaysia. Almost exclusively used as a human food, rice provides 25 percent to 80 percent of the calories in the daily diet of some 3 billion Asians, or half the world's population. Its successful cultivation depends on the controlled management of water, relatively easy in humid tropical river valleys with heavy, impermeable, water-retaining soils though more difficult in upland and seasonally dry districts. Throughout Asia, the necessary water management systems have left their distinctive marks on the landscape. Permanently diked fields to contain and control water, levees against unwanted water, and reservoirs, canals, and drainage channels to control its availability and flow are common sights. Terraces to extend level land to valley slopes are occasionally encountered as well (see Figure 4.23).

Intensive subsistence farming is characterized by large inputs of labor per unit of land, by small plots, by the intensive use of fertilizers, mostly animal manure, and by the promise of high yields in good years (see the feature "The Economy of a Chinese Village"). Vegetables and some livestock are part of the agricultural system, and fish may be reared in rice paddies and ponds. Food animals include swine, ducks, and chickens. Religion is a factor as well; because Muslims eat no pork, hogs are absent in their areas of settlement. Hindus generally eat little meat, mainly goat and lamb but not pork or beef. The large number of cattle in India is vital for labor, as a source of milk and cheese, and as producers—through excrement—of fertilizer and fuel.

Urban Subsistence Farming

Not all of the world's subsistence farming is based in rural areas. Urban agriculture is a rapidly growing activity, with some 800 million city farmers worldwide. Occurring in all regions of the world but most prevalent in Asia, urban agricultural activities range from small garden plots, to backyard livestock breeding, to fish raised in ponds and streams. Using the garbage dumps of Jakarta, the rooftops of Mexico City, and meager dirt strips along roadways in Kolkata (Calcutta) or Kinshasa, millions of people are feeding their own families and supplying local markets with vegetables, fruit, fish, and even meat—all produced within the cities themselves and all without the expense and spoilage of storage or long-distance transportation.

In all parts of the developing world, urban food production has reduced the incidence of adult and child malnutrition in rapidly expanding cities. City farming is, as well, a significant outlet for underemployed residents. In some cities in the developing world, one-fifth to two-thirds of all families are engaged in agriculture.

There are both positive and negative environmental consequences of urban agricultural activities. On the plus side, urban farming helps convert waste from a problem to a resource by reducing runoff and erosion from open dumps and by avoiding the costs of wastewater treatment and solid waste disposal. In Khartoum, Sudan, for example, about 25 percent of the city's garbage is consumed by farm animals; in Kolkata, India, city sewage is used to supply lagoons which, in turn, produce some 6,000 tons of fish annually. Nearly everywhere, human and animal wastes, vegetable debris, and table scraps are composted

Swidden Agriculture

The following account describes shifting cultivation among the Hanunóo people of the Philippines. Nearly identical procedures are followed in all swidden farming regions:

> When a garden site of about one-half hectare (a little over one acre) has been selected, the swidden farmer begins to remove unwanted vegetation. The first phase of this process consists of slashing and cutting the undergrowth and smaller trees with bush knives. The principal aim is to cover the entire site with highly inflammable dead vegetation so that the later stage of burning will be most effective. Because of the threat of soil erosion the ground must not be exposed directly to the elements at any time during the cutting stage. During the first months of the agricultural year, activities connected with cutting take priority over all others. It is estimated that the time required ranges from 25 to 100 hours for the average-sized swidden plot.
>
> Once most of the undergrowth has been slashed, chopped to hasten drying, and spread to protect the soil and assure an even burn, the larger trees must be felled or killed by girdling (cutting a complete ring of bark) so that unwanted shade will be removed. The successful felling of a real forest giant is a dangerous activity and requires great skill. Felling in second growth is usually less dangerous and less arduous. Some trees are merely trimmed but not killed or cut, both to reduce the amount of labor and to leave trees to reseed the swidden during the subsequent fallow period.
>
> The crucial and most important single event in the agricultural cycle is swidden burning. The main firing of a swidden is the culmination of many weeks of preparation in spreading and leveling chopped vegetation, preparing firebreaks to prevent flames escaping into the jungle, and allowing time for the drying process. An ideal burn rapidly consumes every bit of litter; in no more than an hour or an hour and a half, only smoldering remains are left.
>
> The Hanunóo, swidden farmers of the Philippines, note the following as the benefits of a good burn: (1) removal of unwanted vegetation, resulting in a cleared swidden; (2) extermination of many animal and some weed pests; (3) preparation of the soil for dibble (any small hand tool or stick to make a hole) planting by making it softer and more friable; (4) provision of an evenly distributed cover of wood ashes, good for young crop plants and protective of newly-planted grain seed. Within the first year of the swidden cycle, an average of between 40 and 50 different types of crop plants have been planted and harvested.
>
> The most critical feature of swidden agriculture is the maintenance of soil fertility and structure. The solution is to pursue a system of rotation of 1 to 3 years in crop and 10 to 20 in woody or bush fallow regeneration. When population pressures mandate a reduction in the length of fallow period, productivity of the region tends to drop as soil fertility is lowered, marginal land is utilized, and environmental degradation occurs. The balance is delicate.

Source: *Based on Harold C. Conklin,* Hanunóo Agriculture, *FAO Forestry Development Paper No. 12.*

or applied to garden areas, and nearly everywhere, vegetable gardens and interspersed fruit trees, ornamental plants, and flowers enhance the often drab urban scene. Negative consequences include the use of untreated human waste as fertilizers, which exposes both producers and consumers to infectious diseases such as cholera and hepatitis.

Expanding Crop Production

Continuing population pressures on existing resources are a constant spur for ways to increase the available food supply. Two paths to promoting increased food production are apparent: (1) expand the land area under cultivation and (2) increase crop yields from existing farmlands.

The first approach—increasing cropland area—is not a promising strategy. Approximately 70 percent of the world's land area is agriculturally unsuitable, being too cold, too dry, too steep, or totally infertile. Of the remaining 30 percent, most of the area well suited for farming is already under cultivation, and of that area, millions of hectares annually are being lost through soil erosion, salinization, **desertification**, and the conversion of farmland to urban, industrial, and transportation uses. Only the rain forests of Africa and the Amazon Basin of South America retain sizable areas of potentially farmable land. The soils of those regions, however, are fragile, are low in nutrients, have poor water retention, and are easily eroded or destroyed following **deforestation**.

When population pressures dictate land conversion, serious environmental deterioration may result. Clearing of wet tropical forests in the Philippines, the Amazon Basin, and Indonesia has converted dense woodland to barren desolation within a very few years as soil erosion and nutrient loss have followed forest destruction. In Southeast Asia, some 10 million hectares (25 million acres) of former forestland are now wasteland, covered by useless sawgrass that supplies neither forage, food, nor fuel. By most measures, world food output cannot reasonably be increased by simple expansion of cultivated areas.

The Economy of a Chinese Village

The village of Nanching is in subtropical southern China on the Zhu River delta near Guangzhou (Canton). Its traditional subsistence agricultural system was described by a field investigator. The system is still followed in its essentials in other rice-oriented societies.

In this double-crop region, rice was planted in March and August and harvested in late June or July and again in November. March to November was the major farming season. Early in March, the earth was turned with an iron-tipped wooden plow pulled by a water buffalo. The very poor who could not afford a buffalo used a large iron-tipped wooden hoe for the same purpose.

The plowed soil was raked smooth, fertilizer was applied, and water was let into the field, which was then ready for the transplanting of rice seedlings. Seedlings were raised in a seedbed, a tiny patch fenced off on the side or corner of the field. Beginning from the middle of March, the transplanting of seedlings took place. The whole family was on the scene. Each took the seedlings by the bunch, 10 to 15 plants, and pushed them into the soft inundated soil. For the first 30 or 40 days, the emerald green crop demanded little attention except keeping the water at a proper level. But after this period came the first weeding; the second weeding followed a month later. This was done by hand, and everyone old enough for such work participated. With the second weeding went the job of adding fertilizer. The grain was now allowed to stand to "draw starch" to fill the hull of the kernels. When the kernels had "drawn enough starch," water was let out of the field, and both the soil and the stalks were allowed to dry under the hot sun. Then came the harvest, when all the rice plants were cut off a few inches above the ground with a sickle. Threshing was done on a threshing board. Then the grain and the stalks and leaves were taken home with a carrying pole on the peasant's shoulder. The plant was used as fuel at home.

As soon as the exhausting harvest work was done, no time could be lost before starting the chores of plowing, fertilizing, pumping water into the fields, and transplanting seedlings for the second crop. The slack season of the rice crop was taken up by chores required for the vegetables that demanded continuous attention, since every peasant family devoted a part of the farm to vegetable gardening. In the hot and damp period of late spring and summer, eggplant and several varieties of squash and beans were grown. The green-leafed vegetables thrived in the cooler and drier period of fall, winter, and early spring. Leeks grew year round.

When one crop of vegetables was harvested, the soil was turned and the clods broken up by a digging hoe and leveled with an iron rake. Fertilizer was applied, and seeds or seedlings of a new crop were planted. Hand weeding was a constant job; watering with the long-handled wooden dipper had to be done an average of three times a day, and in the very hot season when evaporation was rapid, as frequently as six times a day. The soil had to be cultivated with the hoe frequently as the heavy tropical rains packed the earth continuously. Instead of the two applications of fertilizer common with the rice crop, fertilizing was much more frequent for vegetables. Besides the heavy fertilizing of the soil at the beginning of a crop, usually with city garbage, additional fertilizer, usually diluted urine or a mixture of diluted urine and excreta, was given every 10 days or so to most vegetables.

Source: *Adapted from C. K. Yang,* A Chinese Village in Early Communist Transition *(Cambridge, MA: Massachusetts Institute of Technology, 1959).*

Intensification and the Green Revolution

Increased productivity of existing cropland rather than expansion of cultivated area has been the key to agricultural production over the past few decades. Between 1960 and 2009, world grain yields rose nearly 140 percent. Crop output, however, varies considerably from year to year, adversely or favorably affected by weather, insect damage, plant diseases, and other growing season conditions. Overall, despite dramatic population growth, grain production per capita today is higher than it was in the 1970s. The vast majority of that production growth was due to increases in yields rather than expansions in cropland. The largest increases were in Asia, primarily China and India, and South America. Unfortunately, grain yields have been nearly stagnant in sub-Saharan Africa.

Two interrelated approaches to those yield increases mark recent farming practices. First, throughout much of the developing world, production inputs such as water, fertilizer, pesticides, and labor have been increased to expand yields on a relatively constant supply of cultivable land. Irrigated area, for example, have doubled since 1960. Global consumption of fertilizers has dramatically increased since the 1950s, and inputs of pesticides and herbicides have similarly grown. Traditional practices of leaving land fallow (uncultivated) to renew its fertility have been largely abandoned, and double and triple cropping of land where climate permits has increased in Asia and even in Africa, where marginal land is put to near-continuous use to meet growing food demands. Second, many of these intensification practices are linked to the **Green Revolution**—the shorthand reference to a complex of seed and management innovations adapted to the needs of intensive agriculture and designed to bring larger harvests from a given area of farmland.

Using conventional plant breeding techniques of cross-pollination, American researcher Norman Borlaug developed a dwarf, high-yielding wheat variety at a Mexican research center in the 1940s. Borlaug was later awarded the Nobel Peace Prize, and Mexico soon went from importing half its wheat to being a wheat exporter. Similarly, the International Rice Institute in the Philippines developed dwarf rice strains that yielded many more grains per plant. These high-yielding dwarf varieties respond dramatically to heavy applications of fertilizer, resist plant diseases, and can tolerate much shorter growing seasons than traditional native varieties can. Adopting the new varieties and applying the irrigation, mechanization,

fertilization, and pesticide practices they require have created a new "high-input, high-yield" agriculture. Most poor farmers on marginal and rain-fed (nonirrigated) lands, however, have not benefited from the new plant varieties, which require abundant water and chemical inputs.

Expanded food production made possible through the Green Revolution has helped alleviate some of the shortages and famines predicted for subsistence agricultural regions since the early 1960s, saving an estimated one billion people from starvation. According to World Bank calculations, almost 90 percent of people in developing countries now have adequate diets, versus 55 percent in 1950. As **Figure 8.11** shows, however, not all world regions share those positive results equally. Although total food production has more than doubled in Africa since 1960, population growth has steadily reduced that continent's per capita food output. Although the *number* of undernourished people globally remains near the 800 million mark because of population growth, total world food supply has increased even faster than population, and the United Nations predicts that it will continue to do so through at least 2050.

A price has been paid for the successes of the Green Revolution. Irrigation, responsible for an important part of increased crop yields, has destroyed large tracts of land; excessive salinity of soils resulting from poor irrigation practices is estimated to have a serious effect on the productivity of 20 million to 30 million hectares (80,000–120,000 square miles) of land around the world, out of a world total of some 270 million hectares of irrigated land. And the huge amount of water required for Green Revolution irrigation has led to serious groundwater depletion, conflict between agricultural and growing urban and industrial water needs in developing countries—many of which are in dry climates—and to worries about scarcity and future wars over water.

And very serious genetic consequences are feared from the loss of traditional and subsistence agriculture. With it is lost the food security that distinctive locally adapted native crop varieties provided and the nutritional diversity and balance that multiple-crop intensive gardening assured. Unlike commercial monoculture farming, subsistence polyculture farming minimized the risk of major crop failures. Many different crops and many different varieties of each crop guaranteed some yield despite adverse weather, disease, or pest problems.

Commercial agriculture, however, aims at profit maximization, not food security. Poor farmers unable to afford the capital investment that the Green Revolution demands have been displaced by a commercial monoculture, one often oriented toward specialty and industrial crops designed for export rather than to food for domestic markets. Traditional rural society has been disrupted, and landless peasants have been added to the urbanizing populations of affected countries. The presumed benefits of the Green Revolution are not available to all subsistence agricultural areas or advantageous to everyone engaged in farming (see the feature "Women and the Green Revolution"). Africa is a case in point (see Figure 8.11). Green Revolution crop improvements have concentrated on wheat, rice, and corn. Of these, only corn is important in Africa, where principal food crops include millet, sorghum, cassava, manioc, yams, cowpeas, and peanuts. Belated research efforts directed to African crops, the continent's great range of growing conditions, and its abundance of yield-destroying pests and viruses have denied it the dramatic

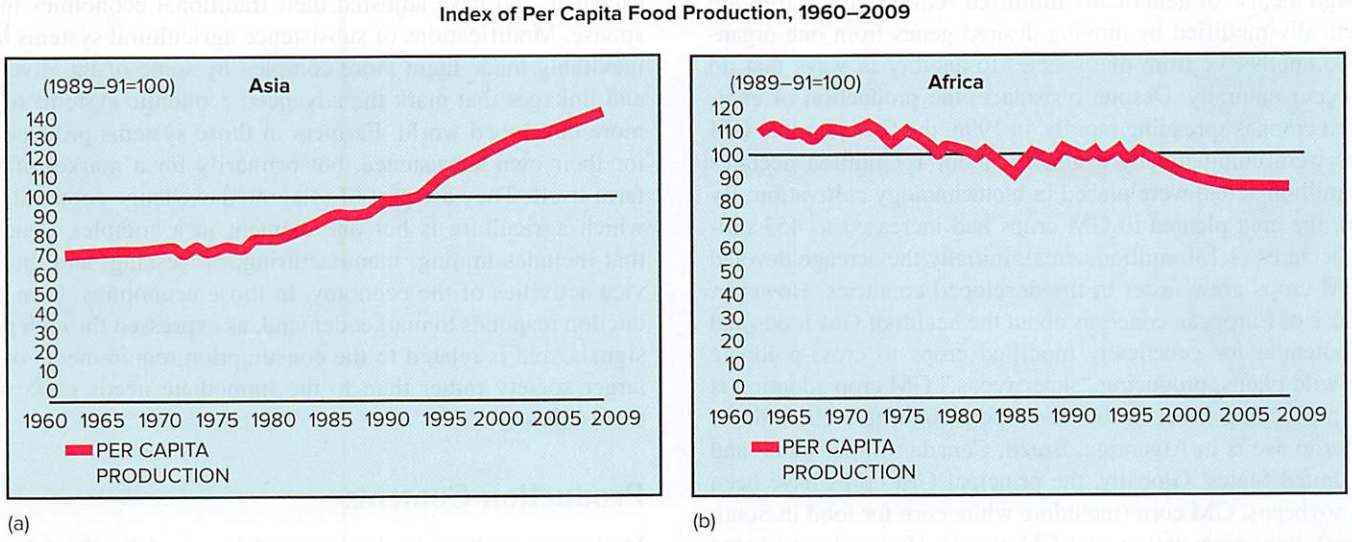

Figure 8.11 Trends in per capita food production, 1960–2009. Globally, per capita production of food increased steadily over the 50-year span shown. The intensification and expansion of farming in Asia resulted in food production outpacing population growth, in contrast to Malthus's predictions. It was a different picture in Africa, where total production of food grew steadily but didn't keep pace with population growth, resulting in less food per person. The food security problem in sub-Saharan Africa continues, with about 30 percent of the population suffering chronic malnutrition.

