CHAPTER 11

Agriculture

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FIGURE 11.1 Hong Dong, Thailand. Hmong farmers practice shifting cultivation high on this hillside in the mountainous region of northern Thailand.

We left our hotel inside the walls of the old city of Chiang Mai early in the morning and drove west into a forested area and up a mountain to a Hmong village to a visitor site frequented by tourists. Heading into the forest on a planned six-hour hike that was described as "easy to moderate," I was happy to have two Hmong guides, two Thai hiking guides, and our two tour guides to lead our group of 20 through the forest. We quickly learned that the hike was not at all "easy," though one of our Thai hiking guides, who was in his 50s, wore flip-flops.

After a long hike up the mountain, we had a lunch of fried rice served out of banana leaves and then headed deeper into the forest toward our destination, a more remote Hmong village. We happened first upon a small cluster of about five or so houses and a dog that kept watch. Within a half-mile of the houses, we saw small plots of sugarcane, an avocado tree, and a pepper tree. We rounded a bend and looked up the hillside to where the residents of the houses were farming in the hot afternoon sun, bent over with short-handle hoes on a field readied for crop production (**Fig. 11.1**). Forest surrounded the field. Looking around, we could see a former field sitting fallow where trees were shorter than the rest of the forest. Hmong migrated to Thailand from China in the 1800s and settled in the northern hills to practice shifting cultivation, a system of crop production that has sustained them for generations and continues to do so.

In this chapter, we examine the origins of agriculture and trace the geography of changes in the production of food and the raising of livestock, from the earliest domestication of plants to contemporary developments, including genetic modification and commercial agribusiness.

CHAPTER OUTLINE

11.1 Compare and Contrast the Three Agricultural Revolutions.

Before the beginning of agriculture, people hunted, gathered, and fished for food. Then, during the First Agricultural Revolution, which occurred 10,000 years ago, farmers successfully planted and grew crops and domesticated animals. This was the beginning of agriculture. Domesticating plants and animals required effort, observation, and resiliency as early farmers learned which wild plants they could grow and what animals they could tame.

During the Second Agricultural Revolution, between the eighteenth and twentieth centuries, both population and agricultural yields increased dramatically. The Third Agricultural Revolution is better known as the Green Revolution, which focuses on genetically modifying seeds and changing land-use techniques to increase yields for a global population that is quickly multiplying.

Hunting, Gathering, and Fishing

The size of hunting and gathering clans varied according to climate, seasonal shifts, and resource availability. Communities were adept at tracking the migration cycles of fish and land animals. Using tools and fire, hunter-gatherers altered their environments to establish more reliable food supplies.

What people hunted or gathered depended on where they lived. Native Americans in the Pacific Northwest, the Ainu of Japan and coastal East Asia, and communities in coastal western Europe caught salmon as they swam up rivers and negotiated rapids and falls. Archaeologists have found huge accumulations of fish bones at Native American sites near salmon runs. In the Great Plains, Native Americans hunted bison and developed cultural festivals and rituals around the hunt. Archaeologists have found evidence of Lakotas running bison herds off cliffs called buffalo jumps. Hunters worked together to run the bison off a cliff so that they fell to their deaths (**Fig. 11.2**).

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FIGURE 11.2 Deadwood, South Dakota. Tatanka buffalo site commemorates how Lakota hunters used buffalo jumps. Lakota hunters rode on horseback to herd buffalo across the prairie and drove them off of cliffs.

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FIGURE 11.3 Aleutian Islands. This island is part of the Aleutian volcanic island chain off the coast of Alaska. Archaeologists and anthropologists are finding evidence the ancient Aleuts used the abundance of birds on the islands for food, fire kindling, and tools. The rocky islands are still covered with birds.

In the colder climates of North America, Native Americans followed the migrations of the caribou herds. Archaeologists have found hunting structures thousands of years old that First Nations in Canada used to hunt caribou. Farther north, in the coastal zone stretching from present-day Alaska to Russia, the Aleut developed specialized techniques for fishing cod and salmon and hunting whales, walrus, and seal. Archaeologists found evidence that the Aleut, whose Aleutian islands are rocky and not well-suited for agriculture, lived not only on sea life, but also on the bird populations on the islands, including puffins and gulls (**Fig. 11.3**). Aleut ate duck eggs, hunted certain species in winter, made spoons and brooms from bones, and used downy feathers for kindling in fires. (Rudebusch 2018).

Hunter-gatherers migrated to take advantage of cyclical movements of animals and to avoid exhausting the supply of edible plants in any one area. In the Pacific Northwest, after the summer salmon runs, Native Americans hunted deer during the fall and again in the spring, taking advantage of seasonal movements to trap deer where they crossed rivers or in narrow valleys. During the winter, people lived off dried meat and other stored foods. In addition to hunting game on land, hunter-gatherers harvested shellfish, trapped fish by cutting off small patches of standing water from the open sea, and invented tools to catch fish, including harpoons, hooks, and baskets.

Before developing agriculture, hunter-gatherers worked on perfecting tools, controlling fires, and adapting environments to their needs. The first tools used in hunting were simple clubs, tree limbs that were thin at one end and thick and heavy at the other. Over time, hunter-gatherers used bone

and stone and developed spears, which made hunting far more effective. By fashioning stone into hand axes and, later, handle axes, hunters could skin their prey and cut the meat. Hunter-gatherers used axes to cut down trees and build better shelters and tools.

Early human communities also became adept at using fire for controlled burns. The first opportunities to control fire were offered by natural conditions like lightning. Archaeological digs of ancient settlement sites suggest that people captured a fire caused naturally and worked to keep the fire burning continuously. Later, people learned to spark fire by rapidly rotating a wooden stick in a small hole surrounded by dry tinder and fanned by oxygen. Fire became the focal point of settlements and a tool both for cooking food and for driving hunted animals off a cliff or into a ravine to be killed.

The First Agricultural Revolution: Origins and Diffusion of Agriculture

The idea to move from hunting and gathering to domesticating plants and animals developed independently in different **hearths** (areas of innovation). **Agriculture** is purposefully growing crops and raising livestock to produce food, feed, and fiber. The transition from hunting and gathering to farming marks the beginning of the **First Agricultural Revolution**.

Geographers have debated how and why farming began. Did early agriculture begin out of *necessity*, because there was too little food to hunt and gather, or out of *luxury*, because the food made available through hunting and gathering gave people the time to experiment with growing crops? Jared Diamond believes that scarcity forced people into farming, that competition forced people to become resourceful and grow their own food. Cultural geographer Carl Sauer believed that luxury was more likely, that a reliable food supply created the opportunity for people to experiment with raising plants or invest the time to domesticate animals.

Plant Domestication Growing seed crops involves seed selection, sowing, watering, and well-timed harvesting. The innovation of seed crop agriculture developed in more than one hearth and at different times. The first hearth for plant cultivation was the **Fertile Crescent**, which includes the lands between the Tigris and Euphrates rivers in present-day Iraq and extends west to Syria. **Figure 11.4** shows the Fertile Crescent and the Nile River Valley, which is considered another hearth of agriculture.

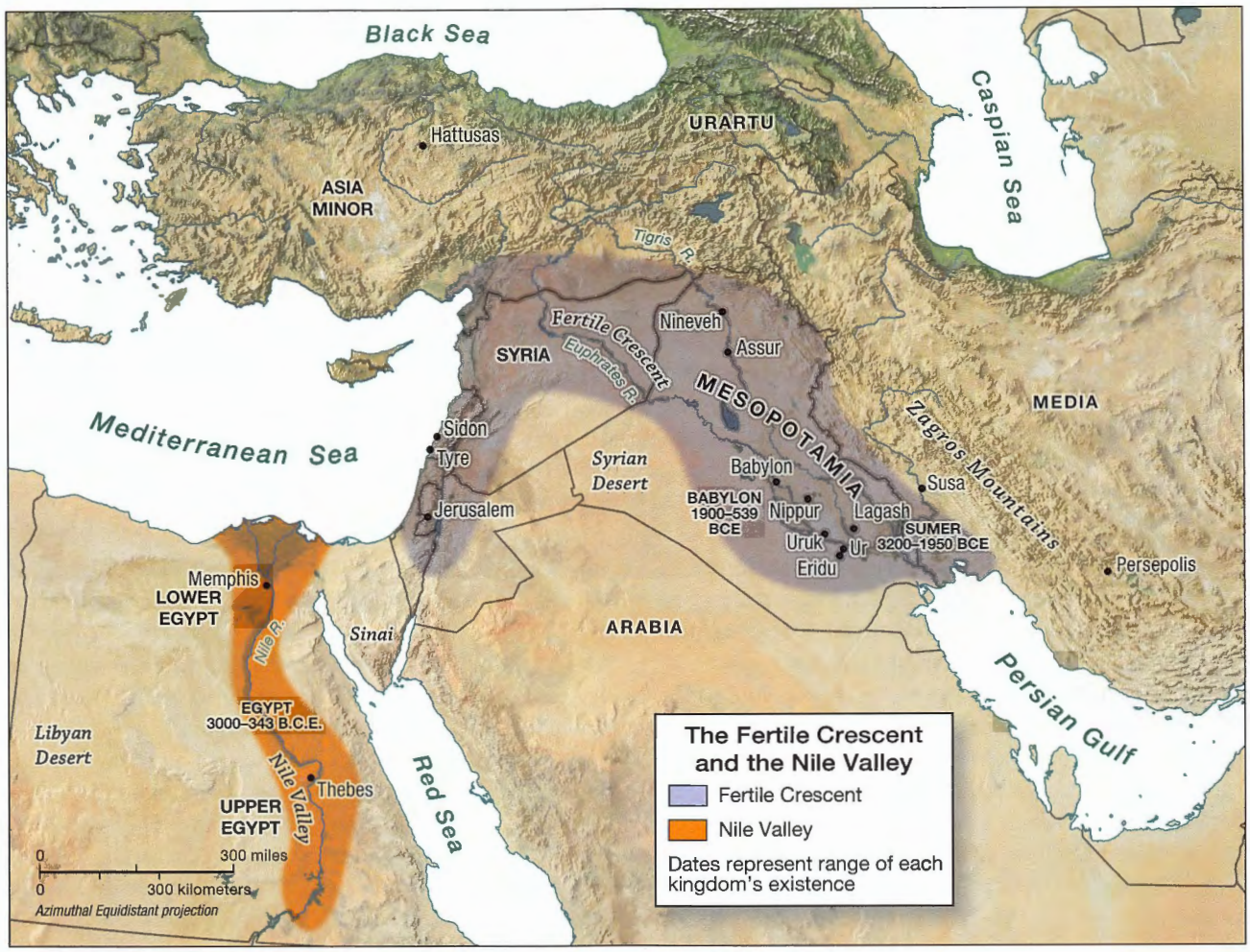


FIGURE 11.4 The Fertile Crescent and Nile River Valley. The Fertile Crescent and Nile River Valley were two hearths of the First Agricultural Revolution. Modern political boundaries are shown for reference.

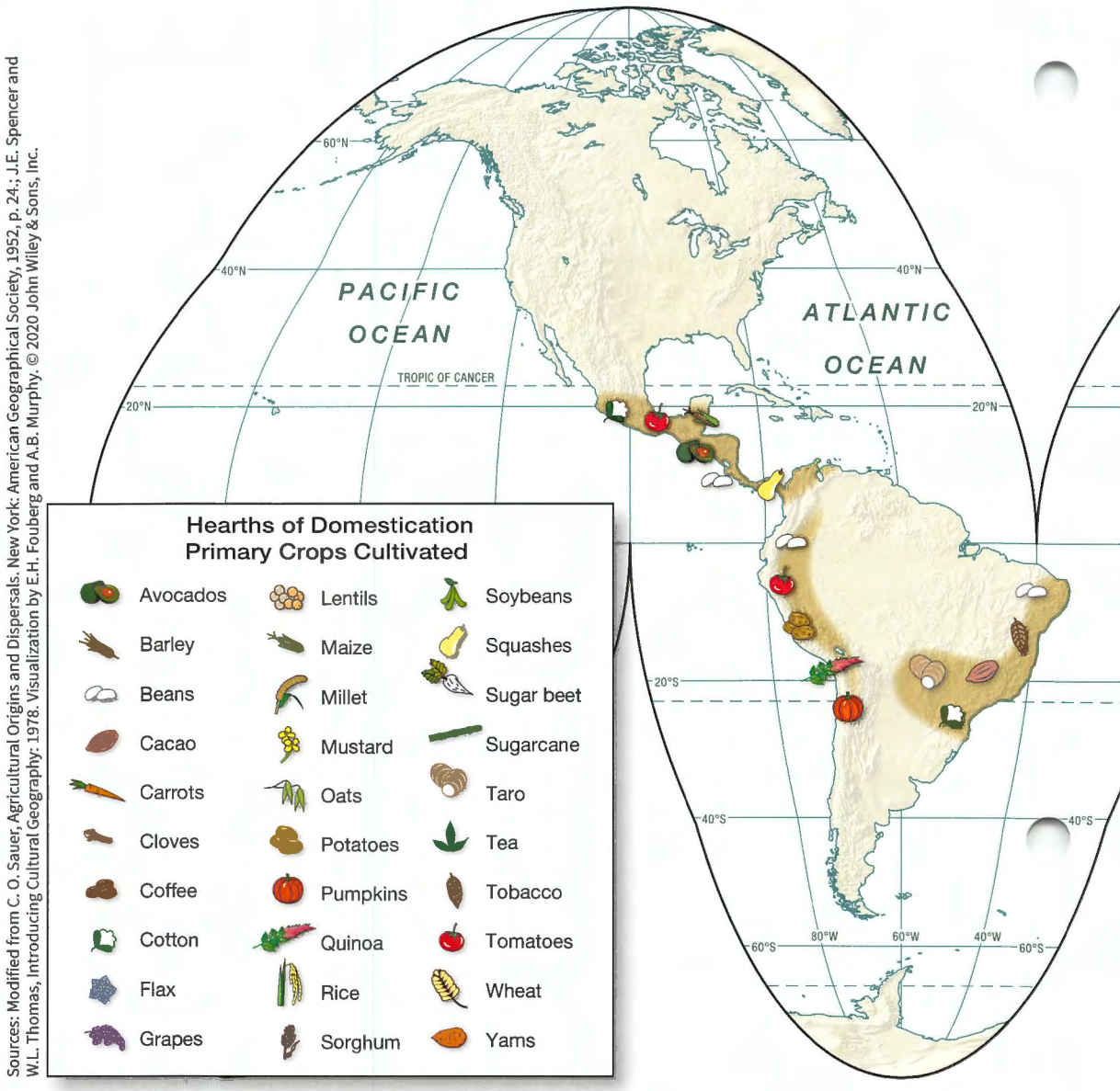
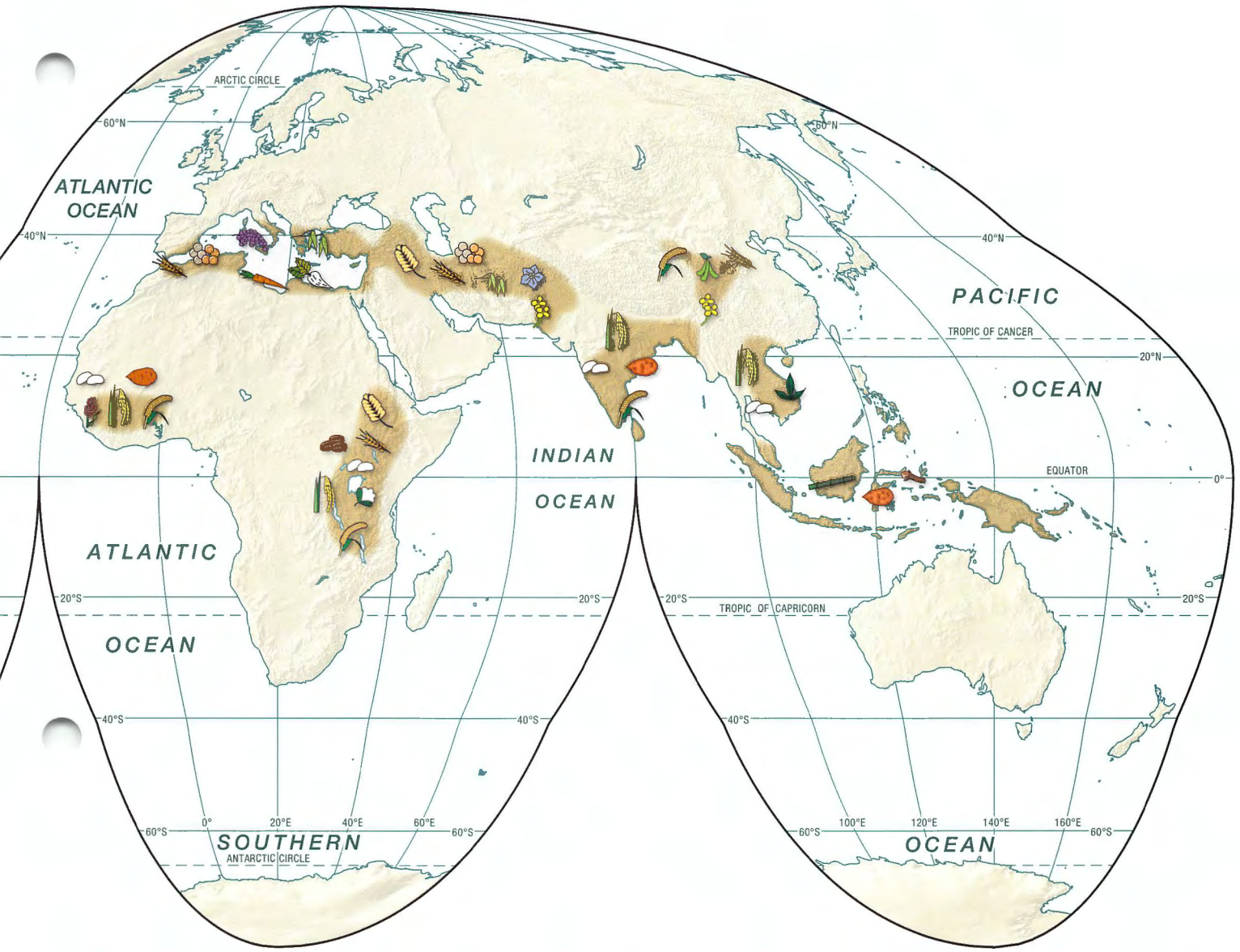


FIGURE 11.5 Hearths of Early Domestication. The domestication of plants and animals occurred around the world. Each hearth of agriculture focused on domesticating certain crops that are shown on this map as well as animals not shown on this map. For example, the Fertile Crescent was the hearth for the domestication of goats and sheep as well as oats and lentils. Mesoamerica was the hearth of domestication for maize (corn), tomatoes, avocados, and the turkey.

Plant domestication changed the plants themselves. Farmers chose seeds from the largest, hardiest plants to save for planting the next year. Over time, domesticated plants grew larger than their counterparts in the wild. By analyzing seeds, archaeologists can determine which plants grew in abundance and the dates when they were commonly grown. Farmers in the Fertile Crescent grew wheat and barley.

Farming began in more than one hearth. **Figure 11.5** maps the major agricultural hearths and the primary crops each cultivated. Farmers domesticated several crops, including yams and rice, independently, each experimenting with spreading seeds and growing crops. For example, Southeast Asians domesticated rice, yams, beans, and sugarcane. The Indus Civilization grew wheat, barley, and mustard. Farmers in Central America grew avocados, tomatoes, and cotton. Archaeological research on agriculture is ongoing, and scientists revise the timeline of what crops were grown, where they were first grown, and when. Researchers debate whether agriculture developed independently in each hearth or if crop domestication diffused from certain hearths to others.

Agriculture increased food security and changed civilizations. Growing enough grain to store a surplus enabled people to settle permanently in one place and create villages and towns. People could do jobs other than farming, including working as artisans, metalworkers, soldiers, shamans, and leaders. Trade of surpluses, handmade goods, and resources grew among agricultural hearths. Civilizations grew and built great structures, from the Egyptian pyramids in the Nile to Angkor Wat in Southeast Asia.



Animal Domestication Domestication of animals, or adapting wild animals for human use, began around 10,000 years ago, also in the Fertile Crescent. Archaeologists study bone fragments and tools to identify where domestication of animals began. Researchers have found, for example, that goat bones became smaller over time as farmers domesticated goats. In the Fertile Crescent, farmers first domesticated goats in the Zagros Mountains around 8000 BCE (in present-day Iran), followed by sheep in Anatolia (present-day Turkey) around 7500 BCE. Soon after, people in the same region domesticated pigs and cattle.

Around the same time, farmers domesticated chickens in Southeast Asia. Southeast Asians also domesticated several kinds of pigs, the water buffalo, and some waterfowl (ducks and geese). In South Asia (eastern India and western Burma), farmers domesticated cattle. In Central Asia, farmers domesticated yaks, horses, some species of goats, and sheep. In the Andean highlands, early Americans domesticated the llama and alpaca, along with a species of pig and the turkey.

Some species of animals may have been domesticated almost simultaneously in different places. The water buffalo, for example, was probably domesticated in both Southeast and South Asia during the same period. Camels were domesticated in both western and eastern ends of Southwest Asia. The pig was domesticated in numerous areas. Different species of cattle were domesticated in regions other than South Asia. Dogs and cats attached themselves to human settlements very early (they may have been the first animals to be

Author Field Note Domesticating Eland in Nairobi, Kenya

"At Hunter's Lodge on the Nairobi-Mombasa road, we met an agricultural officer who told us an animal domestication experiment station was not far into the bush, just 10 miles south. On his invitation, we spent the next day observing his work. In some herds, domestic animals (goats) were combined with wild gazelles, all penned together in a large enclosure. This was not working well; all day the gazelles sought to escape. By comparison, the eland in this photo were docile, manageable, and in good health. Importantly, they also were reproducing in captivity. Here, our host describes the program."

– H. J. de Blij

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FIGURE 11.6 **Nairobi, Kenya.**

domesticated) and in widely separated regions. Single, specific hearths can be pinpointed for only a few animals, including the llama and the alpaca, the yak, the turkey, and the reindeer.

Humans used the relatively small animals they domesticated first for milk, eggs, meat, and hides. They used larger animals as beasts of burden, or as sources of meat or providers of milk. The integrated use of domesticated plants and domesticated animals eased the work burden for early farmers. Animal waste fertilized crops, animals pulled plows, and crops fed animals. The advantages of animal domestication stimulated the rapid diffusion of livestock raising among places linked by trade.

Through domestication and in captivity, animals changed from their wild state. In early animal domestication, people chose the more docile, often smaller goats, pigs, and cattle to breed. Quite possibly, the first domesticated animals attached themselves to human settlements either to scavenge for food by foraging through garbage or to seek protection from predators. Interaction with relatively calm or easily calmed wild animals likely helped humans think they could keep, corral, and tame the animals.

Archaeological research indicates that when animals such as wild cattle were penned in a corral, they physically changed. In the wild, physically strong animals survived. In corrals, animals were protected from predators, enabling calmer, more docile, and sometimes weaker animals to survive. Animals that successfully bred in corrals lived longer than those that did not.

Across the world, only about 40 species of animals have ever been domesticated—and most of these were domesticated long ago. Humans looked for four traits in the animals they domesticated: diet, temperament, growth rate, and size. Herbivores, or animals who graze on grass, are the easiest animals to domesticate. Domesticating omnivores and meat eaters makes less sense, because you have to raise animals just to be eaten by other animals. Animals with docile temperaments and herd mentality like cattle are easier to domesticate than aggressive, independent animals like tigers. Domesticating animals that grow quickly also makes more sense than investing decades into animals that take several years to reach adulthood, like elephants. Animals for domestication were also chosen for their size so they would produce enough meat to make the work of domestication worthwhile.

Jared Diamond, author of *Guns, Germs, and Steel*, explains that 148 animals in the wild meet these four criteria (diet, temperament, growth rate, and size). Humans have successfully domesticated 14 of the 148 animals, and each of the 14 was domesticated at least 4500 years ago.

