Chapter 1

Food Systems

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Learning Objectives

- Explain a systems approach to food systems.
- Describe a public health approach to assessing food systems.
- Provide a broad overview of the US food system, including its key dimensions, components, and challenges.
- Discuss different approaches to food system change, including public health and human rights, and provide examples of changes underway.

Think back to the most recent meal or snack you ate and try to answer these questions:

- Where did the food originate, how was it processed, and how did it get to you?
- How much did it cost, where did the money go, and why?
- How healthy was it?
- How did producing it affect the environment? Workers? Animals?
- Why did you choose it?

Most of us can answer a few of these questions for some of what we eat. Few of us can answer all of them for everything we eat. We at the Johns Hopkins Center for a Livable Future created this textbook to help students of the food system answer questions such as these, not only in relation to their own meals but also for the entire US food supply. To understand the breadth of relevant issues and the opportunities to affect public health, the environment, equity, and other outcomes, we need to examine the food system as a system—complex, diverse, global, and interconnected.

system
A network of interacting components that together form a complex whole, though they are influenced by factors outside their boundaries; also, systems approach, systems thinking, systems theory: approaches, thought patterns, or theory that focus on systems; typically contrasted with linear approaches

food system
A system encompassing all the activities and resources that go into producing, distributing, and consuming food; the drivers and outcomes of those processes; and all the relationships and feedback loops between system components

THE FOOD SYSTEM AS A SYSTEM

A **system** is a network of interacting components that together form a complex whole. The **food system** is a system encompassing all the activities and resources that go into producing, distributing, and consuming food; the drivers and outcomes of those processes; and, the extensive and complex relationships between system participants and components. The food system's functional parts include land-based parts (e.g., agriculture, farmland preservation); environment (e.g., water, soil, energy); economy (e.g., distribution, processing, retail); education; policy; social justice; health; and food cultures (Peemoeller, nd). Although a system's components themselves are important, it is the relationships among components that make a system a system. To give a simplified example, what we eat affects what is produced, which in turn affects what we will eat. Studying systems focuses our attention on the many ways

these relationships may play out—including considering cascades of effects, unintended consequences, feedback loops, and the most strategic and practical ways to intervene for change.

Factors outside a system's boundaries, such as in the social or biophysical environment, also influence change within systems (and vice versa). For example, the food system is driven in part by food system policies. These are part of the system, but also lie within the social environment. The system is also driven by policies that lie primarily outside of the food system's boundaries, such as immigration laws. The food system can be analyzed using categories including scale, production type, governance, drivers (e.g., population and climate change), food security, and supply chains (Clancy, 2011).

subsystems
A system that is also a component of a broader system (e.g., the food production system is a subsystem of the food system)

Is there one food system? In some ways, yes—it's all connected. In other ways, we can understand this grand system as a network of interconnected **subsystems** (or systems that are components of a broader system) existing at different scales from local to global, and across geography and time. There are food systems in Baltimore and Annapolis, and a food system in the state of Maryland that encompasses both. All of these interact in different ways with each other, with the US food system, and with food systems around the world that send us products and shape the food prices experienced by consumers from Baltimore to Bangkok. That's why in this book you will sometimes see the term, *food system*, and sometimes *food systems*. Figure 1.1 provides a concept model of the food system (Nourish, 2012).

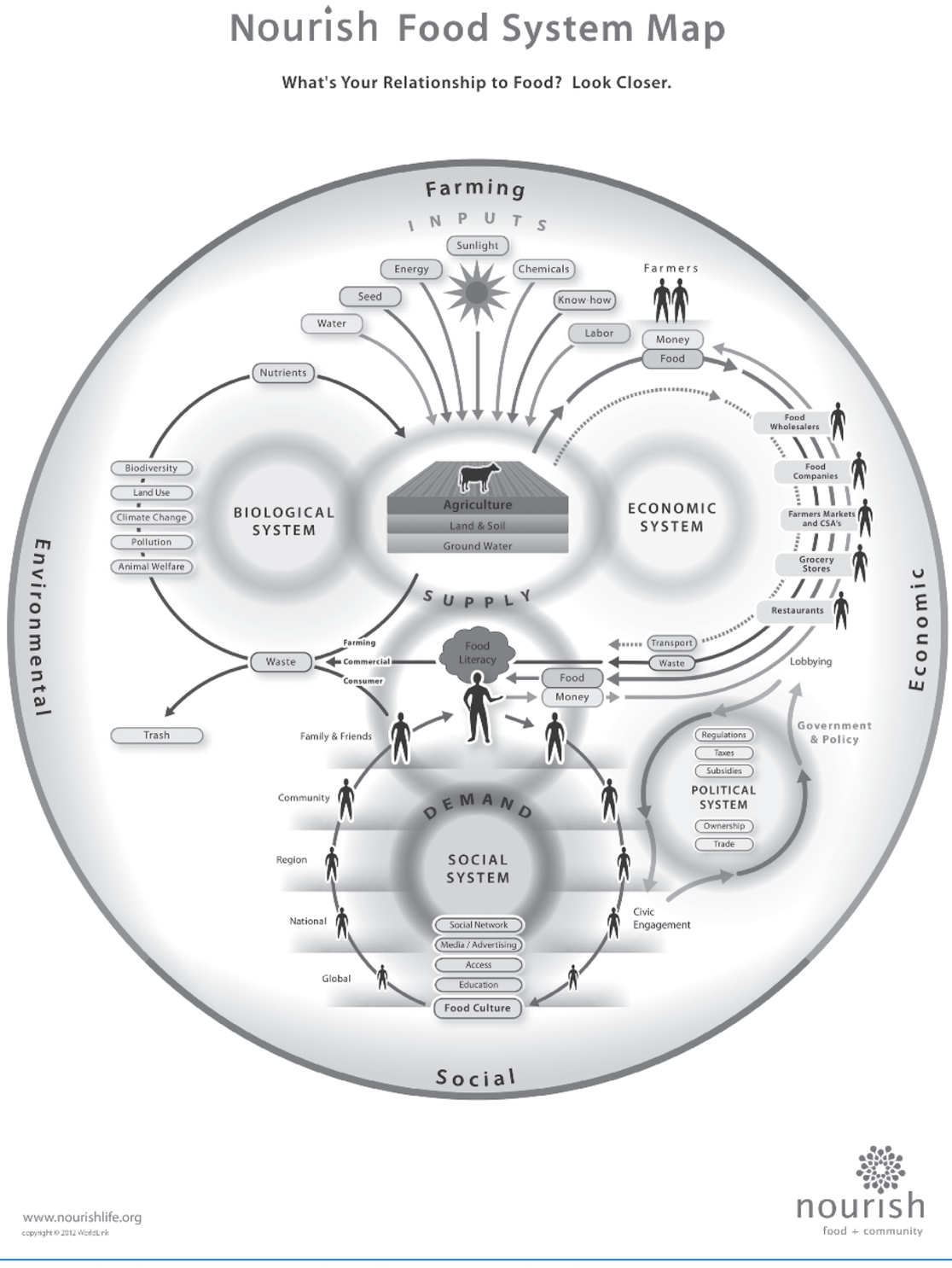
The model depicts multiple interacting systems: biological, economic, social, and political. In the biological system, components including biodiversity, land use, and climate change interact to create or destroy nutrients, which feed into agriculture (chapters 11, 12). Agriculture also uses additional **inputs**, or resources, including water, soil, energy, and sunlight, as well as chemicals, labor, and know-how. From agriculture comes food, which travels through an economic system (chapter 7) from wholesaling and food processing (chapter 13) to a distribution system including transport and stores, restaurants and farmers markets (chapter 14), and from there into the social or demand system. That system comprises the many environments in which we live (chapter 17) and make food choices (chapters 15, 16), and the factors that drive such choices, including culture (chapter 9), marketing (chapter 10), and behavior change interventions (chapter 18). Coming out of the demand system are money, which travels back up through the economic system, and varying levels of civic engagement, which plays into the political system affecting food (chapter 8). This graphic depicts waste as the main output of the system, and indeed it is an important one, as described in focus 15.3. Other important outputs not depicted include effects such as health (chapter 2), environmental quality (chapter 3), equity (chapter 4), food security (chapter 5), and community food security (chapter 6.)