Source: Data from Food and Agriculture Organization.

regionwide increase in food production experienced elsewhere in the developing world. No crop research or genetic modifications can fully compensate for an underlying limitation of African agricultural productivity: 80 percent of the continent's sub-Saharan farmland is severely depleted of the basic nutrients needed to grow crops, a condition that has been steadily worsening since the 1990s.

Some successes have been reported. The most widely cultivated tuber and second most important food staple in sub-Saharan Africa, cassava has been transformed from a low-yielding subsistence hedge against famine to a high-yielding cash crop. Virus-resistant varieties of sweet potatoes and both white and yellow corn and faster-growing bananas are already available (though not yet widespread) and other food and fiber crops are receiving attention from African biotechnology scientists in Kenya, South Africa, and Egypt, with contributions from American and other Western investigators. And in some physically favored areas benefiting in part from foreign investment but particularly reflecting local small farmer enterprise, encouraging pockets of crop specialization and growth in farm productivity, agribusiness creation, and rural income have been emerging. Uganda, for example, enjoys two growing seasons, ample rainfall, rich volcanic soils, and millions of small farmers rapidly expanding production of cash crops, most aimed at export markets in Asia, Europe, and North America.

In many areas that had shown the greatest past successes, Green Revolution gains are falling off. The FAO now considers the productivity gains of Green Revolution technologies for Asian rice cultivation to have leveled off. Little prime land and even less water remain to expand farming in many developing countries. Climate change has created new challenges including higher temperatures, expanded pest ranges, and more frequent droughts.

Another means of increasing production is biotechnology—through the use of **genetically modified (GM) crops**. Crops are genetically modified by moving desired genes from one organism to another or from one species to another in ways that do not occur naturally. Despite resistance, the production of engineered crops is spreading rapidly. In 1996, the first year that GM crops were commercially available, about 1.7 million hectares (4.3 million acres) were placed in biotechnology cultivation. By 2016, the area planted to GM crops had increased to 457 million hectares (1,130 million acres). Initially the acreage devoted to GM crops grew faster in the developed countries. However, because of European concerns about the health of GM foods and the potential for genetically modified crops to cross-pollinate with wild plants, producing "superweeds," GM crop adoption is now proceeding faster in the developing countries. The bulk of GM crop use is in Argentina, Brazil, Canada, China, India, and the United States. Globally, the principal GM crops have been GM soybeans, GM corn (including white corn for food in South Africa), transgenic cotton, and GM canola. Herbicide resistance (Roundup Ready soybeans) and insect resistance (Bt corn and cotton) have been the most important of the genetic crop modifications introduced, as well as the ones responsible for the significant increase in productivity and reduction in costs of the crops involved.

Even in those world regions favorable for Green Revolution introductions, its advent has not always improved diets or reduced dependency on imported food. Often, the displacement of native agriculture involves a net loss of domestic food availability. In many instances, through governmental directive, foreign ownership or management, or domestic market realities, the new commercial agriculture is oriented toward food and industrial crops for the export market or toward specialty crop and livestock production for the expanding urban market rather than food production for the rural population.

The genetic diversity of our food supply is now a major concern. The monocultures of the Green Revolution have reduced plant genetic diversity, while globalization has created more uniform diets around the world. Only 150 crops are commercially grown and three grains: rice, wheat, and corn provide 60 percent of the world's calories. The genetic diversity of these crops has dropped dramatically. For example, in Sri Lanka, the number of rice varieties has dropped by 95 percent. "Seed banks" rather than native cultivation have been created to preserve genetic diversity for future plant breeding and as insurance against climate change or catastrophic pest or disease susceptibility of inbred varieties. Much of the world's crop genetic diversity is located in developing countries where crops were first domesticated and where subsistence farmers continue to use diverse varieties (**Figure 8.12**). However, conserving the world's crop genetic diversity will be a challenge because these places face strong population growth pressures and efforts to commercialize and intensify agriculture.

Commercial Agriculture

Few people or areas still retain the isolation and self-sufficiency that are characteristic of subsistence economies. Nearly all have been touched by a modern world of trade and exchange and have adjusted their traditional economies in response. Modifications of subsistence agricultural systems have inevitably made them more complex by some of the diversity and linkages that mark the advanced economic systems of the more developed world. Farmers in those systems produce not for their own subsistence, but primarily for a market off the farm itself. They are part of integrated exchange economies in which agriculture is but one element in a complex structure that includes mining, manufacturing, processing, and the service activities of the economy. In those economies, farm production responds to market demand, as expressed through price signals, and is related to the consumption requirements of the larger society rather than to the immediate needs of farmers themselves.

Production Controls

Modern agriculture is characterized by *specialization*—by enterprise (farm), by area, and even by country; by *off-farm sale* rather than subsistence production; and by *interdependence* of producers and buyers linked through markets. Farmers in a free market economy supposedly produce those crops that their estimates of market price and production cost indicate will yield the

Women and the Green Revolution

Traditional agricultural labor is often divided by gender, as seen in Figure 8.9 where men prepare the swidden plot and women, often with children on their back, plant the crops. Women farmers grow at least half of the world's food (and up to 80 percent in some African countries). They are responsible for an even larger share of food consumed by their own families: 80 percent in sub-Saharan Africa, 65 percent in Asia, and 45 percent in Latin America and the Caribbean. Further, women comprise between one-third and one-half of all agricultural laborers in developing countries. For example, African women perform about 90 percent of the work of processing food crops and 80 percent of the work of harvesting and marketing.

Women's agricultural dominance in developing states is increasing, as male family members continue to leave for cities in search of paid urban work. In Mozambique, for example, for every 100 men working in agriculture, there are 153 women. In nearly all other sub-Saharan countries, the female component runs between 120 and 150 per 100 men. The departure of men for near or distant cities means, in addition, that women must assume effective management of their families' total farm operations.

Despite their important role, however, women do not share equally with men in the rewards from agriculture, nor benefit from new agricultural technologies. First, most women farmers are involved in subsistence farming and food production for the local market, which yields little cash return. Second, they have far less access than men to credit at bank or government-subsidized rates that would make it possible for them to acquire the Green Revolution technology, such as hybrid seeds and fertilizers. Third, women cannot own land in some cultures and so are excluded from agricultural improvement programs and projects aimed at landowners. For example, many African agricultural development programs are based on the conversion of communal land, to which women have access, to private holdings, from which they are excluded. In Asia, inheritance laws favor male over female heirs, and female-inherited land is managed by husbands.

At the same time, the Green Revolution and its greater commercialization of crops has generally required an increase in labor per hectare, particularly in tasks typically reserved for women, such as weeding, harvesting, and postharvest work. If women are provided no relief from their other daily tasks, the Green Revolution for them may be more burden than blessing. But when mechanization is added to the new farming system, women tend to be losers. Frequently, such predominantly female tasks as harvesting or dehusking and polishing of grain—all traditionally done by hand—are given over to machinery, displacing rather than employing women. Even the application of chemical fertilizers (a "man's task") instead of cow dung ("women's work") has reduced the female role in agricultural development programs. The loss of those traditional female wage jobs means that already poor rural women and their families have insufficient income to improve their diets even in the light of substantial increases in food availability through Green Revolution improvements.

If women are to benefit from the Green Revolution, new cultural norms—or culturally acceptable accommodations within traditional household, gender, and customary legal relations—will be required. These must permit or recognize women's landowning and other legal rights not now clearly theirs, access to credit at favorable rates, and admission on equal footing with males to government assistance programs. The FAO is working to promote gender-based equity in agricultural development.

greatest return. Theoretically, farm products for which demand at a given price increases will command an increased market price. That, in turn, should induce increased production to meet the demand. In some developing countries, that market equilibrium is broken and the farm economy distorted when government policy requires uneconomically low food prices for urban workers. It may also suffer material distortion under governmental programs protecting local producers by inhibiting farm product imports or subsidizing production by guaranteeing prices for selected commodities.

Where free market conditions prevail, however, the crop or the mix of crops and livestock that individual commercial farmers produce is a result of an appraisal of profit possibilities. Farmers must assess and predict prices, evaluate the physical nature of farmland, and factor in the possible weather conditions. The costs of production (seed, fuel, fertilizer, capital equipment, labor, and so on) must be reckoned. A number of unpredictable conditions may thwart farmers' aspirations for profit. Among them are the uncertainties of growing season conditions that follow the original planting decision, the total yield that will be achieved (and therefore the unit cost of production), and the supply and price situation that will exist months or years in the future, when crops are ready for market.

Beginning in the 1950s in the United States, specialist farmers and corporate purchasers developed strategies for minimizing those uncertainties. Processors sought uniformity of product quality and timing of delivery. Vegetable canners—of tomatoes, sweet corn, and the like—required volume delivery of raw products of uniform size, color, and ingredient content on dates that accorded with cannery and labor schedules. And farmers wanted the support of a guaranteed market at an assured price to minimize the uncertainties of their specialization and stabilize the return on their investment.

The solution was contractual arrangements or vertical integration (where production, processing, and sales are all coordinated within one firm) that unite contracted farmer and purchaser-processor. Broiler chickens of specified age and weight, cattle fed to an exact weight, wheat with a minimum protein content, popping corn with prescribed characteristics, potatoes of the kind and quality demanded by particular fast-food

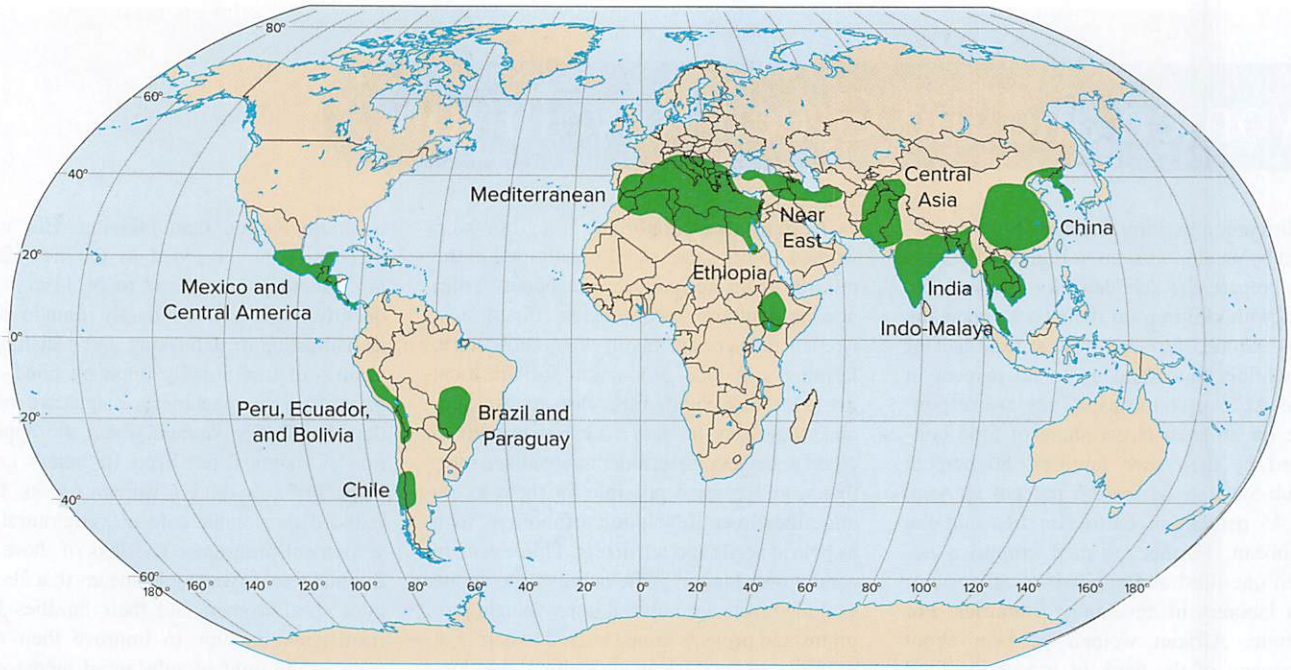

Figure 8.12 Areas with high current genetic diversity of crop varieties. Loss of crop varieties characterizes the commercial agriculture of much of the developed world. In place of the many thousands of species and subspecies (varieties) of food plants grown since the development of agriculture 15,000 or more years ago, fewer than 100 species now provide most of the world's food supply. Most of the diversity loss has occurred in the last 100 years or so. In the United States, for example, 96 percent of commercial vegetable varieties listed by the Department of Agriculture in 1903 are now extinct. Crop breeders, however, require genetic diversity to develop new varieties that are resistant to evolving plant pest and disease perils. That need requires the protection of plant stocks and environments in those temperate and subtropical zones where food plants were first domesticated and are home to the wild relatives of our current food crops. Comparable losses of species diversity are being felt in livestock as well. Half the livestock breeds that existed in Europe in 1900 are already extinct, and almost half the remainder are at risk or endangered.

Sources: J. G. Hawkes, The Diversity of Crop Plants *(Cambridge, MA: Harvard University Press, 1983); and Walter V. Reid and Kenton R. Miller,* Keeping Options Alive: The Scientific Basis for Conserving Biodiversity *(Washington, DC: World Resources Institute, 1989), Figure 5, p. 24.*

chains, and similar product specification became part of production contracts between farmer and buyer-processor. In the United States, the percentage of total farm output produced under contractual arrangements or by vertical integration has risen dramatically. For example, the vast majority of hogs are sold under some form of contract today while in 1980 only 5 percent were sold that way. The term *agribusiness* is applied to the growing merging of the older, farm-centered crop economy and newer patterns of more integrated production and marketing systems.

Contract farming is spreading as well to developing countries, though it is often criticized as another adverse expression of globalization subjecting small farmers to exploitation by powerful Western agribusiness. The FAO, however, argues that well-managed contract arrangements are effective in linking the small farmers of emerging economies with both foreign and local sources of advanced advice, seeds, fertilizers, machinery, and profitable markets at stable prices. The agency cites successful examples of contract farming in northern India, Sri Lanka, Nepal, Indonesia, Thailand, and the Philippines and sees in the arrangements a most promising approach to market-oriented production in areas still dominated by subsistence agriculture.

Even for family farmers not bound by contractual arrangements to suppliers and purchasers, the older assumption that supply, demand, and the market price mechanism are the effective controls on agricultural production is not wholly valid. In reality, those theoretical controls are joined by a number of nonmarket governmental influences that may be as decisive as market forces in shaping farmers' options and spatial production patterns. If there is a glut of wheat on the market, for example, the price per ton will come down, and the area sown to it should diminish. It will also diminish regardless of supply if governments, responding to economic or political considerations, impose acreage controls.

Distortions of market control may also be introduced to favor certain crops or commodities through subsidies, price supports, market protections, and the like. The political power of farmers in the EU, for example, secured for them generous subsidies. European farm supports are seen as necessary to protect farmers from price volatility and low prices brought about by increasing global yields. In Japan, the home market for rice is largely protected and reserved for Japanese rice farmers, even though their production efficiencies are low and their selling price is high by world market standards. In the United States, programs of farm price supports, ethanol subsidies, acreage controls, financial assistance, and other governmental involvements in agriculture have been of recurring and equally distorting effect (**Figure 8.13**).

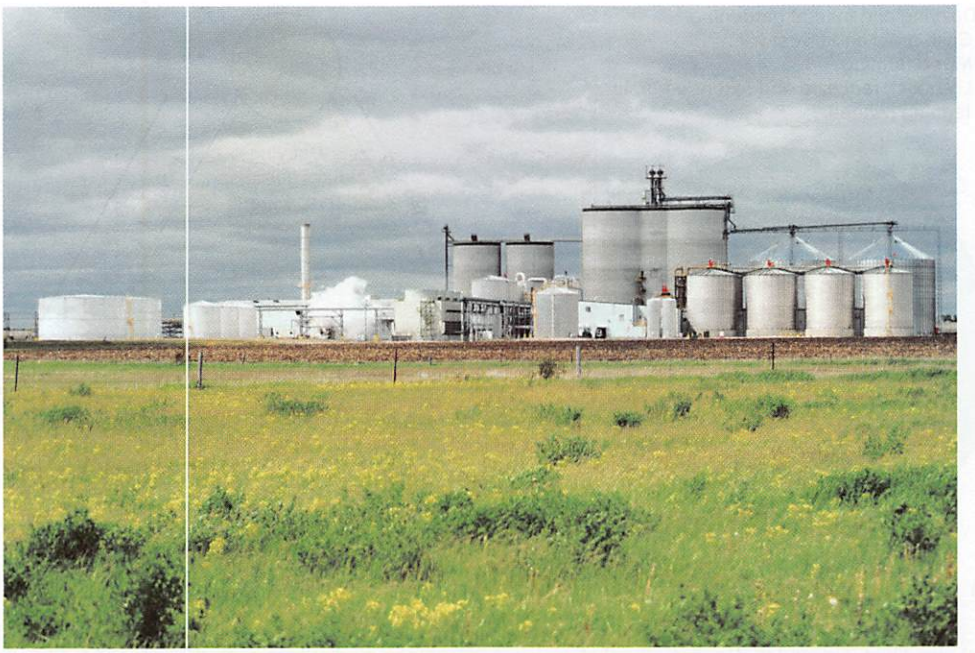

Figure 8.13 Ethanol plants have expanded throughout the Corn Belt. Federal subsidies for growers and mandates for blending ethanol into gasoline have bolstered the corn ethanol industry. Critics decry the heavy subsidies and the use of food crops for transportation fuel.

