Reaping What We Sow

How the Practices of Industrial Agriculture Put Our Health and Environment at Risk

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U.S. PIRG Education Fund

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Larger and More Specialized Farms Harm Public Health, the Environment, and the Future of Farming

Threats to public health

- Misuse of antibiotics, leading to antibiotic-resistant bacteria
- Nitrogen and phosphorus pollution trigger toxic algal blooms in waterways
- Bacteria and viruses from manure pollute lakes, rivers and streams
- Overuse of pesticides linked to lower IQ
- Overproduction of foods that contribute to obesity

Environmental damage

- Dead zones in lakes, estuaries and bays
- Pollution that increases global warming
- Loss of wetlands and grasslands

Threats to the future productivity of agriculture

- Topsoil loss
- Aquifer depletion
- Herbicide-resistant weeds

Photo credits: *Cornfield*: Karen Perhus via Dreamstime; *Hog confinement*: U.S. EPA via Wikimedia; *Runoff from livestock*: Tim McCabe via USDA NRCS; *Erosion from field*: Tim McCabe via USDA NRCS.

Executive Summary

Shaped by modern technologies, financial influences and public policy, American agriculture has evolved into an efficient system that produces all the food the country needs and more. However, in addition to the benefits that our food system offers, the shift to larger and more specialized farms has damaged public health and the environment.

Raising thousands of animals in confined spaces encourages the misuse of antibiotics that leads to antibiotic-resistant infections in people. Policies and financial systems that prioritize industrial-scale production of corn and soybeans lead to the loss of topsoil and depletion of aquifers, imperiling the long-term productivity of the nation's agricultural lands.

Such damage is avoidable. The adoption of farming practices that focus not just on short-term production but also consider the broader environmental and health consequences of agriculture can enable America to continue producing abundant food. Consumers are expressing increasing preference for food produced sustainably. Now is the time to reform agricultural practices to better protect public health, the environment, and our future ability to grow food.

Figure ES-1. Field Sizes for Common Crops Increased from 1987 to 2007[2]

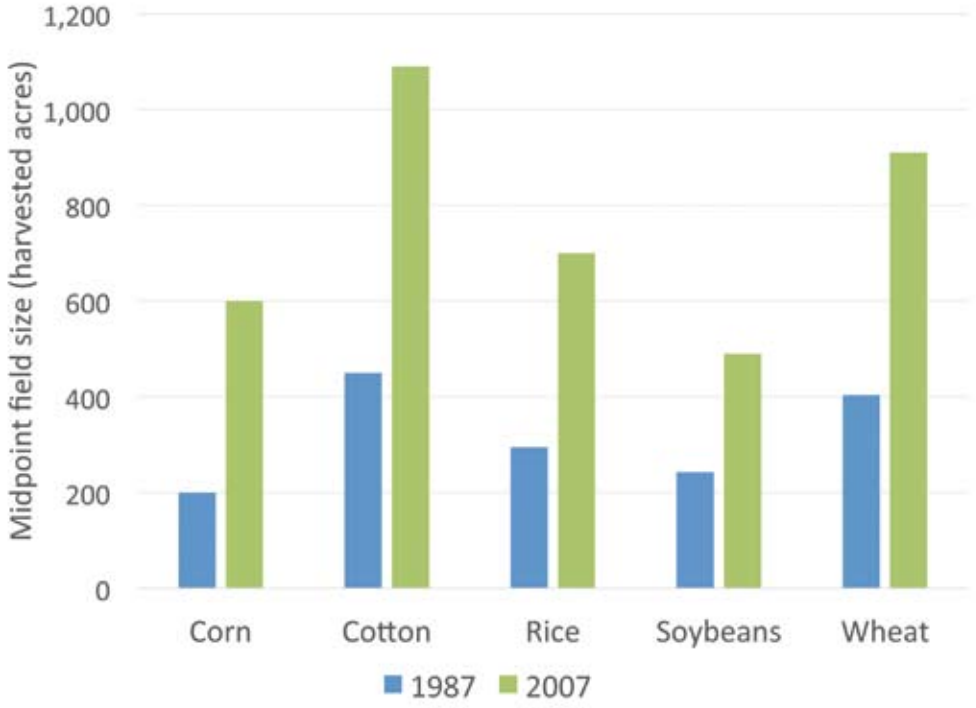
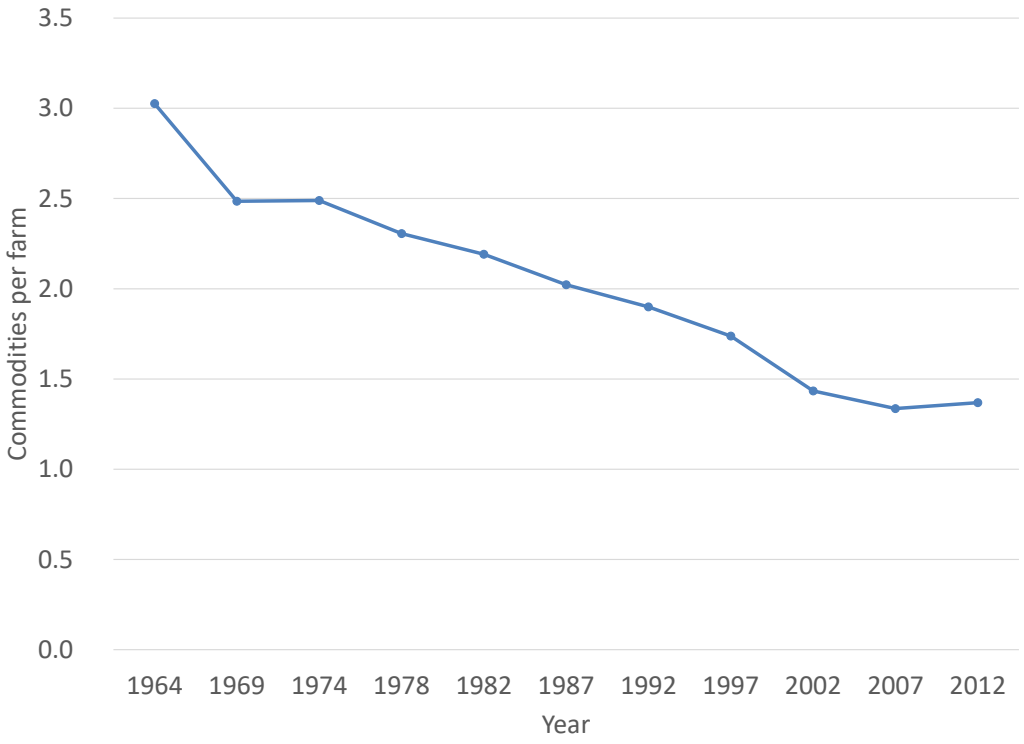