inputs
Resources and materials entering a production system, such as feed, drugs, energy, water, and labor

Imagine that the static diagram shown in figure 1.1 is animated, with flows of inputs and outputs moving constantly back and forth across every arrow. Each piece, whether small or large, is separately animated with its own internal logic: every farmer, every farm, every aquifer for irrigation, every crop, every distribution truck and driver, each policy maker making policy that shapes those activities, and so on. Turn on the switch and let it roll, change, and evolve—that's a food system.

Systems approaches developed originally in the field of engineering. Although many food system analyses and activities, and most of what you will read about in this textbook, take place in the "real" world, formal systems approaches seek to model the complex reality of food systems using software, as described in focus 1.1 and box 1 in the online supplement. Once created, such models enable analysts to input varying conditions and thus to gain insights into how the impacts may play out. By contrast,

FIGURE 1.1 The Food System



Source: Nourish Food System Map, www.nourishlife.org. Copyright 2012 WorldLink, all rights reserved.

systems thinking (or systems approaches) take a more conceptual approach to understanding and working with complexity. There is increasing recognition of the benefits of a systems approach for advancing the quality of public health activities. Focus 1.2 provides further examples of the utility of a systems approach to food.

FOCUS 1.1. COMPLEX ADAPTIVE SYSTEMS

Ross A. Hammond

The food system is a classic example of a complex adaptive system (CAS)—a system composed of many different actors at many different levels of scale, interacting with each other in subtle or nonlinear ways that strongly influence the overall behavior of the system. Actors can be people but also larger social units, such as firms and governments, and smaller biological units, such as cells and genes. The CAS perspective has proved enlightening in the study of food systems and other economic, political, social, physical, and biological systems (Axelrod, 1997; Hammond & Dube, 2012; Holland, 1992; Miller & Page, 2002) because it can help researchers to analyze, model, and anticipate interactions between system actors and overall system dynamics. CASs share many general properties, including the following:

- *Individuality*: Each level is composed of autonomous actors who adapt their behavior individually. Change within CASs is often driven by decentralized, local interactions of these individual parts.
- *Heterogeneity*: Substantial diversity among actors at each level—in goals, rules, adaptive repertoire, and constraints—can shape dynamics of a CAS in important ways.
- *Interdependence*: CASs usually contain many interdependent interacting pieces, connected across different levels, often with feedback.
- *Emergence*: CASs are often characterized by emergent, unexpected phenomena—patterns of collective behavior that form in the system are difficult to predict from separate understanding of each individual element.
- *Tipping*: CASs are also often characterized by "tipping." Nonlinearity means that the impacts caused by small changes can seem hugely out of proportion. The system may spend long periods in a state of relative stability, yet be easily tipped to another state by a disturbance that pushes it across a threshold.

Complexity can be a significant challenge for policy makers and for intervention design. The interconnected dynamics of a complex system may lead policy efforts to overlook potential synergies, and successful interventions in a single area may be counteracted by responses elsewhere in the system. Policies that do not take into account the full set of actors and their responses can even backfire dramatically, as illustrated by the Lake Victoria catastrophe (Fuggle, 2001; Murray, 1989). In 1960, a nonnative species of fish (the Nile perch) was introduced into Lake Victoria, with the policy goal of improving the health and wealth of the communities surrounding the lake in Kenya, Tanzania, and Uganda through this new protein source. But the policy did not take into account the other actors in the system—specifically, the other organisms forming the lake's complex ecosystems. Although the perch initially appeared a success, its introduction set off a chain reaction. The perch wiped out the native cichlid species of fish, which were crucial in controlling a species of snail living in the lake. The snails flourished and with them the larvae of schistosomes, to whom they play host. Schistosomes are the cause of the often-fatal disease of schistosomiasis or bilharzia in humans, and their exploding numbers created a public health and economic crisis. Thus, the original policy goal (improving health) backfired because the adaptive reaction of another set of actors in the system was not anticipated.

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Other characteristics of complex systems also pose policy design challenges. Nonlinearity makes prediction difficult—multiple forces shape the future and their effects do not aggregate simply. Heterogeneity means that any given intervention may not work equally well across all contexts or subgroups. Decentralized dynamics can be a challenge because many conventional policy levers and interventions are centralized or top-down.