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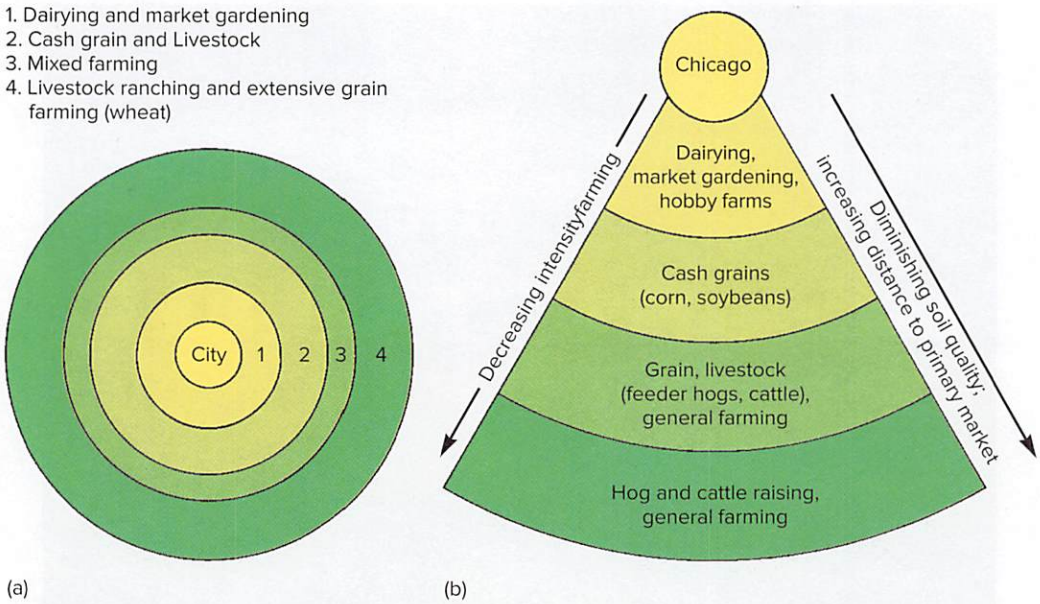
A Model of Agricultural Location

Early in the 19th century, before such governmental influences were the norm, Johann Heinrich von Thünen (1783–1850) observed that uniformly fertile areas of farmland were used differently. Around each major urban market center, he noted, there developed a set of concentric land-use rings of different farm products (**Figure 8.14**). The ring closest to the market featured intensive agriculture producing heavy, bulky, or perishable commodities that were both expensive to ship and in high demand. The high prices that they could command in the urban market made their production an appropriate use of high-value land near the city. Surrounding rings of farmlands farther away from the city were used for less perishable commodities with lower transport costs, reduced demand, and lower market prices. Less intensive farming such as grain farming replaced the **market gardening** of the inner ring. At the outer margins of profitable agriculture, farthest from the single central market, livestock ranching and similar extensive land uses were found. After all, transport costs were low for livestock in von Thünen's day because cattle could walk to market.

To explain this pattern of concentric rings of activity, von Thünen constructed a formal spatial model—the **von Thünen model**—perhaps the first one developed to analyze human activity patterns. He concluded that the uses to which parcels were put was a function of the differing "rent" values placed on seemingly identical lands. Those differences, he claimed, reflected the costs transporting farm products to the central market town ("A portion of each crop is eaten by the wheels," he observed). The greater the distance, the higher the cost to the farmer, because transport charges had to be added to other expenses. When a commodity's production costs plus its transport costs just equaled its value at market, a farmer was at the economic margin of its cultivation. A simple trade-off emerged: the greater the transportation costs, the lower the rent that could be paid for land.

Because in the simplest form of the model, transport costs are the only variable, the relationship between land rent and distance from market can be easily calculated by reference to each competing crop's *transport gradient.* Perishable, bulky, or heavy commodities such as dairy products, fruits, vegetables, and bedding plant and tree nurseries would encounter high transport rates per unit of distance; other items, such as grain, would have lower rates. Land rent for any farm commodity decreases with increasing distance from the central market, and the rate of decline is determined by the transport gradient for that commodity. Crops that have both the highest market price and the highest transport costs will be grown nearest to the market. Less perishable crops with lower production and transport costs will be grown at greater distances from the market (**Figure 8.15**). Because in this model, transport costs are uniform in all directions away from the center, a concentric zonal pattern of land use called the *von Thünen rings* results.

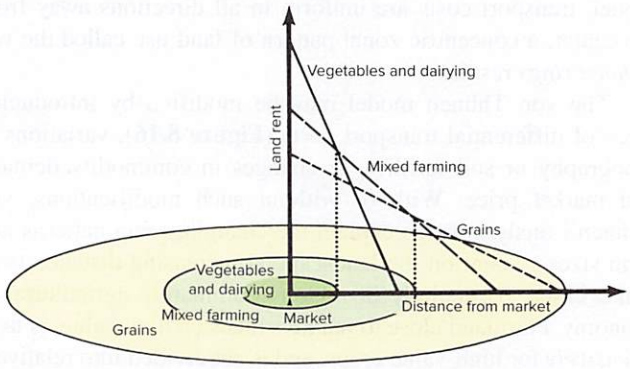
The von Thünen model may be modified by introducing ideas of differential transport costs (**Figure 8.16**), variations in topography or soil fertility, or changes in commodity demand and market price. With or without such modifications, von Thünen's analysis helps explain the changing crop patterns and farm sizes evident on the landscape at increasing distance from major cities, particularly in regions dominantly agricultural in economy. Farmland close to markets takes on high value, is used *intensively* for high-value crops, and is subdivided into relatively small units. Land far from markets is used *extensively* and in larger units.



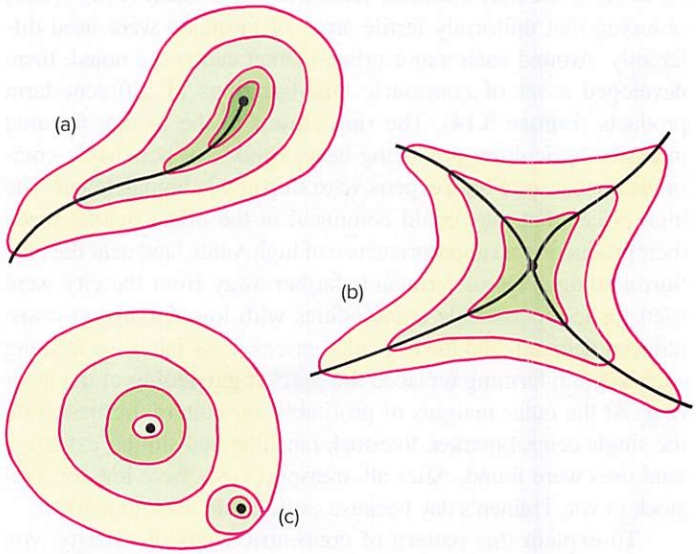
AP Figure 8.14 (*a*) von Thünen's model. Recognizing that as distance from the market increases, the value of land decreases, von Thünen developed a descriptive model of intensity of land use that holds up reasonably well in practice. The most intensively produced crops are found on land close to the market; the less intensively produced commodities are located at more distant points. The zones of the diagram represent modern equivalents of the land-use sequence von Thünen suggested in the 1820s. As the metropolitan area at the center increases in size, the agricultural specialty areas are displaced outward, but the relative position of each is retained. Compare this diagram with Figure 8.17. (*b*) This schematic view applies the model to the agricultural zones in the sector south of Chicago. There, farmland quality decreases southward as the boundary of recent glaciation is passed and hill lands are encountered in southern Illinois. On the margins of the city near the market, dairying competes for space with livestock feeding and suburbanization. Southward into flat, fertile central Illinois, cash grains dominate. In southern Illinois, livestock rearing and fattening and general farming are the rule.

Source: (b) Modified from Bernd Andreae, Farming Development and Space: A World Agricultural Geography, *translated by Howard F. Gregor (Berlin; Hawthorne, N.Y.: Walter de Gruyter and Co., 1981).*

Historian and geographer William Cronon uses the von Thünen model to help explain the frontier stages during the settlement of the American West. Starting in Chicago, the center of the U.S. agricultural economy, a westward traveler would first encounter a zone of intensively farmed dairies, market gardens, and orchards before reaching the corn and wheat cash grain operations of the Iowa prairie. Farther west, the traveler would reach the open range cattle ranches of the Great Plains, then a zone of trapping, hunting, and Indian trade, and beyond that lay the wilderness. Thus, the settlement of the interior of the continent and the closing of the frontier was intimately connected to the growth of cities and the expansion of urban markets for



AP Figure 8.15 Transport gradients and agricultural zones.



AP Figure 8.16 Ring modifications. Modifications of model assumptions will alter the details but not the underlying pattern of the *von Thünen rings.* For example, a growth in demand, and therefore market price of a commodity, would merely expand its ring of production. An increase in transport costs would shrink the production area, while reductions in freight rates would extend it. (*a*) If transport costs are reduced in one direction, the shape—but not the sequence—of the rings will be affected. (*b*) If several roads are constructed or improved, land-use sequences assume a star shape. (*c*) The addition of a smaller outlying market results in the emergence of a set of von Thünen rings that is subordinate to it.

produce, grain, and cattle. In industrial and postindustrial economies, the basic forces determining land use near cities are often those associated with urban expansion itself. For example, peripheral city growth, hobby farms, you-pick agritourism farms, and the withholding of land from farming in anticipation of future suburban development may locally alter the von Thünen rings. Nonetheless, we can affirm the validity of von Thünen's fundamental insights that the city and countryside are intimately connected and that the distance from the city shapes rural land values and land uses.

Intensive Commercial Agriculture

Following World War II, agriculture in the developed world's market economies turned increasingly to concentrated methods of large-scale production. Machinery, chemicals, irrigation, and dependence on a restricted range of carefully selected and bred plant varieties and animal breeds all were employed in a concerted effort to maximize efficiency and productivity on each unit of farmland.

The goal, of course, was to increase off-farm sales as American agriculture increasingly shifted from an objective of partial self-sufficiency to a total commitment to the commercial, exchange economy. Prior to 1950, most U.S. farms had a significant subsistence orientation; they were *general farms* growing a variety of crops, some for sale and some for feed for farmstead livestock—a milk cow or two, chickens for the pot and for household eggs, and a few hogs and steers, partly for farm slaughter and use. Their extensive kitchen gardens supplied vegetables and fruits for farm family seasonal consumption and home canning. In 1949, the average American farm sold only $4,100 worth of products. By 2012, however, most farms had a full commitment to the market, average off-farm sales rose to $187,000, and farm families—like other Americans—shopped at supermarkets for their food needs. With the increases in capital investment and the need for larger farms to maximize return on that investment, many inefficient small farms have been abandoned. Consolidation has reduced the number and enlarged the size of farms still in production. To stay in business, many operations have had to expand by factors of 10 or 100, whether measured in crop acreage of number of livestock. From a high of 6.8 million in 1934, the number of U.S. farms dropped to 5.7 million in 1949 and to 2.1 million by 2012, with many of the smallest units counting as "farms" only because of a generous Department of Agriculture definition.

The reorientation of farm production goals in the United States and in most other highly developed market economies has led to significant changes in regional farm production patterns. Reflecting the drive for enhanced, more specialized output and the investment of large amounts of capital (for machinery, fertilizers, and specialized buildings, for example), all modern agriculture is *intensive*. But the several types of farm specializations differ in how much capital is invested per hectare of farmed land (and, of course, in the specifics of those capital inputs). Those differences underlie generalized distinctions between traditional intensive and extensive commercial agriculture.

The term **intensive commercial agriculture** is now usually understood to refer specifically to the production of crops that give high yields and high market value per unit of land. These include fruits, vegetables, bedding plants for urban gardens, and dairy products, all of which are highly perishable, as well as some "factory farm" production of livestock. Dairy farms and **truck farms** (horticultural or "market garden" farms that produce a wide range of vegetables and fruits) are found near most medium-size and large cities. Because the product is perishable, transport costs increase because of the special handling that is needed, such as the use of refrigerated trucks and custom packaging. Note the distribution of truck and fruit farming in **Figure 8.17**, which also suggests the importance of climatic conditions in commercial fruit and vegetable growing.

Feed grain and livestock farming involves the growing of grain on a producing farm to be fed to livestock, which constitute the farm's cash product. In Western Europe, three-fourths of cropland is devoted to production for animal consumption; in Denmark, 90 percent of all grains are fed to livestock for conversion not only into meat but also into butter, cheese, and milk. Although livestock-grain farmers work their land intensively, the value of their product per unit of land is usually less than that of the truck farm. Consequently, in North America at least, feed grains and livestock farms are centered in the Midwest, farther from the main markets than are horticultural and dairy farms.

Normally, the profits for marketing livestock (chiefly hogs and beef cattle in the United States) are greater per pound than those for selling corn or other feed, such as alfalfa and clover. As a result, farmers convert their corn into meat on the farm by feeding it to the livestock, efficiently avoiding the cost of buying grain. They may also convert farm grain at local feed mills to the more balanced feed modern livestock rearing requires. Where land is too expensive to be used to grow feed, especially near cities, feed must be shipped to the farm. The grain-livestock belts of the world are close to the great coastal and industrial zone markets. The Corn Belt of the United States and the livestock region of Western Europe are two examples.

In the United States—and commonly in all developed countries—the traditional feed grains and livestock operations of small and family farms have been largely supplanted by very-large-scale concentrated animal feeding operations or *livestock factory farms* involving thousands or tens of thousands of closely quartered animals. From its inception in the 1920s, the intensive, industrialized rearing of livestock, particularly beef and dairy cattle, hogs, and poultry, has grown to dominate meat, dairy, and egg production. To achieve their objective of producing a marketable product in volume at the lowest possible unit cost, operators of livestock factory farms confine animals to pens or cages, treat them with antibiotics and vitamins to maintain health and speed growth, provide processed feeds that often contain the low-cost animal by-products or crop residue, and deliver them under contract to processors, packers, or their parent company (**Figure 8.18**). Although serious concerns have been voiced about animal waste management and groundwater, stream, and atmospheric pollution, contract-based concentrated

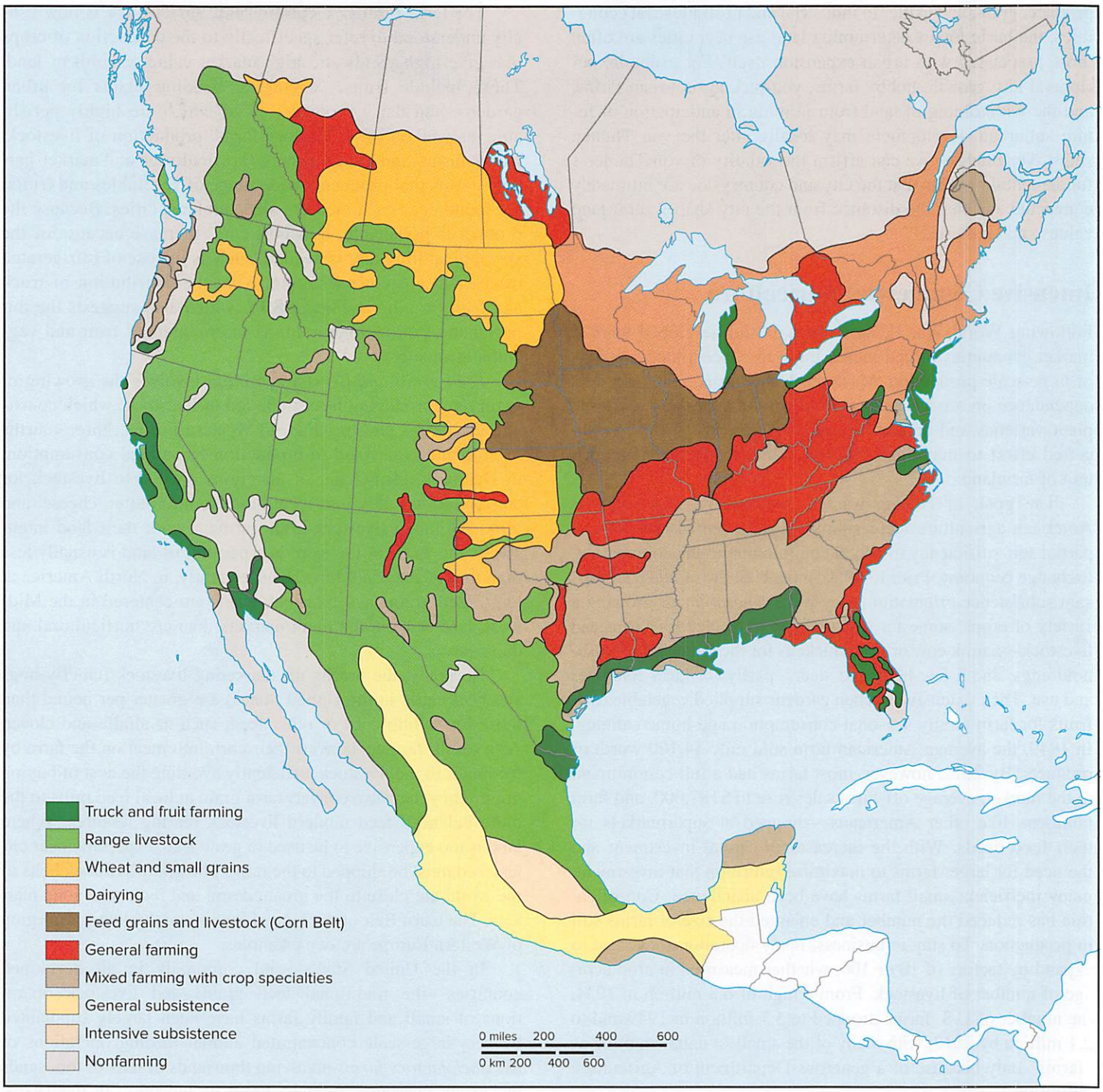


Figure 8.17 Generalized agricultural regions of North America.