Modern attempts at animal domestication have failed because of problems with the animal's diet, growth rate, breeding, disposition, or social structure. For example, several experimental stations in the savanna are trying to find ways to domesticate Africa's wildlife. In East Africa, farmers are attempting to domesticate the eland to make it serve as a source of meat and a stable protein source (**Fig. 11.6**).

Subsistence Agriculture

Growing only enough food to survive, or practicing **subsistence agriculture**, was the norm throughout most of human history. Subsistence farmers held land in common and shared any surplus among the members of the community. In subsistence farming communities, accumulation of personal wealth was generally restricted. Traditions and festivals were often created to redistribute surplus from families who had bountiful production to those who did not.

Traditional subsistence agriculture declined with European colonization. As Europeans colonized other lands and settler populations expanded, they used treaties and force to acquire lands owned by subsistence agricultural communities. Colonizers and eventually the countries that replaced them

(including the United States and Canada) legally changed land ownership from communal to individual. This shift from large areas of land owned communally to particular plots of land owned by individuals undermined the economic system of subsistence agriculture and left lasting consequences that are still felt in communities today (**Fig. 11.7**).

A return to subsistence agriculture has taken hold in parts of the world where farmers feel that production for the global market has not benefited them financially or culturally. For example, indigenous people in the southern Mexican states of Oaxaca, Chiapas, and Guerrero have largely returned to subsistence agriculture. *The Nation* reported in 2010 that Zapatista farmers have "in effect chosen to withdraw from the national economy, some weaning themselves off expensive chemical fertilizers and subsisting on corn they can grow, harvest, and barter."

Shifting Cultivation In tropical climates where vegetation, sunlight, and rainfall are plentiful, farmers engage in a form of subsistence agriculture called shifting cultivation. Also called swidden or slash-and-burn agriculture, **shifting cultivation** is the process of clearing and burning a plot of land, farming it for 2 to 10 years, and then moving on to a new field while leaving the plot to regenerate. Shifting cultivation is most common in tropical and subtropical climate regions where soils stay fertile for a few years after vegetation is cut down and burned. Once stripped of their natural vegetative cover and deprived of the constant input of nutrients from decaying vegetative matter on the forest floor, soils in these regions can quickly lose their nutrients as rainwater leaches out organic matter. When this happens, farmers leave the field to regenerate and move to another parcel of land.

Shifting cultivation is a sustainable form of agriculture in places where land is abundant and the population is relatively sparse. The term *slash and burn* suggests that farmers are drivers of deforestation in the tropics, but that is not the case. In the tropical forest regions of Africa, farmers allow fields to sit fallow for 30 years so they can be replenished before they are farmed again. In South America and Southeast Asia, farmers leave fields fallow for 10 to 20 years before farming them again. If the population of a village practicing shifting cultivation grows too large or the distance to usable land becomes too great, part of the village's population may establish a new settlement in another part of the forest.

For indigenous peoples of the Amazon Basin, sedentary farmers of Africa's savanna areas, villagers in much of India, and peasants in Indonesia, subsistence is not only a way of life, but a state of mind. Experience has taught farmers and their families that subsistence farming is often precarious and that times of comparative plenty will be followed by times of scarcity.

Author Field Note Persevering on the Lake Traverse Reservation, South Dakota

"The U.S. government used the Dawes Act in 1887 to change ownership on Native American reservations. The Sisseton-Wahpeton Sioux Oyate communally owned the Lake Traverse Reservation. In 1891, the U.S. government passed a congressional act to allot the reservation lands and then open "surplus" lands to non-Indians. The U.S. government counted the number of tribal members and surveyed the land using the township and range system. It allotted 160 acres to each tribal member and divided the reservation's 918,779 acres into 309,914 acres allotted to tribal members and 608,866 acres opened for non-Indians. On April 15, 1892, non-Indians perched on horseback around the reservation, waiting for the reservation to officially open. They quickly snapped up the glacially rich land. The allotment of the reservation had no regard for where the tribe's historical burial grounds or sacred places were. It completely disrupted the economic system by moving individuals apart on small acreages. And it had no thought for the future of the tribe. Within a generation, each 160-acre plot of land would be divided among the allotee's descendants. And each of those plots would be divided again within a generation. Today, land ownership on the reservation is checkerboarded. After generations of splitting the inheritance, tribal members who have land often have tiny plots too small to farm. Despite allotment and assimilation, Native Americans persevered, and the Sisseton-Wahpeton Sioux Oyate tribal government has created new job opportunities at tribally-owned businesses, including gas stations, casinos, and a manufacturing plant called Dakota Western, which produces plastic and biodegradable trash can liners and garbage bags."

– E. H. Fouberg

Photo by E.H. Fouberg. © 2020 John Wiley & Sons, Inc.

FIGURE 11.7 **Lake Traverse Reservation, South Dakota.**

With shifting cultivation, farmers avoid **monoculture**, which is more taxing on the soil and makes it more difficult for a community to build a nutrient-rich diet. Instead, farmers plant a diversity of crops, both for self-consumption and for trade in local markets (**Fig. 11.8**). In northern Thailand, hill tribes such as the Hmong, Lisu, Yao, Khamu, and Karen plant rice, sticky rice, maize, beans, gourds, eggplants, sugarcane, taro, yams, sesame, and chili peppers (see Fig. 11.1). In Africa, shifting cultivators plant yams, cassava, bananas, oil palm, maize, and other crops. In the Amazon in South America, shifting cultivators plant trees such as acai palms and avocado trees, as well as crops such as cassava, plantains, maize, and sweet potatoes.

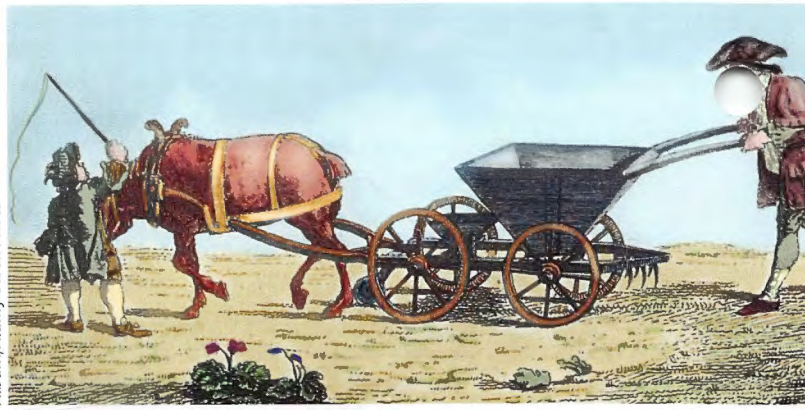
Photo by A.B. Murphy. © 2020 John Wiley & Sons, Inc.

FIGURE 11.8 **Mopti, Mali.** Farmers who produce a variety of crops using shifting cultivation, also called swidden agriculture, sell their produce at the market on a Saturday morning.

The Second Agricultural Revolution: Mechanization of Agriculture

To fuel the industrialization and urbanization that occurred from the 1700s on, people needed to create a Second Agricultural Revolution, moving beyond subsistence farming to generating the surpluses needed to feed thousands of people working in factories instead of on agricultural fields. Like the Industrial Revolution (see Chapter 12), the **Second Agricultural Revolution** included a series of innovations, improvements, and techniques developed in different places at different times, which together significantly improved the production of crops and livestock.

In the 1700s, the British and the Dutch invented the seed drill, improved livestock breeding methods, consolidated land into larger farms, and began using new crop rotation systems. The seed drill enabled farmers to avoid wasting seeds and to plant in rows, making it simpler to distinguish weeds from crops (**Fig. 11.9**). In addition, governments encouraged land consolidation to increase the scale of production. Great Britain's Enclosure Act encouraged consolidation of fields into large, single-owner holdings. Farmers increased the size of their farms, pieced together more contiguous parcels of land, fenced in their land, and instituted crop rotation. They also improved their methods of soil preparation, fertilization, crop care, and harvesting.



Album/Alamy Stock Photo

FIGURE 11.9 **Great Britain.** The seed drill helped farmers improve yields. By planting crops in clear rows, farmers could tell the difference between crops and weeds.

Mechanization and Advances in Breeding

Successful innovation fueled more advancements. By the 1830s, European farmers were using new fertilizers on crops and giving artificial feeds to livestock. Increased agricultural output in the primary economic sector made it possible to feed much larger urban populations, enabling the growth of the secondary economic sector (manufacturing). In 1831, Cyrus McCormick, a farmer in Lexington, Virginia, perfected his father's design for a mechanical reaper (**Fig. 11.10**). At the time, farmers were limited in their production not by what they could sow (plant), but by what they could reap (harvest) because harvesting required much more time and labor than planting. Harvesting involved laborers cutting grain with a scythe, followed by more laborers who bundled the grain into bales. McCormick's mechanical reaper was pulled by horses and both cut and bundled grain. His invention diffused quickly during the 1840s, reportedly increasing yields of individual farmers by at least 10 times. McCormick's company eventually became International Harvester and is now Case IH, one of the largest agricultural implement companies in the world today.

Advances in breeding livestock enabled farmers to develop new breeds that were either strong milk producers or good for beef. The most common breeds of dairy cattle found in North America today trace their lineage back to the Second Agricultural Revolution in Europe. In the 1700s and 1800s, European farmers bred dairy cattle to adapt to different climates and topography. For example, the black-and-white Holstein dairy cow came from the Netherlands and is well suited to graze on

Hulton Deutsch/Getty Images

FIGURE 11.10 Midwest, United States. Pioneers used the mechanical reaper designed by Cyrus McCormick to cut and bundle grain on the prairie. Pulled by horses, the mechanical reaper sped up harvesting and diffused around the world.

grass and produce high quantities of milk. Scottish Highland cattle were bred for their meat (**Fig. 11.11**) and are raised in the United States as American Highland cattle. Scottish farmers also bred the red-and-white Ayrshire dairy cattle to produce milk well suited for butter and cheese. Both Scottish cattle breeds forage for food in rough, rocky topography, which makes them well suited for similar topographies and climates in the Americas.

Innovations in machinery that occurred with the Industrial Revolution in the late 1800s and early 1900s helped sustain the Second Agricultural Revolution. The railroad helped move agriculture into new regions, including the Great Plains. Geographer John Hudson traced the major role that railroads and agriculture played in changing the landscape of that region from Native American communal hunting and agricultural lands to individual, homesteaded farms. Railroad companies advertised in Europe to attract immigrants to the Great Plains region, and the railroads took the new migrants to railroad-built towns.

The Columbian Exchange

The **Columbian Exchange** was the movement of goods, people, and diseases between Europe, Africa, and the Americas across the Atlantic Ocean that began with Spanish and Portuguese exploration in the late fifteenth century. This trade pattern, called the triangular trade network, brought new seeds and livestock to each continent. Through the Columbian Exchange, new crops came into Europe from trade with Africa and the Americas. The diffusion of crops and seeds was greatly accelerated by the worldwide trade and communications networks established with the development of European exploration and colonization (**Fig. 11.12**).

Places known today for growing certain crops, like Idaho and Ireland for potatoes, Hawai'i for pineapples, and Colombia for coffee, are not the places the crops originated. The corn grown in the American Corn Belt diffused from Central America. During the Colombian Exchange, Portuguese traders carried corn across the Atlantic and into Africa and Europe, where it became a staple in some regions. The white potato we associate with Ireland and Idaho came originally from the Andean highlands. It was brought to Europe in the 1600s, where it became a staple in Ireland and the North European Plain. Likewise, the banana we associate with Central America came from Southeast Asia, as did a variety of yam.

The Columbian Exchange brought many new crops to places with similar climates, soils, and topography. Farmers found crops that could grow in places that previously did not support agriculture, bringing new lands that were previously defined as marginal into cultivation. The system of trade did not only include seeds. Europeans also forcibly enslaved Africans and moved them across the Atlantic to labor on plantations in the Americas. European migrants brought diseases to the Americas, infecting and killing millions of indigenous people, overturning civilizations, and dispossessing Natives of their land.

The Columbian Exchange not only changed the landscape of crops among Europe, Africa, South America, and North America, but it also set up a system of unequal exchange that is foundational to globalization. **Unequal exchange** is the idea that global trade is set up to structurally benefit some more than others, creating an unevenness in wealth in the capitalist world economy. Those who produce the food, first enslaved

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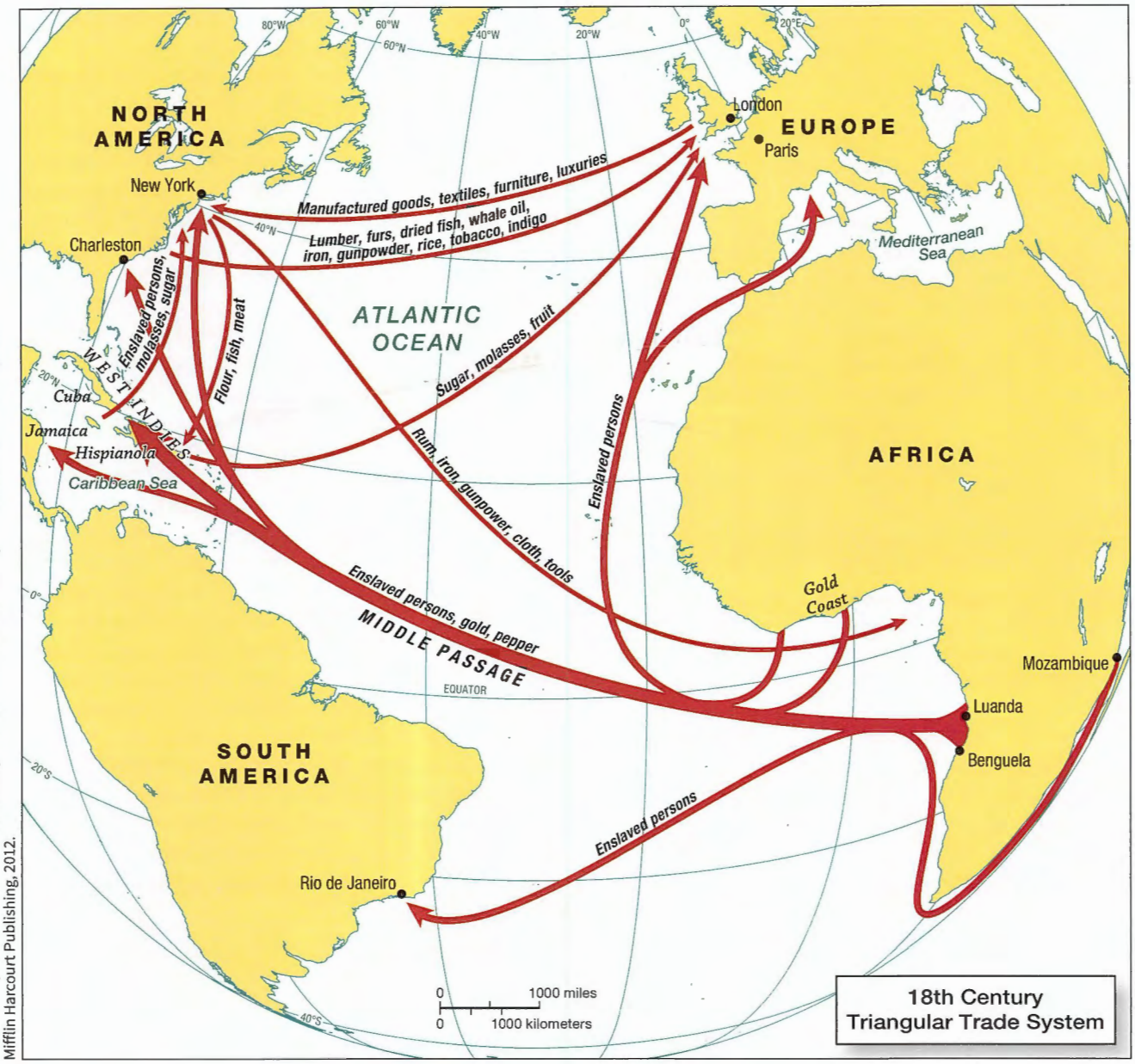
FIGURE 11.11 Edinburgh, Scotland. Scottish Highland cattle have fluffy coats with heavy undercoats that make them well suited for living in colder climates. Farmers bred and named Scottish Highland cattle during the agricultural revolution that led up to the Industrial Revolution.



Source: Adapted from "Ancient World History: Patterns of Interaction" by Roger Beck, et al., Boston: Houghton Mifflin Harcourt Publishing, 2012.

FIGURE 11.12 Triangular Trade System. The eighteenth-century triangular trade system among Europe, Africa, and the Americas helped establish the foundations of the capitalist world economy.

Africans and now farm workers, receive little income compared to those who process food into products and trade it globally. For example, a coffee farmer may sell beans for $1.50 a pound, but by the time you buy a pound of coffee at Target, it is $9 a pound. Large coffee companies buy the beans, roast them, brand them, and sell them to retail outlets that mark the price up for consumers. This system of unequal exchange dates back to European colonialism and the beginnings of the capitalist world economy.

The Impact of the Rise of States on Agriculture

In the process of colonizing much of the world between the sixteenth and twentieth centuries, Europeans divided the world into states or countries (see Chapter 8). Under international law, states are territories with defined borders. The meaning of land and its ownership changed with the rise of the state system. Land became a system of control and power.

This change has greatly impacted hunter-gatherers and subsistence farmers. The relatively small groups of hunter-gatherers who migrate cyclically often move across country borders and are experiencing pressures to change their livelihoods. In many cases, the state pressures hunter-gatherers to settle in one place and farm. Some nongovernmental organizations encourage settlement by digging wells or building medical buildings, permanent houses, or schools for hunter-gatherers. Even hunter-gatherers who continue to use their knowledge of seeds, roots, fruits, berries, insects, and animals to gather and trap the goods they need for survival do so in the context of a highly interconnected economic world (**Fig. 11.13**).

From 1500 to 1950, European powers sought to "modernize" the economies of their colonies by ending subsistence farming and integrating farmers into colonial systems of production and exchange. Their methods included both taking land and implementing tax systems to force farming. By demanding that farmers pay taxes, they forced subsistence farmers to sell some of their produce to raise cash to pay taxes.

Colonial powers also compelled many subsistence farmers to devote some land to a crop such as cotton that would be sold on the world market, thus bringing them into the commercial economy. They encouraged commercial farming by conducting soil surveys, building irrigation systems, and establishing lending agencies that provided loans to farmers. Because it was difficult to squeeze sellable quantities of surplus from subsistence farming areas, colonizers also designed forced cropping schemes. If farmers in a subsistence area cultivated a certain acreage of food crops, they were required to grow a specified acreage of a cash crops as well. Whether this crop would be grown on old land or newly cleared land was the farmers' decision. If no new lands were available, the farmers would have to give up food crops for the compulsory cash crops. In many areas, severe famines resulted and local economies were disrupted from the push for cash crop production.

Subsistence land use continues to give way to more intensive farming and cash cropping—even to mechanized farming in which equipment does much of the actual work. Societies from South America to Southeast Asia are being profoundly affected. Land that was once held communally is being parceled out to individuals for cash cropping. In the process, small landowners are often squeezed out, leaving the land in the hands of wealthier farmers and the owners of commercialized farming operations.

For too long, governments have focused on how "to tempt [subsistence farmers] into wanting cash by the availability of suitable consumer goods," as A.N. Duckham and G.B. Masefield wrote in *Farming Systems of the World* in 1970. In the interests of "progress" and "modernization," subsistence farmers have been pushed away from their traditional modes of livelihood, even though many aspects of subsistence farming may be worth preserving. Regions with shifting cultivation may not have neat rows of plants, carefully turned soil, or precisely laid-out fields. Yet shifting cultivation conserves both forest and soil; its harvests are often substantial, given environmental limitations; and it requires better organization than one might assume. It also requires substantially less energy than more modern techniques of farming. It is no surprise, then, that shifting cultivation has been a sustained method of farming for thousands of years.

The Third Agricultural Revolution: The Green Revolution

World population grew rapidly in the 1900s, and agricultural companies, researchers, and farmers created new technologies designed to expand agricultural production to feed the growing population. The goal was not necessarily to expand the amount of arable land, but to find ways to increase productivity on the land that existed and to create seeds that grow in more marginal lands. The **Green Revolution** is the use of biotechnology to create disease-resistant, fast-growing, high-yield seeds, as well as fertilizers and pesticides, and the result has been a large increase in crop production, especially in staple crops like rice, corn, and wheat. Because of the fundamental ways biotechnology has changed agriculture, the Green Revolution is also called the **Third Agricultural Revolution**.

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FIGURE 11.13 Lake Eyasi, Tanzania. A Hadza man practices archery on land his ancestors have lived on for thousands of years. The Hadza people live in the Rift Valley in east Africa and have hunting grounds that stretch into the Serengeti plain.

Agricultural scientist Donald Baker suggests that we can think about the three agricultural revolutions by considering the "critical factor" that spurred each revolution. The First Agricultural Revolution depended on a change in human effort. The Second Agricultural Revolution hinged on improving technology with innovations like the seed drill. The Third Agricultural Revolution focuses on engineering the seed and the land. With the Third Agricultural Revolution, farmers genetically engineer seeds to grow in certain circumstances (wind and drought), intensively use technology and irrigation, and expand the use of land, either by not leaving it fallow or by farming marginal land.

Origins of the Green Revolution

The Green Revolution began in North America in the 1930s, when agricultural scientists in the Midwest experimented with technologically manipulated seed varieties to increase crop yields. Then, in the 1940s, American philanthropists interested in combating hunger funded research on crops in Mexico, trying to find hybrid seeds that would grow better. American agricultural scientist Norman Borlaug developed a wheat grain that was resistant to a fungus common in Mexico (**Fig. 11.14**). This disease-resistant wheat grew on a tall stalk, which made it topple before it fully grew. Borlaug then crossed the disease-resistant wheat with a Japanese dwarf wheat to create a dwarf wheat that grew so dependably in Mexico that Mexico became self-sufficient in grain production.

FIGURE 11.14 St. Cresco, Iowa. Norman Borlaug's home has been preserved and is a destination for tourists interested in agriculture and the Green Revolution.

Realizing that technology could help combat global hunger, the Ford Foundation and Rockefeller Foundation funded research into additional staple grains, including rice. In the 1960s, the focal point of the Green Revolution shifted to India, when scientists at a research institution in the Philippines crossed a dwarf Chinese variety of rice with an Indonesian variety and produced IR8. This new rice plant had several desirable properties, including developing more grains of rice on each head and growing a stronger stem that did not collapse under the added weight of the bigger head.

Building on the success of IR8, in 1982 scientists produced IR36, bred from 13 parents to achieve genetic resistance against 15 pests. With a growing cycle of 110 days under warm conditions, farmers could grow three crops per year in some places. By 1992, IR36 was the most widely grown crop on Earth, and in September 1994, scientists developed a strain of rice that was even more productive than IR36. The Green Revolution also brought new high-yield varieties of wheat and corn from the United States to other parts of the world, particularly South and Southeast Asia. India became self-sufficient in grain production by the 1980s, and Asia saw a two-thirds increase in rice production between 1970 and 1995. These drastic increases in production stemmed not only from new seed varieties, but also from the use of fertilizers, pesticides, irrigation, and significant capital improvements.

Outcomes of the Green Revolution

The Green Revolution has had both positive and negative outcomes. The promise of increasing food production in a world in which more than 800 million people are undernourished has led many people to view the Green Revolution only in positive terms. Others worry about social changes, health risks, and environmental hazards. The large-scale monocropping that is often part of Green Revolution agriculture can make farms vulnerable to changes in climate or the infestation of pests. In addition, the higher inputs of chemical fertilizers, herbicides, and pesticides that go along with Green Revolution agriculture can lead to reduced organic matter in the soil and to groundwater pollution.