Figure ES-2. Farms Have Become More Specialized (Average Number of Commodities – Crop or Livestock – Produced per Farm since 1964)[5]



Farms Have Become Larger and More Specialized

Industrial farms have grown larger. Commodity crops like corn, cotton and soybeans are grown on bigger fields than ever before. For example, the midpoint size of a corn field—the size at which half of all acres of corn exist on smaller fields and half exist on bigger fields—tripled to 600 acres from 1987 to 2007.[1] (Figure ES-1 shows midpoint field size for several commodity crops.)

Similarly, livestock are being raised in increasingly larger herds and flocks using practices that harm the health of humans and animals. In 1987, half of all hogs were raised on farms with at least 1,200 hogs, but by 2007 this midpoint increased 24-fold to 30,000 hogs.[3]

At the same time as farm size has increased, variety has decreased. Whereas in 1964, the average farm produced three different products—growing multiple crops, raising different animal species, or a combination of both—today's farms produce on average only slightly more than one product.[4] (See Figure ES-2.)

Our Agricultural System Produces More Food than We Can Consume

The nation's agricultural system now produces more food than we can consume or than is good for us. For example, we have access to two and a half times as much meat, fish, eggs and nuts as nutritionists think we should eat.[6] Similarly, even though Americans, on average, consume far more sugar, fats and oils than recommended by nutritionists, national availability of these nutrients far outpaces what we actually consume.[7]

Larger and More Specialized Farms Harm Public Health and the Environment

In the course of producing this surplus of food, large, specialized farm operations contribute to a host of environmental and public health

problems. The harmful impacts of industrial agriculture include:

- **Loss of topsoil:** Current farming practices are contributing to the loss of topsoil, the layer of ground that contains most organic matter and the nutrients necessary for plant growth. Topsoil has been eroding faster than it can be replaced, which threatens future crop yields.[8]

- **Water pollution:** Applying too much fertilizer, whether manure or synthetic fertilizer, or applying fertilizer at the wrong time can pollute nearby waterbodies with nitrogen and phosphorus. The Environmental Protection Agency (EPA) has repeatedly identified agriculture as the industry with the largest negative impact on water quality in U.S. rivers and lakes.[9]

- **Aquifer depletion:** Roughly 80 percent of national water consumption is due to agriculture.[10] This heavy use has led to aquifer depletion and water scarcity in some of the country's main agricultural regions.

- **Pesticide overuse:** Heavy pesticide use harms people and the environment. Some of the most commonly used pesticides in the U.S. have been linked to cancer, autism and lower IQ.[11] Farm workers and their families face a heightened risk. The overuse of herbicides has created herbicide-resistant weeds, which have infected 60 million acres of crops and will make future farming more difficult.[12]

- **Antibiotic-resistant disease:** Factory farms often feed their animals daily doses of antibiotics. This routine antibiotic use contributes to the emergence of drug-resistant bacteria that can infect people with illnesses that are difficult and sometimes impossible to cure. The World Health Organization, the United Nations, and the Centers for Disease Control and Prevention have declared antibiotic resistance one of the gravest threats facing public health.[13]

- **Obesity:** More than one-third of the U.S. population is obese, a proportion that has increased by 65 percent over the last 30 years.[14] This increased prevalence of obesity, and the related risk of diabetes, heart disease, stroke and other diseases, is tied to overconsumption of some of the main products of industrial agriculture.

- **Climate change:** Improper soil management, methane emissions from cattle, and the production and combustion of biofuels are all sources of agricultural greenhouse gas emissions. Even without accounting for biofuels, the EPA estimates that the agricultural sector was responsible for roughly 9 percent of U.S. greenhouse gas emissions in 2015.[15]

Federal Policies Have Helped Shape the Damaging Production Patterns Seen in Today's Larger and More Specialized Farms

Federal farm policies, such as the long-running direct payment program, have encouraged the transition to industrial farming and its damaging approach to production. Technological advances, bank lending that favors large farm operations, and other forces have also shaped modern agriculture. In 2014, the federal direct payment program was ended, but crop insurance has started to play a similar role in supporting harmful farming practices.