Despite its challenges, complexity can also be a source of opportunity for policy makers and intervention designers. For example, nonlinearity means that near the right thresholds, even small interventions can have big impacts on the system, tipping it to a new state. Understanding heterogeneity in a system can also create an opportunity because it enables interventions to be closely targeted for maximum impact.

agent-based computational modeling (ABM) A quantitative systems modeling technique in which complex dynamics are modeled by constructing "artificial societies" on computers

Systems can be studied qualitatively, via systems mapping or systems thinking, but quantitative systems modeling techniques that have proven useful in other topic areas are also increasingly being applied to the study of food systems. For example, one methodology is **agent-based computational modeling (ABM)**. In ABM, complex dynamics are modeled by constructing "artificial societies" on computers. Every actor (or "agent") is individually represented and placed in a spatial context, with specified initial conditions and a set of rules governing interactions with others and their environment. The models grow macro-level patterns and trends from the bottom up (Epstein, 2006), enabling consideration of multiple (and multilevel) mechanisms. The generated macro-level patterns can be directly compared with data to calibrate the model.

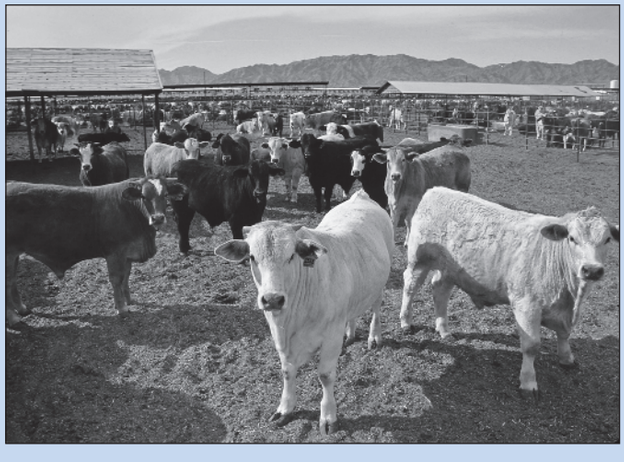
ABM and other complex systems modeling techniques represent a promising avenue for future study of the rich and complex dynamics of food systems and for the design of effective interventions and policies to address outcomes they drive—from obesity and malnutrition through economic development.

Source: Adapted from Hammond (2009).

FOCUS 1.2. FOOD IN THE FOOD SYSTEM

Michael W. Hamm and Richard Pirog

FIGURE 1.2 Industrial Cattle Production Facility



Source: USDA.

Most people go to the supermarket, a restaurant, or a drive-through and buy their food with little thought to what it took moving that food from the farm to our mouths. To illustrate the benefits of taking a system perspective, let's look at putting two food items on our table: a hamburger and fresh apples.

A system needs to be in place for a hamburger to appear on your plate. The beef calves are typically raised on a combination of rangeland and pasture and corn- or soybean-based feeds on the farm or ranch and then on a corn- or soybean-based feed at the finishing facility (figure 1.2). Calves are typically raised to nine hundred pounds on farms or ranches and then sent to finishing facilities for the final three hundred pounds. At the processing facility the final meat products are produced, then shipped in refrigerated or freezer trucks

or trains to a distribution center. They may go through several more distribution points before arriving at the point of purchase.

This system of raising, finishing, slaughtering, and distributing beef has evolved with "efficiency" in mind—how little can be spent to put a hamburger on your plate? Efficiency only increases up to a certain scale, but reaching that scale of maximum efficiency mandates fairly large numbers of animals flowing through the system simultaneously.

This is relevant when considering beef produced in different ways—for example, pasture-finished and close to where we live. It's not simply a matter of a farmer appearing at the farmers market with a chest full of hamburger or buying pasture-raised, local beef at the supermarket. A farmer raising small numbers of beef cattle must find a USDA- or state-certified processing facility (many state certification programs have been eliminated because of cost). These are often distant from the farmer and at a scale that won't accept a few cows at a time. In addition, the per-animal processing cost is higher and the farmer's time is greater due to small volume. Thus, consumer cost is higher—for many prohibitively so. If a goal were to increase the availability of "local, pasture-finished beef" it would require at least four things: a reasonably accessible processor, sufficient volume for the processor over the entire year, a sufficient price to make it worthwhile for the farmer, and distribution to the point of purchase. A lot needs to be in place to move an animal product from the farm to your fork—different system scales do not necessarily have interchangeable components.

A very different example is fresh apples on our table. Their availability in the marketplace year round is partially through diverse harvest times in various regions across the country and world as well as our ability to preserve these apples via postharvest treatment. At harvest, apples are often waxed and stored in controlled-atmosphere rooms (basically low-oxygen environments) to retard spoilage. This can either be on a farm, at a packer-shipper facility, or at a distribution facility. Apples in the marketplace can travel a circuitous route that starts at the orchard and typically goes through storage, packing, shipping, several distributors, and finally a store's produce section (figure 1.3). Because apples are a perennial tree fruit, the farmer has several years of invested activity and cost before the trees bear fruit. A catastrophic weather event (such as a hard freeze soon after fruit set) can destroy or severely limit the harvest for a year. Most apples in the marketplace are grown on large farms within a system built for large volumes—making apples relatively cheap and efficient to produce.

FIGURE 1.3 Uniform Apples in Grocery Store

Source: Chichacha via Flickr Commons. https://www.flickr.com/photos/10673045@N04/2387957261/in/photolist-4D1UuV-4R5YRW.

Michigan is useful as an example because it blends large-scale and small-scale production. Until the new millennium, Michigan apples largely went to juice and sauce processors. With the juice market collapse as offshore apple concentrate hit the market (China now supplies about two-thirds of our domestic apple juice), farmers needed a new strategy. This involved change at multiple points including planting new apple varieties, building controlled-atmosphere storage, and developing supply chains and markets. On the smaller scale the system is no less complicated, but often undeveloped. A small-scale farmer can sell fresh apples directly in season at, for example, a farmers market (figure 1.4). But to sell over an extended season (beyond three

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FIGURE 1.4 Farmers Market Apples

Source: CLF.

months from harvest), a storage facility (controlled-atmosphere refrigeration) is necessary or the apples will go soft and rot. To sell wholesale to a grocery store, two things are usually necessary—aggregation from multiple farms and distribution. This requires a system parallel to that designed to handle large volumes. The farmer can sell directly to these stores, but often there are scale limitations because of buyer needs.