The Green Revolution has also worked against the interest of many small-scale farmers who lack the resources to acquire genetically enhanced seeds and the necessary chemical inputs to grow them. One particularly vocal opponent of the Green Revolution in India, Vandana Shiva, argues that the Green Revolution has been a failure. It has led to reduced genetic diversity, increased vulnerability to pests, soil erosion, water shortages, reduced soil fertility, micronutrient deficiencies, soil contamination, reduced availability of nutritious food crops for the local population, the displacement of vast numbers of small farmers from their land, rural impoverishment, and increased tensions and conflicts. The beneficiaries have been the agrochemical industry, large petrochemical companies, manufacturers of agricultural machinery, dam builders, and large landowners.

It is no easy matter to weigh the enormous increases in food production that have occurred in places that have adopted Green Revolution approaches against the types of social and environmental issues highlighted by Shiva.

A 2005 report in *Scientific American* contends that many small farmers have not benefited from the Green Revolution: "The supply-driven strategies of the Green Revolution . . . may not help subsistence farmers, who must play to their strengths to compete in the global marketplace. The average size of a family farm is less than four acres in India, 1.8 acres in Bangladesh and about half an acre in China." Smaller farmers are in a poor competitive position, and their position is further undermined by the fact that a few large corporations with the seed patents for biotechnologically altered grains and a virtual monopoly of the needed chemical inputs can have tremendous power over the agricultural production process. In addition, the need for capital from the West to implement Green Revolution technologies has led to a shift away from production for local consumers toward export agriculture. In the process, local places become subject to the changing circumstances of the global economy, and a downward fluctuation in the price of a given crop can create enormous problems for places dependent on the sale of that crop.

Despite the negative impacts of the Green Revolution, proponents question why anyone would argue against reducing famine and starvation and feeding the ever-growing world population. Researchers at the International Rice Research Institute, with help from an $18 billion grant from the Bill and Melinda Gates Foundation, bred a genetically modified "Green Super Rice" that does not have to be transplanted as seedlings, but can be seeded directly in the paddy soil. The charting of the genome of rice (the 12 chromosomes that carry all of the plant's characteristics) is making it possible to transform rice genetically so that it will continuously acquire more new properties that could make it resistant to a wider spectrum of diseases and pests. Dozens of Green Super Rice varieties are being planted in several countries, and new varieties are in development.

Genetically Modified Organisms

Agricultural scientists alter the chemical makeup of crops and modify the genes of plants to create genetically engineered (GE) seeds and genetically modified organisms (GMOs). Farmers have been experimenting with hybrid crops and crossbreeding livestock ever since the First Agricultural Revolution. What is different today is that genetic modification involves splicing together genes from different species to create new plants.

According to the Grocery Manufacturers of America, GMOs are now found in 75 percent of all processed foods in the United States. The United States leads the world in the production of genetically engineered crops (**Fig. 11.15**). Since 1996, the percentage of planted acres that are genetically engineered to be herbicide tolerant or insect resistant has grown from below 20 percent to over 80 percent. Genetically engineered seeds are planted on 88 percent of corn acres (up from 25 percent in 2000), 93 percent of soybean acres (up from 54 percent in 2000), and 85 percent of cotton acres in the United States (**Fig. 11.16**).

A major debate has developed around GMOs. Proponents argue that GMOs can help feed an expanding world population and that hard evidence of negative consequences to their use is lacking. Opponents contend that GMO companies are releasing organisms into the environment without adequate understanding of their environmental, health, or socioeconomic consequences. Another concern is the impact of pollen dispersal from GMOs on other organisms and the potential for disease-resistant plants to spur the evolution of superpests.

Some regions have embraced genetically engineered crops, whereas others have banned them. The United States has largely been in the former camp, though there is a growing movement to require labeling of products containing GMOs and a growing demand for organic products. The expansion of organic agriculture in the United States has been, in part, a reaction to the growth of GMOs. Ideological resistance to genetically engineered foods is strong in western Europe. Agricultural officials in most western European countries have declared GMOs to be safe, but labeling is required, and there is strong public reaction against GMOs based on combined concerns about health and taste.

In lower income regions, seeds are a cultural commodity, reflecting agricultural lessons learned over generations. Farmers resist the invasion of foreign, genetically engineered crops. But in their search for new markets, major GMO companies promote their products in the global periphery and semiperiphery.

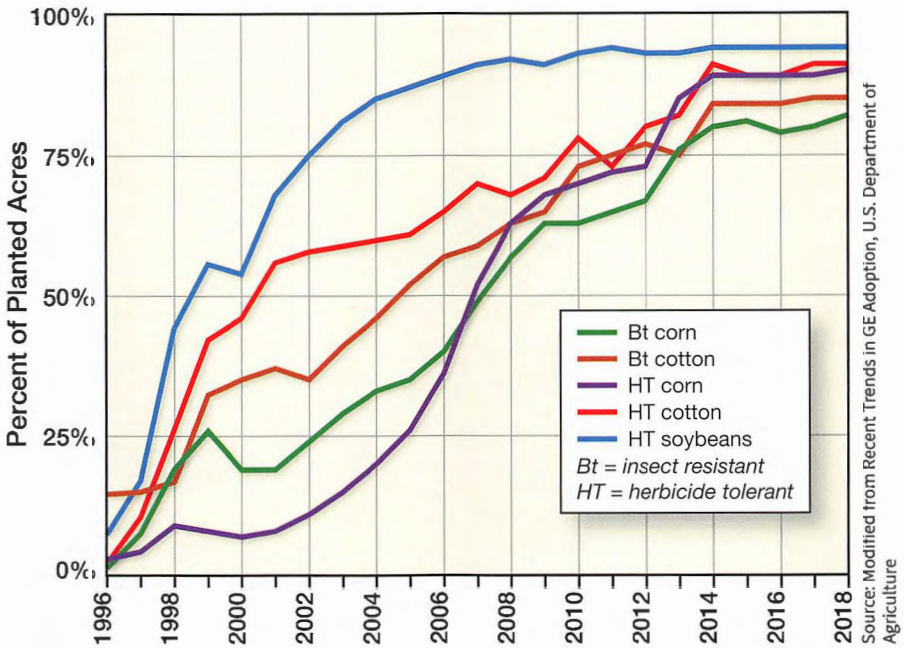


FIGURE 11.15 **Adoption of Genetically Engineered Crops in the United States, 1996–2018.** HT varieties are herbicide tolerant. Roundup Ready seeds produced by Monsanto are an example of herbicide tolerant seeds.

Impacts on Women Shifting from subsistence agriculture to commercial agriculture in the Third Agricultural Revolution has had dramatic impacts on rural areas. Land-use patterns, land ownership arrangements, and agricultural labor conditions have all changed as rural residents cope with shifting economic, political, and environmental conditions. In Latin America, dramatic increases in the production of cash crops (export crops such as fruits and coffee) have occurred at the expense of crop production for local consumption. In the process, subsistence farming has been pushed to ever more marginal lands. In Asia, where the Green Revolution has had the greatest impact, the production of cereal crops (grains such as rice and wheat) has increased for both foreign and domestic markets. In sub-Saharan Africa, total commercialized agriculture has increased, but African farms have remained relatively small and dependent on extensive manual labor.

What this regional-scale analysis does not tell us is how these changes have affected rural communities. These changes can be environmental, economic, and social. A recent study in the small country of Gambia (West Africa) by Judith Carney has shown how changing agricultural practices have altered not only the rural environment and economy, but also relations between men and women (**Fig. 11.17**). Over the last 30 years, international developmental assistance to Gambia has led to ambitious projects designed to convert wetlands to irrigated agricultural lands, making possible year-round production of rice. By the late 1980s, virtually all of the country's suitable wetlands had been converted to year-round rice production. This transformation created tensions within rural households because lands women traditionally used for family subsistence were converted into commercialized farming plots. In addition, when rice production was turned into a year-round occupation, women found themselves with less time for other activities crucial for household maintenance.

Author Field Note Expanding Acreage of Roundup Ready Soybeans in Presho, South Dakota

"Driving across the semiarid ranchlands of western South Dakota, I noticed the presence of a crop in the landscape that was recently found only in the eastern, more humid region of the state: soybeans. I called a colleague who works in agriculture at South Dakota State University to ask, 'When did the cattle ranchers of western South Dakota start growing soybeans?' He replied, 'When the soy biodiesel plants started popping up in Nebraska and Kansas and when genetically modified soybeans made it possible to grow the crop here.' He explained the development of Roundup Ready soybeans, a particular genetically modified soybean that can grow in more arid regions of the country. First you plant the soybean; then you use an airplane to spray Roundup, a common weed killer that is manufactured by the company that produces the Roundup Ready soybeans, over the field. The application of Roundup over the entire field saves a lot of time and energy for the farmers because the genetically modified soybeans are resistant to the Roundup, but the weeds are killed. Monsanto, the company that produces Roundup, has developed soybeans, corn, cotton, and other crops that are resistant to Roundup."

– E. H. Fouberg

FIGURE 11.16 **Presho, South Dakota.**

Guest Field Note Growing Rice and Gender Disparity in Gambia

Judith Carney
University of California, Los Angeles

I am interested in women and rural development in sub-Saharan Africa. In 1983, I went to Gambia to study an irrigated rice project that was being implemented to improve the availability of rice, the dietary staple. What grabbed my attention? The donors' assurance that the project would benefit women, the country's traditional rice growers. Imagine my surprise a few months after project implementation when I encountered hundreds of angry women refusing to work because they received nothing for their labor from the first harvest.

In registering women's traditional rice plots as "family" land, project officials effectively sabotaged the equity objectives of the donors. Control now was concentrated under male heads of household who reaped the income produced by female labor. Contemporary economic strategies for Africa depend increasingly upon labor intensification. But whose labor? Human geography provides a way of seeing the significance of gender in the power relations that mediate culture, environment, and economic development.

© Judith Carney

FIGURE 11.17 Gambia.

This situation underscores the fact that in Africa, as in much of the periphery, agricultural work is overwhelmingly carried out by women. In sub-Saharan Africa and South Asia, 60 percent of all employed females work in the agriculture sector. A geographical perspective helps to shed light on how changes in agricultural practices throughout the world not only alter rural landscapes, but also affect family and community relationships.

TC Thinking Geographically

Many arguments have been raised about the impacts of the **Green Revolution**, both pro and con. How might the **scale** at which the Green Revolution is examined affect the arguments that are made about it? What types of factors are likely to be considered if the question is "Has the Green Revolution been good for Asia?" as opposed to "Has the Green Revolution been good for a village or a particular agricultural community in India?"

11.2 Describe the Spatial Patterns of Agriculture.

Whatever the time period or process involved, agriculture leaves a distinct imprint on the cultural landscape, from land surveys to land ownership to land use. Globalization has made an imprint on landscapes and agribusiness. What is produced where is not simply a product of the environment and locally available plants; the modern geography of agriculture depends on factors ranging from climate and government regulation to technology and shifting global consumption patterns.

National Land Survey Methods

Flying from the west coast of the United States to the east coast, if you have a window seat, you will see the major imprint agriculture makes on the cultural landscape. The green circles standing out in the grain belts of the country are places where center pivot irrigation systems rotate to provide irrigation to a circle of crops. The checkerboard pattern on the landscape reflects the system used in most of the country (**Fig. 11.18**). The pattern of land ownership seen in the landscape reflects the **cadastral system**—the method of land survey through which land ownership and property lines are defined. Cadastral systems were adopted in places where settlement could be regulated by law, and they impose a remarkable uniformity across the land.

The prevailing survey system used throughout much of the United States, the one that appears as checkerboards across agricultural fields, is the federal rectangular survey system,

NNehring/E+/Getty Images

FIGURE 11.18 Great Plains, United States. The square pattern of land ownership found in the township and range land survey system marks farmland and towns as you fly over the Great Plains. The circles are from center-pivot irrigation systems.

also known as the **township and range system**, with farms spaced by sections, half sections, or quarter sections (**Fig. 11.19**). The U.S. government adopted the rectangular survey system after the American Revolution. Designed to facilitate the settlement of non-Indians in the farmlands of the interior of the United States, the system imposed a rigid checkerboard pattern on the land (**Fig. 11.20**). The imprint of the rectangular survey system is evident in Canada as well, where the government adopted a similar cadastral system as it sought to allocate land in the Prairie provinces.

Portions of the United States and Canada have different cadastral patterns, reflecting different ideas of how land should be divided and used. Among the most significant is the **metes-and-bounds** survey approach adopted along the east coast, which uses natural features like rivers and trees to demarcate irregular parcels of land (see **Fig. 11.20**).

One of the most distinctive regional approaches to land division can be found in the Canadian Maritimes and in parts of Quebec, Louisiana, and Texas, where a **long-lot survey** system was implemented. This system divided land into narrow parcels stretching back from rivers, roads, or canals. The long-lot survey system spread from France through relocation diffusion with French migrants to Quebec and then Louisiana (**Fig. 11.21**).

Many parts of the world do not have cadastral systems, so field patterns are irregular. But whether regular or irregular, societies with property ownership have parcels of land divided into neat, clearly demarcated segments. The size and order of those parcels are heavily influenced not just by land partition schemes, but also by rules about property inheritance. In systems where one child inherits all of the land—such as those associated with the traditional Germanic practice of **primogeniture**, in which all land passes to the eldest son—parcels tend to be larger and farmers work a single plot of land. This is the norm in northern Europe and in the principal areas of northern European colonization—the Americas, South Africa, Australia, and New Zealand.

In areas where land is divided among heirs, however, considerable fragmentation can occur over time. This is the norm throughout much of Asia, Africa, and southern Europe, as well as most of the allotted Indian reservations in the United States (see Fig. 11.7). Farmers in these areas tend a variety of scattered small plots of land. In some places, land reform initiatives have consolidated landholdings to a degree, but fragmentation is still common in many parts of the world.

Spatial Layout of Agriculture Around Towns and Cities

Once agricultural goods are produced, they need to be transported from fields to consumers. Agricultural goods such as milk, fresh meat, and produce are **perishable**, susceptible to spoiling in transit. As patterns of production emerged around cities and towns, goods that were heavy to transport and highly perishable were produced within a short drive of the city center. Social scientists noticed geographical patterns of land use based on the perishability of products and the cost of transportation.

Craig Aurness/Corbis/VCG/Getty Images

FIGURE 11.19 Garden City, Iowa. Small towns and cities were initially laid out following the one-mile square sections of the township and range land survey system.

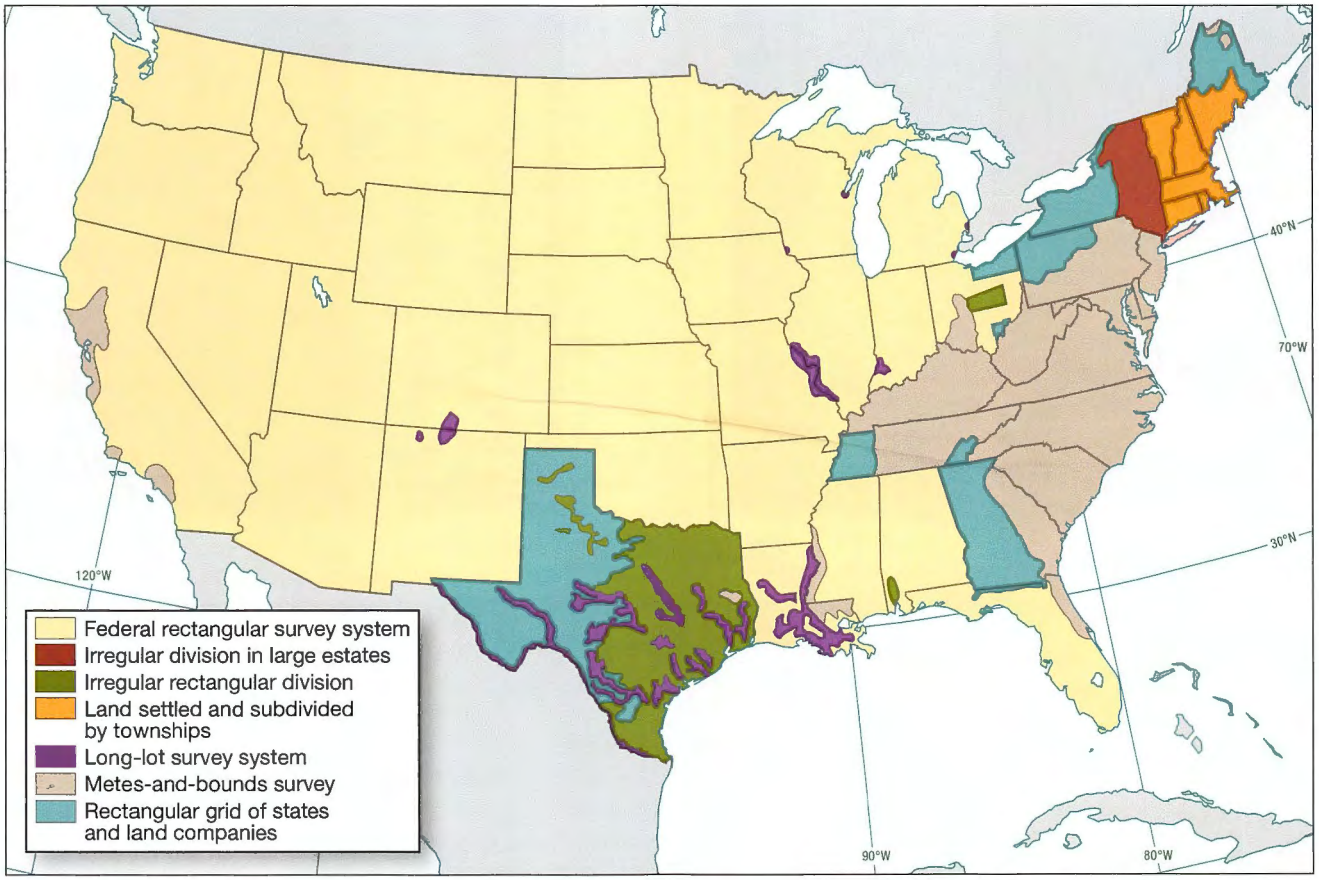


FIGURE 11.20 Dominant Land Survey System in the United States. Most of the United States uses the federal rectangular survey system, which is also known as township and range. Small areas influenced by French settlers use long-lots, and the east coast uses metes-and-bounds.

von Thünen In the 1800s, one German farmer, Johann Heinrich von Thünen (1783–1850), experienced the Second Agricultural Revolution firsthand: He farmed an estate not far from the town of Rostock, in northeast Germany. Studying the spatial patterns of land use around his town and similar towns, von Thünen noted that as he moved away from a town, one commodity or crop gave way to another. He also noticed that this process occurred without any visible change in soil, climate, or terrain. When he mapped the patterns, he found that each town was surrounded by a set of concentric rings within which agricultural goods were grown.

Closest to the town, farmers generally produced commodities that were perishable and commanded high prices, such as dairy products and strawberries. In this zone, much effort would go into production, in part because of the value of the land closer to the city. In von Thünen's time, the town was still surrounded by a belt of forest that provided wood for fuel and building, but immediately beyond the forest, the ringlike pattern of agriculture continued. In the next ring, crops were less perishable and bulkier, including wheat and other grains. Still farther out, farmers raised livestock for meat, hides, and other products.

Von Thünen used his observations to build a model of the spatial distribution of agricultural activities around settlements (**Fig. 11.22**). As with all models, he had to make several assumptions. He assumed that the terrain was flat, that soils and other environmental conditions were the same everywhere, and that there were no barriers for transportation to market. Von Thünen assumed that the cost of transportation would be greater at distances farther from the market and that the cost of transportation would be added to the cost of producing a crop or commodity. With these assumptions, transportation costs and accessibility would determine how farmers used land.

The **von Thünen model** (including the ring of forest) is often described as the first effort to analyze the spatial character of economic activity. Agricultural production that matches von Thünen's model is not solely the result of distance and transportation cost, however, and some of von Thünen's assumptions only rarely hold true. Around any given city, you can find differences in climate, precipitation patterns, access to transportation, topography, and soil quality that farmers factor into the goods they produce.

Even if von Thünen's model does not always work, the general pattern makes intuitive sense, and you can find support for it at certain scales and even in certain cities. If you drive east out of Denver on a major highway, you cannot miss a certain zonation that puts dairying and market gardening nearest the city (**Fig. 11.23**), cash grains such as corn and soybeans in the next zone, more extensive grain farming and livestock raising beyond, and cattle ranching in the outermost zone. This pattern does not work in all directions. It is truncated by the Rocky Mountains to the west and other urban areas of Colorado to the north and south. Thus von Thünen's model is a general

Andia/Alamy Stock Photo

A

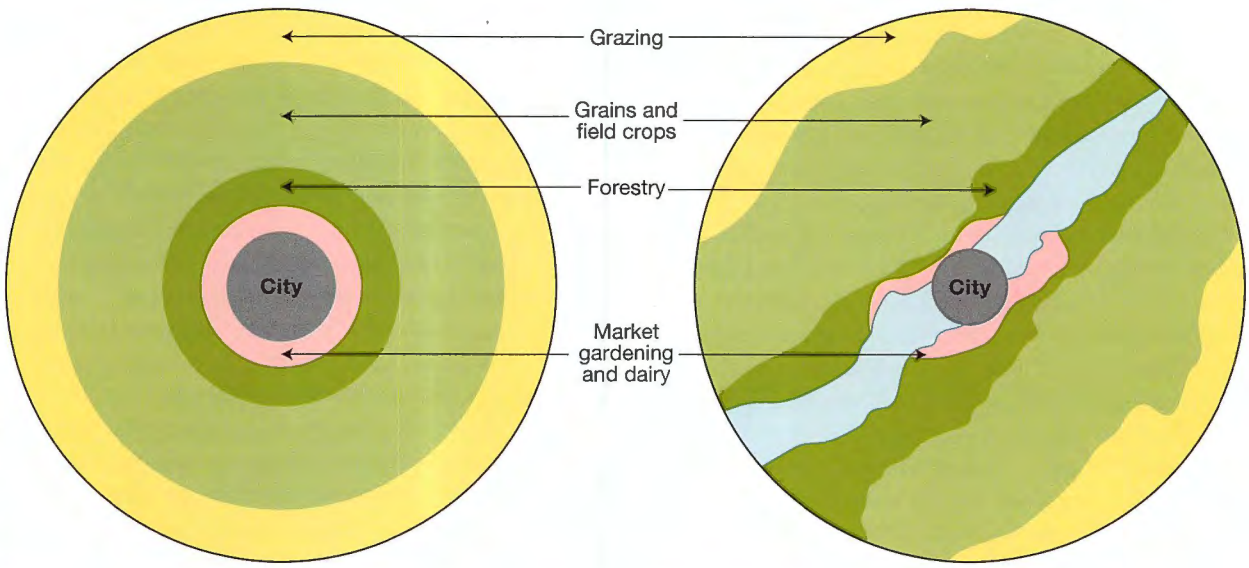
Russ Heinl/All Canada Photos/Alamy Stock Photo

B

Matthew D White/Photolibrary/Getty Images

C

FIGURE 11.21A, B, AND C The French long-lot land survey system diffused from **A)** France to **B)** Quebec and then to **C)** Louisiana with French migrants and settlers.



Source: Based on Von Thünen Model from PennState College of Earth and Mineral Sciences. Visualization by E.H. Fouberg and A.B. Murphy. © 2020 John Wiley & Sons, Inc.

FIGURE 11.22 von Thünen Model. The key influence on land use in the von Thünen model is the cost of transporting goods to market. Perishable, high-priced goods like milk and produce are farmed closest to the city. Being close to the city allows transportation systems to get milk and produce to market quickly and frequently.

Andrew Linscott/Alamy Stock Photo

FIGURE 11.23 Aurora, Colorado. Several dairy farms and dairies are located within the suburbs of the Denver metropolitan area.