Crop insurance incentivizes farms to specialize and produce the same few crops. Farmers who grow one or two commodity crops like corn and soybeans have more insurance options than farmers who grow fruits and vegetables.[16] In addition, farms with multiple crops often need to insure each variety separately, a time-consuming process that makes large single-crop fields more economically viable than more diverse farms. Other federal policies also encourage practices

that damage public health and the environment. For example, programs that provide funding to farms that invest in conservation measures have given the most grants to concentrated animal feeding operations to build additional manure storage facilities.[17] While some of these investments, such as anaerobic digesters, can be important for reducing global warming pollution, this funding also provides an incentive to farmers to continue raising huge, single-species herds rather than addressing the root of the problem by reducing herd size. Additionally, the federal Renewable Fuel Standard has encouraged the conversion of environmentally vulnerable land into cornfields.

America produces much more food than we need to live healthy lives. That abundance creates the opportunity to rethink the nation's agricultural policies in order to protect our environment, our health, and our ability to produce food sustainably for generations to come. By shifting key public policies, we can change how our food system operates, and better protect public health and the environment. Necessary changes include:

- Reforming crop insurance and renewable fuel programs to end excessive production of commodity crops and discourage planting on unsuitable land.
- Requiring farms to adopt sustainable practices in order to receive federal funding, and put effort into ensuring that farms continue to comply.
- Increasing support for crop diversification, which returns nutrients to the soil and disrupts pest cycles.
- Ending the routine use of antibiotics in food-producing animals.
- Changing incentives to help farmers address the cause of excess manure production from factory farms, rather than just funding manure storage facilities or anaerobic digesters that deal with the consequences of the problem.
- Holding industrial farms accountable for polluting our water supply.
- Increasing policy support for sustainable agricultural practices, such as organic production that consumers have increasingly indicated they prefer.

Introduction

North Carolina's Duplin County has fewer than 60,000 residents, but its hog farms produce twice as much waste as the New York City metropolitan area.[18]

Duplin County has been a top hog-producing region for the last 40 years. Duplin was the North Carolina county with the highest pig population in both 1978 and 2012, but it accomplished that mark in vastly different ways.[19] In 1978, Duplin's pig farms fit the storybook notion of a farm. Eighty percent of hog farmers raised fewer than 100 pigs at a time, and most of them grew crops or raised other livestock alongside their pigpens. Now, just 9 percent of farms have fewer than 100 pigs, and factory farms that raise thousands of hogs in confinement have become the norm.[20]

The small family farms that comprised most of the Duplin hog farming industry were either forced out or acquired by large corporations. Instead of using the surrounding land to grow a diverse array of crops or to raise other kinds of animals, these industrial farms have built silos and lagoons to store the millions of tons of manure these pigs produce each year.

This manure storage system is not safe or sustainable. Even people who grew up raising and slaughtering pigs on their family farms have started fighting against the local hog industry, largely because the air pollution from these factory farms has been causing respiratory illness.[21] Manure lagoons are also a significant source of greenhouse gas emissions, and they can be susceptible to flooding and polluting local waterways, as seen in October 2016 in the aftermath of Hurricane Matthew.[22]

The transition toward intensive farming that has occurred in Duplin County is not unique—nor are the resultant public health and environmental impacts. Across the country, in the name of producing more food at a lower cost for a nation that already has enough, farms have been pushed to consolidate and grow larger while producing less variety. Much of this change has been driven and supported by federal policy and corporate agribusinesses that prioritize commodity grains over crop diversity. These commodity grains are often used as animal feed, enabling the spread of intensive livestock farms. Practices on both specialized crop and animal farms create pollution, threaten public health, and risk the future of farming.

This report explores the policies that have enabled these harmful practices, the problems that have resulted, and the potential to improve our agricultural system and protect public health and the environment. The U.S. has abundant capacity to feed the country, now and in the future, while improving public health, maintaining clean water, and reducing global warming pollution.