Thus a complicated set of relationships, infrastructure, information, and technology exists for the vast majority of food found in the marketplace. In some cases, strategies to aggregate smaller farms' products and channel them into the existing system for large-scale distribution are evolving (see focus 6.1), whereas in others a system that parallels the existing one needs development. Issues of efficiency, profitability, accessibility, and affordability arise as these parallel or alternative systems develop. These two examples illustrate many interacting system factors for consideration in making change and help explain the challenges and costs of supplying food through alternative systems. Policies and regulations at varying levels of government as well as in the private sector tend to reinforce the dominant system and make alternatives difficult to develop. Without appreciating and approaching multiple points across this system and the policies that support or inhibit alternative development, it is unlikely that long-lasting change will occur.

PUBLIC HEALTH

This book examines food systems by applying the perspectives of many disciplines and using diverse lenses. Chapter focus and perspective contributors write from their own points of reference. From among the many disciplines present, this book contains a particular emphasis on public health approaches to understanding and addressing the food system, including health, environment, and social equity viewpoints. What does that mean?

Public health is "the science and art of preventing disease, prolonging life and promoting … health … through organized community efforts" (Winslow, 1920, p. 30). And **health**, as defined by the World Health Organization, is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization [WHO], 1946).

A public health approach emphasizes **primary prevention**—looking to root causes and trying to stop harmful exposures before they happen, rather than focusing on addressing the consequences—although it does that, too. Additionally, a

public health
"The science and art of preventing disease, prolonging life and promoting … health … through organized community efforts" (Winslow, 1920, p. 30)

health
"A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization, 1946)

primary prevention
Approach that addresses root causes and tries to stop harmful exposures before they happen; secondary prevention involves treating early stage conditions to prevent worsening; tertiary prevention involves mitigating the effects of disease

public health approach means stepping back and focusing on a **population-based approach**. The field commonly looks to **social determinants of health**, **structural determinants of health**, and **environmental determinants of health**. When public health does focus at the individual level, the emphasis is often on interventions with the potential to target many people's individual risk factors simultaneously. At the same time, because it focuses on populations, public health also emphasizes a need to target efforts to those within populations who experience **health disparities** and populations marginalized by poverty, discrimination, or environmental injustice. Additionally, public health approaches are applied, evidence-based, and multidisciplinary. Although traditionally public health emphasized a linear method of understanding problems (*x* causes *y*), both qualitative and systems approaches have lately attracted much interest. Today systems thinking and leadership is one of the field's eight core competencies for professionals (Council on Linkages Between Academia and Public Health Practice, 2010).

Public health professionals have long worked on food system issues from a variety of angles. Perhaps most popular have been research and interventions addressing obesity, food marketing, **healthy food** access, food safety, nutrition, and food insecurity. Additionally, lines of work have focused on the public health implications of **industrial food animal production (IFAP)**, occupational health, and impacts of pesticides and other chemicals used in food production and processing, among others. Most recently, a movement within public health has sought to address food system issues more broadly and systemically, including engaging in community food security and in food and agriculture planning and policy efforts. All of these topics are addressed in this book. In addition, a public health lens is applied to other food system topics that have received less attention. Focus 1.3 presents a public health vision for a healthy, sustainable food system.

population-based approach
Approach or intervention aimed at changing factors affecting the entire population

social determinants of health
Social and economic conditions that affect human health, such as where a person lives

structural determinants of health
Factors related to the economic, political, and social hierarchal issues (e.g., level of power and privilege) that affect health

environmental determinants of health
Factors in the biophysical environment, including the built environment, that affect health

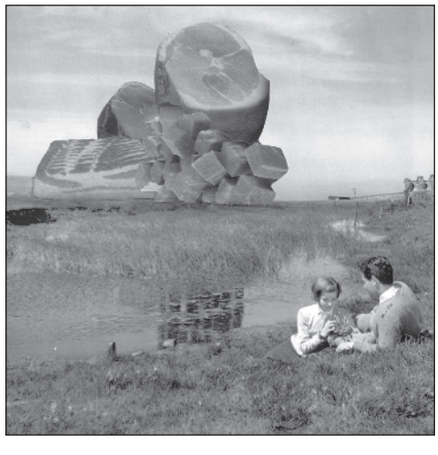
health disparities
Differences in health status among groups of people based on factors such as socioeconomic status (SES), race, ethnicity, immigration status, environmental exposures, gender, education, disability, geographic location, or sexual orientation

THE US FOOD SYSTEM: AN OVERVIEW

The writer, Wendell Berry said, "Eaters … must understand that eating takes place inescapably in the world, that it is inescapably an agricultural act, and how we eat determines, to a considerable extent, how the world is used" (Berry, 1990, p. 149). Our food system shapes our world (see figure 1.5). The US food system, serving a population of 314 million, sells more than $1.8 trillion in goods and services each year and produces nine billion animals (Food Chain Workers Alliance, 2012; US Department of Agriculture [USDA] National Agricultural Statistics Service, 2012). This system, which affects and is affected by the global food system, is responsible for the following:

- 80 percent of consumptive water use (USDA Economic Research Service, 2012a)
- 51 percent of US land use (USDA Economic Research Service, 2012b)

FIGURE 1.5 Meatscape (Reflecting "How the World is Used")



Source: Nicholas Lampert.

healthy food
"Foods that provide essential nutrients and energy to sustain growth, health and life while satiating hunger; usually fresh or minimally processed foods, naturally dense in nutrients, that when eaten in moderation and in combination with other foods, sustain growth, repair and maintain vital processes, promote longevity, reduce disease, and strengthen and maintain the body and its functions. Healthy foods do not contain ingredients that contribute to disease or impede recovery when consumed at normal levels" (as defined by the University of Washington Center for Public Health Nutrition, 2008)

industrial food animal production (IFAP)
An approach to meat, dairy, and egg production characterized by specialized operations designed for a high rate of production, large numbers of animals confined at high density, large quantities of localized animal waste, and substantial inputs of financial capital, fossil fuel, feed, pharmaceuticals, and indirect inputs embodied in feed (e.g., fuel and freshwater)

overweight
Adults are considered overweight if their body mass index (BMI) is 25.0 or higher, that is, if they are 10 to 20 percent heavier than what is considered a healthy weight range for someone of their height

- 16 percent of energy use (Canning, Charles, Huang, Polenske, & Waters, 2010)
- $1.139 trillion in consumer spending, or 9.8 percent of total personal income (USDA Economic Research Service, 2013)
- One-fifth of US private sector jobs (more than the health care sector!) (Food Chain Workers Alliance, 2012)
- Over 13 percent of US gross domestic product

Historically, most food in the United States and globally was produced with minimal nonhuman energy inputs and was consumed within a short distance of its production location. Significant change has been underway for more than one hundred years, but since World War II our food and agriculture system has undergone near total transformation. Today's food system is primarily industrial. An industrial system essentially treats a farm as a factory, using a set of inputs (seed, feed, pesticides, fertilizer, antibiotics, irrigation, fossil fuels) to create a set of outputs (product, waste, contamination) with an emphasis on specialization, standardization, and efficient throughput. The overall goal is to achieve the greatest possible yield at the lowest possible cost to the firm.