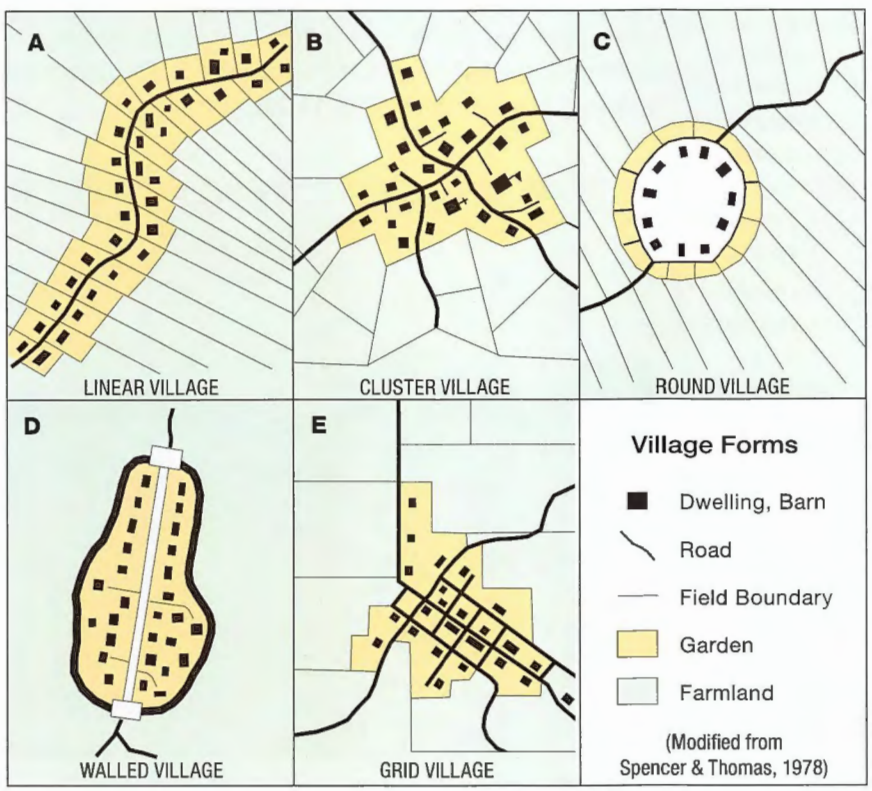
guideline, but is not consistently confirmed because how and where people live often differ from the assumptions of his model.

Even when agricultural production does not conform to the concentric rings of von Thünen's model, his underlying concern with the interplay of land use and transportation costs still explains many agricultural patterns. Fresh flowers grown in the Caribbean for sale in New York City could be viewed as the application of the von Thünen model on a larger scale, for it is less expensive to grow flowers in the Caribbean and ship them to New York City than it is to grow them in other locations.

Agricultural Villages

Although the twentieth century has witnessed unprecedented urban growth throughout the world, half of the world's people still reside in villages and rural areas. In China, 43 percent of the 1.4 billion people live in rural areas. In India, with a population of over 1.3 billion, between 60 and 70 percent of the people live in places the government defines as non-urban. Small rural settlements are home to most of the inhabitants of Indonesia, Bangladesh, Pakistan, and other countries of the global economic periphery, including those in Africa. Agricultural villages remain one of the most common forms of settlement.

In core regions of the world economy, by contrast, agriculture has taken on a very different form, and true farming villages, in which farming or providing services for farmers are the dominant activities, are disappearing. In the United States, where farming once was the leading economic activity, less than 2 percent of the labor force remains engaged in agriculture, and the population of most rural villages and towns is a mix of farmers and people who commute to work in urban areas.



Source: Adapted from: J. E. Spencer and W. H. Thomas, Introducing Cultural Geography. New York: John Wiley & Sons, Inc., 1978, p. 154.

FIGURE 11.24 Village Forms. Five different representative nucleated village layouts are shown here. Compare Figure 11.21 to these five village layouts and note how apparent the linear village is in Quebec.

Types of Agricultural Villages

Traditionally, people who lived in villages either farmed the surrounding land or provided services to those who did the farming. They were closely connected to the land, and most of their livelihoods depended, directly or indirectly, on the cultivation of cultivating nearby farmland. Geographers have derived a classification of agricultural villages based on their layout that gives us an idea of what the people who built villages valued (**Fig. 11.24**). All the patterns in Figure 11.24 are examples of nucleated villages, or villages clustered around a central point, or nucleus.

Nucleated settlement is by far the most prevalent rural residential pattern in agricultural areas around the world (**Fig. 11.25**). When houses are grouped together in tiny clusters or hamlets, or in slightly larger clusters we call villages, their spatial arrangement also has significance. Houses in Japanese farming villages, for example, are so tightly packed together that only the

FIGURE 11.25 Aquitaine, France. The agricultural village of Aquitaine demonstrates three features of rural France: people living in nucleated villages, a highly fragmented land ownership pattern, and land divided according to the French long-lot system.

narrowest passageways remain between them. This village form reflects the pressure to allocate every possible square foot of land to farming. Villages are nucleated so people do not use land where crops could grow. In the populous Indonesian island of Java, villages are located every half mile or so along rural roads, and settlement there is also defined as nucleated.

In the hilly regions of Europe, villages frequently are clustered on hills, leaving the level land for farming. Often an old castle sits atop the hill, so in earlier times, the site offered protection as well as land conservation. In many low-lying areas of western Europe, villages are located on dikes and levees, so that they often take on linear characteristics (Fig. 11.24A). Villages oriented along roads or rivers also have this characteristic. Where there is space, a house and outbuildings may be surrounded by a small garden; with farms and pasturelands just beyond.

In other cases, a village may take on the characteristics of a cluster (Fig. 11.24B). It may have begun as a small hamlet at the intersection of two roads and then developed by accretion. The European version of the East African circular village, with its central cattle corral, is the round village or rundling (Fig. 11.24C). This layout was first used by Slavic farmer-herdsmen in eastern Europe and was later modified by Germanic settlers.

In many parts of the world, farm villages were fortified to protect their inhabitants against marauders. Ten thousand years ago, the first farmers in the Fertile Crescent faced attacks from the horsemen of Asia's steppes and clustered together to ward off this danger. In Nigeria's Yorubaland, the farmers would go out into the surrounding fields by day, but retreat to the protection of walled villages at night. Villages, as well as larger towns and cities in Europe, were frequently walled and surrounded by moats. When the population became so large that people had to build houses outside the original wall, a new wall would be built to protect them as well. Walled villages (Fig. 11.24D) still exist in rural areas of many countries—reminders of a turbulent past.

More modern villages, notably planned rural settlements, may be arranged on a grid pattern (Fig. 11.24E). Grid patterns are not, however, a twentieth-century invention. Ancient Rome, ancient Greece, Indus cities such as Mohenjo-Daro and Harappa, ancient cities in central Mexico, and early cities in China all had streets laid out in grid patterns.

Functional Differentiation Within Agricultural Villages

Villages everywhere display certain common qualities, including evidence of social stratification and differentiation of buildings. The range in size and quality of houses, representing their owners' wealth and standing in the community, reflects social stratification. Material well-being is the chief determinant of stratification in Western commercial agricultural regions, where it translates into more elaborate homes. In Africa, as in most other places, a higher social position in the community is associated with a more impressive house. The house of the chief or headman may not only be more elaborate than others, but may also be in a more prominent location. In India, caste still strongly influences daily life, including village housing; the manors of landlords, often comprising large walled compounds, stand in striking contrast to the modest houses of domestic workers, farm workers, carpenters, and craftspeople. The poorest people of the lowest castes live in small, one-room, wattle- and thatch dwellings. In Cambodia, the buildings in stilt villages built throughout the Mekong Basin look similar (**Fig. 11.26**).

FIGURE 11.26 Siem Reap, Cambodia. A stilt village in the rural countryside of Cambodia. In the dry fall and winter, the stilts of the houses are exposed. In the wet spring and summer, as shown in this photo, monsoon rains inundate the village, covering the stilts with water.

The functional differentiation of buildings within farm villages (like the functional zonation of cities—where different areas of the city play different roles and function differently) is more elaborate in some societies than in others. Protection of livestock and storage of harvested crops are primary functions of farm villages, and in many villages where subsistence farming is the prevailing way of life, the storage place for grains and other food is constructed with as much care as the best-built house. Moisture and vermin must be kept away from stored food; containers of grain often stand on stilts under a carefully thatched roof or behind walls made of carefully maintained sun-dried mud. In India's villages, the paddy-bin made of mud (in which rice is stored) often stands inside the house. Similarly, livestock pens are often attached to houses, or, as in Africa, dwellings are built in a circle surrounding the corral.

The functional differentiation of buildings is greatest in Western cultures, where a single farmstead may contain as many buildings as an entire hamlet elsewhere in the world. A prosperous North American farm is likely to include a two-story farmhouse, a stable, a barn, and various outbuildings, including shops to store farm implements and tools, and silos for grain storage (**Fig. 11.27**). The space these structures occupy can exceed that used by entire villages in Japan and other agrarian regions where space is at a greater premium.

Aerial Archives/Alamy Stock Photo

FIGURE 11.27 Southern Illinois. The modern American farm typically has a two-story farmhouse surrounded by several outbuildings that include shops for storing implements and tools and silos for grain storage.

TC Thinking Geographically

Think of an agricultural **region** where you have visited or lived. Describe the imprint of agriculture on the landscape, and consider what the **cultural landscape** tells you about how agriculture is produced in this region or how production has changed over time.

11.3 Explain the Map of Global Agricultural Production.

Understanding global agricultural patterns requires looking at more than market location, land use, and transportation costs—the factors analyzed by von Thünen. We must also consider the effects of different climate and soil conditions, variations in farming methods and technology, the role of governments and social norms, and the lasting impacts of history.

Commercial farming has come to dominate in the world's economic core, as well as some places in the semiperiphery and periphery. Commercial farming is the agriculture of large-scale grain producers and cattle ranches, mechanized equipment, and factory-type labor forces. It is a world apart from the traditional farms of Asia and Africa.

The spatial expansion of modern commercial agriculture began in the eighteenth and nineteenth centuries when Europe became a market for agricultural products from around the world. Moreover, European countries manufactured and sold in their colonies the finished products made from imported raw materials. Thus, cotton grown in Egypt, Sudan, India, and other countries colonized by Europe was bought cheaply, imported to European factories, and made into clothes—many of which were then exported and sold, often in the very colonies where the cotton had been grown in the first place.

Major changes in transportation and food storage, especially refrigeration, further intertwined agricultural production and food-processing regions around the world. The beef industry of Argentina, for example, secured a world market when the invention of refrigerated ships made it possible to transport a highly perishable commodity over long distances. More than 80 percent of the fruits and vegetables sold in U.S. supermarkets arrive through the **cold chain**, a system of harvesting produce that is not quite ripe and ripening it by controlling temperature from the fields to the grocery store (**Fig. 11.28**).

European colonial powers required farmers in their colonies to cultivate specific crops. One major impact of colonial agriculture was the establishment of **monoculture** (dependence on a single agricultural commodity) throughout much of the colonial world. Colonies became known for certain crops, and colonizers came to rely on those crops. Farmers in Ghana still raise cacao; those in Mozambique still grow cotton; and Sri Lankans still produce tea.

Nature Picture Library/Alamy Stock Photo

FIGURE 11.28 Hong Kong. Thousands of pounds of produce sit in cold storage, waiting to be shipped via cold chain across the world.

The World Map of Climates

Before we can study the distribution of agriculture in the world today, we need to examine **Figure 11.29**, the distribution of climate zones. All of the elements of weather—absorption of the sun's energy, rotation of the Earth, circulation of the oceans, movement of weather systems, and the jet stream—produce a pattern of climates represented in the map, and those climate patterns have a profound impact on what can be grown where. Rice and oil palm are grown in tropical latitudes. Soybeans, sunflowers, and corn are grown at the mid-latitudes. Wheat is grown on the poleward side of the mid-latitudes both north and south of the equator.

Figure 11.29 provides one means of understanding the distribution of climatic regions (areas with similar climatic characteristics) across the planet.

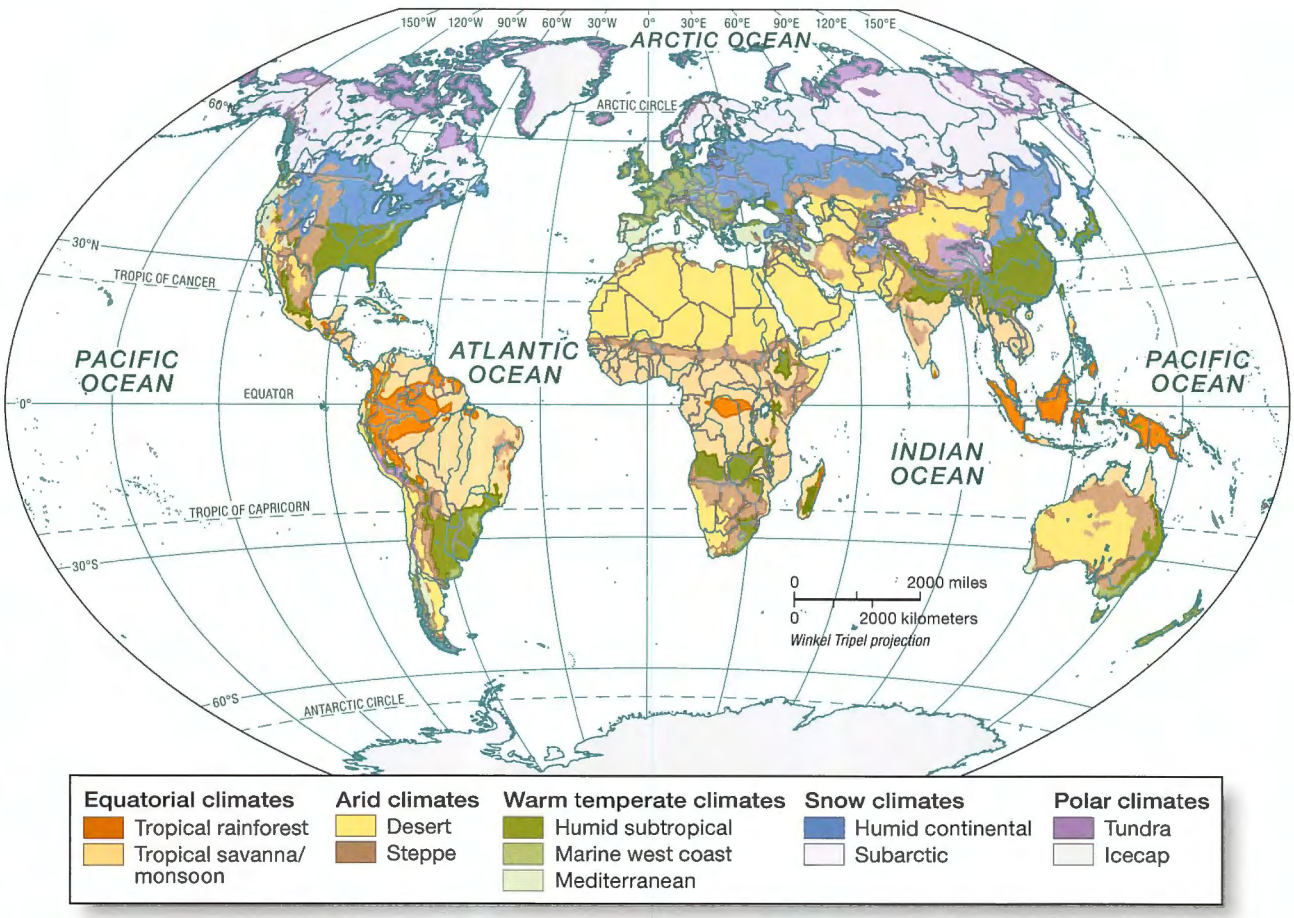
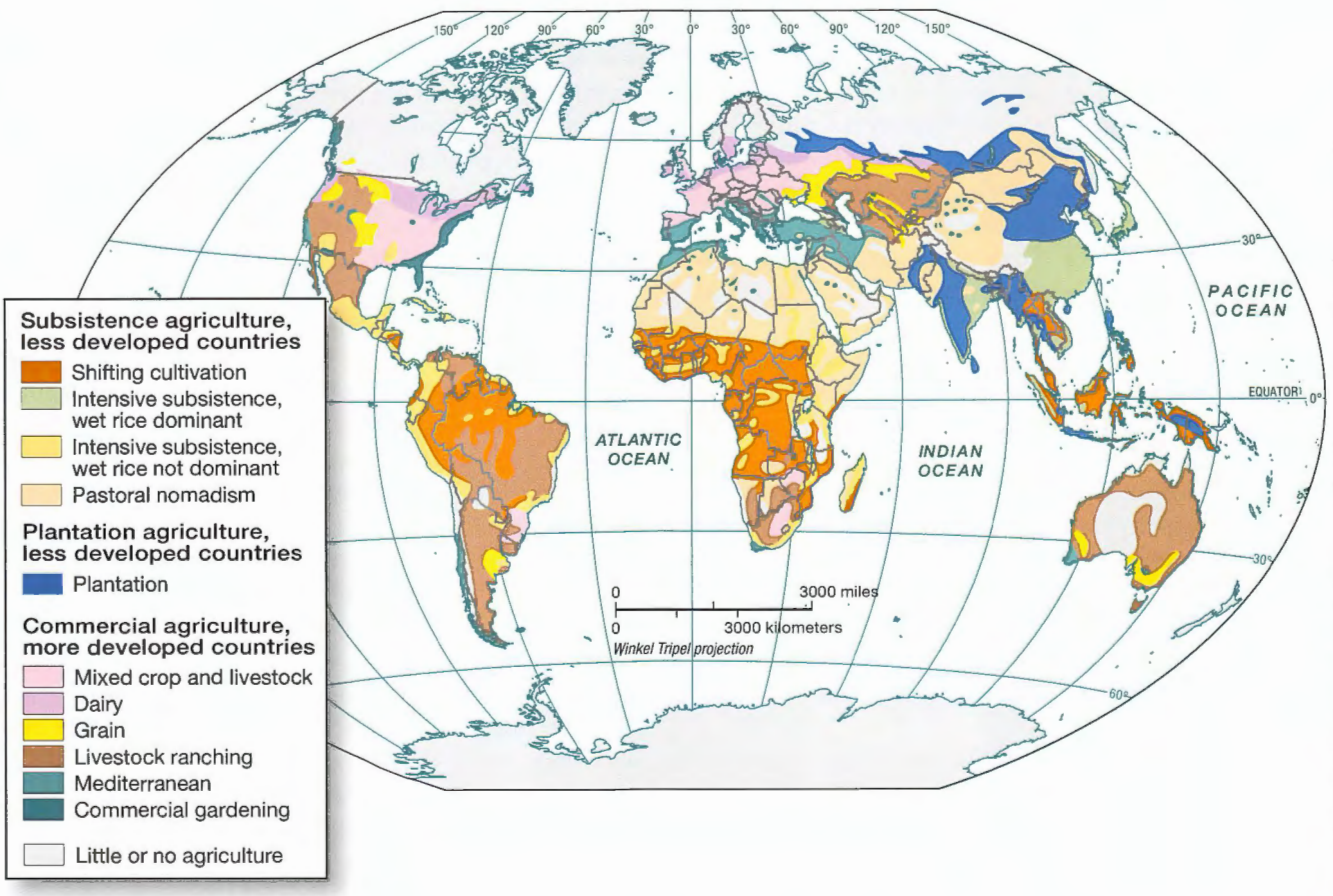


FIGURE 11.29 World Climates. Climates generally follow lines of latitude because the amount of incoming solar radiation varies by latitude. Climates are shaped further by the presence of mountains (as is seen in western North and South America), by the proximity to warm or cold ocean currents, and by proximity to and migration of high and low pressure belts.

- **Equatorial climates** are hot or very warm and generally humid. Equatorial rainforests have no dry season. Tropical savanna and tropical monsoon are grouped because they both have a distinct dry season and a distinct wet season. Both climate zones are wet when the subsolar point (the sun's direct rays) are nearby and dry when the subsolar point is in the opposite hemisphere.
- **Arid climates** include true desert and steppe or semi-arid. True deserts receive almost no precipitation, and semi-arid regions receive very little precipitation. Semi-arid regions are found next to deserts.
- **Warm temperate climates** include the humid subtropical. If you know the local climate in Atlanta or Nashville or Jacksonville, you understand why this climate is called humid. It is moist and generally warm because it just outside the tropics. Marine west coast and Mediterranean climates are along coasts and are found next to each other because they are created by the same conditions. Both marine west coast and Mediterranean climates experience wet winters and dry, hot summers.
- **Snow climates** are found closer to the poles, and include humid continental and subarctic. Humid continental climates are found in the U.S. upper Midwest, southern Canada, and western Russia. Humid continental climate areas are in the middle of continents. Land heats and cools more quickly that water, so temperatures are more extreme in humid continental regions than other parts of the world. Winters are quite cold and summers can get quite hot. Subarctic climates are found poleward of humid continental regions.
- **Polar climates** include tundra and icecap climates and are found poleward of snow climates or at very high elevations. The polar location means temperatures are cold throughout the year. As a result, plant life does not break down and nourish the soil during the year, and a layer of permafrost (frozen ground) exists year-round.

The World Map of Agriculture

When comparing the world map of agriculture (**Fig. 11.30**) with the distribution of climate types across the world (Fig. 11.29), we can see the correlation between climate and agriculture. For example, drier lands rely on livestock ranching, whereas



Source: Modified from Moseley, W.G., E. Perramond, H.M. Hapke, and P. Laris, An Introduction to Human-Environment Geography, New York: Wiley, 2013.

FIGURE 11.30 World Agriculture. The type of agriculture practiced varies with climate. Compare this map with Figure 11.29. Livestock raising is common in semiarid and savanna climate zones. Crop farming and commercial grain farming are found in places that receive higher rainfall. Dairy production generally occurs where climates are cooler. In addition to climate, land ownership patterns factor into the type of agricultural production globally. Where parcels of land are small, farmers generally focus on subsistence production.

moister climates are characterized by grain production. Understanding the major agricultural regions shown in Figure 11.30 requires looking at both environmental and social variables.

Plantation Agriculture Colonialism profoundly shaped nonsubsistence farming in many lower income countries. Colonial powers implemented agriculture systems to benefit their needs, a practice that has tended to lock lower income countries into production of one or two cash crops. Cash crop farming has the benefit of providing cash to the periphery, even if the conditions of sale to the core are unfavorable. In the Caribbean whole national economies depend on sugar, which was introduced by the European colonizers in the 1600s. Caribbean countries want to sell the sugar at the highest possible price, but they are not in a position to dictate prices because sugar is produced by many countries around the world, as well as by farmers in the global economic core. Governments in the core place quotas on imports of agricultural products, including sugar, and subsidize domestic production of the same commodities within their own countries.

Occasionally, producing countries consider forming a cartel to present a united front to the importing countries and to gain a better price, as oil-producing countries did during the 1970s. Such collective action is difficult to coordinate, as the wealthy importing countries can buy products from countries that are not members of the cartel.

Also, if a group of countries controls exports of a good, non-producing countries may create incentives for their own production of the good. For example, although cane sugar accounts for 75 percent of the commercial world sugar crop each year, farmers in the United States, Europe, and Russia also produce sugar from sugar beets. Sugar beets already yield 25 percent of the annual world sugar harvest, and core countries could incentivize higher production.

When cash crops are grown on large estates, we use the term **plantation agriculture** to describe the production system. Plantations are colonial legacies that persist in peripheral, primarily tropical, countries along with subsistence farming. Figure 11.30 shows that plantation agriculture continues in South and Southeast Asia and China. Laid out to produce bananas, sugar, coffee, and cocoa in Middle and South America, rubber, cocoa, and tea in West and East Africa, tea in South Asia, and rubber in Southeast Asia, plantations have outlasted the period of decolonization and continue to provide specialized crops to wealthier markets. Many of the most productive plantations are owned by European or American individuals or corporations.

Multinational corporations have tenaciously protected their economic interests in plantations. In the 1940s and 1950s, the Guatemalan government began an agrarian reform program that entailed renting unused land from foreign corporations to landless citizens at a low appraised value. The United Fruit Company, an American firm with extensive holdings in the country, was greatly concerned by this turn of events. The company had close ties to powerful individuals in the American government, including Secretary of State John Foster Dulles, CIA Director Allen Dulles (the two were brothers), and Assistant Secretary of State for Inter-American Affairs John Moors Cabot. In 1954, the United States supported the overthrow of the government of Guatemala because of stated concerns about the spread of communism. This ended all land reform initiatives, but led many commentators to question the degree to which the United Fruit Company was behind the coup. Indeed, except for President Dwight Eisenhower, every individual involved in the decision to help topple Guatemala's government had ties to the company. This example illustrates the inextricable links between economics and political motivations—and it raises questions about the degree to which multinational corporations based in wealthy countries influence decisions about politics, agriculture, and land reform in other parts of the world.