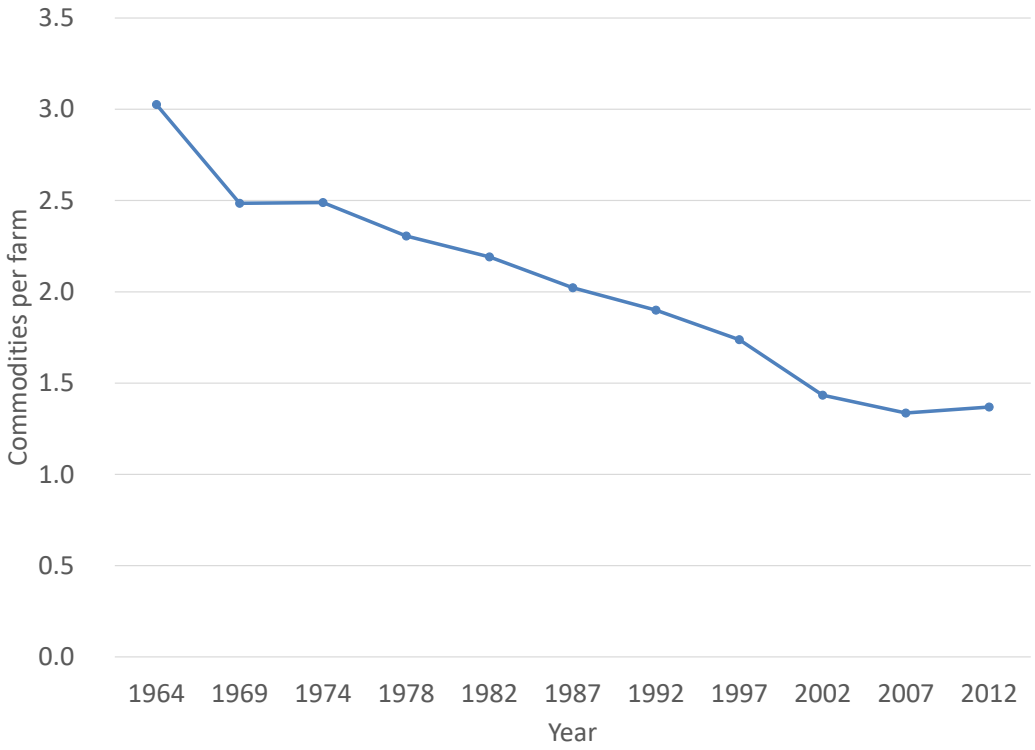
The Rise of Large, Specialized Crop and Animal Operations

Agriculture in the U.S. is dominated by large, specialized and highly productive farms. This is the result of federal agricultural policies, financial and corporate forces, and technological innovations that have pushed farm sizes up and the number of products per farm down. This has enabled changes to farming methods that have increased both output and harm from agriculture.

Until the mid-20th century, farms produced a mix of complementary products. In 1964, the average farm produced an average of three different products—varied crops, multiple types of animals, or a mix of crops and animals.[23] Often, plants and animals were raised in combinations that complemented each other and supported the overall health of the farm. Farmers grew grains to feed their livestock, which in turn produced manure that fertilized the soil. Many farms planted combinations of crops—like corn, oats and hay—that supported each other by cycling different nutrients through the soil.[24] Cover crops, planted after the harvest to protect and return nutrients to the soil, were commonplace in American agriculture through the mid-20th century.[25]

A farmstand in Massachusetts in 1940 sells a wide variety of fruits and vegetables beneath a sign that proclaims, "all grown on this farm." Credit: National Archives and Records Administration.

Figure 1. The Average Number of Commodities – Crop or Livestock – Produced per Farm over Time Has Declined since 1964[28]



After World War II and through the mid-20th century, the development of artificial fertilizers and pesticides and the availability of mechanized equipment changed farm practices.[26] Synthetic fertilizers and pesticides made it possible for farms to maximize short-term yield without crop rotations or cover crops. Faster and more sophisticated mechanical equipment enabled farmers to work larger fields of a single crop and to manage larger herds. Encouraged by federal policies, the overall result is that farms became larger, more specialized and more productive.

Decreasing Variety

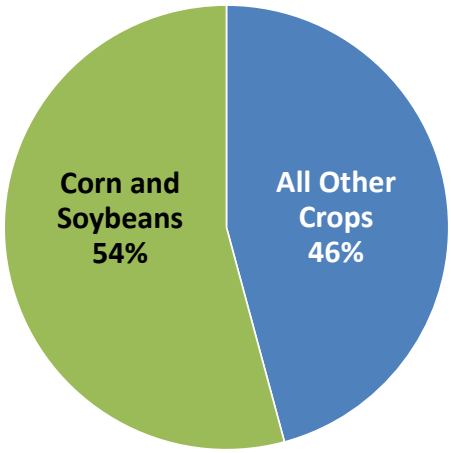
As chemical fertilizers and automated equipment improved and became more common, farmers started to maximize their productivity by planting large fields with a single crop. This increased crop production made it cheaper for livestock farms to buy animal feed than to provide land for livestock grazing. This facilitated a transition to large farms that raise just one type of animal, fed in confined quarters. As a result, most farms today are highly specialized. In the short run, these changes have resulted in the nation producing far more food than we can consume but, as will be discussed in later sections, those improvements may have come in ways that limit the long-term productivity of land.

Today, farms produce on average only slightly more than one product. Recent data from the federal government show how overwhelmingly common single-product farms have become, with roughly 1.4 commodities produced per farm in 2012.[27] (See Figure 1.)

Most single-crop farms focus on the same few crops, those that are non-perishable and easily traded as commodities: corn,

soybeans and other grains. The result is that the majority of the acreage in the nation is planted in just a handful of crops. Soybeans and corn grown for grain made up more than half of all cropland acres harvested in 2012, while all other crop varieties, including the fruits and vegetables that offer more nutritional value, are grown on far fewer acres.[29] (See Figure 2.)

Figure 2. Corn and Soybeans Comprised More Than Half of All Acres Harvested in 2012[30]



Rising Farm Sizes

At the same time that variety has decreased, farm size has increased. The change has occurred for both crop farming and animal farming. In 1987, the average acre of land was farmed as part of a 600-acre farm; by 2011, the average acre was cultivated as part of a 1,100-acre farm.[31] Because the number of crops per farm dropped in the same period, average field size has risen. Commodity crops like corn, cotton and soybeans are grown on bigger fields than ever before. For example, the midpoint size of a corn field—the size at which half of all acres of corn exist on smaller fields and half exist on bigger fields—tripled to 600 acres between 1987 and 2007, and the midpoint size of a cotton field more than doubled.[32] Figure 3 shows average field size for several commodity crops has risen over the last 30 years.