Food System Challenges

Our industrial food system is at the nexus of some of the most significant public health and environmental challenges we face today. Recent concerns about food safety range from melamine contamination of imported Chinese dairy products, to massive recalls of bacteria-contaminated ground turkey and peanut butter, to horsemeat in Irish hamburger and processed foods distributed throughout Europe, to arsenic in our rice and antibiotic residues in the shrimp we consume from southeast Asia. High obesity rates have focused attention on sugar-sweetened beverages, processed foods, and restaurant meals, and our national economic problems focus our attention (at least to an extent) on the nearly 15 percent of the population who are food insecure—including many of those who produce, process, and sell our food. Confronted by the enormity of the health problems associated with **overweight** and **obese** consumers, dire predictions are made of a health system—already the most expensive in the world—staggering under the need for more services. The health care system is further challenged by the crisis of antibiotic-resistant infections that has been linked in part to the misuse of antibiotics in animal agriculture. And farmers confront extreme weather events, such as droughts and floods, occurring with greater frequency, a broken farm policy with political gridlock in Washington, increasing concentration and near-monopoly control of everything from genetically modified seed to vertical integration of industrial food animal production and slaughter facilities, declining aquifers, community and worker exposures to contaminated air, water, and soil—and more.

Table 1.1 summarizes these and other challenges. Some of these derive from divorcing production from ecologic realities. Others represent unintended consequences of political and economic

TABLE 1.1 Key Food System Challenges

Public Health Challenges
- Food insecurity
- Food safety gaps
- Lack of healthy food access, affordability
- Obesity and diet-related disease
- Antibiotic resistance
- Chemical contaminants
- Lack of worker protection
- Soil, water, and air contamination
- Vulnerability to terrorism

Environmental (and Future Food Security) Challenges
- Climate change
- Soil depletion
- Water scarcity
- Peak oil and peak phosphorous
- Biodiversity loss
- Farmland loss
- Fisheries collapse

Additional Future Food Security Challenges
- Loss of small- and mid-sized farms
- Aging farmers
- Lack of food reserves
- Lack of planning for food security crises

Social Challenges
- Corporate concentration and monopoly control
- High, volatile food prices
- Challenging livelihoods of farmers and workers in the food system
- Policy gaps for genetically modified organisms
- Loss of rural community

developments or shifts in global trading patterns, and still others are the product of insufficient commitment to health promotion and equitable distribution of goods and services within society. These food system challenges are intertwined with other subsystems in the broader society; poverty, for example, is not a "food system problem" per se, and yet it indisputably contributes to many of the food system's most pressing problems. A systems perspective reminds us that the challenges, and the solutions we devise to address them, interact in complex ways. Enacting a living wage, for example, might reduce poverty and thus food insecurity; it could also lead to closure

obese
Adults are considered obese if their body mass index (BMI) is 30 or higher, that is, if they are over 20 percent heavier than what is considered a healthy weight range for someone of their height

of supermarkets, which operate on slim profit margins, and thus without additional intervention, might reduce food access in low-income neighborhoods.

As these threats accumulate, another concept from systems theory is useful as well: **resilience**, or a system's capacity to recover from disturbances. Disturbances that are sufficiently powerful versus a system's level of resilience can force the system across a threshold, precipitating major change and a new way of operating. Perspective 1.1 discusses resilience in more detail.

resilience
Ability to recover from perturbations

Perspective 1.1. When Your Boat Rocks, You Want Resilience Not Efficiency

Laura Jackson

Imagine being on a boat in calm seas and you are asked to bring a cup of soup to the captain. The task is an ordinary one and the only question is how fast should you walk without spilling the soup? Now imagine the same cup of soup, except that the boat is being tossed by huge waves. Walking speed is now no longer an issue. Instead you are looking for solid handholds, watching for the next wave to hit, keeping your knees flexed and your senses on high alert.

The first situation is an efficiency problem. The second situation is a resilience problem. Individuals, households, cities, businesses large and small, farmers, and even countries regularly provide for some level of resilience against all kinds of shocks. We buy house insurance, health insurance; wear seat belts and put money in savings; and get an education to increase our options in life. These measures cost money and time, yet we usually find the investment more than worthwhile. Better safe than sorry.

The resilience idea has taken off recently and is increasingly seen alongside or even replacing established concepts such as sustainability. *Resilience* is a good word that adds something new and useful to consider. What is the difference? In the context of agriculture, I think there are two big distinctions between *sustainability* and *resilience*.

First, there is the way things fail. Agricultural sustainability is about protecting nonrenewable resources: conserving what we have for future generations and renewing the health of soil and water to protect the future productivity (yield) of cropping systems. In contrast, according to authors Brian Walker and David Salt (2006), resilience thinking involves acknowledging the potential for a system-wide breakdown, a catastrophe. Like Humpty Dumpty, some systems can never be put back together again. In nature, we see countless examples of irreversible changes, such as lakes that go from crystal clear to perennially clouded with algae. Likewise, human civilizations (and their agricultural systems) can and do fail: the Roman Empire, Easter Island, the Mayans.

Second, there is the idea of the complex adaptive system. The idea of steady-state sustainability involves a relatively simple, closed agricultural system that behaves the same way, whether resources are abundant or scarce. The resilience idea applied to agriculture involves complex systems that adapt and change together, linking social and ecological processes. Soil, water, plants, livestock—the basic ecology of the food chain—are connected to transportation and processing infrastructure, the market economy, and human nutrition.

Resilience theory says that we could cross a threshold after which the agricultural system would transform itself into something completely different—and not necessarily in a good way. The threshold might be a very high price for diesel or phosphorus, rapid climate change, or a combination of factors. We don't know exactly where that threshold is in agriculture, just as we don't know when that next wave is going to hit the boat.