Commercial Agriculture As Figure 11.30 shows, by far the largest areas of commercial agriculture lie outside the tropics. Dairying is widespread at the northern margins of the midlatitudes—particularly in the northeastern United States and in northwestern Europe. Commercial gardening is found in the eastern and southeastern United States and in widely dispersed in small areas where environments are favorable.

Only one form of agriculture mentioned in the legend of Figure 11.30 refers to a particular climatic zone: Mediterranean agriculture. As the map shows, this kind of specialized farming occurs only in areas where the dry summer Mediterranean climate prevails (Fig. 11.29): along the shores of the Mediterranean Sea, in parts of California and Oregon, in central Chile, at South Africa's Cape, and in parts of southwestern and southern Australia. Farmers here grow a special combination of crops: grapes, olives, citrus fruits, figs, certain vegetables, dates, and others. From these areas come many wines. These and other commodities are exported to distant markets because Mediterranean products tend to be popular and command high prices.

Mixed crop and livestock farming is widespread in the more humid parts of the midlatitudes, including much of the eastern United States, western Europe, and western Russia, but it is also found in South America and South Africa. Commercial grain farming prevails in the drier parts of the midlatitudes, including the southern Prairie Provinces of Canada, in the Dakotas and Montana in the United States, as well as in Nebraska, Kansas, and adjacent areas. Spring wheat (planted in the spring and harvested in the summer) grows in the northern zone, and winter wheat (planted in the autumn and harvested in the spring of the following year) is used in the southern area. An even larger belt of wheat farming extends from Ukraine through Russia into Kazakhstan. The Argentinean and Australian wheat zones are smaller in area, but their exports are an important component of world trade.

Even a cursory glance at Figure 11.30 reveals the wide distribution of livestock ranching, the raising of domesticated animals to produce meat and byproducts such as leather and wool. In addition to the large cattle-ranching areas in the United States, Canada, and Mexico, much of eastern Brazil and Argentina is devoted to ranching, along with large tracts of Australia and New Zealand, as well as South Africa. You may see a Thünian pattern here: livestock ranching on the periphery and consumers in the cities. Refrigeration has overcome the

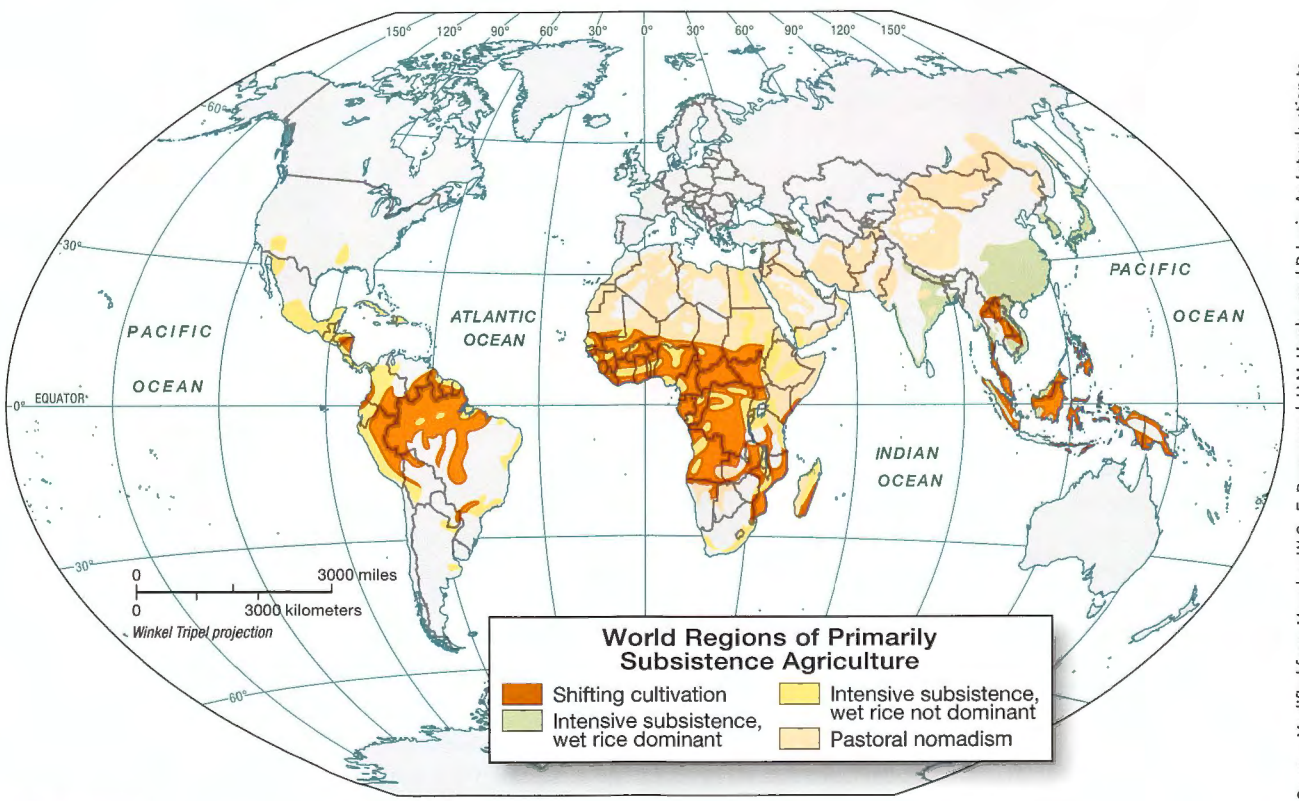
problem of perishability, and high volume has lowered the unit cost of transporting beef, lamb, and other animal products.

Subsistence Agriculture The map of world agriculture labels four types of subsistence agriculture: shifting cultivation, intensive subsistence—wet rice dominant, intensive subsistence—wet rice not dominant, and pastoral nomadism. In some regions that are labeled as subsistence, that label does not tell the whole story (**Fig. 11.31**). For example, in Southeast Asia, rice is grown on small plots and with a lot of labor, so that subsistence and export production occur side by side. Despite the region's significant rice exports, most Southeast Asian farmers are subsistence farmers. Thus, Southeast Asia appears on the map as primarily a subsistence grain-growing area.

Drug Agriculture Certain important agricultural activities cannot easily be mapped at the global scale and therefore do not appear in Figure 11.30. One of those activities is the cultivation of crops that are turned into illegal drugs. Because of the high demand for drugs—particularly in the global economic core—farmers in the periphery often find it more profitable to cultivate poppy, coca, or marijuana plants than to grow standard food crops. Cultivation of these plants has increased steadily over the past several decades, and they now constitute an important source of revenue for parts of the global economic periphery. Coca, the source plant of cocaine, is grown widely in Colombia, Peru, and Bolivia. Over half of the world's cultivation of coca occurs in Colombia alone.

Heroin and opium are derived from opium poppy plants, grown predominantly in Southeast and South Asia, especially in Afghanistan and Myanmar. In the 2013 World Drug Report, the United Nations reported that 74 percent of the world's opium production took place in Afghanistan. The U.S.-led overthrow of the Taliban in Afghanistan in 2001 created a power vacuum in the country and an opportunity for illegal drug production to quickly rebound (the austere Taliban government had virtually eradicated opium production in Afghanistan by 2001). Most opium production in Afghanistan today occurs in five unstable southern provinces.

U.S. government policies have affected production of illegal drugs in Latin America. During the 1980s and 1990s, the U.S. government worked with local authorities to crack down on coca production in Colombia. As a result, much of the drug production and trafficking moved north to northern Mexico. In June 2005, *The Economist* quoted one American official as reporting that "Mexican criminal gangs 'exert more influence over drug trafficking in the U.S. than any other group.' Mexicans now control 11 of the 13 largest drug markets in the United States." Marijuana and opium production in Mexico is on the rise, and the United States Drug Enforcement Agency (DEA) is concerned about the high potency of marijuana coming out of Mexico and Canada. Despite Afghanistan's dominance as a heroin producer, most heroin (which is derived from opium) consumed in the western United States comes from opium grown in Mexico, whereas the heroin consumed in the eastern United States comes from opium grown in Colombia.



Source: Modified from Moseley, W.G., E. Perramond, H.M. Hapke, and P. Laris, An Introduction to Human-Environment Geography, New York: Wiley, 2013.

FIGURE 11.31 World Regions of Primarily Subsistence Agriculture. Areas of subsistence agriculture include parts of South America, Africa, and Asia.

Drug cartels that oversee the drug trade have brought crime and violence to the places where they hold sway (**Fig. 11.32**). There are areas in Rio de Janeiro where the official police have little control, and drug lords have imposed reigns of terror over swaths of the countryside in parts of Central and South America, Southwest Asia, Southeast Asia, and elsewhere. The drug trade depends on the voracious appetite for mind-altering substances in North America and Europe in particular.

The supply of marijuana in the United States traditionally came from Mexico and Canada, as the DEA has reported. But an increasing amount of marijuana consumed in the United States is grown in the United States. Since 1996, a total of 16 states — mostly in the West—have legalized marijuana for medicinal purposes, and in 2013 Colorado and Washington legalized it entirely (though they forbid consumption in public places and have placed additional restrictions on cultivation for personal use and the amount of marijuana people can purchase). An April 2011 article in *The New York Times* valued marijuana production at $40 billion, "with California, Tennessee, Kentucky, Hawaii and Washington the top five production states," despite the fact that medicinal marijuana is not legal in Tennessee or Kentucky.

Marijuana production has more than a monetary impact. Marijuana grown indoors consumes massive amounts of electricity. The cost of indoor production includes grow lamps that are the kinds used in operating rooms, dehumidifiers, air conditioners, electric generators, water pumps, heaters, carbon dioxide generators, ventilation systems, and electrical control systems. Studies estimate that the energy used to produce marijuana in the United States costs about $6 billion a year (around 1 percent of all power consumed in the United States). Marijuana grown outdoors has much lower energy costs than marijuana grown indoors. Growers may plant crops on public lands using only energy from sunlight, especially in the West, because the remote location of public lands makes detection less likely. Also, the land is public and therefore not owned by any one person to whom a crop could be traced.

TC Thinking Geographically

Analyze the world agriculture map and the world climate map. Find an agricultural type that does not seem to correspond with a certain climate **region**. Hypothesize why the two do not overlap and what variables in addition to climate need to be considered to understand the location of this agricultural type.

Source: Modified from "CRS Report for Congress", Mexico's Drug Cartels, October 16, 2007.

FIGURE 11.32 Mexican Drug Cartel Regions of Influence in Mexico. Mexican drug cartels claim swaths of the country and fight with each other for control of territory. Control of territory is important in order to move cocaine, methamphetamine, and marijuana into the United States. The cartels involved and their territorial control have changed as the Mexican government has worked to disrupt the control of the cartels since its war on drugs began in 2006.

11.4 Analyze How Commercial Agriculture Operates.

With modern agriculture and food production, it is possible for many people to put farming largely out of their minds. As a result of the industrialization of agriculture and improvements in transportation, consumers come in contact with farmers much less frequently than in previous generations. On a freezing cold winter day in Cincinnati, Ohio, they can purchase fresh strawberries grown in Chile. Consumers can also purchase highly processed foods with long shelf lives and forget where the item was purchased, much less think of the farm work that went into the ingredients.

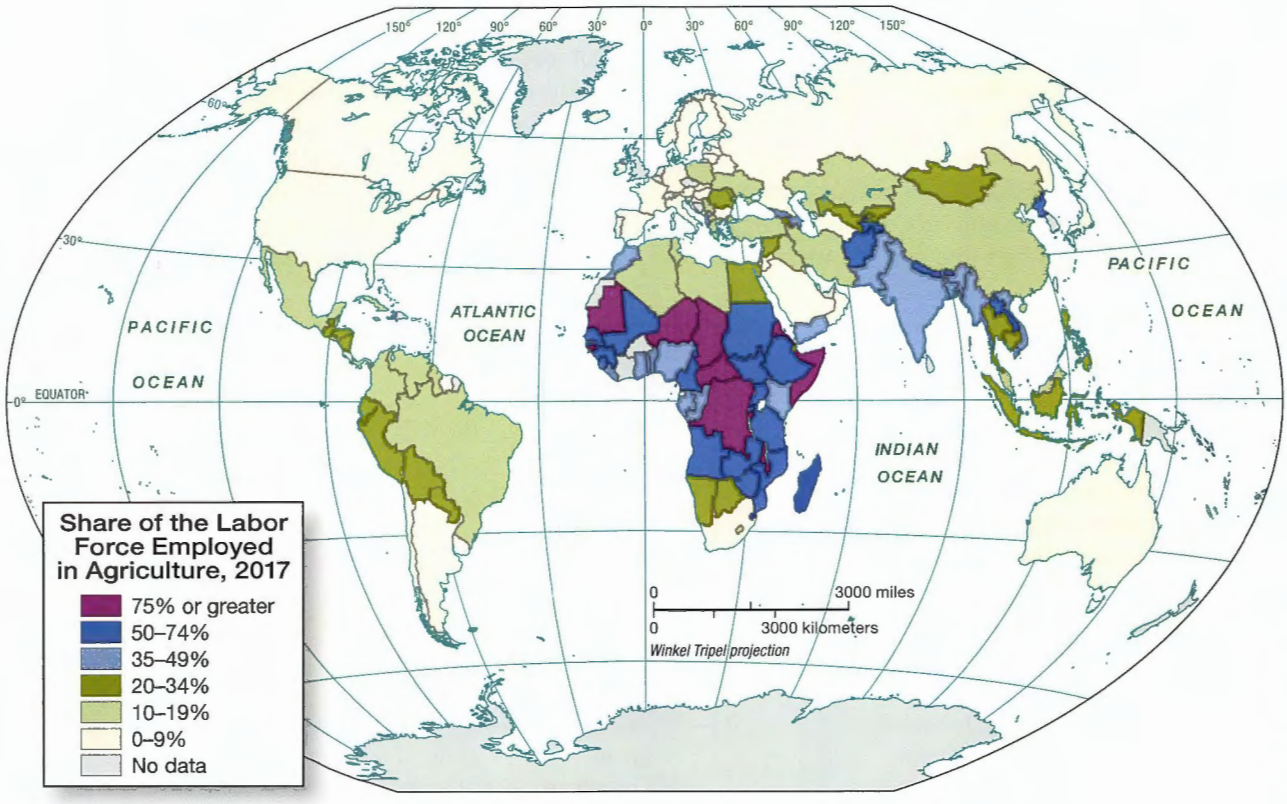
The commodity chains involved in agricultural production and delivery are increasingly complicated and interconnected. The label on your strawberries may say "grown in Chile," but imagining exactly how your strawberries are produced, whether in a field, in a greenhouse, in an urban farm, is increasingly difficult in a system of globalized, commercial agriculture.

Farms and Farmers

Examining the proportion of people employed in agriculture gives us an idea of whether agriculture is more commercial (intensive) or subsistence (extensive) in a country (**Fig. 11.33**). India is the second largest agricultural producer in the world (after China), with its agricultural goods valued at $358,905 million and 42.74 percent of its labor force employed in agriculture. The United States is the third largest agricultural producer in the world, with its agricultural goods valued at more than $32.7 billion. The share of the U.S. labor force employed in agriculture is much smaller, though, at only 1.66 percent. The same amount of agricultural production requires much more labor in India than it does in the United States, pointing to a more commercial (intensive) approach to agriculture in the United States.

Two other countries with similar total production have similar differences in how labor intensive their agricultural production is. The agricultural goods produced in the United Kingdom are valued at $24.6 billion, and those produced in Malaysia are valued at $23.6 billion. Figure 11.33 reveals the difference in labor, with 1.1 percent of the United Kingdom and 11.01 percent of the Malaysian labor force employed in the agriculture. In this case, the United Kingdom is using more commercial methods of agricultural production than Malaysia.

The data on labor force in agriculture are even more interesting if you look at the definition provided by the



Source: Modified from Roser, M., "Employment in Agriculture", Our World in Data.

FIGURE 11.33 Share of Labor Force Employed in Agriculture. The proportion of the labor force employed in agriculture varies by country. Countries in Africa have the highest proportion of their labor forced employed in agriculture. Countries in North America and western Europe have 9 percent or less of their labor force employed in agriculture.

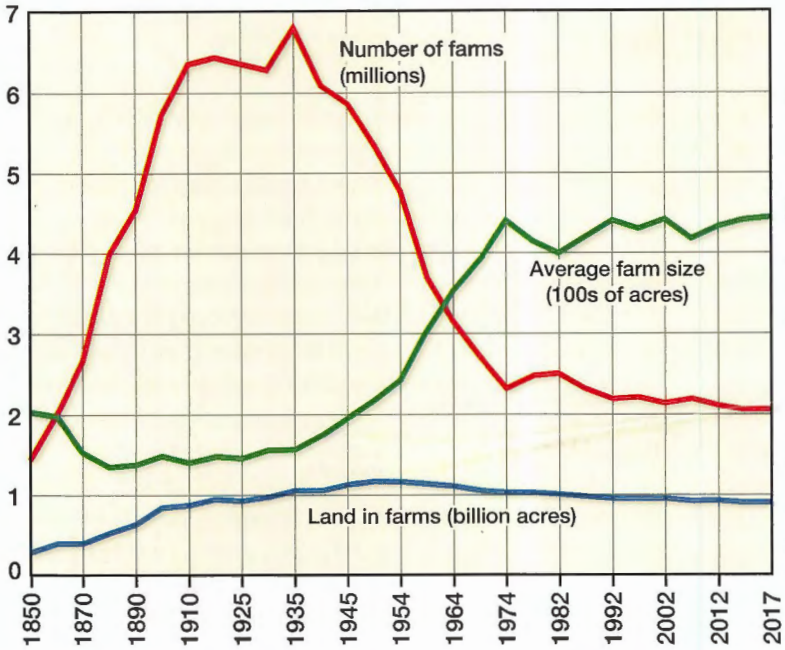


FIGURE 11.34 Number of Farms, Land in Farms, and Average Farm Size. The amount of land in farms has stayed relatively steady while the number of farms has fallen since the Great Depression and the average size of farms has grown.

World Bank: "share of persons of working age who were engaged in any activity to produce goods or provide services for pay or profit in the agricultural sector (agriculture, hunting, forestry and fishing)" (2018). The 1.1 percent of the United Kingdom's labor force employed in agriculture includes those who "provide services" to producers. Many of these workers include research scientists for universities, workers for seed companies, or workers for producers of chemicals (antibiotics, pesticides, and herbicides). Lobbyists for industry groups such as wheat producers and cattle ranchers, as well as engineers who design, sell, and repair farm implements, are also part of the agricultural labor force.

In the United States, total agricultural production is at an all-time high, but the proportion of the labor force in agriculture is at an all-time low. Mechanization and efficiencies created by new technologies have led to a significant decrease in the number of workers needed in agricultural production. In 1950, one farmer produced enough to feed 27 people; today, one farmer in the United States produces enough to feed 144 people. The mechanization of agriculture goes beyond machinery such as combines and harvesters. New technologies include hybrid seeds and genetically engineered crops, pesticides, and herbicides, all of which are designed to increase yields.

The drive toward economic efficiency has meant that between 1910 and 2017, the number of farms in the United States has fallen and then tapered off, while the amount of land in agriculture has stayed relatively consistent. As a result of these two trends, the average size of farms (acres in production) in the United States has risen (**Fig. 11.34**). The United States currently has about 2.05 million farms in operation with an average size of 444 acres (compared to 135 acres in 1935) (USDA). Of the 2.05 million farms, 2.8 percent are classified as large and produce 39 percent of all agricultural goods, and 88.8 percent are classified as small and produce 25.8 percent of all agricultural goods. While we tend to think of farms as family farms or corporate farms, most corporate farms are owned by families. Nonfamily farms account for 2.2 percent of all farms and produce 12.6 percent of all agricultural goods (**Fig. 11.35**).

Bid Rent Theory

Another way of thinking about production of agricultural products around towns and cities is to consider the cost of land. Land values are generally higher closer to the central city and lower farther away from the city. The cost of land affects what farmers produce because where land values are high, farmers want to grow valuable crops like market produce that will help them pay for the rent on their land. Where land values are low, farmers grow more common crops that need a lot of space to grow, like grain.

The **bid rent theory** holds that the price and demand for land will go up the closer it is to the central city. Agriculture, retail, manufacturing, and residential will all compete for the land closest to the central city, driving up its cost. In agriculture, the bid rent theory helps us understand whether farmers will use intensive agricultural practices or extensive agricultural

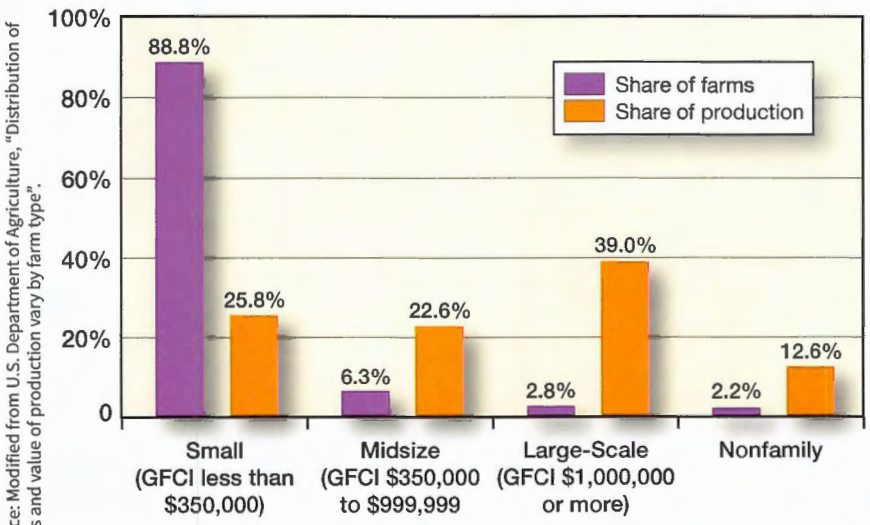


FIGURE 11.35 Farms and Their Value of Production by USDA Farm Type. Small farms make up the largest proportion of farms in the United States, but large-scale farms generate the largest share of production.

practices. Intensive agricultural practices use a great deal of capital relative to the land area farmed, whereas extensive agricultural practices use less capital.

Intensive agricultural practices include applying fertilizers, insecticides, and high-cost inputs to achieve the highest yields possible. They often occur closer to the city where land values are high. With the rapid growth of world cities and the expansion of big data and artificial intelligence, intensive agriculture is rapidly growing near major cities. One form is **indoor vertical farms**, also known as plant factories, which rely on growing produce hydroponically, without soil (**Fig. 11.36**). Sensors throughout the building constantly collect data and gather it into the Cloud. Companies like Microsoft are developing artificial intelligence systems to help farmers analyze data and change conditions for optimal crop yields. These plant factories are located close to city centers, use space efficiently, and require serious technology investments. The next step is automation, which will use robotics to harvest fresh produce from indoor vertical farms and deliver it to a customer in the city the same day.

AzmanL/E+/Getty Images

FIGURE 11.36 Tokyo, Japan. Farmers grow market produce using vertical farming and other high-tech methods to save space.

Extensive agricultural practices use less capital and larger areas of land to cultivate what has traditionally been a lower yield. Applying bid rent theory, extensive agriculture takes place farther from the city center, where land values are low relative to labor and capital. Crops grown extensively include grains like wheat and rice and tubers like yams, taro, cassava, and potatoes.

Modern agriculture, especially in large agricultural countries like the United States and Canada, challenges the traditional conception of extensive agriculture. Farmers who put millions of dollars into seeds, fertilizers, GPS-guided combines, drones, and data are using a combination of intensive practices, including high technology and high capital, and extensive practices, including more remote, expansive fields. The result is a high yield, often even in adverse conditions like drought.