Figure 3. Field sizes for Common Crops Increased from 1987 to 2007[33]

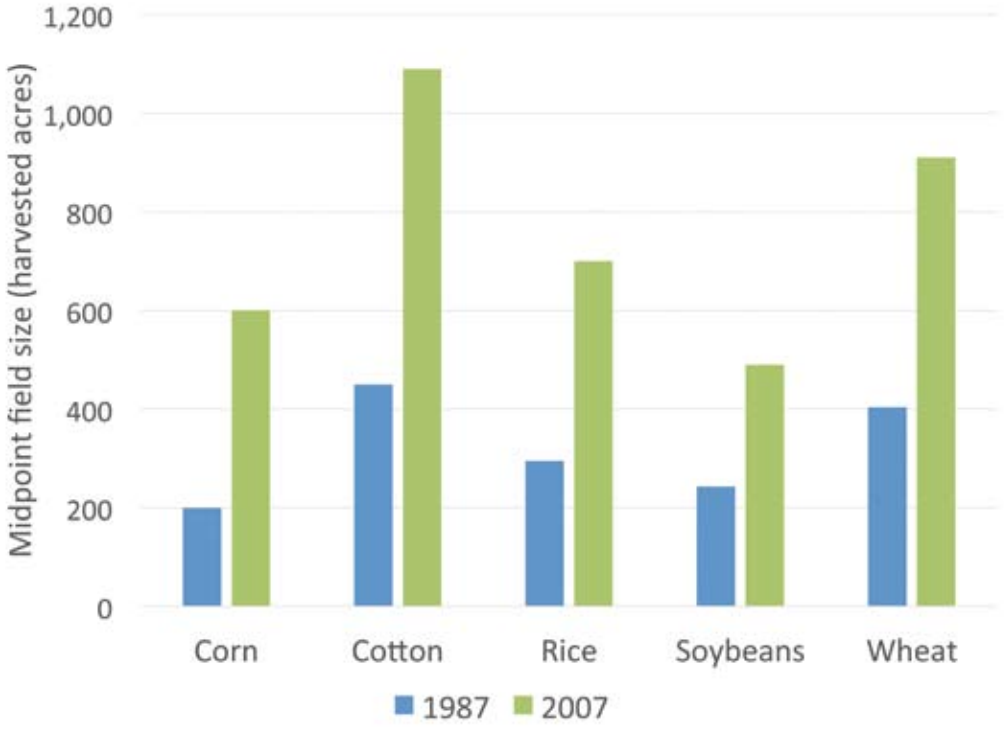
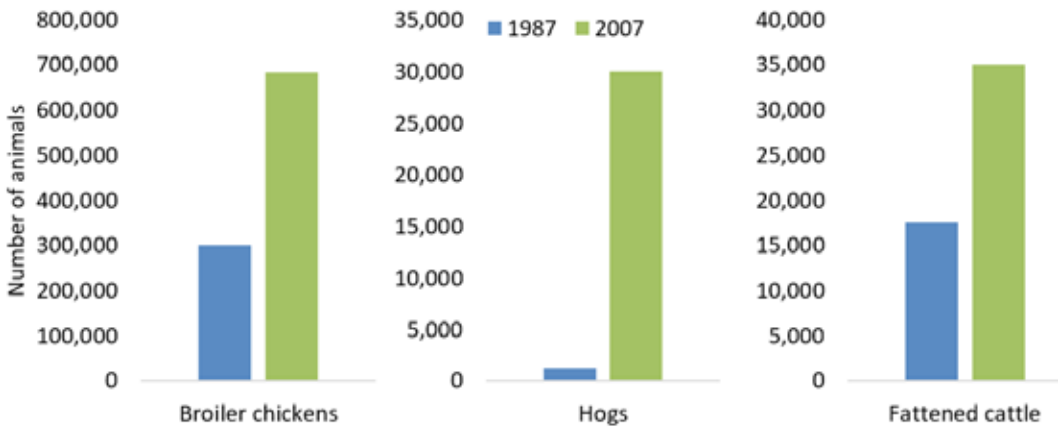


Figure 4. The Number of Animals on the Midpoint Livestock Farm Increased Dramatically between 1987 and 2007[35]



Similarly, livestock are being raised in larger herds. For example, half of all hogs in 1987 were raised on farms with at least 1,200 hogs, but by 2007 half of all hogs were raised in herds of at least 30,000, a 24-fold increase.[34] Similar trends have been seen across most of major types of livestock (see Figure 4).

The rise of large, specialized crop and animal farming has changed the impact of American agriculture. Farms now produce an overabundance of food—far more than we can consume—but they also create widespread health and environmental problems.

Modern Farms Produce an Overabundance of Food

The modern agricultural system now produces so much food that the nation regularly has a large surplus. U.S. farms produce far more food than we can eat, with the result that we waste a large share of the food produced each year.