Sources: U.S. Bureau of Agricultural Economics; Agriculture Canada; and Secretaría de Agricultura y Recursos Hidráulicos, Mexico.

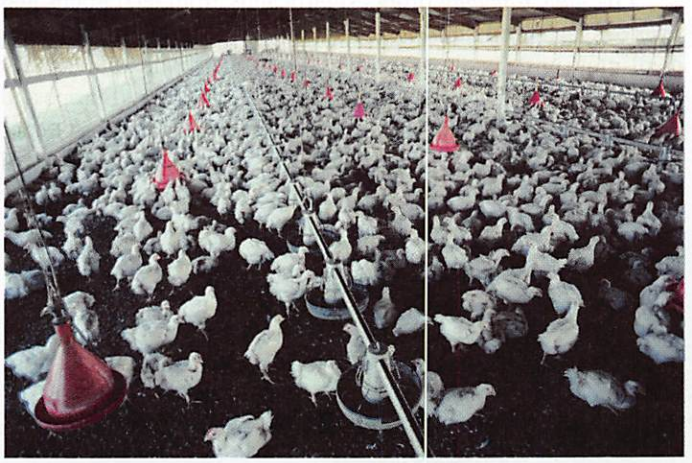
feeding operations now provide almost all supermarket meat and dairy products. The location of this form of intensive commercial farming, however, is often determined not by land value or proximity to market, but by land-use restrictions and environmental standards imposed by state and county governments.

Extensive Commercial Agriculture

Farther from the market, on less expensive land, there is less need to use the land intensively. Cheaper land and lower profits per unit of land leads to larger farm units. **Extensive commercial agriculture** is typified by large wheat farms and livestock ranching.

There are, of course, limits to the land-use explanations attributable to von Thünen's model. Although it is true that farmland values decline westward with increasing distance from the northeastern market of the United States, they show no corresponding increase with increasing proximity to the massive West Coast market region until the specialty agricultural areas of the coastal states themselves are reached. The western states are characterized by extensive agriculture, but as a consequence of environmental, not distance, considerations. Climatic conditions obviously affect the productivity and the potential agricultural use of an area, as do soils and topography. In North America, of course, increasing distance westward from eastern markets happens to be associated with increasing aridity and the beginning of mountainous terrain. In general, rough terrain and dry climates, rather than simple distance from market, underlie the widespread occurrence of extensive agriculture.

Large-scale wheat farming requires sizable capital inputs for planting and harvesting machinery—a large tractor might cost $300,000 and a combine (harvester) $500,000. However, the inputs per unit of land are low; and wheat farms are very large. Nearly half the farms in Saskatchewan, for example, are more than 400 hectares (1,000 acres). The average farm in Kansas is larger than 300 hectares (740 acres), and in North Dakota, more than 525 hectares (1,300 acres). In North America, the spring wheat (planted in spring, harvested in autumn) region includes the Dakotas, eastern Montana, and the southern parts of the Prairie provinces of Canada. The winter wheat (planted in fall, harvested in midsummer) belt centers on Kansas and includes adjacent sections of neighboring states (**Figure 8.19**). Argentina is the only South American country to have comparable large-scale wheat farming. In the Eastern Hemisphere, the system is fully developed only east of the Volga River in northern Kazakhstan and the southern part of western Siberia, and in southeastern



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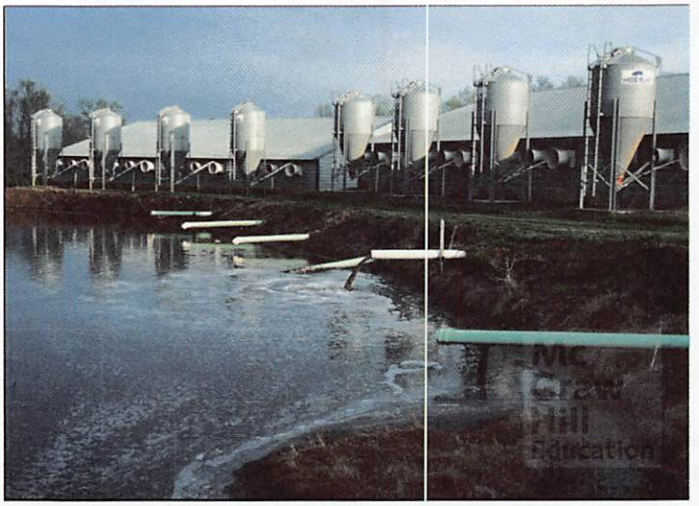

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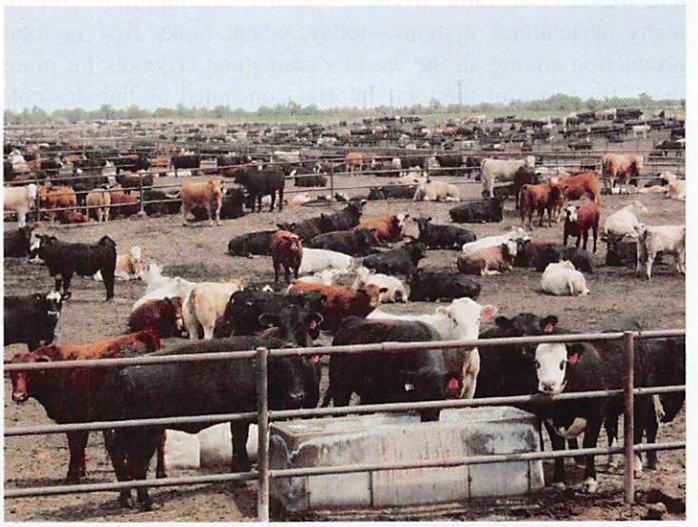

(c)

Figure 8.18 Industrial poultry and livestock farming is an example of intensive commercial agriculture. (*a*) Most of the chicken consumed in developed countries comes from factory-style poultry farms such as this. Thousands of broiler chickens are raised together in a single barn for about 45 days before slaughtering. (*b*) On this hog farm in Georgia, 900 animals are fed and raised indoors in large rectangular barns for the four or five months that it takes them to grow to market weight. Animal manure is collected in lagoons. (*c*) Large cattle feedlot operations supply much of the country's beef supply.

(a) ©Digital Vision./Photodisc/Getty Images; (b) Source: Jeff Vanuga, USDA Natural Resources Conservation Service; (c) ©Cathryn Dowd

Figure 8.19 Contract harvesters follow the ripening wheat northward through the plains of the United States and Canada.
©Glow Images

and western Australia. Because wheat is an important crop in many agricultural systems—today, wheat ranks first in total production among all the world's grains and accounts for more than 20 percent of the total calories consumed by humans collectively—it is a truly global commodity, bought and sold internationally (**Figure 8.20**).

Livestock ranching differs significantly from feed grains and livestock farming and, by its commercial orientation, from the nomadism it superficially resembles. A product of the 19th-century growth of urban markets for beef and wool in Western Europe and the northeastern United States, ranching has been primarily confined to areas of European settlement. It is found in the western

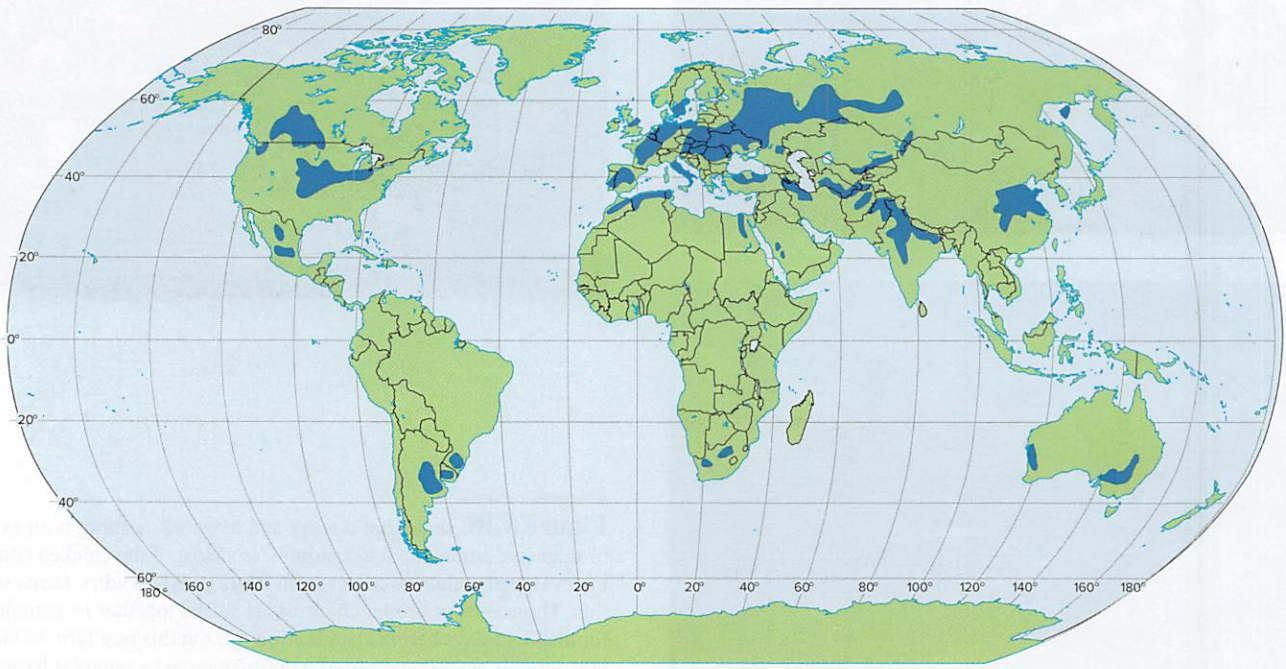

Figure 8.20 Principal wheat-growing areas. Only part of the world's wheat production comes from large-scale farming enterprises. In western and southern Europe, eastern and southern Asia, and North Africa, wheat growing is part of general or intensive subsistence farming. Recently, developing country successes with the Green Revolution and subsidized surpluses of the grain in Europe have altered traditional patterns of production and world trade in wheat.

United States and adjacent sections of Mexico and Canada (see the range livestock region on Figure 8.17); the grasslands of Argentina, Brazil, Uruguay, and Venezuela; the interior of Australia; the uplands of South Island, New Zealand; and the Karoo and adjacent areas of South Africa (**Figure 8.21**). All except New Zealand and the humid pampas of South America have semiarid climates. All these areas, even the most remote from markets, were a product of improvements in transportation by land and sea, refrigerated train cars and trucks, and meat-canning technology.

In all of the ranching regions, livestock range has been reduced as crop farming has encroached on their more humid margins, and as feedlots have supplemented traditional grazing. Recently, the growing global demand for beef has been blamed for expanded cattle ranching and extensive destruction of tropical rain forests in Central America and the Amazon Basin, although in recent years, Amazon Basin deforestation has reflected the expansion of soybean farming more than beef production.

In areas of livestock ranching, young cattle or sheep are allowed to graze over thousands of acres. In the United States, when the cattle have gained enough weight so that weight loss in shipping will not be a problem, they are sent to feed grain livestock farms or to feedlots near slaughterhouses for accelerated fattening. Because ranching can be an economic activity only where alternative land uses are nonexistent and land quality is low, ranching regions of the world characteristically have low population densities, low capital investment per land unit, and relatively low labor requirements.

Special Crops

Under special circumstances, usually related to unique physical geography, some places far from markets may become intensively developed agricultural areas. Two special cases are Mediterranean agriculture and plantation agriculture (Figure 8.21).

Most of the arable land in the Mediterranean basin itself is planted to grains, and much of the agricultural area is used for grazing. **Mediterranean agriculture** as a specialized farming economy, however, is known for grapes, olives, oranges, figs, vegetables, and similar commodities. These crops need warm temperatures year round and a great deal of sunshine in the summer. The Mediterranean agricultural lands indicated in Figure 8.21 are among the most productive in the world. Farmers benefit from a predictable climate with few storms or severe weather problems. Also, the precipitation pattern of Mediterranean climates—winter rains and dry summers—lends itself to the controlled use of water. Of course, much capital must be spent for the irrigation systems. This is another reason for the intensive use of the land for high-value crops that are, for the most part, destined for export to industrialized countries or areas outside the Mediterranean climatic zone and even, in the case of Southern Hemisphere locations, to markets north of the equator.

Climate is also considered the vital element in the production of what are commonly known as *plantation crops*. **Plantation agriculture** involves the introduction of foreign investment, management, and marketing into an indigenous culture and economy, often employing a nonnative labor force to produce an introduced

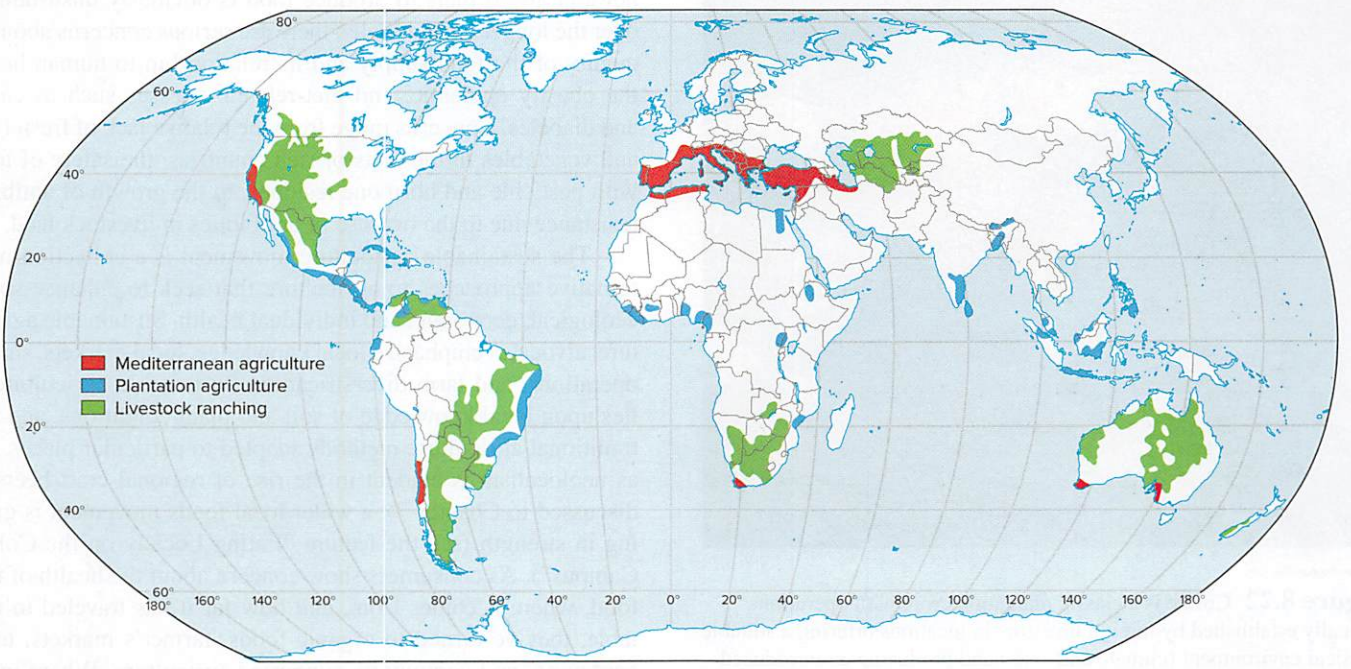

Figure 8.21 Livestock ranching and special crop agriculture. Livestock ranching is primarily a midlatitude enterprise catering to the urban markets of industrialized countries. Mediterranean and plantation agriculture are similarly oriented to the markets provided by advanced economies of Western Europe and North America. Areas of Mediterranean agriculture—all of roughly comparable climatic conditions—specialize in similar commodities, such as grapes, oranges, olives, peaches, and vegetables. The specialized crops of plantation agriculture are influenced by both physical geographic conditions and present or, particularly, former colonial control of the area.

crop for foreign markets. The plantation itself is an estate whose resident workers produce one or two specialized export crops. Those crops, although native to the tropics, were frequently foreign to the areas of plantation establishment: African coffee and Asian sugar in the Western Hemisphere and American cacao, tobacco, and rubber in Southeast Asia and Africa are examples (**Figure 8.22**). Plantation developers from Western countries such as Britain, France, the Netherlands, and the United States became interested in the tropics partly because the climate allowed them to produce agricultural commodities that could not be grown at home. Custom and convenience usually retain the term *plantation* even where native producers of local crops dominate, as they do in cola nut production in Guinea, spice growing in India or Sri Lanka, or sisal production in the Yucatán.