Organic Agriculture: Consumer Demand

Organic agriculture, the production of crops without the use of synthetic or industrially produced pesticides and fertilizers, is growing globally in terms of land devoted to organic farming (69.8 million hectares), number of organic farmers (2.9 million), and the market value of organic food ($97 billion). Organic foods are sold at the highest rates in the United States, Germany, France, and China. Australia, Argentina, and China have the most land in organic production.

Comparing the number of hectares in organic production to the number of organic producers gives an idea of whether organic production is intensive or extensive. India has the most organic producers (835,200) but only has 1.78 million hectares of land in organic production. Indian organic farmers are producing on small plots, using a lot of labor and not a lot of technology. India has 0.46 organic producers per hectare of organic farmland. The United States has fewer organic producers (14,217) and more land (2.03 million hectares) in organic production. American organic producers are producing on larger plots, using less labor and more technology. The United States has 0.007 organic producers per hectare of organic farmland.

Sales of organic food in the United States went from under $200 million in 1980 to $8 billion by 2000 and $40 billion in 2017 (**Table 11.1**). In 2000, the sales of organic food reached a tipping point, where more organic food was purchased in supermarkets than in health food stores. Organic foods are sold in three out of four conventional grocery stores and approximately 20,000 natural food stores in the United States, with increasing demands for organic animal products such as meats and dairy.

Organic foods are now 5.7 percent of all food sales in the United States, up from 3.4 percent in 2010. The growth rate is so strong that some predict organic sales will approach 10 percent of total U.S. food sales within a decade. Denmark already hit double digits with 13.3 percent of total food sales in organic. Sweden, Switzerland, and Austria follow with 9.1, 9.0, and 8.6 percent of total food sales in organic, respectively. Farmers who can gain organic certification from a government or an internationally recognized third party are increasingly at a competitive advantage (**Fig. 11.37**).

Organic farming has helped some farmers extract themselves from major corporate farming interests. However, the largest organic food seller in the United States, WhiteWave Foods, is a subsidiary of Danone, which is ranked 24 on the list of the largest food producers in the country. The second largest organic food producer, Hain Celestial Group, stands at 64

TABLE 11.1 **Organic Sales per Year from 2000 to 2017 for United States, India, and World.**

Organic Sales per Year, 2000–2017
Retail Sales, Millions of Euros

Year	United States	India	World
2000	8000		15,156
2001	8000		16,355
2002	8514		18,798
2003	8510		19,615
2004	8945		20,938
2005	10,658	39	23,560
2006	12,447		27,958
2007	13,271		31,754
2008	13,865	8	34,137
2009	15,247	13	36,945
2010	17,320	20	41,282
2011	18,066	31	43,916
2012	21,766	51	49,584
2013	23,626	70	54,863
2014	26,420	101	61,344
2015	35,156	144	75,317
2016	38,402	172	84,459
2017	40,011	186	92,062

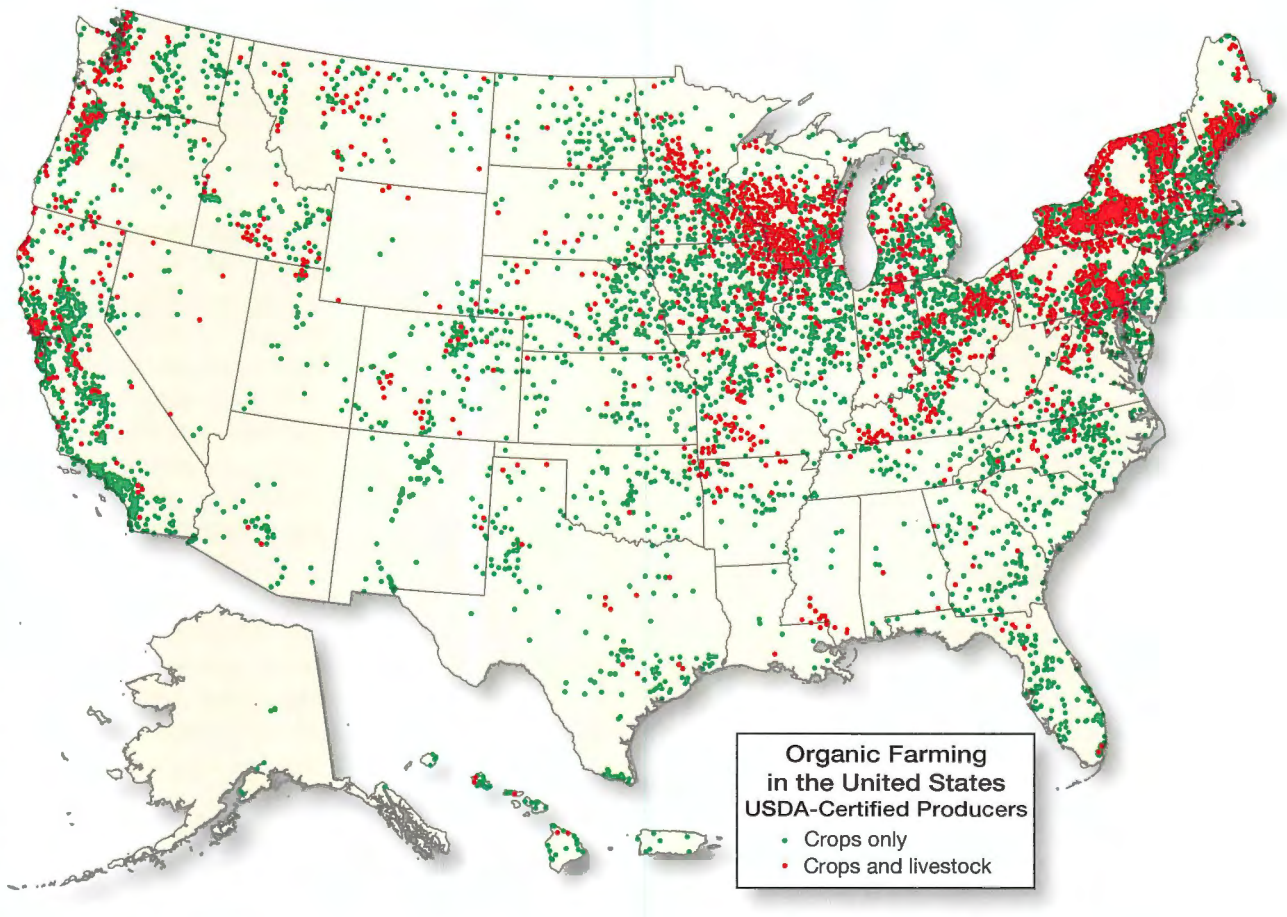
Source: Data from: https://statistics.fibl.org/

on the list of largest producers overall. The third largest organic producer is General Mills, which is likely a familiar brand for their cereals, and is ranked 10 on the list.

The organic movement has some clear environmental benefits, particularly in reducing the levels of synthetic chemicals in soil and water. The putative health and taste advantages of organic produce help ensure the continued growth of the organic movement.

Ethanol and Biodiesel: Government Impacts

Grains, other plant life, vegetable oils, and animal fats can be converted into fuel, either ethanol or biodiesel. **Ethanol** is a renewable fuel made from plant materials called biomass. Ethanol is added to about 98 percent of all gasoline sold in the United States. **Biodiesel** is also a renewable fuel, and it is made from vegetable oils, animal fats, or recycled restaurant grease. Ethanol is used more frequently in colder climates because it has properties that prevent it and the gasoline it's mixed with from freezing in cold temperatures. Biodiesel is used in warmer climates because its components can freeze and crystalize in cold weather.



Source: Modified from "New Map Identifies Organic Farming Hotspots", The Cornucopia Institute.

FIGURE 11.37 **Organic Farming in the United States.** Organic farming is widespread in the United States and is found in all 50 states. Organic livestock production coincides well with the map of dairy production in the United States (see Fig. 11.30).

Much of the corn produced in the United States and the sugar produced in Brazil is converted into ethanol and used for fuel. The two countries account for 85 percent of the ethanol produced worldwide. In 2018, 38 percent of all corn produced in the United States was processed into fuel instead of food or feed. Ethanol production took off in both Brazil and the United States in the 1970s when the price of oil rose and the price of corn and sugar dropped. In the 1980s, when the price of oil fell again, federal and state governments subsidized ethanol production. The current federal ethanol subsidy in the United States gives ethanol blenders a tax credit of $0.45 for every gallon of ethanol they blend with gasoline, at a cost to taxpayers in taxes not paid of $5.7 billion annually.

While ethanol and biodiesel are renewable fuels that burn cleaner than gasoline, each comes with several environmental concerns. The chief concern is that not all products used to create the fuels are efficient. The efficiency by acre of ethanol and biodiesel depends on the product used to create the fuel (**Fig. 11.38**). The biggest source of ethanol in the United States is corn (maize), but the number of gallons per acre from corn is much lower (401 gallons/acre) than for switchgrass (1150 gallons/acre). Most biodiesel in the United States is derived from soybeans, which yield 59 gallons of biodiesel per acre, while microalgae produce 5020 gallons of biodiesel per acre.

Scientists do not agree on the net energy savings or cost of ethanol or biodiesel over hydrocarbons like oil. Dozens of variables that are difficult to quantify go into the calculations of energy and water use for production. Land use is the first variable. A field of corn can be a carbon dioxide sink because the plants use carbon dioxide to grow through photosynthesis. But the actual production and then burning of the corn release carbon dioxide. Because ethanol is plant based, burning ethanol still creates carbon dioxide, but most studies agree that burning ethanol releases less carbon dioxide than burning hydrocarbons does. Another concern with biofuel is that ethanol burns less efficiently than gasoline. Gasoline produces more miles per gallon than ethanol. It takes energy to refine both fuels, but it takes less energy to create biodiesel than it does to create ethanol.

How much more water is used for ethanol and biodiesel production depends on where the corn or soybeans are planted. If they are planted in a rain-fed cornfield, they do little to deplete aquifers or divert rivers. If they are planted in irrigated fields, switching land use to more corn and soybeans to meet demands for biofuels leads to much higher water consumption rates. Consumptive water use is a measurement of the gallons of water needed to refine gallons of fuel. In rank order from least to most, it requires 1.0 gallon of water to produce 3.0 gallons of soy biodiesel, 1.5 gallons of water to produce 3.0 gallons of oil, and 3.0 gallons of water to produce 4.0 gallons of ethanol (NAP 2008).

Ethanol refineries are generally located close to areas of corn production, which helps reduce the cost of transporting biomass from cornfields to refineries (**Fig. 11.39**). The counties that produce the most corn stover (remnants of corn plants after

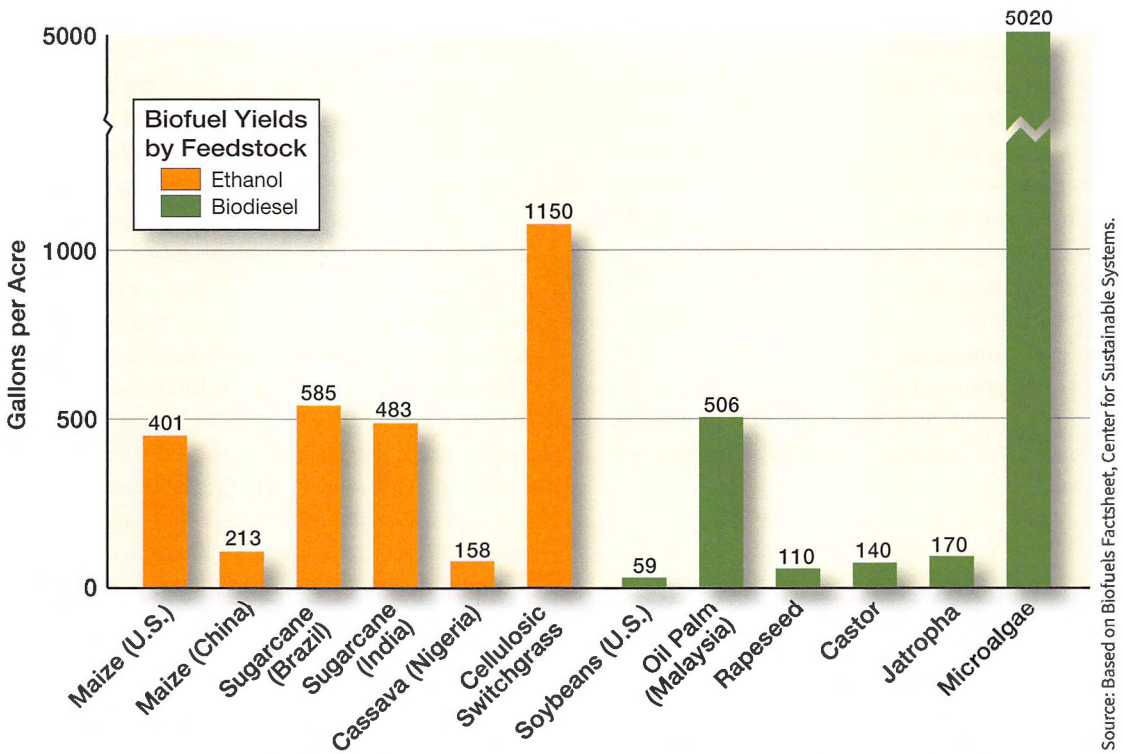
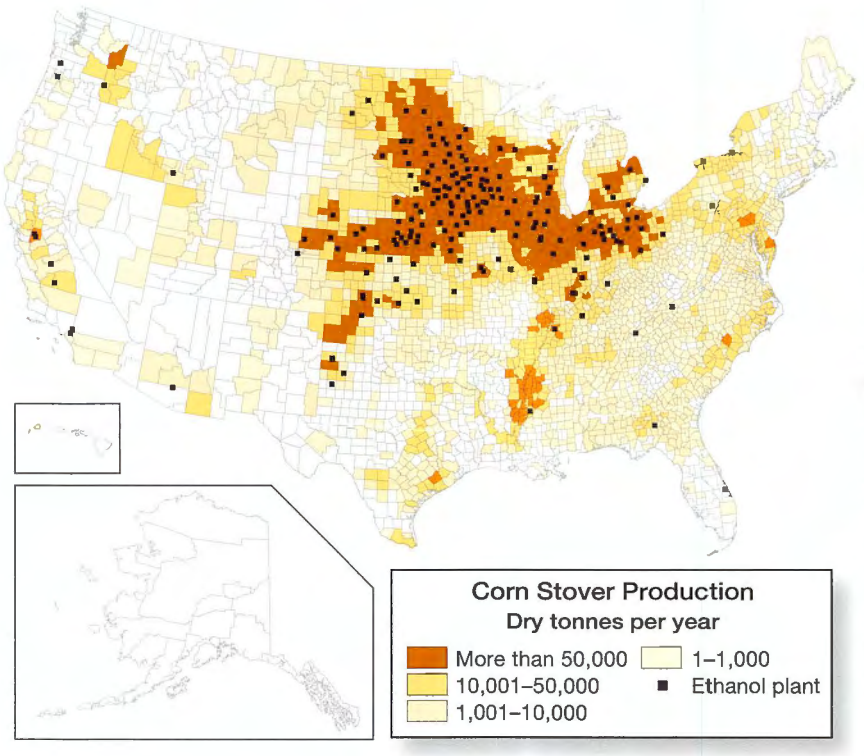


FIGURE 11.38 Biofuel Yields by Feedstock. Grains, other plant life, vegetable oils, and animal fats can be converted into fuel, either ethanol or biodiesel. The efficiency by acre of ethanol and biodiesel depends on the product used to create the fuel. The y-axis shows the gallons of ethanol produced by acre, and the x-axis lists different sources for ethanol and biodiesel.



Source: Based on The Biofuels Atlas from the National Renewable Energy Laboratory.

FIGURE 11.39 Corn Stover Production. Corn stover is the remnants of corn plants after harvesting the ears of corn. It is the stalks, leaves, and cobs that remain in a field after harvest. Farmers can harvest that biomass and sell it for ethanol production.

harvesting) are concentrated in the **Corn Belt**, stretching from North Dakota, South Dakota, and Nebraska east through Minnesota and Iowa to Wisconsin, Illinois, and Indiana.

Biodiesel refineries are located close to high soybean-production counties in several cases in the Great Plains, Midwest, and Mississippi River region, because 57 percent of biodiesel in the United States comes from soybean oil (**Fig. 11.40**). However, soybean production areas do not explain the location of all of the biodiesel refineries on the map. Biodiesel refineries on the west coast and east coast are located close to population centers, where plenty of used cooking oil is available for producing biodiesel. Some locations on the map are close to livestock production centers, including hog production in the Carolinas and Virginia and chicken production in the South and Delmarva Peninsula, because animal fats are also used to produce biodiesel.

Coffee: Fair Trade

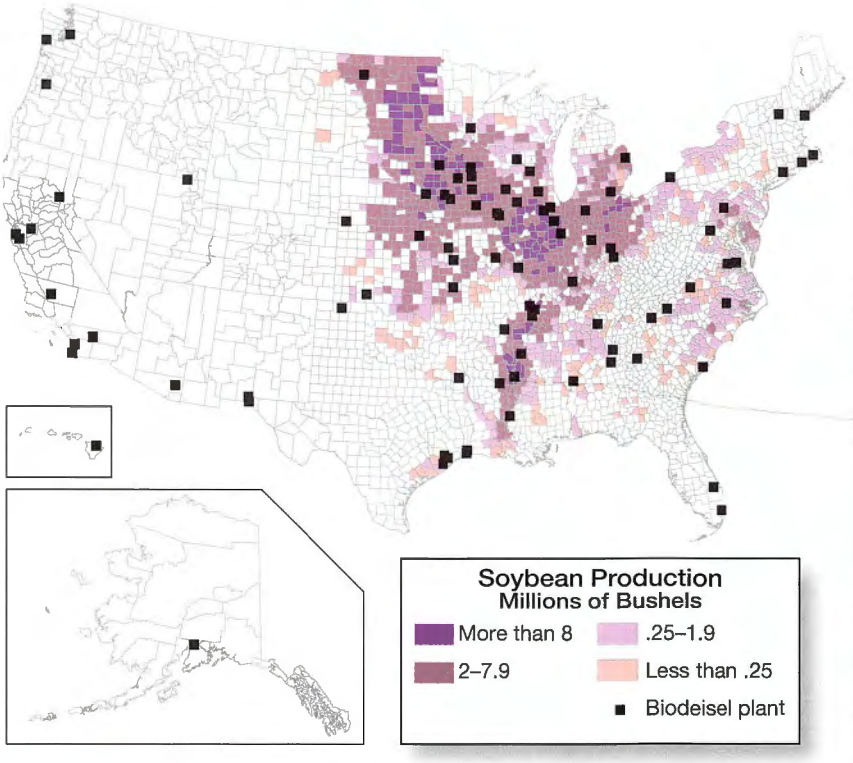
Agriculture is also affected by social and cultural factors. As incomes rise, many people start consuming more meat and processed foods, seek out better-quality fruits and vegetables, or demand fresh produce year-round. Consider the case of coffee, one the most important luxury crops in the modern world. Coffee was first domesticated in present-day Ethiopia, but today it is grown primarily in Middle and South America, where approximately 70 percent of the world's annual production is harvested.

In the early eighteenth century, coffee was virtually unknown in most of the world. Yet after petroleum, coffee is now the second most valuable legally traded commodity in the world. The United States buys more than half of all the coffee sold on world markets annually, and western Europe imports most of the rest. A well-known image of coffee production in North America is Juan Valdez, portrayed as a simple yet proud Colombian peasant who handpicks beans by day and enjoys a cup of his own coffee by night. This image is quite contrary to the reality of much coffee production in Latin America. In most cases, coffee is produced on enormous, foreign-owned plantations, where it is picked by local laborers who are hired at very low wage rates. Most coffee is sent abroad, and if the coffee pickers drink coffee, it is probably of the imported and instant variety.

In the past few decades, however, coffee production has undergone changes as more consumers demand fair trade coffee and more coffee producers seek fair trade certification.

The aim of fair trade is to raise the income of certified producers by reducing the number of actors in the supply chain. Coffee producers form democratically run cooperatives that, if certified, can be registered on the International Fair Trade Coffee Register. Coffee importers then purchase the fair trade coffee directly from the registered cooperatives. Being registered guarantees coffee producers a "fair trade price" of $1.40 per pound of coffee (plus bonuses of $0.30 per pound for organic).

When organic agriculture bears a fair trade certification, some producers in the periphery and semiperiphery benefit substantially, though they also have to abide by rules established in the core. Over 1.3 million farmers and workers in 70 countries, mainly in the periphery and semiperiphery, are connected to the 1150 fair trade–certified producer organizations worldwide (**Fig. 11.41**). The fair trade campaign pressured Starbucks into selling fair trade coffee, and Starbucks now buys around 20 million pounds of fair trade coffee each year. That amounts to just 5 percent of its total purchases, but it is the largest purchaser of fair trade coffee in the world. Other retailers have followed suit; for example, all espresso sold at Dunkin' Donuts in North America and Europe is fair trade certified. Fair trade coffee is available at large retail outlets and under corporate brands at Target, Walmart, and Sam's Club. The corporate embrace of fair trade coffee has boosted the movement considerably, though it has also raised concerns about corporate co-optation of fair trade standards.



Source: Data from AFDC TransAtlas at the National Renewable Energy Laboratory and Soybean production by county at U.S. Department of Agriculture. Visualization by E.H. Fouberg and A.B. Murphy. © 2020 John Wiley & Sons, Inc.

FIGURE 11.40 Biodiesel Plants in the United States. Biodiesel plants are located in soybean production zones or close to major population centers.

The push for fair trade production shows how social movements can influence agriculture. And fair trade goes beyond coffee. Dozens of commodities and products, ranging from tea, bananas, fresh-cut flowers, and chocolate to soccer balls, can be certified fair trade. According to Fair Trade International, consumers spent more than $6.5 billion on fair trade–certified products in 2012.

Poultry and Hogs: Agribusiness

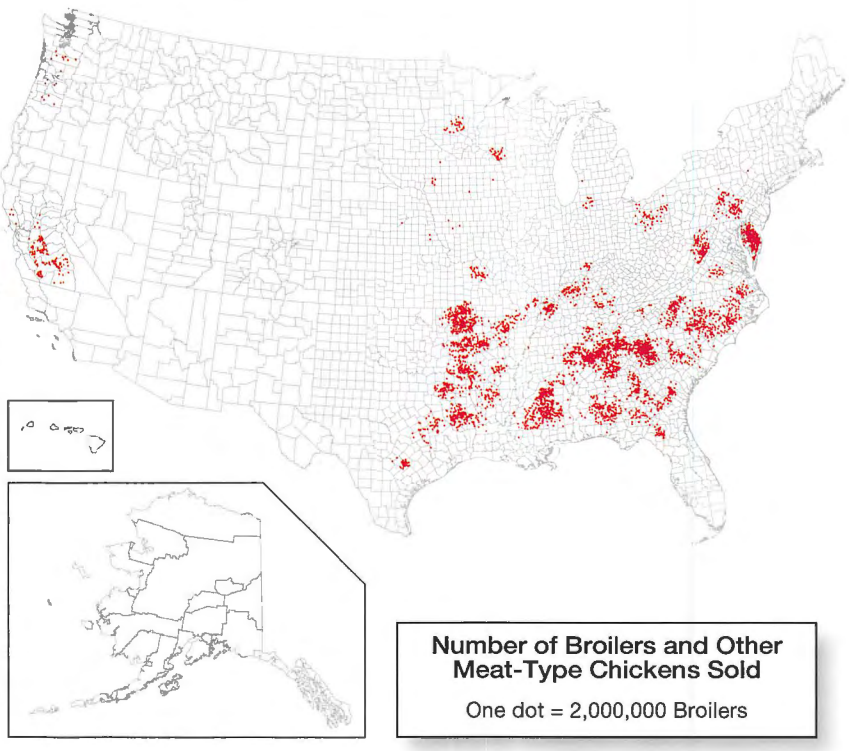
The commercialization of crop production and new agricultural technologies have changed how agricultural goods are grown and have sparked the rapid growth of *agribusiness*: the businesses that provide a vast array of goods and services to support the agricultural industry. As part of a networks of agribusiness, farmers are tied to an extensive web of production and consumption. Agribusiness also helps concentrate agricultural industries because fewer farmers produce more to take advantage of economies of scale in order to compete in agribusiness. Both trends are revealed in the development of the poultry industry in the United States.