Even though Americans consume far more food than we need and more than a third of us are obese, the nation's farms provide more than enough.[39] The nation produces and imports nearly twice as much meat, fish, eggs and nuts as we consume, nearly 50 percent more grains and vegetables, and 60 percent more fats and oils.[40]

Federal dietary recommendations are at odds with federal crop subsidies, which disproportionately go to commodities that are used to make sugar and oils and feed animals. National availability of meat, fat and sugar all outpace what nutritionists recommend we consume.[41] The USDA's dietary guidelines include a few different

Figure 6. Modern U.S. Agriculture Produces More Food Than We Need[43]

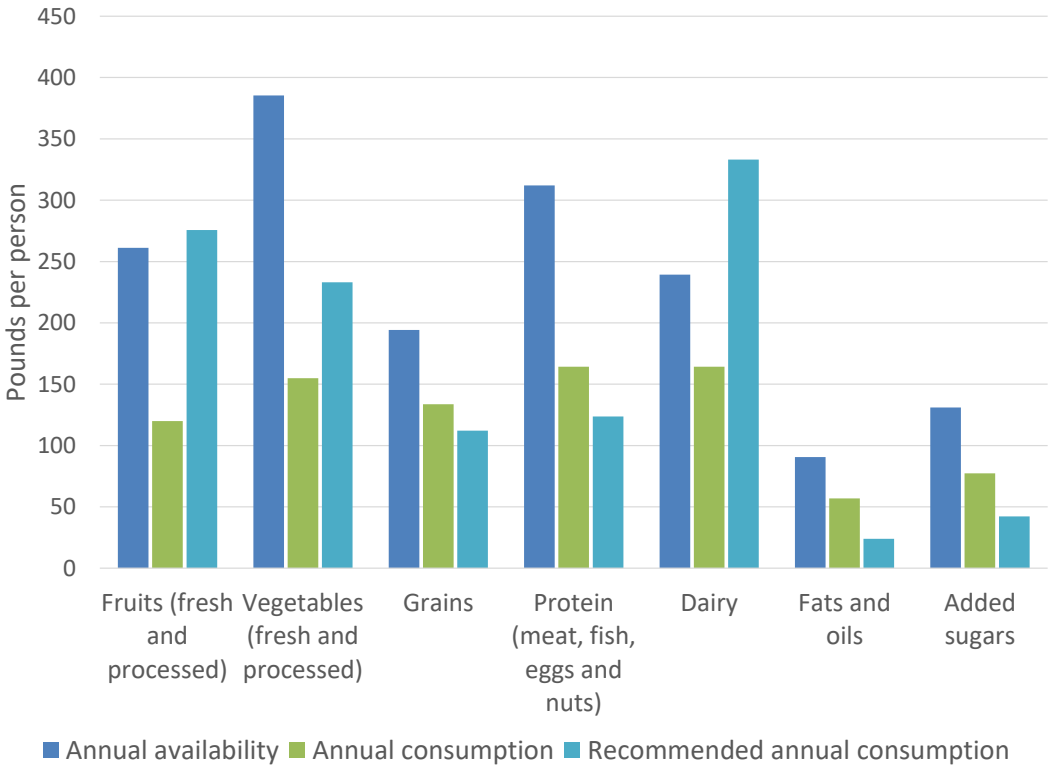
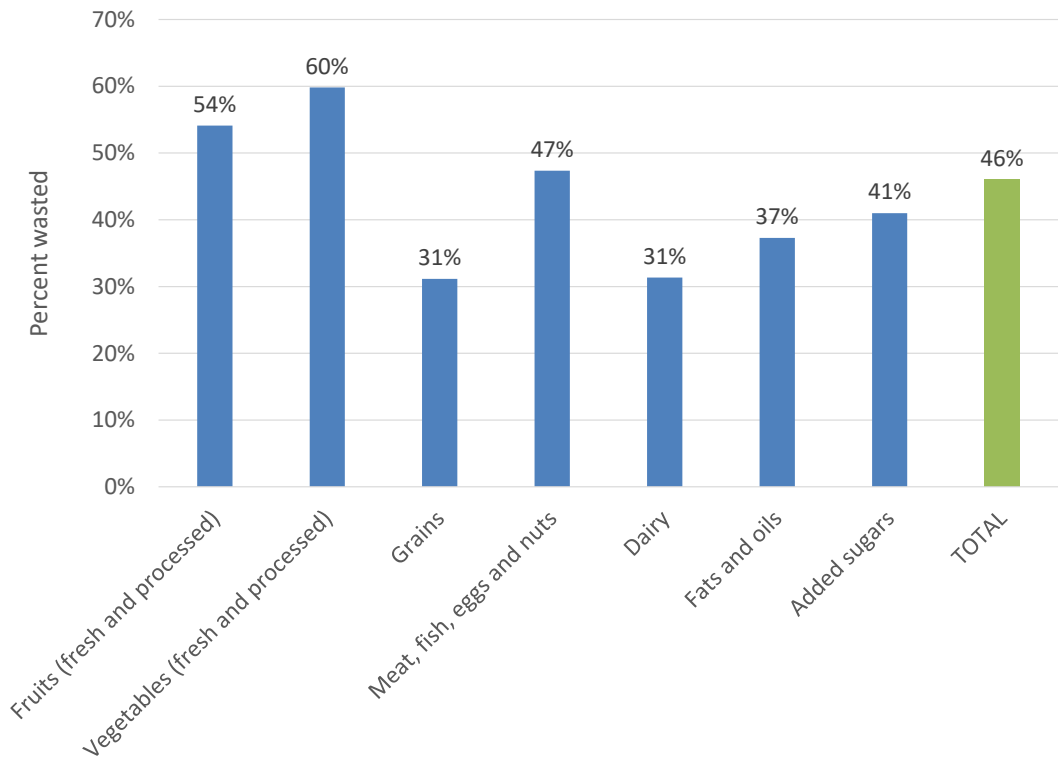