We have already experienced a radical shift in Iowa agriculture, a Humpty Dumpty–type moment. From the 1860s through the early 1950s, most Iowa farmers practiced a long crop rotation, with two to three years in small grains and pasture, followed by two to three years in row crops. It was integrated with livestock on the farm, cycled nutrients, managed weeds through rotation and tillage, and in the early years used on-farm energy for traction (oats-powered horses). One could say it was fairly resilient, at least for ninety years, weathering many changes in technology, crop breeding, and public policy. However, after World War II the sudden availability of inexpensive nitrogen fertilizer, first-generation broadleaf and grass herbicides, and favorable government policies precipitated a major transformation to the corn, beans, and concentrated livestock systems that we see today. Once the process was underway, there was no going back.

Is the current agricultural food system resilient? According to the research on resilience, efficiency has a dark side. Efficient, streamlined systems have eliminated unprofitable, redundant features. To translate to agriculture, there is no need to grow nitrogen-fixing alfalfa when fertilizer is cheap. Livestock can be raised more efficiently in a specialized operation. Regional differences in climate and infrastructure lead to "comparative advantage" so it simply does not pay to keep any cattle on grass in northern Iowa. However, redundancy can be a lifesaver if there is a sudden change in input costs, land prices, or climate. As the saying goes, "don't put all your eggs in one basket."

Resilience might be improved by investing in the know-how, tools, and infrastructure to produce different varieties or species of crops and livestock, reduce dependence on inputs, or find alternative markets. This is "inefficient" and certainly expensive under the current system. But similar to insurance, by the time we wish we carried some, it could be too late.

Other insurance policies that could provide some system resilience include the following:

- Growing perennial plants keeps roots in the ground and limits soil erosion in the event of a severe rain event. Fields of corn and soybeans are vulnerable from October through June.
- Keeping the groundwater clean and the creeks swimmable; investing in parks and privately owned natural areas will keep options open for future generations who may need to use the land in different ways. Areas that sacrifice their quality of life could miss out on economic opportunities.
- A diversity of people with a wide range of skills in a strong local community can help one another out in uncertain times, providing resilience. Who knows, they might let you borrow a piece of equipment.
- Commodity markets can internalize costs of greater soil and water conservation, passing on some of the responsibility of supporting clean water and ecosystem services to processors, retailers, and consumers.

Tremendous changes are ahead in energy, fertilizer, global commodities markets (both demand and supply), and most of all, climate. And those are just the known threats. Unfortunately, the market and government farm policies are largely discouraging resilience right now. The average farmer probably can't afford resilience. Likewise, most university and corporate agricultural research continues to pursue efficiency and optimization. With a laser focus on yield trend lines, will agriculture be able to flex its knees when that next wave hits?

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Food System Benefits

Although it is clear that our food system is not healthy, it is also important to recognize the many positives that do derive, at least for now, even from our damaged and threatened food system. First, today's US food supply may be more plentiful and by some definitions inexpensive than at any time in

history. The food from today's system provides most of us in the United States with enough nutrition to support our basic well-being and the energy to continue our life activities and even thrive (even if many people's diets are damaging over the long term, and even if they might thrive yet more by eating healthier diets). And, for those who do eat nutritious diets, their eating may not only be protective against illness but also can provide positive health benefits from energy to strength to a feeling of well-being—even if the foods were produced using environmentally or socially damaging methods. Further, our food often provides pleasure, comfort, and excitement. Food is at the core of most cultures and religions; it bonds friends, families, and, in some cases, communities together; and is also often a vehicle to help bridge cultures. As noted above, the food system provides livelihood to a fifth of the population. Agriculture preserves farmland, which, even when damaged, is in many ways preferable environmentally to development on that land because better practices can later restore soil quality and the ecosystem. Many of these benefits can be further strengthened and refined by efforts for food system reform.

The challenges across the food system call for comprehensive and coordinated responses from many sectors of society. What sorts of change are needed? The Kellogg Foundation has defined "good food" as food that is healthy, green, fair, and affordable. We would add to this list accessible and humanely produced. Most food falls somewhere on the spectrum between this ideal and the extreme of health, environmentally, and socially damaging production. Often, once a food meets criteria such as humaneness or healthiness, affordability suffers. Yet, as described in chapter 6; perspectives 4.5, 11.2, and 17.2, and focuses 6.1, 17.3, and 18.3; and elsewhere in this book, many efforts are underway to solve the simultaneous equations and produce truly good food. Beyond the qualities of the food itself, there is need for efforts to promote a healthier and more sustainable food *system*, encompassing all the food system activities, the policies and politics, the economic forces, the culture, and so on.

Focus 1.3 extends beyond the qualities of the food to present public health-oriented principles of a healthy, sustainable food system—endorsed by four major health-oriented professional associations.

FOCUS 1.3. PRINCIPLES OF A HEALTHY, SUSTAINABLE FOOD SYSTEM

We, the American Public Health Association, the American Dietetic Association, the American Nurses Association, and the American Planning Association, support socially, economically, and ecologically sustainable food systems that promote health—the current and future health of individuals, communities, and the natural environment.

A healthy, sustainable food system is:

Health Promoting

- Supports the physical and mental health of all farmers, workers, and eaters
- Accounts for the public health impacts across the entire life cycle of how food is produced, processed, packaged, labeled, distributed, marketed, consumed, and disposed

Sustainable

- Conserves, protects, and regenerates natural resources, landscapes, and biodiversity
- Meets our current food and nutrition needs without compromising the ability of the system to meet the needs of future generations

Resilient

- Thrives in the face of challenges, such as unpredictable climate, increased pest resistance, and declining, increasingly expensive water and energy supplies

Diverse in

- Size and scale—includes a diverse range of food production, transformation, distribution, marketing, consumption, and disposal practices, occurring at diverse scales, from local and regional to national and global
- Geography—considers geographic differences in natural resources, climate, customs, and heritage
- Culture—appreciates and supports a diversity of cultures, sociodemographics, and lifestyles
- Choice—provides a variety of health-promoting food choices for all

Fair

- Supports fair and just communities and conditions for all farmers, workers, and eaters
- Provides equitable physical access to affordable food that is health promoting and culturally appropriate

Economically Balanced

- Provides economic opportunities that are balanced across geographic regions of the country and at different scales of activity, from local to global, for a diverse range of food system stakeholders
- Affords farmers and workers in all sectors of the system a living wage

Transparent

- Provides opportunities for farmers, workers, and eaters to gain the knowledge necessary to understand how food is produced, transformed, distributed, marketed, consumed, and disposed
- Empowers farmers, workers, and eaters to actively participate in decision making in all sectors of the system

A healthy, sustainable food system emphasizes, strengthens, and makes visible the interdependent and inseparable relationships between individual sectors (from production to waste disposal) and characteristics (health promoting, sustainable, resilient, diverse, fair, economically balanced, and transparent) of the system.