Early in the twentieth century, poultry production in the United States was highly disaggregated, with many farmers raising a few chickens as part of a multifaceted farming operation. Over the past 50 years, however, poultry production has changed. Today, the farmers on the Delmarva Peninsula east of Washington, D.C., account for 8 percent of poultry production in the United States, and they do so by contracting and working directly with four major poultry companies. In an article on modern agriculture, David Lanegran summarized the impact of this transformation as follows:

> Today, chickens are produced by large agribusiness companies operating hatcheries, feed mills, and processing plants. They supply chicks and feed to the farmers. The farmers are responsible for building a house and maintaining proper temperature and water supply. Once a week the companies fill the feed bins for the farmers, and guarantee them a price for the birds. The companies even collect market ready birds and take them away for processing and marketing. Most of the nation's poultry supply is handled by a half dozen very large corporations that control the process from chicks to chicken pieces in stores.

© Lindsay Naylor

FIGURE 11.41 Los Altos, Chiapas, Mexico. A Mayan farmer picks ripe coffee beans for sale to North American customers as fair trade coffee.



Courtesy of: United States Census of Agriculture, National Agricultural Statistics Service.

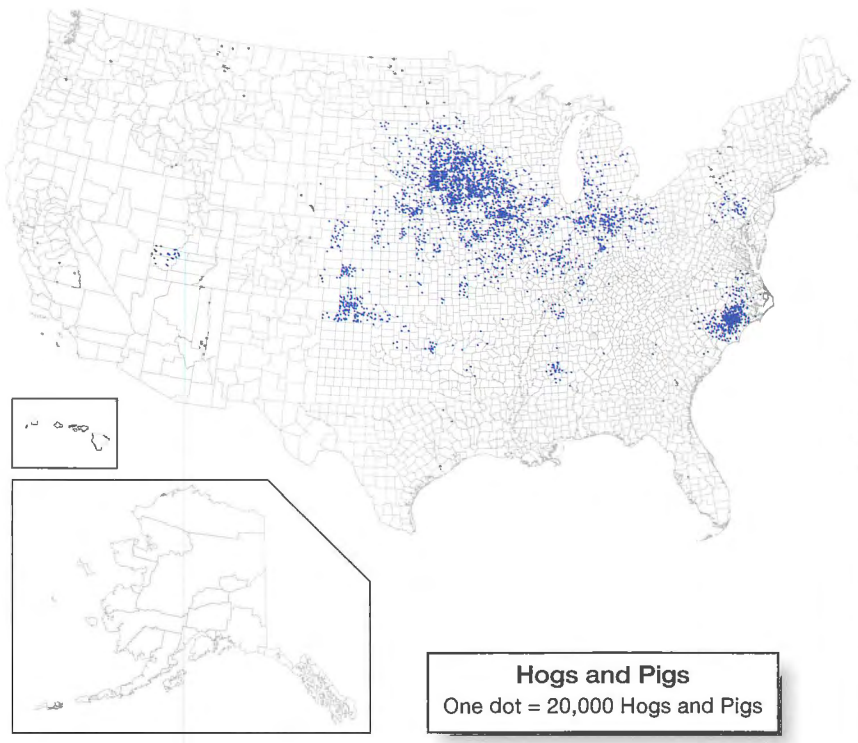
FIGURE 11.42 Broiler Chicken Sales in the United States. Broiler chickens are grown for meat, which means they will be processed and consumed once sold. Farmers typically sell broiler chickens to one of 40 large processing companies, including Tyson and Purdue. Ninety-five percent of broiler chickens in the United States are produced by farmers who are under contract with a large processing firm and are required to follow their standards and use their feed from hatched egg to table.

Lanegran goes on to show how selective breeding has produced faster-growing, bigger chickens, which are housed in enormous broiler houses that are largely mechanized.

Broiler houses are concentrated in northwestern Arkansas, northern Georgia, the Delmarva Peninsula (Delaware, Maryland, and Virginia), the Piedmont areas of North Carolina, and the Shenandoah Valley of Virginia (**Fig. 11.42**). Lanegran shows that the "farmers" who manage these operations are involved in manufacturing as much as in farming. They are as likely spend their time talking to bank officers, overseeing the repair of equipment, and negotiating with vendors as they are to tending their animals. Thus, they symbolize the blending of the rural and the urban in wealthier parts of the world—as well as the interconnections between rural places and distant markets.

The poultry example is not unusual. During the 1990s, hog production on the Oklahoma and Texas panhandles increased rapidly with the arrival of corporate hog farms. John Fraser Hart and Chris Mayda described the quick change with statistics. In 1992, the U.S. Census of Agriculture counted just over 31,000 hogs marketed in Texas County, Oklahoma, and just four years later "the panhandle was plastered with proliferating pork places, and Texas County alone produced 2 million hogs. It was the epicenter of an area that produced 4 million hogs, 4 percent of the national total and one-seventh as many finished hogs as the entire state of Iowa." The availability of both inexpensive water and natural gas on the Oklahoma panhandle was enticing for corporate hog farms, which require both. Hart and Mayda explain that the "reasonable" price of land and the accessibility to "growing metropolitan markets of the South and the West" also made the region attractive for hog production. As in poultry production, a corporation built a processing plant, and production (both by farms owned by the corporation and those owned privately) increased to meet the demand (**Fig. 11.43**).

Because of agribusiness, the shelves of urban supermarkets in the United States, with their range and variety of products, are a world apart from the constant quest in some areas for sufficient, nutritionally



Courtesy of: United States Census of Agriculture, National Agricultural Statistics Service.

FIGURE 11.43 Hogs and Pigs in the United States. Hog and pig production is concentrated in the Corn Belt in and around Iowa and also in North Carolina. The earliest stages of hog production are done inside buildings using systems designed to reduce the possibility of disease spreading among the livestock.

balanced food. A global network of farm production is oriented to one-fifth of the world's population that is highly urbanized, wealthy, and powerful. Few farmers in distant lands have real control over land-use decisions, for the higher income people in the global economic core play a disproportionate role in deciding what will be bought at what price. The colonial era may have come to an end, but as the map of agricultural regions reminds us, its imprint remains strong.

TC Thinking Geographically

Compare and contrast the **pattern** of commercial and subsistence agriculture on the world map. If a community wanted to abandon commercial agriculture and return to subsistence agriculture, what steps would it need to take in terms of land ownership, agricultural goods produced, and land use to be successful?

11.5 Examine the Challenges of Feeding Everyone.

Currently, enough food is produced worldwide to feed Earth's population, but in the face of inadequate distribution systems and widespread poverty, food security looms as a significant issue for the twenty-first century.

The United Nations (UN) World Food Program defines **hunger** as living on less than the daily recommended 2100 calories the average person needs to live a healthy life. While news stories focus on starving populations in the wake of wars and natural disasters, acute emergencies account for less than 8 percent of the global hungry. Chronic undernourishment is a much greater problem, impeding childhood development, weakening immune systems, and undermining the social fabric of communities. Globally, 11 percent of the population, or around 815 million people, went hungry in 2016, according to the UN Food and Agricultural Organization. Undernourishment is a key factor in the deaths of 45 percent of children worldwide who do not live to age 5.

In response to widespread undernourishment and famine, in 1985 the U.S. Agency for International Development created the Famine Early Warning System, which collaborates with other organizations worldwide to monitor food stores and predict food insecurity. Many governments and nongovernmental organizations provide food aid to populations in need. The UN World Food Program is the largest source of food aid in the world. It delivers food that is tailored to meet nutritional needs based on the population in a certain location. A typical food basket includes a staple food such as wheat flour or rice; a protein (often lentils or other legumes); vegetable oil; sugar; and salt.

Despite these initiatives, the battle against hunger and undernourishment is far from won. The World Food Program identifies several causes of hunger globally:

- Poverty trap: People who cannot afford food become weaker, which makes it more difficult to find or keep a job, creating a cycle of poverty and hunger.
- Lack of investment in agriculture infrastructure: Countries that lack infrastructure to keep produce cold at the point of harvest until it can be shipped globally by cold chain, and countries that lack infrastructure such as roads to move food are at a disadvantage in production and consumption.
- Climate and weather: Natural disasters have longer-lasting impacts in peripheral countries. Climate change is creating extended droughts, exacerbating threats from new pests, and altering growing conditions for traditional crops.
- War and displacement: Conflict disrupts agriculture. Refugees and internally displaced peoples from farming areas no longer live on their farms and cannot produce crops.
- Unstable markets: Fluctuating and unpredictable food prices make it difficult to access healthy foods consistently.
- Food wastage: About one-third of all food produced globally is never consumed.

These six factors help explain why people go hungry in a world with enough food for everyone.

Finding your way out of food insecurity and undernourishment is not easy. Undernourished people rarely have the **agency**, the capacity to make independent choices and act intentionally to affect change, to combat the poverty and the political and social issues at the root of undernutrition and famine. In their landmark work on **vulnerability**, geographers Michael Watts and Hans Bohl found three interrelated causes of food insecurity:

1. Declining control over local food resources
2. Lack of political power
3. Political-economic structures

Farmers in vulnerable agricultural areas, like South Asia and sub-Saharan Africa, have less say over local food production and hand over decision making to agribusiness, including seed and fertilizer suppliers. Politically, farmers have little agency if their governments are corrupt or the political system has institutional inefficiencies. Governments that actively create policies to disempower or disadvantage certain groups as a means of control set the stage for food insecurity and famine.

According to the World Health Organization, **malnutrition** has several forms, including "undernutrition (wasting,

stunting, underweight), inadequate vitamins or minerals, overweight, obesity, and resulting diet-related noncommunicable diseases." Worldwide, 462 million adults are underweight and 224 million children under age 5 are underweight. Of the children under age 5 who are underweight, 17 million are severely wasted, 52 million are wasted, and 155 million are stunted. Also worldwide, 1.9 billion adults and 41 million children are overweight or obese.

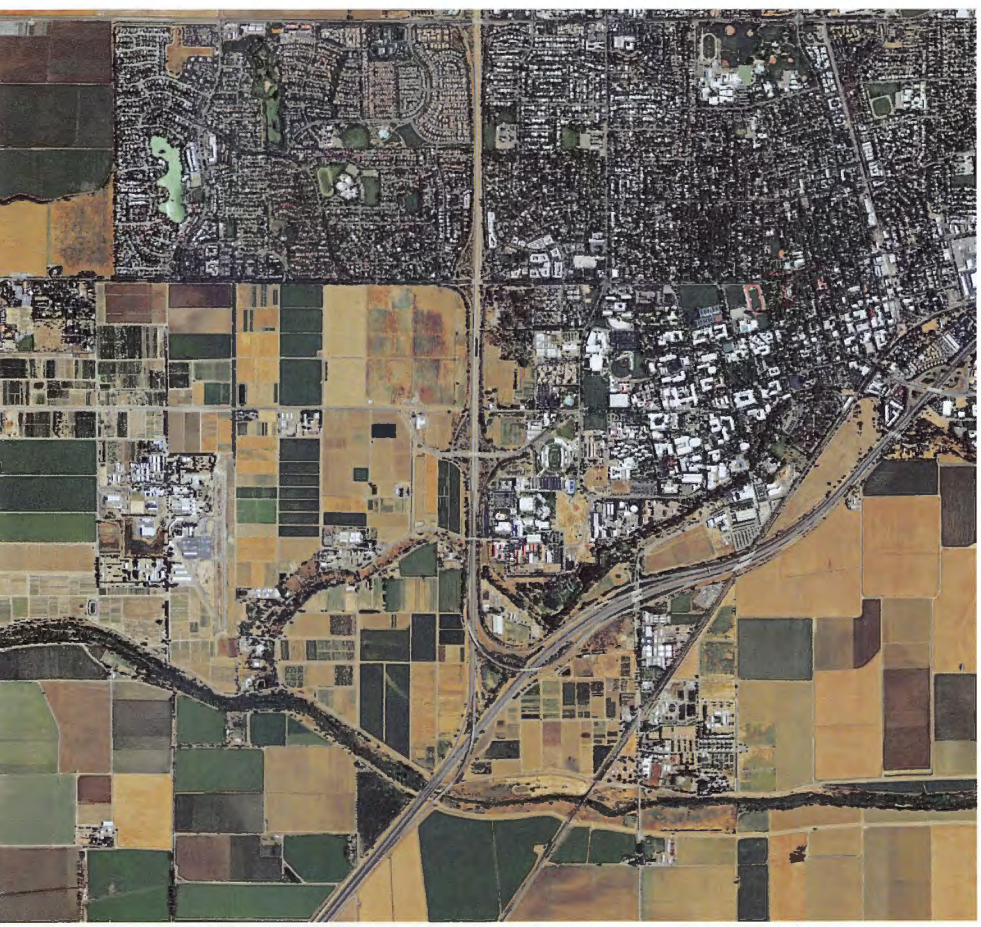
Conversion of Farmland to Nonfarm Use

As the world population increases and the footprints of cities continue to grow, developers are converting fertile, productive farmlands to housing, retail, offices, and infrastructure (**Fig. 11.44**). In the 1800s and early 1900s, cities near productive farmlands often grew because farmers could supply food to the residents (see discussion of von Thünen). Rapid suburban growth after World War II and urban sprawl since the 1980s have converted farmland to urban development. A recent report by American Farmland Trust found that "over 70 percent of urban development and about 54 percent of low-density residential development occurred on agricultural land" between 1992 and 2012. The authors of the study mapped lands by their PVR value (productivity, versatility, and resiliency), and found that land with high PVR value was more likely to be developed (**Fig. 11.45**). In that time period, 11 million acres of productive farmland in the United States, a size equivalent to 47 percent of the state of Indiana, were converted to nonagricultural use.

The conversion of farmlands into housing developments is not confined to areas close to major cities that could become suburbs. Expendable wealth and the desire to have a place to "get away from it all" have led highly productive commercial agricultural areas to be converted into regions for second homes. On the Delmarva (Delaware, Maryland, Virginia) Peninsula in the United States, for example, where poultry production is concentrated, the price of land rose as city-dwellers from Pennsylvania, Washington, D.C., Maryland, and New York bought land on the Eastern Shore to build second homes. Once the new residents settled on the peninsula, they demanded higher environmental standards. But rising land prices and stricter environmental standards impact the cost of chicken production. As the urban population continues to grow and expendable wealth increases, more agricultural lands will be converted to second homes, especially on coastlines or idyllic country landscapes.

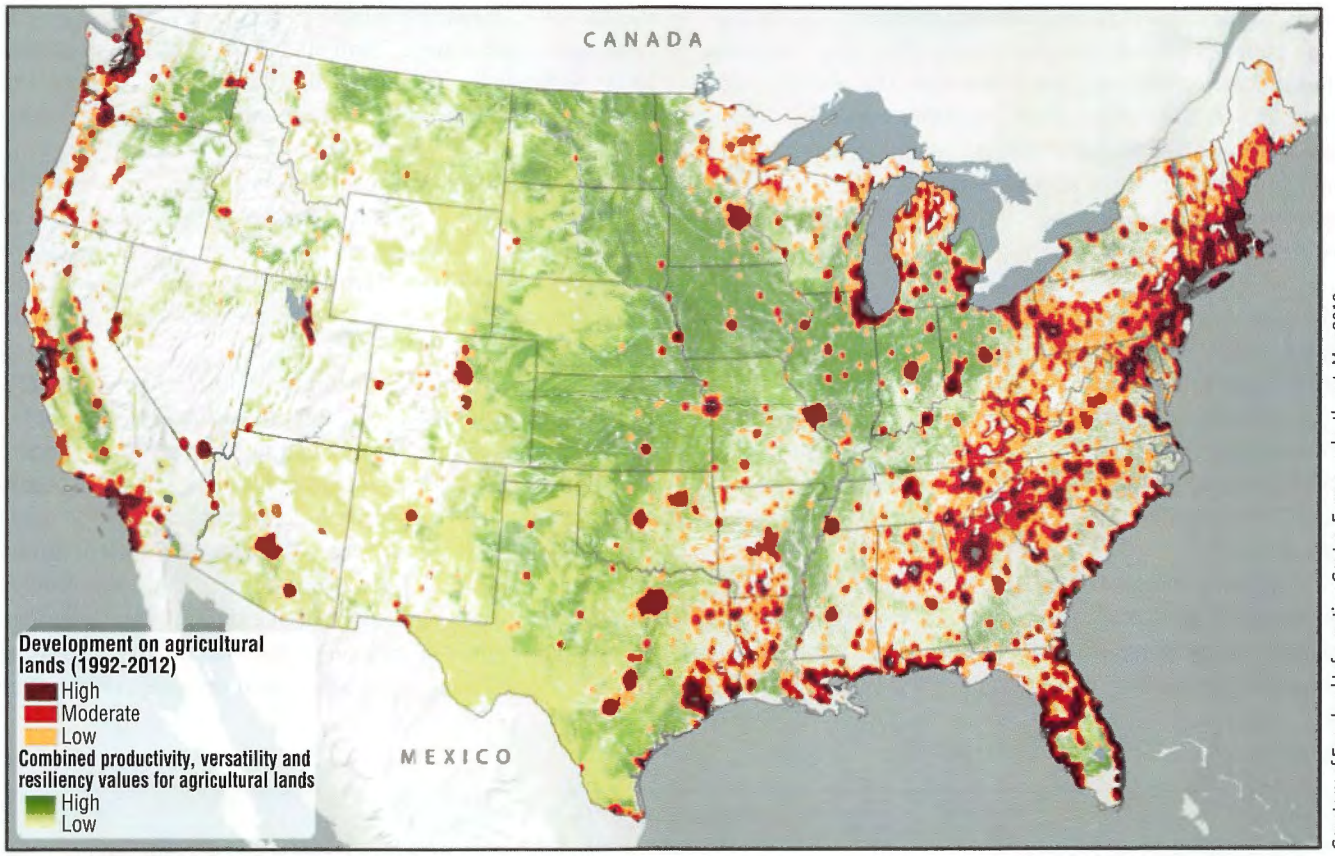
Conversion of productive farmland to urban, suburban, and rural residential, retail, and office use and infrastructure is not confined to the United States. The European Environmental Administration reported that when agricultural lands have been converted to artificial surfaces, it is often for housing.

Even though productivity on remaining agricultural land has risen because of technology, irrigation, pesticides, fertilizers, and engineered seeds, the loss of productive farmland will have a ripple effect on land use, especially forests. Because of the combination of pressure on agricultural land and climate change, more forestlands are being converted to agricultural lands. The results of this trend are not ideal. Cutting and burning forestland both removes a carbon dioxide sink and releases large quantities of carbon dioxide into the atmosphere. Moreover, because soils in forests are different from soils in productive farmlands, planting in newly converted forestlands may require more pesticides, fertilizers, and irrigation, which create additional strains on the global water supply.



Aerial Archives/Alamy Stock Photo

FIGURE 11.44 Davis, California. As suburbs spread from urban areas into productive farmlands, the number of borders between farming and residential zones multiplies.



Courtesy of Farmland Information Center, Farms under threat, May 2018.

FIGURE 11.45 Farms Under Threat: Conversion of Agricultural Land to Urban and Low-Density Residential Development. This map from American Farmland Trust, whose charge is to preserve farmland, highlights where development on agricultural lands in the contiguous United States took place over two decades. Urban areas are shown in gray on the map (look at Atlanta and Minneapolis to see the gray centers of cities) and are often encircled by high rates of development on agricultural land.

Food Security

The National Research Council identifies four major issues that affect food security worldwide:

1. varying abilities to balance production and consumption across regions and countries,
2. accelerating conversions of agricultural land to urban uses,
3. increasingly energy-intensive food production methods in a world of shrinking fossil fuel resources, and
4. expanding use of food crops for biofuel production.

The first issue highlights the fact that where agricultural goods are produced does not overlap with where goods are consumed. The second and fourth issues both point to how we use agricultural lands. Converting farmland to suburbs and using productive farmland to grow crops like soybeans that are destined for biofuels reduces the amount of productive land that is available for growing food for people and feed for livestock.

The third issue points to the fluctuating price factors that producers weigh. Each price factor impacts farmers' bottom line and their ability to maintain their operation, whether they are using hydrocarbons (fossil fuels) to run implements and irrigation systems; buying farm insurance; taking out loans for operations, equipment, or land; taking out a bridge loan to stay afloat; selecting an expensive drought-resistant seed or a less-expensive seed; selecting and applying fertilizers and pesticides; or buying or renting land.

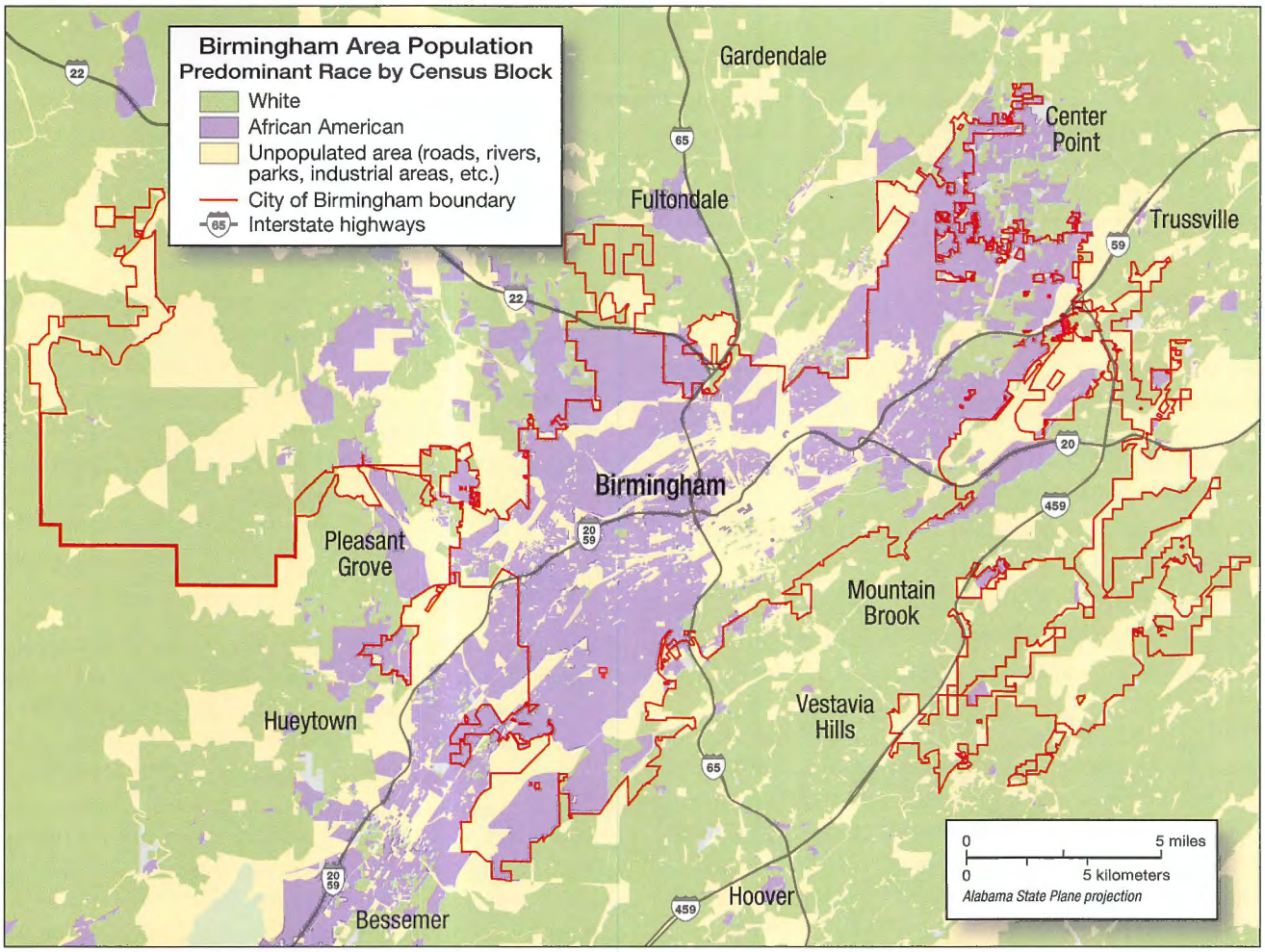
Food Deserts

Malnourishment in the form of obesity or undernourishment can be linked to living in a **food desert**, a small region or area with limited access to fresh, nutrient-rich foods. Urban food deserts are typically found in low-income neighborhoods where medium-size and large grocery stores are largely absent. The only grocery stores within easy reach are convenience stores offering processed, energy-dense but nutrient-poor food. Rural food deserts can cover large expanses. Rural areas often lack local grocery stores or public transportation to major towns with stores. A White House Task Force on Childhood Obesity, led by former First Lady Michelle Obama reported that 23.5 million Americans live in food deserts, including 6.5 million children.