Figure 7. Food Waste Occurs in Every Food Group[45]



diets for healthy eating. The numbers in this report all come from their "Healthy U.S.-Style Eating Pattern."[42] Recommendations in other eating patterns highlighted in the dietary guidelines, such as the "Healthy Mediterranean-Style Eating Pattern," all vary slightly, but overall, if we followed nutritional guidelines, farms would need to boost dairy and fruit production. Figure 6 shows production, actual consumption, and recommended consumption for various food groups. Grain production volume is in addition to crops grown for animal feed and biofuels production.

This excess food is available after accounting for food that is exported. The excess is thrown away after it spoils or cannot be sold. Overall, more than 700 pounds of food are wasted per person in the U.S. each year.[44] This food loss, which comprises 46 percent of our initial food supply, occurs at every point along the chain from producer to consumer. Sixteen percent of all food that is available at the farm or factory, or immediately after being imported, is lost before making it to the store. Another 10 percent of food available at the market level is discarded before reaching consumers, and 27 percent of food in homes or at restaurants is left uneaten. Figure 7 shows the percentage of food waste in each food group.

In short, American farms produce an overabundance of food, enough that we have plenty to eat and still have enough to waste. Producing that agricultural bounty, however, creates health and environmental problems.

Damage from Industrial Farming Practices

American farms have become increasingly specialized, growing just one or two crops or raising one type of animal, and doing so on large farms. Farms have been very successful at maximizing short-term productivity, but often at the cost of creating a range of environmental and public health problems and threatening the long-term viability of American agriculture. Soil loss, water pollution, aquifer depletion, increased pesticide and fertilizer use, the rise of antibiotic-resistant bacteria, obesity, and global warming are all side effects of our nation's embrace of industrial agriculture.

Large farms are not always more damaging than small farms. There are small farms that apply excessive pesticides and fertilizers to their monocultured fields, and large farms that maintain crop rotations, practice conservation tilling practices, and prioritize soil health. However, in general, as the nation's average farm size has increased, harmful practices have followed.

Industrial Crop Farming Harms Soil and Water

The intensification and specialization of crop farming has created environmental and public health problems, including soil depletion, water pollution, aquifer depletion and increased pesticide use.

Loss of Topsoil

Current farming practices are contributing to the loss of topsoil, which will have long-term consequences for agricultural production. It takes 300 years to produce a single inch of topsoil, the layer of ground that contains most organic matter and nutrients necessary for plant growth. In many places in the U.S., agricultural practices are eroding it faster than it can be replaced.[46] Regions with topsoil that is fully eroded away will not be able to support agriculture. One study predicts that soil loss is already starting to threaten agricultural output.[47]

Leaving fields bare after harvest and before the next marketable crop is planted makes it easier for wind and water to carry away soil. Planting cover crops such as rye, winter peas or buckwheat retains soil and nutrients. However, just 6 percent of farms, including only 0.8 percent of farms larger than 1,000 acres, report using cover crops.[48] Additionally, despite requiring minimal labor, conservation tilling—the practice of planting on fields that remain at least partially covered by the previous year's crop residue—is used by less than 10 percent of all farms.[49] These techniques are simple to implement and can even be profitable for farmers, but without farm policy encouraging good practices, farms appear unlikely to change their routines at a large enough scale.[50]

An additional problem of mono-cropping and industrial-scale farming is nutrient depletion. Repeated plantings of corn decrease soil nitrogen levels and lower yields if not counteracted with fertilizer. Growing different crops can help return nutrients to the soil and reduce the need for fertilizer. Three- and four-crop rotations in a diversified system are ideal

A cover crop beginning to sprout between rows of wheat that have been left untilled on a farm in South Dakota. Photo: Colette Kessler, USDA Natural Resources Conservation Service, South Dakota

for maintaining healthy soil.[51] Most corn and soybean fields in the 10 states with the highest production are grown in a two-crop rotation, and more diversified rotations are rare. Forty percent of corn acres in these states don't utilize any rotation at all.[52]

Water Pollution

The Environmental Protection Agency (EPA) has repeatedly identified agriculture as the industry with the largest negative impact on water quality in U.S. rivers and lakes.[53] Agricultural activity has harmed 146,000 miles of rivers and streams, 1.1 million acres of lakes, reservoirs, and ponds, and 203,000 acres of wetland, and is one of the top three sources of pollution for all of these categories of bodies of water.[54] (See Table 1.) This pollution stems from the substances applied to crop fields—chemical fertilizers, manure and pesticides, among others—and the soil itself, when it is carried off by wind or water.

Repeatedly planting the same fields with the same crops depletes nutrients in the soil. To ensure crops have adequate nutrients, farmers supplement the soil with manure, mined phosphorus or artificial fertilizer. Across the country, 96 percent of acres planted with corn are treated with nitrogen fertilizer, and 94 percent of acres receive both nitrogen and manure.[56] Too often, farms use these supplements to excess, or apply them in ways that increase the risk of runoff.