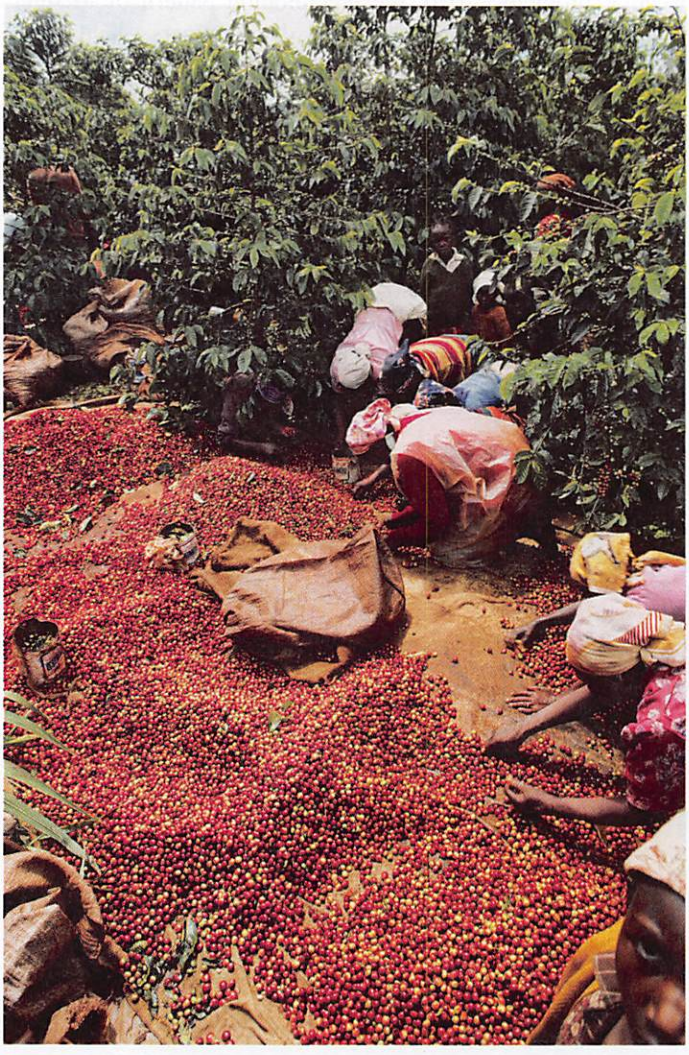

Figure 8.22 Coffee is a classic plantation crop, with operations typically established by foreign investors in locations offering a suitable physical environment (climate and soils) and producing an introduced crop for export to distant foreign market. While coffee was first domesticated in Africa, it is grown in many tropical countries, mostly for export to developed countries in the midlatitudes. Note that the female laborers on this Kenyan coffee plantation are still responsible for child care even as they work in the fields.

The major plantation crops and the areas where they are produced include tea (India and Sri Lanka), jute (India and Bangladesh), rubber (Malaysia and Indonesia), cacao (Ghana and Nigeria), cane sugar (Cuba and the Caribbean area, Brazil, Mexico, India, and the Philippines), coffee (Brazil and Colombia), and bananas (Central America). As Figure 8.21 suggests, for ease of access to shipping, most plantation crops are cultivated along or near coasts because production for export rather than for local consumption is the rule.

Sustainable Agriculture

The adoption of large-scale, highly industrialized commercial agriculture has increased overall agricultural productivity and benefited successful farmers and agribusinesses. But it has not come without significant costs. The negative effects of industrialized agriculture on the health of rural communities, ecosystems, and food systems have convinced many of the need for a more sustainable mode of agriculture. As farms have grown larger and replaced human labor with machinery, the population involved in farming has dramatically declined. This has led to depopulation of rural areas and struggles to maintain the institutions and basic services necessary for a high quality of life. Industrialized agriculture relies upon heavy inputs of fertilizers, pesticides, and herbicides, each of which has had a negative effect on rural populations, wildlife, surface waterways, and coastal systems that receive agricultural runoff (for more, see Chapter 13). Industrialized agriculture relies on large quantities of fossil fuels to fuel the machinery, manufacture petrochemical-based fertilizers, and distribute the food around the world. Heavy reliance on nonrenewable fossil fuels to produce food is obviously unsustainable over the longer term. Finally, there are serious concerns about the quality of the food supply and its relationship to human health, the obesity epidemic, and diet-related diseases such as cancer and diabetes. Concerns range from the relative lack of fresh fruits and vegetables in the diets of rich countries, the safety of foods with pesticide and hormone residues, to the growth of antibiotic resistance due to the overuse of antibiotics in livestock feed.

The sustainable agriculture movement is a collection of alternative approaches to agriculture that seek to enhance social, ecological, economic, and individual health. Sustainable agriculture advocates emphasize local knowledge, local markets, smaller operations, and farm diversification. Sustainable agriculture relies upon local knowledge of soil and plant conditions, and uses traditional agriculture methods adapted to particular places. Just as neolocalism is evident in the rise of regional craft beers (as discussed in Chapter 7), a wider local foods movement is growing in strength (see the feature "Eating Locally on the College Campus"). As consumers show concern about the health of their food, where it comes from, and how far it has traveled to their table, they've turned to organic foods, farmer's markets, urban gardening, and community-supported agriculture. Where industrial agriculture creates monocultures and specialized producers, sustainable agriculture advocates believe in farm diversification and biodiversity. They argue that a region with many smaller producers growing many different crops and raising different livestock is more resilient and creates a healthier local economy and

Eating Locally on the College Campus

Stereotypes associate college life with a diet of fast food hamburgers and greasy pizza. However, many college students are starting to pay close attention to their food choices. They are asking where their food comes from and how it affects human health, animal welfare, and the environment. Some are even getting involved in producing their own food in campus gardens.

Several Midwestern colleges and universities have made commitments to growing more of their own food. A couple of generations ago, many of their students came from farms and had experience with fieldwork, milking cows, gathering eggs, butchering chickens, gardening, and canning. Back then, farms were small, nonspecialized general farming operations. Today, cash grain farmers plant thousands of hectares of just two crops—corn and soybeans. Livestock farmers raise thousands of hogs, turkeys, or chickens and dairies may house thousands of milk cows. Although the Midwest is among the most productive of agricultural landscapes, very little is produced for direct local consumption. Meat and milk are shipped to distant markets, soybeans are refined for industrial processes, and corn goes to animal feed, to Asian or European markets, or to produce ethanol fuel. And no longer do Midwest colleges and universities get their students from farms or supply their cafeterias from local farms. Instead, the students come from cities and suburbs, and cafeteria food is delivered by large refrigerated trucks.

At Calvin University in Grand Rapids, Michigan, the dining services has altered menus to incorporate the abundant greens produced by the campus farm. Students also collect and process hundreds of bottles of maple syrup from campus trees as well as collecting honey from bee hives located in the campus farm.

At Gustavus Adolphus College in Saint Peter, Minnesota, the Big Hill Farm grew out of an undergraduate senior project and is an important piece in the college's commitment to environmental sustainability. The college supports the farm with land, tillage equipment, and paid summer student internships. A grant paid for a greenhouse, which extends the short Minnesota growing season. The farm and the student dining service have a mutually beneficial relationship. Food waste from the dining service is composted and used as fertilizer and soil amendment on the farm, while the farm produces lettuce, tomatoes, peppers, beans, onions, melons, pumpkins, berries, and much more for the cafeteria. Where possible, the farm uses rare heirloom seed varieties to promote crop diversity. Extra produce is sold at the local farmer's market. Students are now eating healthier, locally grown food, and the college is reducing its impact on the environment. Students who work on the farm learn lifetime skills and describe their labors as both exhausting and deeply rewarding.

Figure 8A Student workers at the Calvin University campus farm.
Courtesy of Alicia De Jong

environment. In many ways, sustainable agriculture is a return to methods of agriculture that were widely used prior to World War II, Thus, critics question whether sustainable agriculture will be able to maintain the productivity gains of industrial agriculture and feed the world's growing population.

8.3 Primary Activities: Resource Exploitation

In addition to agriculture, primary economic activities include fishing, forestry, and the mining and quarrying of minerals. These industries involve the direct exploitation of natural resources that are unequally distributed in the environment.

Fishing, forestry, and fur trapping are **gathering industries** based on harvesting the natural bounty of renewable resources that can easily be depleted through overexploitation. Livelihoods based on these resources are areally widespread and involve both subsistence and market-oriented components. Mining and quarrying are **extractive industries,** removing nonrenewable metallic and nonmetallic minerals, including the mineral fuels, from the Earth's crust. They are the initial raw material phase of modern industrial economies.

Resource Terminology

Resources or **natural resources** are the naturally occurring materials that a society perceives to be useful to its economic and material well-being. Their occurrence and spatial distribution

are the result of physical processes over which people have little or no direct control. The fact that things exist, however, does not mean that they are resources. To be considered such, a given substance must be *understood* to be a resource—and this is a cultural, not purely a physical, circumstance. Native Americans may have viewed the resource base of Pennsylvania, West Virginia, or Kentucky as composed of forests for shelter and fuel and as the habitat of the game animals (another resource) on which they depended for food. European settlers viewed the forests as the unwanted covering of the resource that *they* perceived to be of value: soil for agriculture. Still later, industrialists appraised the underlying coal deposits, ignored or unrecognized as a resource by earlier occupants, as the item of value for exploitation (**Figure 8.23**).

Resources may be classified as *renewable* or *nonrenewable*. **Renewable resources** are materials or energy sources that are replenished by natural processes. The sun's energy, wind, water, food crops, soils, forests, fish, and animals are renewable resources. Even renewable resources can be exhausted if exploited to extinction or destruction. Soil can be eroded or its fertility destroyed, and an animal species may be driven to extinction. That is, some resources are renewable only if carefully managed. The **maximum sustainable yield** of a resource is the maximum rate of use that will not impair its ability to be renewed or to maintain the same future productivity. For fishing and forestry, for example, that level is marked by a catch or harvest equal to the net growth of the replacement stock. If that maximum exploitation level is exceeded, the renewable resource becomes a nonrenewable one—an outcome increasingly likely in the case of Atlantic cod and some other food fish species. **Nonrenewable resources** exist in finite amounts or are generated in nature so slowly that for all practical purposes, their supply is finite.

Figure 8.23 Resources are defined by a culture's values and perceptions. The indigenous population treated this forested West Virginia landscape as a prime hunting area. The original hardwood forest covering these hills were removed by European American settlers who saw greater resource value in the underlying soils. The soils, in turn, were selectively stripped away for access to the still more valuable coal deposits below. Future generations may value this landscape more for its beauty and recreational opportunities.

Fishing

Although fish and shellfish account for just 17 percent of all human consumption of animal protein, an estimated 1 billion people—primarily in developing countries of eastern and southeastern Asia, Africa, and parts of Latin America—depend on fish as their primary source of protein. Fish are also very important in the diets of most advanced states, both those with and those without major domestic fishing fleets. Globally, the average person consumes 20 kg (44 pounds) of fish per year. Although most of the world annual fish harvest is consumed by humans, up to one-fifth is processed into fish meal to be fed to livestock or used as fertilizer. Those two quite different markets have increased both the demand for and the annual harvest of fish. Indeed, so rapidly have demand pressures on the world's fish stocks expanded that evidence is unmistakable that at least locally, their *maximum sustainable yield* is being exceeded.

The annual fish supply comes from three sources:

- The *inland catch,* from ponds, lakes, and rivers
- *Fish farming (or aquaculture),* in which fish are produced in a controlled and contained environment
- The *marine catch,* all wild fish harvested in coastal waters or on the high seas

The inland catch supplies a modest fraction of the global fish catch, while fish farming continues to grow, producing about half of the world's fish harvest. While the world's ocean catch is still the most important source of fish, its annual harvest has been stable or declining since the late 1980s (**Figure 8.24**). Most of the marine catch is made in coastal wetlands, estuaries, and the relatively shallow coastal waters above the *continental shelf*—the gently sloping extension of submerged land bordering most coastlines and reaching seaward for varying distances up to 150 kilometers (about 100 miles) or more. Near shore, shallow embayments and marshes provide spawning grounds, and river waters supply nutrients to an environment highly productive of fish. Increasingly, these areas are also seriously affected by pollution from runoff and ocean dumping, an environmental assault so devastating in some areas that fish and shellfish stocks have been destroyed, with little hope of revival.

Commercial marine fishing is largely concentrated in northern waters, where warm and cold currents join and mix and where such familiar food species as herring, cod, mackerel, haddock, and flounder congregate or *school* on the broad continental shelves and *banks*—extensive elevated portions of the shelf where environmental conditions are most favorable for fish production (**Figure 8.25**). Two of the most heavily fished regions are the Northeast Pacific and Northwest Atlantic. Tropical fish species tend not to school and, because of their high oil content and unfamiliarity, are less acceptable in the commercial market. They are, however, of great importance for local consumption. Only a very small percentage of total marine catch comes from the open seas that make up more than 90 percent of the world's oceans.

Modern technology and more aggressive fishing fleets from more countries greatly increased annual marine capture in the years after 1950. That technology included use of sonar, radar, helicopters, and satellite communications to locate schools of fish;

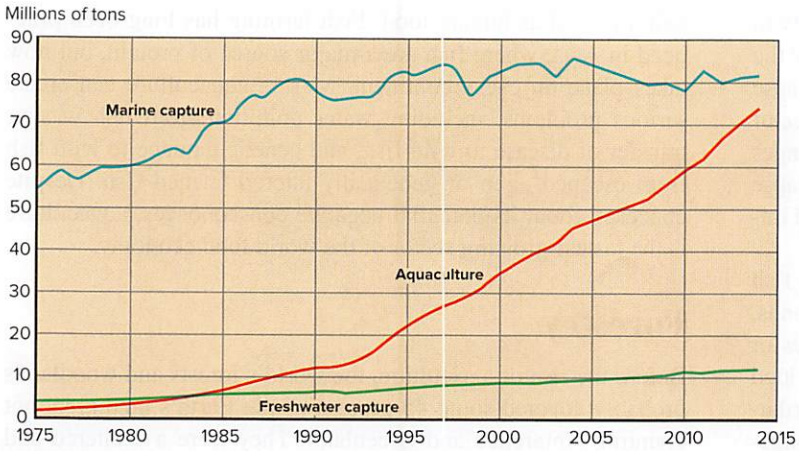

Figure 8.24 Officially recorded annual fish harvests, 1975–2014. The marine catch shows evidence of overfishing, while aquaculture continues its rapid growth. The FAO estimates that 20 to 40 million tons per year of unintended marine capture of juvenile or undersized fish and nontarget species are discarded each year.

Source: Food and Agriculture Organization (FAO).

more efficient nets and tackle; and factory trawlers to follow fishing fleets to prepare and freeze the catch. In addition, more nations granted ever-larger subsidies to expand and reward their marine trawler operations. The rapid rate of increase led to inflated projections of the continuing or growing productivity of fisheries and to optimism that the resources of the oceans were inexhaustible.

Quite the opposite has proved to be true, however. In fact, in recent years, the productivity of marine fisheries has been stagnant because *overfishing* (catches above reproduction rates) and pollution of coastal waters have seriously endangered the supplies of traditional and desirable food species. The United Nations reports that about one-third of wild fish stocks are being overfished. The plundering of U.S. and Canadian coastal waters has imperiled a number of the most desirable fish species; in 1993, Canada shut down its cod industry to allow stocks to recover, and U.S. authorities report that 67 North American species are overfished and 61 harvested to capacity.