Source: American Public Health Association, American Dietetic Association, American Nurses Association, and American Planning Association. (2010).

These principles in many ways reflect the public health vision we as authors hold. We also complement that vision with one that places even more robustly the food system's people and their dignity at the center. The **human right to adequate food**, according to the United Nations, "is realized when every man, woman and child, alone or in community with others, has physical and economic access at all times to adequate food or means for its procurement" (United Nations Economic and Social Council, 1999). Although some imagine the right to be about a government obligation to provide food, in actuality, the core implication is that people should have the wherewithal to procure their own food. Additionally, the right requires that

human right to adequate food
Realized when every man, woman, and child, alone or in community with others, has physical and economic access at all times to adequate food or means for its procurement, according to the United Nations (United Nations Economic and Social Council, 1999)

FIGURE 1.6 Human Dignity: Workers Standing up for an Increase in the Minimum Wage

Source: Jim Weber, The Commercial Appeal.

governments respect and protect the right and facilitate food access (and if truly needed, provide food in order to fulfill the right). A rights framework makes these activities government's duty, not kindness or charity, and places human dignity at the center (see figure 1.6).

Another important aspect of this human rights approach is that it goes well beyond addressing hunger to encompassing food system goals such as those expressed in the "Healthy Sustainable Food System" statement. "Adequate" food is that which provides appropriate nutrients and calories, is safe from contamination, and is accessible, acceptable, and available to all people within a society and to future generations. The 1976 International Covenant on Economic, Social and Cultural Rights indicates that states are obligated to take measures "to improve methods of production, conservation and distribution of food by making full use of technical and scientific knowledge, by disseminating knowledge of the principles of nutrition and by developing or reforming agrarian systems in such a way as to achieve the most efficient development and utilization of natural resources" (United Nations General Assembly, 1976, p. 4).

Beyond the tenets of the right to food, another aspect of affirming the dignity of individuals is avoiding stigma around dietary choices, food insecurity, or obesity (as described in focus 18.1). It is easy to incorrectly infer information about someone's total diet based on small observations. Additionally, the food choices available to each of us are constrained by systemic factors well beyond our preferences. And, the factors we prioritize in decision making vary widely, such as from nutrition, environment, or animal welfare to taste, cost, convenience, or social status, each of which could lead to a different set of food choices. Even among those motivated to change their diets, it is notoriously difficult to do so, and particularly to maintain lasting change (Kolata, 2008). Broader changes in the food system can lead to new healthy defaults and norms that more readily facilitate individual changes.

As chapter, focus, and perspective authors describe throughout this book, positive change is afoot in every sector of our food system. Growing numbers of farms are transitioning to methods that use more **agroecology** principles (i.e., methods with benefits for the environment, health, and society), and even in mainstream industrial production some environmentally beneficial methods, such as **no-till farming** (planting crops without tilling the soil), are becoming widespread. The number of farmers markets bringing local produce to consumers multiplies annually. Growing consumer interest in health and in foods produced with reduced negative impact has created markets for these products and others. As demand changes, new institutions are being established, from farm-to-school programs and food hubs to aggregate food, to institutional composting facilities and to gleaning programs that gather and distribute unharvested food. More broadly, programs to address food insecurity increasingly seek to make available higher-quality food to those in need, through emergency feeding,

agroecology
The science and practice of applying ecological principles to agriculture to develop practices that work with nature to mimic natural processes and conserve ecological integrity; other labels for ecological approaches to agriculture include *ecological agriculture, agricultural ecology, sustainable agriculture, permaculture*

no-till farming
Planting crops directly into the residue of the former crop without plowing

school meals, and other programs, and to improve access to food assistance programs. Interventions are also proliferating to bring fresh food into underserved areas. There is also increasing attention to the experiences of workers within the food system and a newly vibrant movement of workers standing up for better treatment. One of the most active areas of engagement has been intervening to prevent and address obesity. Following several decades of incessant increases in rates of obesity, some studies have observed a leveling off (Ogden, Carroll, Kit, & Flegal, 2014). It is too early to know whether this trend will endure or to understand fully the contribution of healthier diets to the trend.

These changes have been driven in part by concern about the previously described threats—and in part by a groundswell of positive interest in food and a tremendous energy among everyday consumers to learn about food; eat "fo**o**d with a story" and food they can trust; and appreciate high-quality, fresh, and well-prepared foods. As consumers get educated through these mainstream movements, many become motivated to support broader changes, whether addressing challenges in their communities or supporting the kinds of food production they would like to see expand. A growing food justice movement seeks to address the inequities throughout the food system and to bring new leadership to all of these efforts.

These changes are important and can contribute to positive evolution for public health, environment, and social equity. At the same time, these changes still remain but a small part of our overall food system. The vast majority of food production, processing, distribution, and consumption has yet to be significantly affected.

"Wicked Problems"