Consumers in urban food deserts are more likely to purchase unhealthy foods like chips, sugary cereals, and snack cakes, because they are cheaper than fresh fruits and vegetables. The USDA created a Food Access Research Atlas at the scale of the United States that is accessible online. You can zoom into certain cities or states and map food deserts in rural and urban areas. The atlas maps the distance to a grocery store at different increments, creating zones of 0.5 and 1.0 miles for urban areas and zones of 10 or 20 miles for rural areas. It also maps low-income Census tracts, and Census tracts where more than 100 households do not have a vehicle. Food deserts in both rural and urban areas overlap frequently with race, because disadvantaged minorities often have lower incomes. A comparison of **Figure 11.46A** with **Figure 11.46B** shows that the Census tracts of Birmingham, Alabama, where most people are African American, are also the Census tracts classified as food deserts.

Walgreens, a major drugstore chain in the United States, recognized in 2011 that 45 percent of its stores are "located in areas that don't have access to fresh food." So Walgreens committed to turning at least 1000 of its stores into **food oasis** stores, locations where fresh fruits and vegetables, whole grains, and lean, fresh meats are available at affordable prices. Walgreens opened its first store in Chicago and has its headquarters in a Chicago suburb. Building on this history, Walgreens opened its first 10 food oasis stores in food deserts in Chicago. The most recent reports show that Walgreens is falling far behind its goal of opening 1000 food oasis stores. While Walgreens has a larger percentage of grocery sales in the U.S. than Trader Joes or Natural Abundance, most groceries sold at Walgreens are packaged foods and not fresh foods.

Geographers Akihiko Michimi and Michael Wimberly found that rural food deserts lack not only larger grocery stores, but also public transportation to reach larger grocery stores (**Fig. 11.47**). In their study of food deserts and access to fruits and vegetables, the geographers found that since the 1980s, in rural areas of the United States a "restructuring of food retail industries has occurred such that local grocery stores that once served small rural communities have been closed" and replaced with larger national chains in regional trade centers. The geographers found one major difference



Source: Based on 2010 Census Block Data, University of Virginia. Visualization by E.H. Fouberg and A.B. Murphy.

FIGURE 11.46A Birmingham, Alabama. Predominantly African American and predominantly white neighborhoods are separated from each other in and around Birmingham.

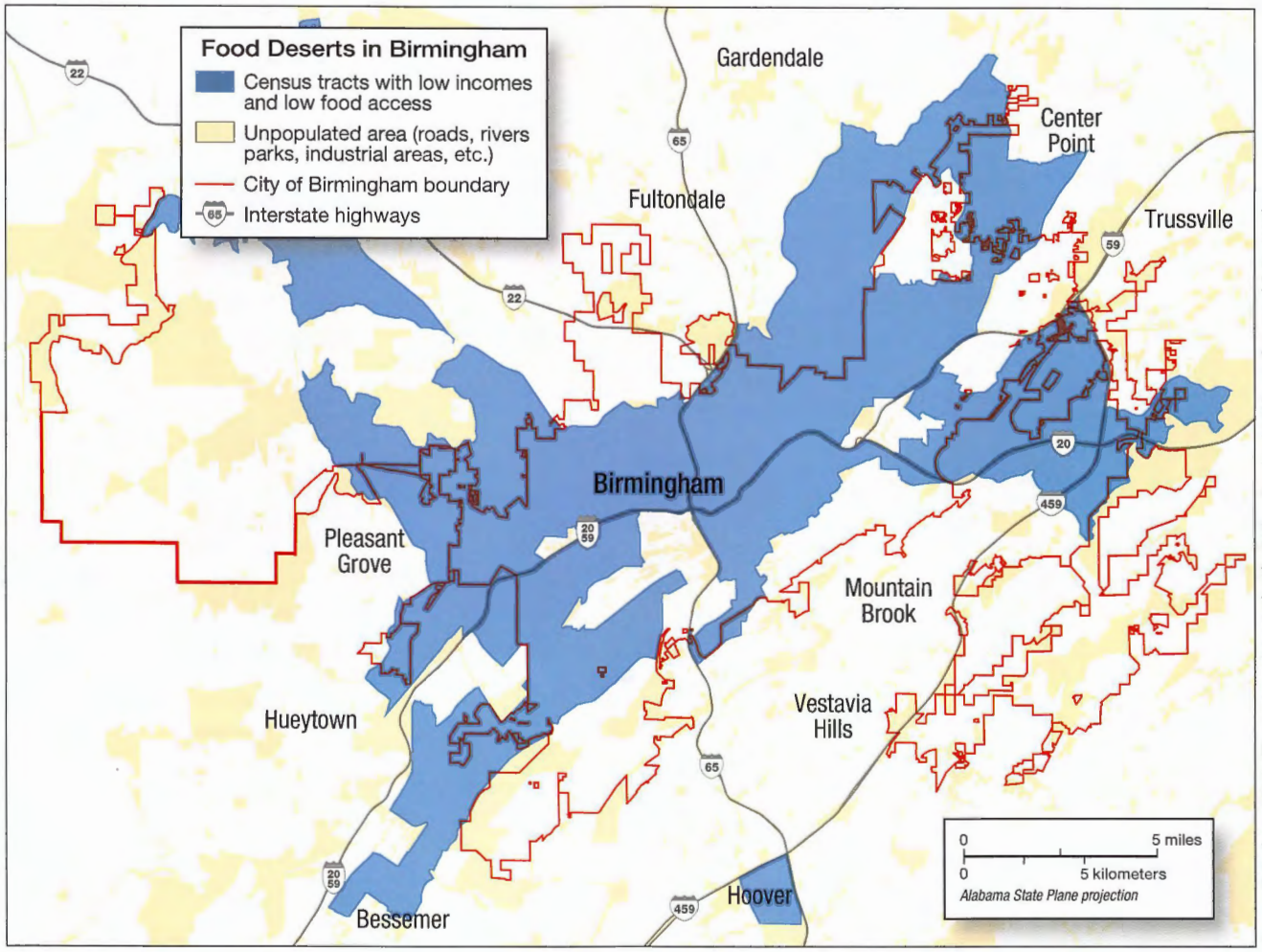


FIGURE 11.46B Birmingham, Alabama. Food deserts are mapped in blue and designated by census tracts that have low incomes and low access to food. Compare 11.46A and 11.46B to see how race correlates with food deserts in Birmingham.

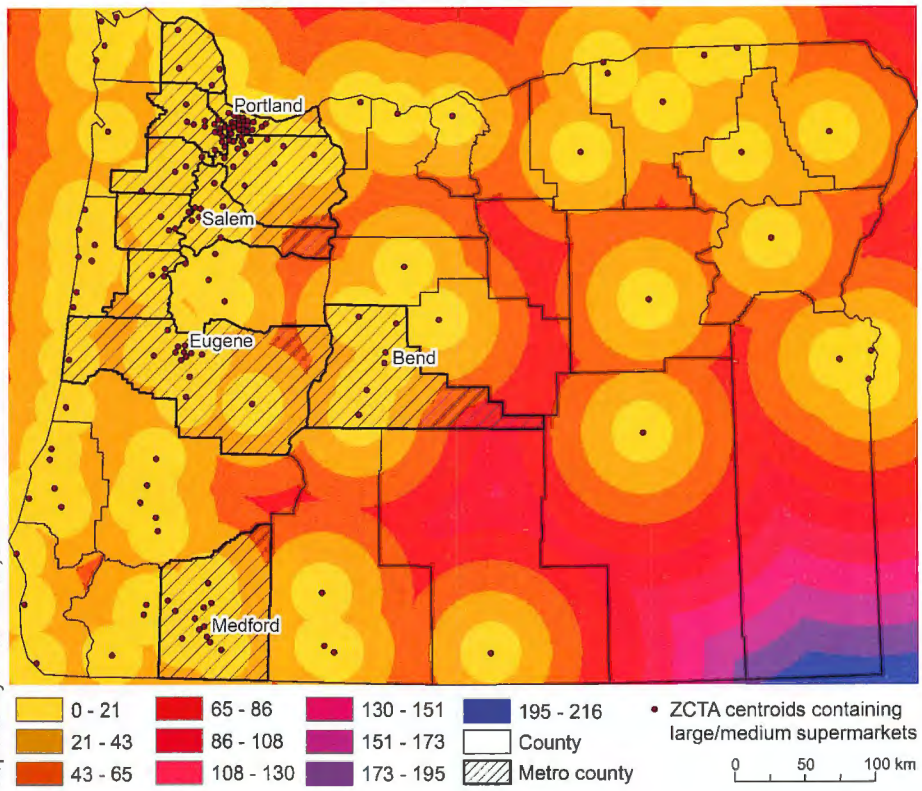
between food deserts in urban and rural areas. In urban food deserts, obesity rates increased and the rate of fruit and vegetable consumption decreased with increasing distance from grocery stores. Rural areas did not have similar correlations between distance and obesity rates and fruit and vegetable consumption. Rural residents may have access to fresh fruits and vegetables in their personal or neighbors' gardens. This diet combines with manual labor in support of the agricultural economy to keep obesity rates lower than expected in rural food deserts.

Urban Agriculture

Globally, billions of people cultivate small plots of land in and around their homes for self-consumption or informal trade. While not captured by formal agricultural statistics or maps, food grown this way plays a vital role in the lives of billions of people. Even city-dwellers in many parts of the world are involved in **urban agriculture**. By cultivating land or raising livestock in small plots near their homes, in rooftop gardens, or in community gardens on converted brownfields or abandoned residential areas, urban farmers are increasing agricultural production in food deserts (**Fig. 11.48**).

Sustainability of Agriculture

Commercial agriculture produces significant environmental changes. For example, the growing demand for protein-rich foods and more efficient technologies is leading to overfishing in many regions of the world, and in many places, fish stocks are declining at an alarming rate. From midcentury to the late 1980s, the fish harvest from oceans and seas increased fivefold, and there seemed to be no limit to it. Countries quarreled over fishing rights, poorer countries leased fishing grounds to richer ones, and fleets of trawlers plied the oceans. International attempts to regulate fishing industries failed. Then in the



Map courtesy of: Aki Michimi, 2011.

FIGURE 11.47 **Food Deserts in Oregon.** Mean distance (km) from population-weighted ZIP Code Tabulation Area (ZCTA) centroids containing large or medium supermarkets in Oregon. The yellow circles around centroids are areas within 13 miles (21 km) of a supermarket and have higher access to food.

Alison Hancock/Shutterstock.com

FIGURE 11.48 **Toronto, Canada.** Urban agriculture takes place on rooftops like this one, in brownfields that used to be industrial zones, or on lots where homes have been abandoned and torn down. Urban agriculture can also be indoor and vertical in densely populated cities (see Fig. 11.36).

1970s and 1980s, overfishing began destroying fish stocks. The cod fisheries on Canada's Grand Banks off Newfoundland collapsed. In 1975, biologists estimated the Atlantic bluefin tuna population at 250,000; today the western stock is listed as critically endangered, and the stock in the Mediterranean is listed as endangered. From ocean perch and king crabs off Alaska to rock lobsters and roughies off New Zealand, fish and shellfish populations are depleted. The total annual catch is also declining and may already be beyond the point of recovery. Much of the damage has already been done, and fishing industries in many parts of the world have reported dwindling harvests and missing species.

On land as well, the industrialization and commercialization of agriculture have accelerated the pace and extent of agriculture's impact on the environment. If you travel to Mediterranean Europe today, you will see a landscape that reflects the clearing of forests in ancient times to facilitate agriculture and trade, as well as evidence of terraces cut into the hills many centuries ago. In recent times, more land has been cleared, and the land that is under cultivation is ever more intensively used.

Significant agriculturally driven changes to the environment go far beyond the simple clearing of land. They range from soil erosion to changes in the organic content of soils to the presence of chemicals in soils and groundwater (herbicides, pesticides, and even antibiotics and growth hormones from livestock feces). In places where large commercial crop farms dominate, the greatest concerns often center on the introduction of chemical fertilizers and pesticides into the environment—as well as soil erosion. And, as we have seen, the movement toward genetically modified crops carries with it another set of environmental concerns.

The growth of organic farming and the move toward the use of local foods in some communities can benefit the environment. Yet such initiatives have had only modest impacts on the majority of the world's peoples and places. A telling sign is that the organic movement has had little effect on the production of the staple foods on which billions of people depend. Moreover, large corporate entities are playing an increasingly prominent role in the organic movement—raising concerns about standards and rendering illusory the ideal of an independent organic farmer engaged in "sustainable" agriculture. Smaller farmers argue that they are priced out of the market by subsidies favoring large farms and by the failure of most agribusinesses to incorporate the environmental and health costs of large-scale, intensive farming into their production costs.

The environmental impacts of large-scale intensive agriculture can be particularly severe when agriculture moves into marginal environments, as has happened with the expansion of livestock herding into arid or semiarid areas (see the map of world climates, Fig. 11.28). The natural vegetation in these areas cannot always sustain the herds, especially during prolonged droughts. As a result, ecological degradation and, in some areas, desertification are the result.

In recent decades, the popularity of fast food chains that serve hamburgers has led to the deforestation of wooded areas in order to open additional pastures for beef cattle, notably in Central and South America. But livestock ranching is an extremely land-, water-, and energy-intensive process. Significant land must be turned over to the cultivation of cattle feed, and the animals themselves need extensive grazing areas. In addition, by stripping away vegetation, the animals can promote the erosion of riverbanks, with implications for everything from water quality to wildlife habitat.

Agricultural production has changed drastically since the First Agricultural Revolution. Today, agricultural products, even perishable ones, are shipped around the world. Agriculture has industrialized, and large-scale agribusiness has replaced small family farms to produce most of our food. A major commonality between ancient agriculture and modern agriculture remains: the need to change. Trial and error were the norms of early plant and animal domestication; those same processes are at play in the biotechnology-driven agriculture of the contemporary era.

TC Thinking Geographically

Spend some time clicking around your city or home town on the USDA Food Access Research Atlas at https://www.ers.usda.gov/data-products/food-access-research-atlas.aspx. Aside from income, hypothesize what other factors overlap with the locations of food deserts in your area. Imagine how the **cultural landscapes** of food deserts looks different than areas where fresh foods are readily available. Look for maps or news articles about food deserts in your area to confirm your hypothesis.

Summary

11.1 Compare and Contrast the Three Agricultural Revolutions.

1. Before the First Agricultural Revolution, people hunted, gathered, and fished for food. The First Agricultural Revolution began around 10,000 years ago in the Fertile Crescent. Whether the first farmers successfully domesticated plants in a time of scarcity or a time of luxury is debated. Plant domestication occurred in multiple hearths, including Southeast Asia, the Indus River Civilization, and Central America. Animal domestication also began in the Fertile Crescent around the same time as plant domestication.

2. The Second Agricultural Revolution, like the Industrial Revolution, was a series of innovations that happened in different places over the eighteenth to twentieth centuries to mechanize agriculture and improve yields. Rather than sow seeds by casting them over the ground and seeing which ones took root, farmers began planting crops in rows using seed drills, improving plowing techniques, creating better breeding systems for livestock, experimenting with new seed hybrids, and expanding irrigation.
3. The Third Agricultural Revolution is better known as the Green Revolution, and it took place in the twentieth century. The hearth of the Green Revolution was the United States, where agricultural scientists set the goal of reducing hunger and ending famine. In the 1940s, agricultural researcher Norman Borlaug bred a strain of disease-resistant dwarf wheat that thrived in Mexico. By 1960, Mexico was independently producing enough wheat to no longer import it. The Green Revolution diffused to India in the 1960s and continues to expand today.

11.2 Describe the Spatial Patterns of Agriculture.

1. A cadastral system is a method of surveying land. Several land survey systems are found in the United States. The major ones include metes and bounds, township and range, and longlot. Metes and bounds is an early survey system in which objects in the environment, such as trees and fence posts are used to define a plot of land. Township and range is an orderly, checkerboard system in which land is surveyed into 1 mile by 1 mile sections. The long-lot system was developed in France and is designed to give multiple farmers access to important waterways and roads.
2. The goods farmers produce vary based on the distance between field and market, the amount of labor required for production, the value of the good, and the perishability of the product. von Thünen studied the spatial pattern of agricultural production around cities and towns and found that distance was the most important factor. Each town is surrounded by a set of concentric rings in which specific agricultural goods are grown.
3. Half of the world's people still reside in villages and rural areas. Geographers classify agricultural villages based on how they are laid out. The five types of agricultural villages are cluster, linear, round, grid, and walled.

11.3 Explain the Map of Global Agricultural Production.

1. On the global map of climates, many climate regions extend west to east because the amount of sunlight places receive depends on their latitude. The world map of agriculture and the global climate map correlate in many cases. Drier climates are likely to be areas of livestock raising. Moister climates are likely to be areas of grain production.
2. Several types of commercial agriculture are practiced. Plantation agriculture is a form of commercial agriculture that is typically left over from colonialism. The colonizers practiced monoculture; they consolidated and took ownership of land and then used enslaved Africans to produce a single crop, such as coffee, bananas, sugar, or cocoa.
3. Subsistence agriculture is different from commercial agriculture because landholdings are generally smaller and production is not monoculture. Subsistence farmers produce a variety of agricultural goods, from fruit trees to grains to market produce. They produce enough for self-consumption and to sell in local markets.

11.4 Analyze How Commercial Agriculture Operates.

1. The drive toward economic efficiency has meant that between 1910 and 2017, the number of farms in the United States has fallen and then tapered off while the amount of land in agriculture has stayed relatively consistent. The result is that the average size of farms (acres in production) in the United States is rising.
2. The bid rent theory says that what farmers produce depends on the cost of the land used for production. Intensive farming includes applying fertilizers, insecticides, and high-cost inputs to achieve the highest yields possible. It often occurs closer to the city, where land values are high. Extensive agricultural practices use less labor and capital and larger areas of land to cultivate what has traditionally been a lower yield. Applying bid rent theory, extensive agriculture takes place farther from the city center, where land values are low relative to labor and capital.
3. The proliferation of GMOs in the United States has resulted in two opposing movements: one moving toward non-GMO alternatives and the other leading to expansion of GMO production. Organic agriculture is a response to demand from consumers for non-GMO agricultural products. The amount of land dedicated to organic agriculture is growing globally. At the same time, increasing demand for ethanol and biodiesel has led to the expansion of GMO corn and soybean production.

11.5 Examine the Challenges of Feeding Everyone.

1. As the world population is growing and cities and towns are expanding, productive agricultural land near cities and towns is under greater pressure. Even though productivity on remaining agricultural land has risen through use of technology, irrigation, pesticides, fertilizers, and engineered seeds, the loss of productive farmland will have a ripple effect on land use, especially forests. Because of the combination of pressure on agricultural land and climate change, more forestlands are being converted to agricultural lands.
2. Malnourishment in the form of obesity or undernourishment can be linked to living in a food desert, a small region or area with limited access to fresh, nutrient-rich foods. Urban food deserts are typically found in low-income neighborhoods where medium-size and large grocery stores are largely absent and the only grocery stores within easy reach are convenience stores offering processed, energy-dense but nutrient-poor food. Rural food deserts can cover a large expanse and lack local grocery stores and public transportation to major towns with stores.

Self-Test

11.1 Compare and contrast the three agricultural revolutions.

1. The agricultural hearth where both plants and animals were first successfully domesticated was:
   - a. the Indus Civilization.
   - b. Southeast Asia.
   - c. the Fertile Crescent.
   - d. Central America.

2. The U.S. government destabilized the traditional subsistence agriculture practice by Native American tribes by changing land from:
   - a. communal ownership to individual ownership.
   - b. individual ownership to communal ownership.
   - c. hunting to farming.
   - d. farming to hunting.

3. The Columbian Exchange moved goods, people, and ideas across the Atlantic Ocean through trade. All of the following are impacts of the Columbian Exchange except:
   - a. Crops well suited for certain climates, soils, and topographies took root in new locations.
   - b. European diseases brought to the Americas infected and killed millions of indigenous people.
   - c. Enslaved Africans were forcibly migrated from Africa to the Americas to labor on plantations.
   - d. Genetically engineered wheat from Mexico diffused to Africa.

4. The hearth of the Green Revolution was _____, which is also the country that has the highest rates of genetically modified organisms (GMOs) in the food supply today.
   - a. the United Kingdom
   - b. France
   - c. China
   - d. the United States

11.2 Describe the spatial patterns of agriculture.

5. Which of the following pairs of land survey systems and locations is incorrect?
   - a. township and range and Great Plains
   - b. metes and bounds and east coast
   - c. progressive cadastral and California
   - d. longlot and Louisiana

6. In the von Thünen model of agricultural land use, the biggest factor in what agricultural goods are produced where is:
   - a. time.
   - b. connectivity.
   - c. distance.
   - d. diffusion.

7. An agricultural village where houses are grouped together in tiny clusters or hamlets is classified as:
   - a. cluster.
   - b. linear.
   - c. round.
   - d. grid.

8. In a place that was surveyed using the township-and-range system, agricultural villages are most likely to be:
   - a. cluster.
   - b. linear.
   - c. round.
   - d. grid.

11.3 Explain the map of global agricultural production.

9. Agricultural products transported in controlled temperatures from field to grocery store are transported using what system?
   - a. cold chain
   - b. commodity chain
   - c. barge
   - d. just-in-time

10. On the world climate map, several climate regions extend west to east because ____ varies by _____.
   - a. cloud cover/latitude
   - b. cloud cover/longitude
   - c. sunlight/latitude
   - d. sunlight/longitude

11. When comparing the world climate map and the world agricultural map, all of the following are connections you can see except:
   - a. drier climates and livestock ranching.
   - b. moister climates and grain production.
   - c. polar climates and commercial dairy farming.
   - d. tropical climates and subsistence agriculture.

11.4 Analyze how commercial agriculture operates.

12. The value of agricultural products in India is higher than in the United States. India also uses more:
   - a. GMOs.
   - b. labor.
   - c. refrigeration.
   - d. von Thünen methods.

13. In the United States, most ethanol is made from ___ and most biodiesel is made from ____.
   - a. switchgrass/sugar
   - b. sugar/switchgrass
   - c. corn/soybeans
   - d. soybeans/corn

14. Growing demand for organic agricultural products in the United States is in part a response to the expansion of:

a. government subsidies.
b. GMOs.
c. school lunch programs.
d. fair trade.

11.5 Examine the challenges of feeding everyone.

15. With climate change, more forests may be converted to agricultural land because:

a. cities are expanding into productive agricultural land.
b. deforestation is a common way to combat climate change.
c. forest soils are nutrient rich and can sustain agriculture well.
d. groundwater supplies are abundant under forests.

16. Malnourishment in food deserts is common because consumers lack access to:

a. snack foods.
b. milk and eggs.
c. fresh produce.
d. fortified grains.

17. Walgreens is trying to combat food deserts by building:

a. food oases.
b. food rivers.
c. food pantries.
d. food cupboards.