Overfishing is partly the result of the accepted view that the world's oceans are common property, a resource open to anyone's use with no one responsible for its maintenance, protection, or improvement. The result of this "open seas" principle is but one expression of the so-called **tragedy of the commons**[1]—the economic reality that when a resource is available to all, each user, in the absence of collective controls, thinks he or she is best served by exploiting the resource to the maximum even though this exploitation means its eventual depletion. In 1995, more than 100 countries adopted a treaty—that became legally binding in 2001—to regulate fishing on the open oceans outside territorial waters. Applying to such species as cod, pollock, and tuna—that is, to migratory and high-seas species—the treaty requires fishermen to report the size of their catches to regional organizations that would set quotas and subject vessels to boarding to check for violations. These and other fishing control

[1]The *commons* refers to undivided land available for the use of everyone; usually, it meant the open land of a village that all used as pasture. The Boston Common, for instance, originally had this function.

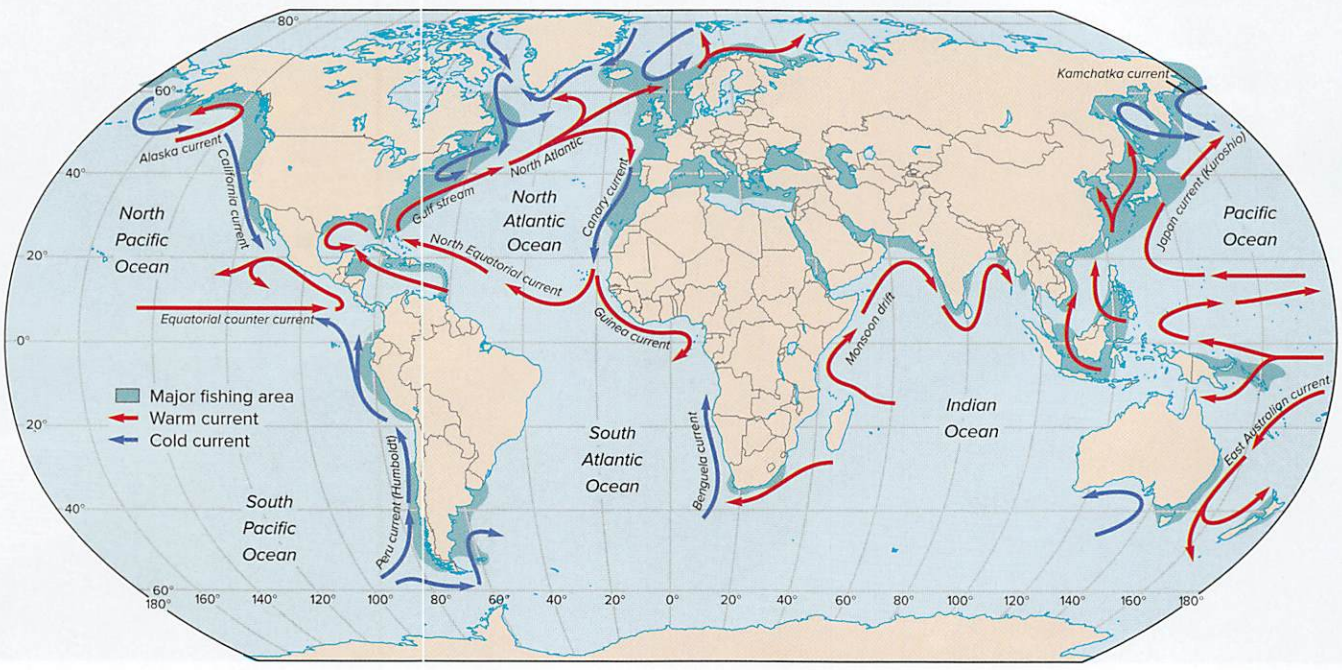

Figure 8.25 The major commercial marine fisheries of the world. The waters within 325 kilometers (200 miles) of the U.S. coastline account for almost one-fifth of the world's annual fish and shellfish harvests. Overfishing, urban development, hydroelectric dams that block access to spawning grounds, and the contamination of bays, estuaries, and wetlands have contributed to the depletion of the fish stocks in those coastal waters.

measures could provide the framework for future sustainability in the fishing industry, although they appear to be too late to save the cod fishery on the Atlantic Coast of Canada. There, the collapse of large fish stocks in the 1990s and the virtual disappearance of cod, haddock, flounder, and hake has induced ecological changes that may prevent the fishery from ever recovering. The collapse of the Atlantic cod fishery caused the loss of 40,000 jobs and immense economic hardship in Canada's Maritime provinces.

One approach to increasing the fish supply is through fish farming or **aquaculture,** the breeding of fish in freshwater ponds, lakes, and canals or in fenced-off coastal bays and estuaries or enclosures (**Figure 8.26**). Aquaculture production has provided nearly half of the total fish harvest in recent years; its contribution to the human food supply is even greater than raw production figures suggest. Whereas one-third of the conventional fish catch is used to make fish meal and fish oil, virtually all farmed fish are used as human food. Fish farming has long been practiced in Asia, where fish are a major source of protein, but now takes place on every continent. Marine aquaculture can create serious problems, including water pollution from fish wastes, transfer of disease to wild fish, and genetic damage to wild fish from escaped alien or genetically altered farmed fish. Despite concerns about its potential negative consequences, aquaculture is the fastest-growing sector of the world food economy.

Forestry

Before the rise of agriculture, the world's forests and woodlands probably covered some 45 percent of the Earth's land area, not counting Antarctica and Greenland. They were a sheltered and productive environment for earlier societies that subsisted on gathered fruits, nuts, berries, leaves, roots, and fibers collected

Figure 8.26 Production of fish, scallops, oysters and other seafood through aquaculture is one of the fastest-growing sectors in world food production. Floating aquaculture platforms, such as these in Japan, are often operated near coastlines where they can contribute to water pollution.
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from trees and woody plants. Few such cultures still exist, although the gathering of forest products remain an important supplemental activity, particularly among subsistence agricultural societies.

Even after millennia of land clearance for agriculture and, more recently, commercial lumbering, cattle ranching, and fuel-wood gathering, forests still cover roughly 30 percent of the world's land area, not counting Greenland and Antarctica. As an industrial raw material source, however, forests are more restricted in area. Although forests of some type reach discontinuously from the equator northward to beyond the Arctic Circle and southward to the tips of the southern continents, *commercial forests* are restricted to two very large global belts. One, nearly continuous, is found in upper-middle latitudes of the Northern Hemisphere; the other is located in the equatorial zones of South and Central America, Central Africa, and Southeast Asia (**Figure 8.27**). These forest belts differ in the types of trees they contain and in the type of market and uses that they serve.

The northern coniferous, or softwood, forest is the largest and most continuous stand, extending around the globe from Scandinavia across Siberia to North America, then eastward to the Atlantic and southward along the Pacific Coast. The pine, spruce, fir, and other conifers are used for construction lumber and to produce pulp for paper, rayon, and other cellulose products. On the south side of the northern midlatitude forest region are the deciduous hardwoods: oak, hickory, maple, birch, and the like. These, as well as the trees of the mixed forest lying between the hardwood and softwood belts, have been greatly reduced in areal extent by centuries of agricultural and urban settlement and development. In both Europe and North America, however, their area has been held constant through conservation, protection, and reforestation. They still are commercially important for hardwood applications: furniture, veneers, railroad ties, and the like. The tropical lowland hardwood forests are exploited primarily for fuelwood and charcoal, although an increasing quantity of special-quality woods are cut for export as lumber. In fact, developing countries in the tropics account for most of the world's hardwood log exports (**Figure 8.28**).

The uses of forests differ significantly between developed and developing countries. In developed countries, trees are primarily cut for various wood product industries, including paper, packaging, personal care products (toilet paper), construction, and furniture. The global leaders in producing forest products are the United States, Canada, China, and Russia. Chiefly because of their distance from major industrial wood markets, the developing countries other than China have seen only limited of industrial wood production. The logic of von Thünen's analysis of transportation costs and market accessibility helps explain the pattern. In developing countries, the primary uses of forests are fuelwood and charcoal. Growing populations that depend upon fuelwood and charcoal for energy place pressure on tropical forest stands. For decades, fuelwood gathering was blamed for tropical deforestation. However, recent evidence suggests that fuelwood gathering is not a major source of forest loss and the real problem is forest conversion to agriculture and forest fires, which may be increasing due to climate change. Rates of deforestation are highest in Africa, Asia, and South America, while Europe and North America have seen an increase in forested area. Deforestation in Brazil's Amazon basin has been well-publicized, but policies to protect the rainforest have dramatically reduced the rates of forest loss since 2000.

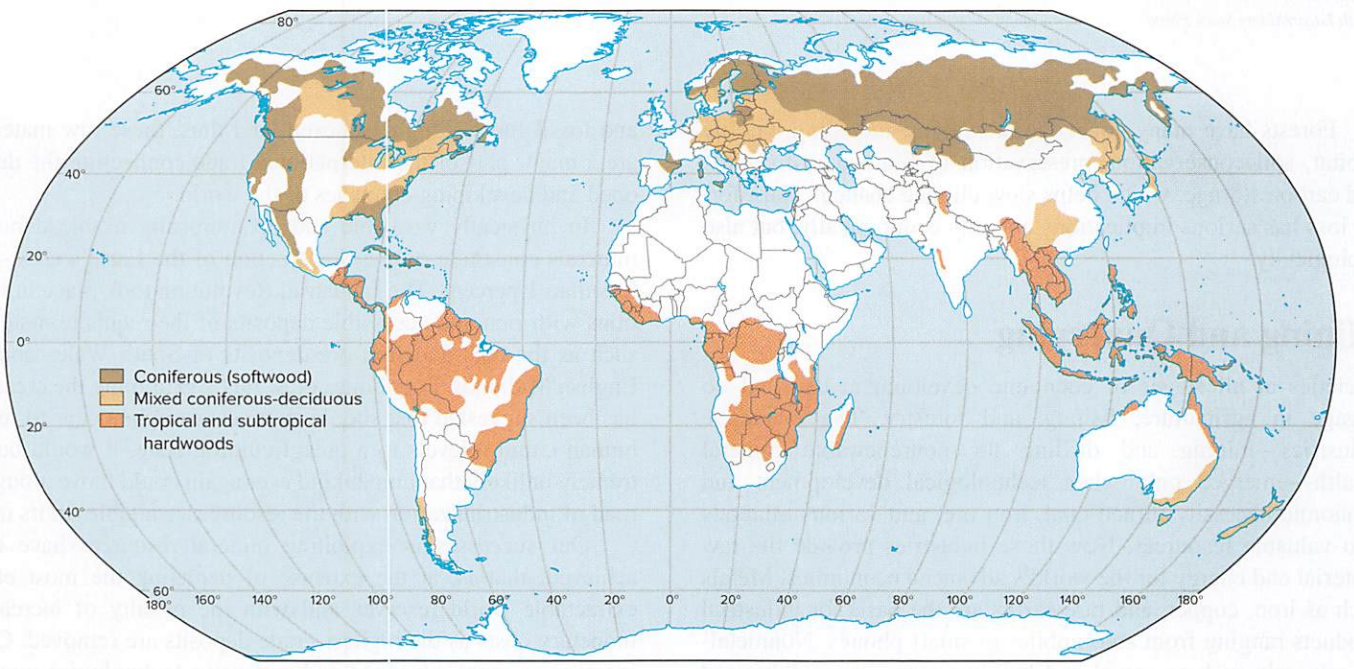

Figure 8.27 Major commercial forest regions. Much of the original forest, particularly in midlatitude regions, has been cut over. Many treed landscapes that remain do not contain commercial stands. Significant portions of the northern forest are not readily accessible and at current prices cannot be considered commercial. Deforestation of tropical hardwood stands involves more clearing for agriculture and firewood than for roundwood production.

Figure 8.28 Loading tropical hardwood lumber for export from Congo.
©Seth Lazar/Alamy Stock Photo

Forests have many noneconomic values, including wildlife habitat, soil conservation, preservation of biological diversity, and carbon storage, which helps slow climate change. Thus, forest loss has serious implications not only economically, but also ecologically.

Mining and Quarrying

Societies at all stages of economic development can and do engage in agriculture, fishing, and forestry. The extractive industries—mining and drilling for nonrenewable mineral wealth—emerged only when technological development and economic necessity turned coal, iron ore, and various minerals into valuable resources. Now those industries provide the raw material and energy for the world's advanced economies. Metals such as iron, copper, and rare earths are the basis for industrial products ranging from automobiles to smart phones. Nonmetallic minerals such as gravel and building stone are widely used in construction, and fossil fuels have provided the energy riches that have made possible the high standards of living in developing countries. The geographic distribution of mineral resources and fossil fuels is highly uneven, and thus, these raw materials are a major part of the international trade connecting the developed and developing countries of the world.

In physically workable and economically usable deposits, minerals constitute only a tiny fraction of the Earth's crust—far less than 1 percent. The Industrial Revolution took place in locations with rich and accessible deposits of the requisite materials such as the coal and iron ore deposits of South Wales and the English Midlands. Economies grew fat by skimming the cream. It has been suggested that should some catastrophe occur to return human cultural levels to a preagricultural state, it would be extremely unlikely that humankind ever again could move along the road of industrialization with the resources available for its use.

Our successes in exploiting mineral resources have been achieved, that is, at the expense of depleting the most easily extractable world reserves and with the penalty of increasing monetary costs as the highest-grade deposits are removed. Costs increase as more advanced and expensive technologies must be applied to extract the desired materials from ever-greater depths in the Earth's crust or from new deposits of lower mineral content. While the Earth's nonrenewable resources are indeed finite,

the exact quantity available depends upon both available technology and prices. In fact, as a consequence of advances in exploration and extraction technologies, known reserves of all fossil fuels and of most commercially important metals are now larger than they were in the middle of the 20th century. **Usable reserves,** also known as proved reserves, are those deposits that can be recovered with reasonable certainty, assuming existing economic and operating conditions (**Figure 8.29**). Usable reserves are not the same as the ultimate crustal limit of a resource. For example, between 1987 and 2010, proved oil reserves increased from 0.91 trillion barrels of oil to 1.38 trillion barrels, despite heavy petroleum consumption—reflecting continued exploration, technological improvements, and price changes. That increasing abundance of at least nonfuel resources is reflected in the steady decrease in raw material prices since the 1950s that has so adversely affected some export-oriented developing world economies.

Metals

Because usable mineral deposits are the result of geological processes, it follows that the larger the country, the more probable it is that such past processes will have occurred within their national territory. And in fact, Russia, Canada, China, the United States, Brazil, and Australia possess abundant and diverse mineral resources. It is also true, however, that many smaller, developing countries are major sources of one or more critical raw materials and therefore become important participants in the growing international trade in minerals.

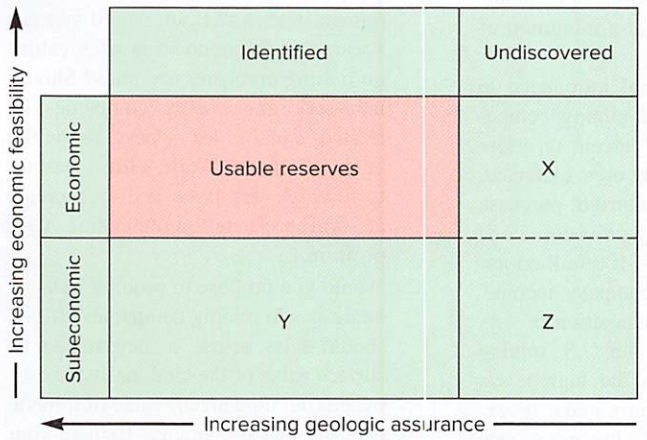

Figure 8.29 The variable definition of reserves. Assume that the large rectangle includes the total world stock of a particular resource. Some deposits of that resource have been discovered and are shown in the left column as "identified." Deposits not yet known are "undiscovered reserves." Deposits that are economically recoverable with current technology are at the top of the diagram. Those below, labeled "subeconomic" reserves, are not attractive for any of several reasons of mineral content, accessibility, cost of extraction, and so on. Only the pink area can be properly referred to as usable reserves. These are deposits that have been identified and can be recovered at current prices and with current technology. *X* denotes reserves that would be attractive economically but are not yet discovered; identified but not economically attractive reserves are labeled *Y;* and *Z* represents undiscovered deposits that would not be attractive now even if they were known.

Source: U.S. Geological Survey.