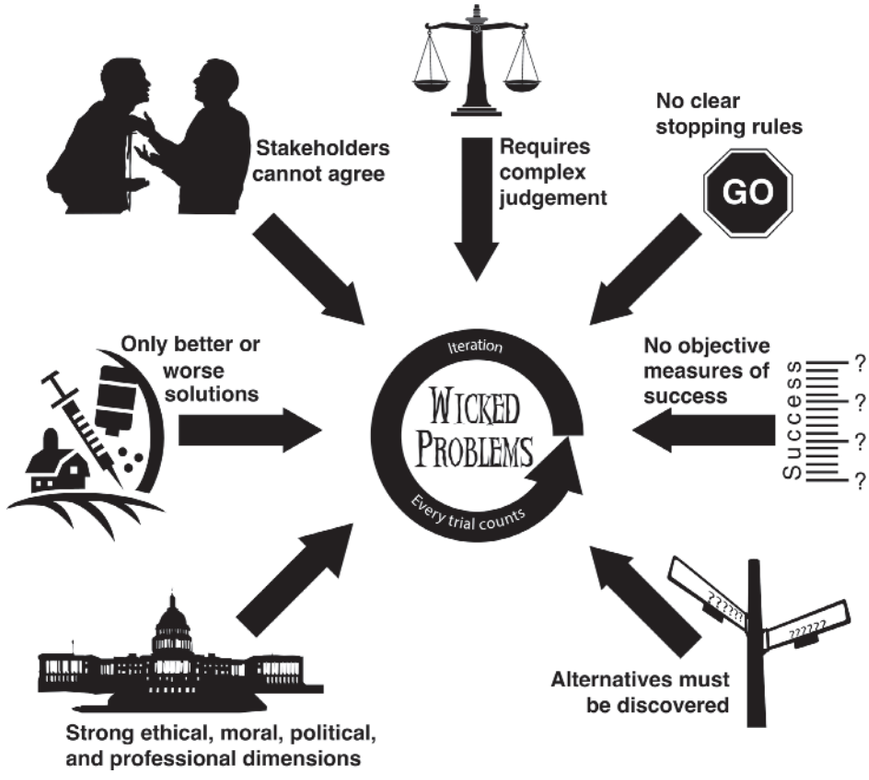
Sociologists use the term, **wicked problems** to describe problems for which stakeholders do not agree on the problem or its causes; each attempt to create a solution changes the problem; solutions are not right or wrong, just better or worse; solutions must be tailored to the situation; and they cannot be solved by people from any one discipline alone; multidisciplinary approaches are required (Kreuter, De Rosa, Howze, & Baldwin, 2004). Food system problems are indeed "wicked" (see figure 1.7)

wicked problems
Problems for which stakeholders do not agree on the problem or its causes; each attempt to create a solution changes the problem; solutions are not right or wrong, just better or worse; solutions must be tailored to the situation; and they cannot be solved by people from any one discipline alone; multidisciplinary approaches are required

As we look to supporting our current food system's capacity to feed the population and to addressing the system's public health, environmental, social equity, and food insecurity harms, the "wickedness" of these problems makes one's head spin. Even answers that initially seem obvious often turn out not to be. For example, it is widely presumed that ending farm commodity subsidies will address obesity. In fact, studies using evidence and modeling are remarkably consistent in finding that the impact on processed food prices and obesity will likely be negligible. Readers of this book will consider that evidence (chapter 7 and focus 7.2) and will have the opportunity to contemplate and review evidence germane to other critical questions, such as these:

- People often prefer foods that are not good for them or the environment. Given that, what, if anything, "should" we do to help improve diets?
- Is "good food" possible, when affordability is one of the criteria? And if not (for now), which should we prioritize: local, green, fair, affordable, or humane?
- How important are small community food security interventions given the vastness of food system problems?
- When current food insecurity is staring us in the face, how much money should we divert to costly conservation interventions that might help reduce future food insecurity?

FIGURE 1.7 Wicked Problems



Source: Adapted by Michael Milli, CLF.

- Is it more efficient to source globally rather than locally or regionally?
- Is it elitist to seek out local and sustainable foods?
- Should all food system workers receive a living wage? Even if it leads potentially to higher food prices and possibly to some stores in low-income communities going out of business?
- Which comes first in changing the food system, supply or demand?
- People have raised "sky is falling" concerns about the food system since at least the time of Thomas Malthus. And the food supply has only increased since then. So is all this worry really necessary? Won't technology help us out?
- Why is it so hard for even motivated individuals to change their diets, especially for the long term?
- What role should corporations play in voluntarily improving the food they provide? What role should policy play in pressuring them?

Overall, we hope the readings in this book will stimulate ideas and energy for improving the food system, including the following:

- Reducing food system public health threats including diet-related disease, food-borne illness, and contaminant exposures for communities and workers

- Reducing food system environmental harms including damage to and overuse of resources and climate change
- Increasing the supply of and demand for foods that are healthy, green, fair, affordable, and humane
- Improving access to and affordability of healthy foods
- Supporting justice and social equity for all food system participants
- Strengthening local and regional food systems
- Ensuring the long-term availability of our food supply
- Encouraging enjoyment of food flavors and freshness while supporting food traditions, community, and conviviality

SUMMARY

The food system encompasses all the activities and resources that go into producing, distributing, and consuming food; the drivers and outcomes of those processes; and all the relationships and feedback loops between system components. When considering the food system, systems thinking is useful in understanding the complex and interactive networks of relationships engaged in bringing us our food and in gaining insights into processes and potential unintended consequences. The US food system occupies a central place in US society, economy, land and resource use, and employment. There are many positives in the mainstream food system (figures 1.8a–d) but also a host of serious problems and challenges. Approaches to food system reform that complement systems strategies include public health and the right to adequate food. The chapter concludes by highlighting some of the questions readers will consider as they proceed through this book.

KEY TERMS

Agent-based computational modeling (ABM)
Agroecology
Environmental determinants of health
Food system
Health
Health disparities
Healthy food
Human right to adequate food
Industrial food animal production (IFAP)
Inputs
No-till farming
Obese
Overweight
Population-based approach
Primary prevention
Public health
Resilience
Social determinants of health
Structural determinants of health
Subsystems
System
Wicked problems

FIGURE 1.8 Even with Its Limitations, Our Food System Provides for Us in Many Ways

Sources: istockphoto 20863061, istockphoto 6218137, istockphoto 33603160, USDA-Robyn Wardell.

DISCUSSION QUESTIONS

1. Why should we study the food system? What is the benefit of a systems approach?
2. Poet Wendell Berry wrote, "A significant part of the pleasure of eating is in one's accurate consciousness of the lives and the world from which food comes." Is this true for you? For others?
3. Is "good food" possible, when affordability is one of the criteria? And if not (for now), which should we prioritize: local, green, fair, affordable, or humane?
4. How important are small community food security interventions given the vastness of food system problems?
5. When current food insecurity is staring us in the face, does it make sense to divert money to costly conservation interventions that might help reduce future food insecurity?
6. Is it more efficient to source globally?
7. Is it elitist to seek out local and sustainable foods or an alternative food system?
8. Should all food system workers receive a living wage? Even if it leads to higher food prices and the possibility that some stores in low-income communities go out of business?
9. Which comes first in changing the food system, supply or demand?

10. People have raised "sky is falling" concerns about the food system since at least the time of Thomas Malthus. And the food supply has only increased since then. So is all this worry really necessary? Won't technology help us out?
11. Why is it so hard for even motivated individuals to change their diets, especially for the long term?
12. What role should corporations play in voluntarily improving the food they provide?

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