The production of most metallic minerals, such as copper, lead, and iron ore, is affected by a balance of three forces: the quantity available, the richness of the ore, and the distance to market. A fourth factor, land acquisition and royalty costs, may equal or exceed other considerations in mine development decisions (see the feature "Public Land, Private Profit"). Even if these conditions are favorable, mines may not be developed or even remain operating if supplies from competing sources are more cheaply available in the market. In the 1980s, more than 25 million tons of iron ore–producing capacity was permanently shut down in the United States and Canada. Similar declines occurred in North American copper, nickel, zinc, lead, and molybdenum mining as market prices fell below domestic production costs. Beginning in the early 1990s, as a result of both resource depletion and low cost imports, the United States became a net importer of nonfuel minerals for the first time. Of course, increases in mineral prices may be reflected in opening or reopening mines that, at lower returns, were deemed unprofitable. However, the developed industrial countries of market economies, whatever their former or even present mineral endowment, find themselves at a competitive disadvantage against producers in developing countries with lower-cost labor and state-owned mines with abundant, rich reserves.

When the ore is rich in metallic content (in the case of iron and aluminum ores), it is profitable to ship it directly to the market for refining. Of course, the highest-grade ores tend to be mined first. Consequently, the demand for low-grade ores has been increasing in recent years as richer deposits have been depleted (**Figure 8.30**). Low-grade ores are often upgraded by various types of separation treatments at the mine site to avoid the cost of transporting waste materials not wanted at the market. Concentration of copper is nearly always mine-oriented (**Figure 8.31**); refining takes place near areas of consumption. The large amount of waste in copper (98 percent to 99 percent or more of the ore) and in most other industrially significant ores should not be considered the mark of an unattractive deposit. Indeed, the opposite

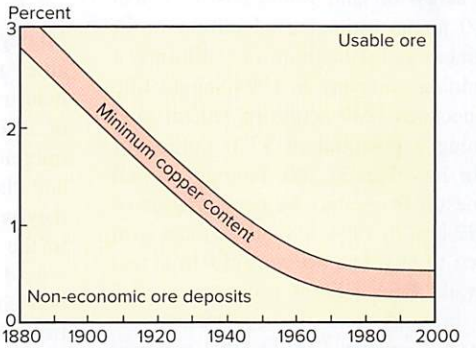

Figure 8.30 Minimum metal content of copper ore for profitable mining. In 1830, 3 percent copper ore in rock was needed to justify its mining; today, rock with 0.5 percent ore content is mined. As the supply of a metal decreases and its price increases, the concentration needed for economic recovery goes down. It also goes down as improved and more cost-effective technologies of rock mining and ore extraction come into play.

Source: Data from the U.S. Bureau of Mines.

AP Geography and Citizenship

Private Land, Private Profit

When U.S. president Ulysses S. Grant signed the Mining Act of 1872, the presidential and congressional goal was to encourage western settlement and development by allowing any "hard-rock" miners (including prospectors for silver, gold, copper, and other metals) to mine federally owned land without royalty payment. It further permitted mining companies to gain clear title to publicly owned land and all subsurface minerals for no more than $12 a hectare ($5 an acre). Under those liberal provisions, mining firms have bought 1.3 million hectares (3.2 million acres) of federal land since 1872; and each year, they remove some $1.2 billion worth of minerals from government property. In contrast to the royalty-free extraction privileges granted to metal miners, oil, gas, and coal companies pay royalties of as much as 12.5 percent of their gross revenues for exploiting federal lands.

Whatever the merits of the 1872 law in encouraging economic development of lands otherwise unattractive to homesteaders, modern-day mining companies throughout the western states have secured enormous actual and potential profits from the law's generous provisions. In Montana, a company claim to 810 hectares (2,000 acres) of land would cost less than $10,000 for an estimated $4 billion worth of platinum and palladium; in California, a gold mining company in 1994 sought title to 93 hectares (230 acres) of federal land containing a potential of $320 million of gold for less than $1,200. Foreign as well as domestic firms may be beneficiaries of the 1872 law. In 1994, a South African firm arranged to buy 411 hectares (1,016 acres) of Nevada land with a prospective $1.1 billion in gold from the government for $5,100. A Canadian firm in 1994 received title to 800 hectares (nearly 2,000 acres) near Elko, Nevada, that cover a likely $10 billion worth of gold—a transfer that Interior Secretary Bruce Babbitt dubbed "the biggest gold heist since the days of Butch Cassidy." And in 1995, Babbitt conveyed about $1 billion worth of travertine (a mineral used in whitening paper) under 45 hectares (110 acres) of Idaho to a Danish-owned company for $275.

The "gold heist" characterization summarized a growing administration and congressional feeling that what was good in 1872 and today for metal mining companies was not necessarily beneficial to the American public that really owns the land. In part, that feeling results from the fact that mining companies commit environmental sins that require public funding to repair or public tolerance to accept. The mining firms may destroy whole mountains to gain access to low-grade ores and leave toxic mine tailings, surface water contamination, and open-pit scarring of the landscape as they move on or disappear. Projected public cleanup costs of more than 500,000 abandoned mine sites, thousands of miles of damaged or dead streams, and several billion tons of contaminated waste are estimated at a minimum of $35 billion.

A congressional proposal introduced in 1993 would have required mining companies to pay royalties of 8 percent on gross revenues for all hard-rock ores extracted, and prohibited them from outright purchase of federal land. The royalty provision alone would have yielded nearly $100 million annually at 1994 levels of company income. Mining firms claim that imposition of royalties might well destroy the U.S. mining industry. They stress both the high levels of investment that they must make to extract and process frequently low-grade ores and the large number of high-wage jobs they provide as their sufficient contribution to the nation. The Canadian company involved in the Elko site, for example, reports that since it acquired the claims in 1987 from their previous owner, it has expended more than $1 billion and also has made donations for town sewer lines and schools and created 1,700 jobs. The American Mining Congress estimates the proposed 8 percent royalty charge would cost 47,000 jobs out of the 140,000 that exist today, and even the U.S. Bureau of Mines assumes a loss of 1,100 jobs.

Public resistance to Western mining activities is taking its toll. State and federal regulatory procedures, many dragging on for a decade or more, have discouraged opening new mines; newly enacted environmental regulations restricting current mining operations (for example, banning the use of cyanide in gold and silver refining) reduce their economic viability. In consequence, both investment and employment in U.S. mining is in a steady decline, eroding the economic base of many Western communities.

Thinking Geographically

1. Should the Mining Act of 1872 should be repealed or amended? If not, what are your reasons that the law should remain in effect? If so, would you advocate for the imposition of royalties on mining company revenues? Should hard-rock and energy companies be treated equally for access to public land resources? Work with a partner to research this issue and then create an oral presentation defending your position.
2. Would you propose to prohibit outright land sales to mining companies? If not, should sales prices be determined by surface value of the land, or by the estimated (but unrealized) value of mineral deposits that it contains? Explain your reasoning.
3. Are cleanup and other charges now borne by the public acceptable given the capital investments and jobs created by mining companies? Do you accept the industry's claim that imposing royalties would destroy American metal mining? Why or why not? Defend your position in a one-page essay.

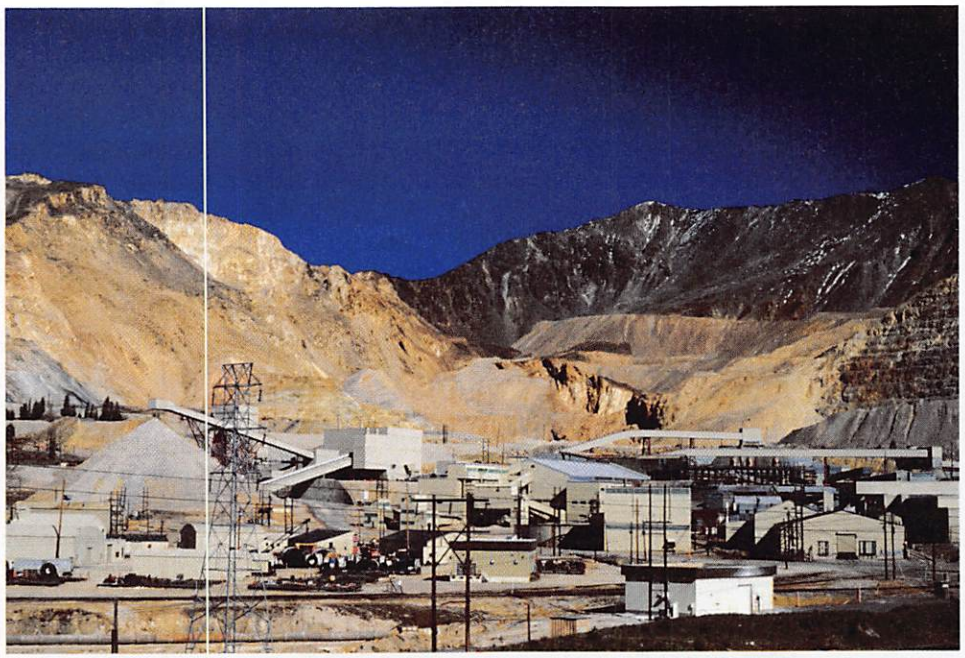

Figure 8.31 Molybdenum mine and concentrating mill at the open pit mine in Climax, Colorado. Concentrating mills crush the ore, separating molybdenum-bearing material from the rocky mass containing it. The great volume of waste removed ensures that most concentrating operations are found near the ore bodies. Because concentrating is a "weight-reducing" process, it saves transportation costs to locate it close to the mine.

may be true. Because of the cost of extraction or the smallness of the reserves, many higher-content ores are left unexploited in favor of the use of large deposits of even very-low-grade ore. The attraction of the latter is a size of reserve sufficient to justify the long-term commitment of development capital and, simultaneously, to ensure a long-term source of supply.

At one time, high-grade magnetite iron ore was mined and shipped from the Iron Range of northeastern Minnesota. Those deposits are now exhausted. However, immense amounts of capital have been invested in the processing of the virtually unlimited quantities of low-grade iron-bearing rock (taconite) into high-grade iron ore pellets. Naturally, such processing of low-grade deposits takes place at the mine site. Large investments do not guarantee the profitable exploitation of the resource. The metals market is highly volatile. Rapidly and widely fluctuating prices can change profitable mining and refining ventures to losing undertakings very quickly. Marginal gold and silver deposits are opened or closed in response to trends in precious metals prices. Taconite processing in the Lake Superior region nearly ceased as the U.S. steel industry declined, but it has restarted in recent years in response to overseas market demand. In capitalist economies, cost and market controls dominate economic decisions. In planned economies, cost may be a less important consideration than other concerns, such as national development and resource independence.

Nonmetallic Minerals

From the standpoint of volume and weight of material removed, the extraction of nonmetallic materials is the most important branch of the extractive industries. The minerals mined are usually classified by their end use. Of widest distribution, greatest use, and least long-distance movement are those used for *construction:* sand and gravel, building stone, and the gypsum and limestone that are the ingredients of cement. Transportation costs play a large role in determining where low-value minerals will be mined. Minerals such as gravel, limestone for cement, and aggregate are found in such abundance that they have value only when they are near the site where they are to be used. For example, gravel for road building has value if it is at or near the road-building project, not otherwise. Transporting gravel hundreds of miles is an unprofitable activity (**Figure 8.32**). For example, while the United States imports 100 percent of its rare earths, it produces 99 percent of its own crushed stone.

The mined *fertilizer* minerals include potash and phosphate, which move in international trade because of their unequal distribution and market value. *Precious* and *semiprecious* stones are also important in the economy of some countries, including the rich diamond deposits of several central African countries and Sri Lanka's gemstones.

Fossil Fuels

The advanced economies have gotten the way they are through their control and use of energy. By using external energy sources, humans can perform tasks beyond the wildest dreams of our human ancestors. This is largely because fossil fuels are incredibly energy-dense. One 42-gallon (166 liter) barrel of oil contains the energy equivalent of 50,000 person-hours of labor. Compare how far $10 of gasoline will take you in an automobile versus how far you could get paying your friends to push that automobile down

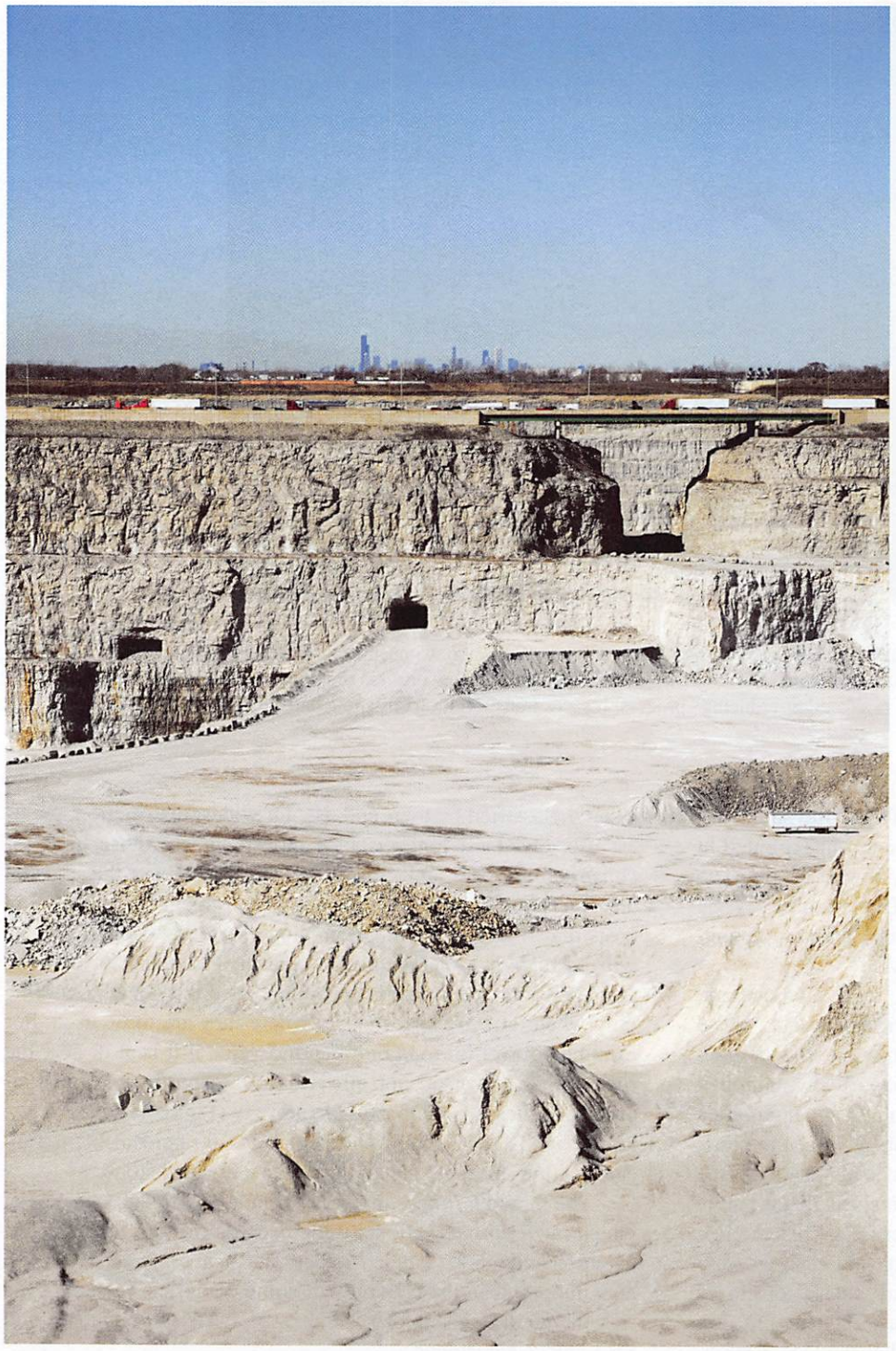

Figure 8.32 The Thornton quarry south of Chicago, depicted here with the city skyline in the distance, is one of the largest aggregate quarries in the world. It produces crushed limestone rock for road base and concrete mixes. Proximity to the market is necessary for low-value nonmetallic minerals unable to bear high transportation costs.

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the road. While slavery made a few rich by harnessing the forced labor of many, fossil fuels can make many "rich" by harnessing fossil fuel energy—at least while prices stay low. Energy consumption goes hand in hand with industrial production and with increases in personal wealth. In general, the greater the level of energy consumption, the higher the gross national income per capita. Further, the application of energy can allow us to transform low-value raw materials into valuable commodities. High-quality iron ore may be depleted, but by massive applications of energy, the iron contained in rocks of very low iron content, such as taconite, can be concentrated for industrial uses.

Because of the close relationship between energy use and economic development, a basic disparity between societies is made clear. Countries that can afford high levels of energy consumption through production or purchase continue to expand their economies and to increase their levels of living. Those without access to energy or those unable to afford it are left behind.

Except for the brief and localized importance of waterpower at the outset of the Industrial Revolution, modern economic advancement has been heavily dependent on the *fossil fuels:* coal, oil, and natural gas. These nonrenewable energy sources represent the capture of the sun's energy by plants and animals in earlier geologic time and its storage in the form of hydrocarbon compounds in sedimentary rocks within the Earth's crust.

Coal was the earliest in importance and is still the most plentiful of the fossil fuels. As the first major industrial energy source, nearby coal deposits were essential to early manufacturing development, as we shall see in Chapter 9. Although coal is a nonrenewable resource, world supplies are so great—on the order of 1.1 trillion metric tons—that its resource life expectancy is measured in centuries, not in the much shorter time scales cited for oil and natural gas. Worldwide, the most extensive deposits are concentrated in the industrialized middle latitudes of the Northern Hemisphere (Table 8.2). China is the world's largest coal producer, responsible for 46 percent of the world production in 2016. The United States is a distant second, contributing 10 percent of world coal production in 2016.

Coal is not a resource of constant quality, varying in *rank* (a measure—from lignite to anthracite—of increasing carbon content and fuel quality) and *grade* (a measure of its waste material content, particularly ash and sulfur). The value of a coal deposit depends on these measures and on its accessibility, which is a function of the thickness, depth, and continuity of the coal seam. Much coal can be mined relatively cheaply by open-pit (surface) techniques,

Table 8.2

Proved Petroleum, Natural Gas, and Coal Reserves, January 1, 2017

	Share of World Total Petroleum (%)	Share of World Total Natural Gas (%)	Share of World Total Coal (%)
North America[a]	13.3	6.0	22.8
Europe and Central Asia	9.5	30.4	28.3
Of which: Russian Federation	6.4	17.3	14.1
Central and South America	19.2	4.1	1.2
Africa	7.5	7.6	1.2
Middle East[b]	47.7	42.5	0.1
Australia	0.2	1.9	12.7
Japan	–.–	–.–	–.–
China	1.5	2.9	21.4
Other Asia Oceania	1.1	5.0	12.4
Total World	100.0	100.0	100.0
Of which OPEC[c]	71.5	NA	NA

[a]Includes Canada, Mexico, United States

[b]Middle East includes the Arabian Peninsula, Iran, Iraq, Israel, Jordan, Lebanon, and Syria.

[c]OPEC: Organization of Petroleum Exporting Countries. Member nations are, by world region:

South America: Venezuela

Middle East: Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and United Arab Emirates (Abu Dhabi, Dubai, Ras-al-Khaimah, and Sharjah)

North Africa: Algeria and Libya

West Africa: Nigeria

Asia Pacific: Indonesia

Source: *Data from the BP Amoco,* Statistical Review of World Energy, *2017.*

in which huge shovels strip off surface material and remove the exposed coal (see Figure 13.17). Much coal, however, is available only by expensive and more dangerous shaft mining, as in Appalachia, China, and most of Europe. In spite of their generally lower heating value, western U.S. coals are attractive because of their low sulfur content. They do, however, require expensive transportation to market or high-cost transmission lines if they are used to generate electricity for distant consumers (**Figure 8.33**).

Oil, first extracted commercially in the 1860s in both the United States and Azerbaijan, became a major power source, raw material for the chemical industry, and favorite transportation fuel. It is used as a raw material for a number of important industries, from plastics to fertilizers. However, its supplies are limited, and it is unlikely to retain its present position of importance in the world energy market.

Estimating how much oil (or natural gas) remains in the world and how long it will last is the subject of heated debate. Given the world economy's dependence on petroleum, the stakes are undeniably high. Some experts subscribe to *peak oil theory*, which is based on the work of American geologist M. King Hubbert. Hubbert began by showing that the rate of oil pumped from a single well over time followed a symmetrical bell curve, rising, peaking, and finally declining. He also noted that the same bell curve applied to the total production from an entire wellfield or an entire country. By knowing the shape of the rising portion of the curve, one can predict the timing of the peak and the inevitable decline that will follow. Peak oil theorists warn that once the world reaches peak oil production, the inevitable decline in production will cause shortages and skyrocketing prices. Estimates of when the world economy would hit peak oil undergo regular revision. Optimists are encouraged by new horizontal drilling techniques and deep sea drilling that have opened up large new oilfields in North Dakota and the Gulf of Mexico. They also point to a steady drop in the price of solar and other alternative energy sources, which they believe will reduce oil demand long before supply becomes an issue. In a different form of assessment, British Petroleum reported that the world had 1.7 trillion barrels of proven oil reserves at the end of 2016—enough to last for 51 years at the 2016 rate of extraction.

Figure 8.33 Long-distance transportation to eastern markets adds significantly to the cost of the low-sulfur western coal useful in meeting federal environmental protection standards. To minimize these costs, unit trains carrying only coal engage in a continuous shuttle movement between western strip mines and eastern utility companies.

Petroleum is among the most unevenly distributed of the major resources (Table 8.2). A total of 80 percent of proved oil reserves are concentrated in just eight countries: Saudi Arabia, Venezuela, Canada, Iran, Iraq, Kuwait, United Arab Emirates, and the Russian Federation. The underlying role of petroleum in geopolitics and military conflicts over the past 30 years is undeniable. The distribution of petroleum supplies differs markedly from that of the coal deposits on which the urban-industrial markets developed, but the substitution of petroleum for coal did little to alter earlier patterns of manufacturing and population concentration. Because oil is easier and cheaper to transport than coal, it was moved in enormous amounts to the existing centers of consumption via intricate and extensive national and international systems of transportation, a textbook example of spatial interaction, complementarity, and transferability (see Chapter 3, particularly Figure 3.2).

Natural gas has been called the nearly perfect energy resource. It is a highly efficient, versatile fuel that requires little processing, and its emissions do not contribute to urban air pollution or acid precipitation, although they do contain carbon dioxide. Geologists estimate that world recoverable gas reserves are sufficient to last another 50 years at current levels of consumption. New discoveries in the United States, such as the Marcellus Shale formation deep under New York, Ohio, Pennsylvania, and West Virginia, are drawing public attention to the rich possibilities of natural gas extraction, as well as the potential negative effects. *Ultimately recoverable reserves,* those that may be found and recovered at much higher prices, might last another 200 years.

As we saw for coal and petroleum, reserves of natural gas are very unevenly distributed (Table 8.2). In the case of gas, however, inequalities of supply are not so readily accommodated by massive international movements. Like oil, natural gas flows easily and cheaply by pipeline, but unlike petroleum, it does not move freely in international trade by sea. Transoceanic shipment involves costly terminal equipment for liquefaction and special vessels to contain the liquid under appropriate temperature conditions.

Where the fuel can be moved, even internationally, by pipeline, its consumption has increased dramatically. For the world as a whole, gas consumption has risen to about one-quarter of global energy consumption.

8.4 Trade in Primary Products

International trade has expanded rapidly since the end of World War II, increasing more than eightfold since 1980. Primary commodities—agricultural goods and fuels—contribute significantly to the total dollar value of those international flows. During much of the first half of the 20th century, the world distribution of supply and demand for those items in general resulted in a colonial pattern of commodity flow: from raw-material producers located within less-developed countries to processors, manufacturers, and consumers of the more developed ones (**Figure 8.34**). The reverse flow carried manufactured goods from the industrialized states for sale to the developing countries. That two-way trade benefited the developed states by providing access to a continuing supply of industrial raw materials and foods not available domestically, as well as markets for their manufactured goods. While the two-way exchange gave less-developed countries some capital to invest in their own development and to purchase imports, they lagged behind in industrialization.

Today, however, world trade flows and export patterns of the emerging economies have changed. Raw materials have greatly decreased, and manufactured goods correspondingly increased in the export flows from developing states. Even with that overall decline in raw material exports, however, trade in unprocessed goods remains dominant in the economic well-being of many of the world's poorest economies. Increasingly, the terms of the traditional trade flows on which they depend have been criticized as unequal and damaging to commodity-exporting countries.

Commodity prices are volatile; they may rise sharply in periods of product shortage or international economic growth. During much of the 1980s and 1990s, however, commodity price movements were downward, to the great detriment of material-exporting economies. Prices for agricultural raw materials, for example, dropped by 30 percent between 1975 and 2000, and those for metals and minerals decreased by almost 40 percent. Such price declines cut deeply into the export earnings of many emerging economies. Of the 141 developing countries, 91 rely on commodities for more than 60 percent of their export earnings and thus are vulnerable to commodity price volatility. Sub-Saharan African countries are particularly dependent on export earnings from a small number of mineral or agricultural commodities. For example, Burundi earned almost half of its export income through tea and coffee exports in 2015.

Whatever the current world prices of raw materials may be, raw material exporting states have long expressed resentment as a group at what they perceive as commodity price manipulation by rich countries and corporations to ensure low-cost supplies. Although collusive price-fixing has not been demonstrated, other disadvantages of being a commodity supply region are evident. Technology, for example, has provided industries in advanced countries with a vast array of materials that now substitute for the ores and metals produced by developing states. Glass fibers replace copper wire in telecommunication applications; synthetic rubber replaces natural rubber; carbon fibers are superior in performance and strength to the metals that they replace; and a vast and enlarging array of plastics are the accepted raw materials for commodities and uses for which natural rivals are not even considered. That is, even as the world industrial economy expands, demands and prices for traditional raw materials remain relatively low.

While prices paid for developing country commodities tend to be low, prices charged for the manufactured goods offered in exchange by the developed countries tend to be high. To capture processing and manufacturing profits for themselves, some developing states have placed restrictions on the export of unprocessed commodities. Malaysia, the Philippines, and Cameroon, for example, have limited the export of logs in favor of increased domestic processing of sawlogs and exports of lumber. Some developing countries have also encouraged domestic manufacturing to reduce imports and to diversify their exports. Frequently, however, such exports meet with tariffs and quotas designed to protect the home markets of the industrialized states.

In 1964, in reaction to the whole range of perceived trade inequities, developing states promoted the establishment of the United Nations Conference on Trade and Development (UNCTAD). Its central constituency—the "Group of 77," which later expanded to 130 developing states—continues to press for a new world economic order based in part on an increase in the prices and values of exports from developing countries, a system of import preferences for their manufactured goods, and a restructuring of international cooperation to stress trade promotion and recognition of the special needs of poor countries. The WTO, established in 1995 (and discussed in detail in Chapter 12) was designed in part to reduce trade barriers and inequities. It has, however, been judged by its detractors as ineffective on issues of importance to developing countries. Chief among the complaints is the continuing failure of the high-income countries to eliminate generous protections for their own agricultural and mineral industries.

In 2001, members of the WTO met in Doha, Qatar, to begin negotiations on opening world markets. Low-income, developing countries argued for the elimination of agricultural subsidies and protectionist policies in the European Union and United States. In turn, the rich economies insisted on significant concessions from poorer countries on trade in both manufactured goods and, particularly, services. The "Doha Round" of trade negotiations continued through 2008, when trade negotiations broke down. Agriculture was the primary roadblock in global trade talks. The goals of greater fairness in world trade, while maintaining special consideration for the economic development needs of poorer countries, have been elusive. The 2015 Nairobi Package included agreements to eliminate export subsidies for agricultural products, a step toward greater openness in world trade.

Figure 8.34 Sacks of cocoa beans are loaded at Tema, Ghana for overseas shipment. Much of the developing world depends on exports of primary products to the developed economies for the major portion of its income. Fluctuations in market demand and price of some of those commodities can have serious and unexpected consequences.

AP KEY WORDS

Use the terms below with a ▮ to focus your study of AP Human Geography key words in this chapter.

agriculture
aquaculture
Boserup thesis
commercial economy
▮ commodity chain
▮ deforestation
▮ desertification
economic geography
▮ extensive commercial agriculture
▮ extensive subsistence agriculture
extractive industry
gathering industry
genetically modified (GM) crops
▮ Green Revolution
▮ intensive commercial agriculture
▮ intensive subsistence agriculture
market economy
▮ market gardening
maximum sustainable yield
Mediterranean agriculture
natural resource
nomadic herding
nonrenewable resource
▮ pastoral nomadism
planned economy
▮ plantation agriculture
post–industrial
primary activity
quaternary activity
renewable resource
resource
secondary activity
service activity
▮ shifting cultivation
▮ soil salinization
subsistence economy
technology
tertiary activity
tragedy of the commons
truck farm
usable reserves
▮ von Thünen model

AP TEST PRACTICE

Multiple Choice Questions

1. **The processing of cattle into meat products, dog food, and fertilizer is**
   (A) an example of a primary economic activity that can be done on small family farms or large commercial farms.
   (B) a primary activity when done on a farm, but secondary if done in a factory.
   (C) a part of the Green Revolution that led to higher yield agriculture and fewer famines.
   (D) a secondary economic activity often done in large-scale commercial agriculture operations that are replacing family-owned farms.
   (E) an economic activity that is declining as more people become vegetarians.

2. **According to the map in Figure 8.7 on page 253, the area of the world in which agriculture makes the largest contribution to the GNP (gross national product) is**
   (A) South America.
   (B) Southeast Asia.
   (C) North America
   (D) Sub-Saharan Africa.
   (E) North Africa.

3. **The process of shifting cultivation**
   (A) is mainly done in tropical areas where large rainfall amounts deplete the soil quickly if it is used for too long.
   (B) requires farmers to rotate their crops in two or three fields to avoid soil depletion.
   (C) is a way to avoid rainforest destruction in developing countries.
   (D) is practiced by a large percentage of the world's population.
   (E) has been practiced in developed countries as part of the Green Revolution.

4. **Rice farming in China and other Asian countries**
   (A) is classified as a type of extensive agricultural production because it requires the use of so much land and water.
   (B) can be done on small family farms.
   (C) has required people to alter the landscape to increase food production.
   (D) is practiced as a type of urban subsistence farming.
   (E) has diffused to Europe and the Middle East over the course of the 19th century.

5. **The participation of women in agricultural production**
   (A) has declined due to increased educational opportunities and the movement of women into factory work.
   (B) has increased in developed countries but is very low in developing countries due to religious and cultural prohibitions against women working.
   (C) has had little effect on the lives of families in developing countries.
   (D) is extremely important since women grow over half the world's food supply.
   (E) has declined in those countries that practice intensive forms of agriculture.

6. **According to the map in Figure 8.12 on page 262, the issue of crop diversity is important because**
   (A) many varieties of crops have gone extinct in the past 100 years.
   (B) loss of diversity is particularly bad in the Mediterranean region and India.
   (C) commercial agriculture has allowed more diversity of crops than do traditional family farms.
   (D) thousands of species comprise the world's food supply today.
   (E) crop breeders require diversity to breed new varieties of crops that will be resistant to new pests and diseases.

7. **The disadvantages of livestock factory farms include all of the following EXCEPT**
   (A) the pollution of streams and groundwater due to mismanagement of animal waste.
   (B) the overuse of antibiotics and vitamins to speed growth and maintain animal health.
   (C) the production of a high volume of animal products for the least possible cost.
   (D) the confinement of animals in small enclosures.
   (E) the takeover of traditional family farms by large agribusiness.

8. **Mediterranean agriculture**
   (A) is found not only around the Mediterranean Sea but also around the Baltic and Caspian Seas.
   (B) relies heavily on wet, intensive farming methods.
   (C) consists of large plantations that grow cash crops like coffee and sugar.
   (D) is done in conjunction with truck farming to bring produce to small European markets.
   (E) is a specialized form of agriculture known for grapes, olives, oranges, and other fruits and vegetables.

9. **Aquaculture refers to**
   (A) the culture of coastal areas that revolves around the lives of fishermen and boating.
   (B) commercial deep-sea fishing operations.
   (C) the breeding of fish in freshwater ponds or in fenced off areas of bays and estuaries.
   (D) raising seaweed and other marine vegetation for human consumption.
   (E) the hunting of marine mammals for their meat and oil products.

10. **The cost of production of metallic minerals such as copper and iron is influenced by all of the following factors EXCEPT**
    (A) the amount of ore available.
    (B) the acceptance of the local population.
    (C) the richness of the resource deposit.
    (D) the distance from the site of the resource to the market.
    (E) land acquisition and royalty costs.

Free Response Questions

1. **Answer Parts A, B, and C below.**
   (A) Define the term *Green Revolution* and explain its importance to agricultural production.
   (B) Explain one demographic result and one economic result of the Green Revolution.
   (C) Explain two negative consequences of the Green Revolution.
   (A) compete with the prices of large commercial farms and are driven out of business.

2. **Answer Parts A, B, and C below.**
   (A) Describe the Von Thünen Model and explain what it is used for.
   (B) Explain one of the problems with using the Von Thünen Model.
   (C) Explain how and why the Von Thünen Model can be modified.

3. **Answer Parts A, B, and C below.**
   (A) Explain the difference between extensive and intensive subsistence agriculture.
   (B) Give one example of extensive subsistence agriculture, explaining why it is used, and one advantage or disadvantage of the practice.
   (C) Give one example of intensive subsistence agriculture, explain why it is used, and one advantage or disadvantage of the practice.