One U.S. Department of Agriculture (USDA) report identified four steps that farmers can take to minimize nitrogen runoff: applying less fertilizer than the maximum amount that the crop can absorb, applying some portion of the total amount after planting seeds in the spring, incorporating the chemical under the surface of the soil, and avoiding fertilizer use in the fall, after crops have been harvested.[57] Just 6 percent of all corn acres met all four of

these criteria in 2010.[58] Inappropriate fertilizer application can pollute nearby streams, rivers and lakes. (The impacts of nutrient pollution are discussed in greater detail in the following section on "Intensive Animal Farming Threatens Public Health," page 20.)

The other main type of water pollution resulting from large-scale specialized crop production is sediment pollution. When topsoil is left exposed, such as after a field has been plowed or has just been seeded, it is vulnerable to wind and rain. Wind and water can move more rapidly across open ground and pick up more soil across a large field, especially if there are no windbreaks or planted buffers on the edge of the field or alongside waterways. Once in a stream or river, these eroded sediments can harm the aquatic ecosystem, because they make the water cloudy, which blocks sunlight and therefore hinders the growth of algae and other underwater plants.[59]

Aquifer Depletion

Roughly 80 percent of national water consumption is due to agriculture.[60] This has led to aquifer depletion and water scarcity in some of the country's main agricultural regions. The USDA's 2012 Census of Agriculture found that 26 percent of all U.S. farmland is irrigated, but this ratio varies greatly by farm size. (See Figure 8.) More than 40 percent of land on the country's largest farms—those that are at least 1,000 acres—is irrigated, compared to just 8 percent of land on farms smaller than 200 acres.[61]

Irrigation is the largest source of groundwater depletion in the United States; 57 billion gallons of groundwater are used on American cropland each day, 3.5 times more than the amount of groundwater used daily in the U.S. public water supply.[63] Scientists at the University of Texas and U.S. Geological Survey have found that regions in the High Plains, where large industrial farms have been drawing water from underground reservoirs many times faster than these sources can be naturally replenished, may only be able to support irrigated agriculture for the next 30 years.[64]

Beyond limiting future food production, aquifer depletion poses threats to both the environment and human health. If the water table lowers, water levels in nearby rivers and lakes can also drop, impacting

Table 1. Agriculture Is a Top Source of Impairment to Rivers, Lakes and Wetlands[55]

Type of waterway	Top Three Sources of Impairment	Total Impaired	Impaired by Agriculture	Percent Impaired by Agriculture
Rivers and streams	**1) Agriculture** 2) Hydromodification 3) Atmospheric deposition	582,031 miles	133,164 miles	23%
Lakes, reservoirs and ponds	1) Atmospheric deposition 2) Nonpoint sources **3) Agriculture**	12,950,960 acres	1,111,390 acres	9%
Wetlands	1) Natural sources & wildlife **2) Agriculture** 3) Atmospheric deposition	665,494 acres	203,199 acres	31%

Figure 8. Larger Farms Rely More Heavily on Irrigation[62]

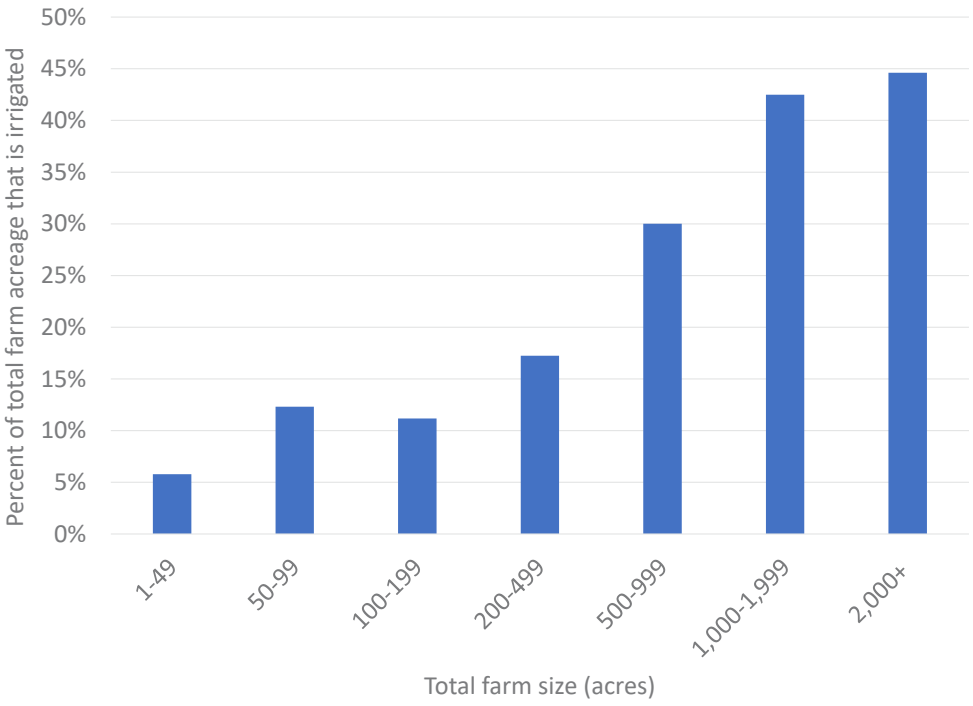
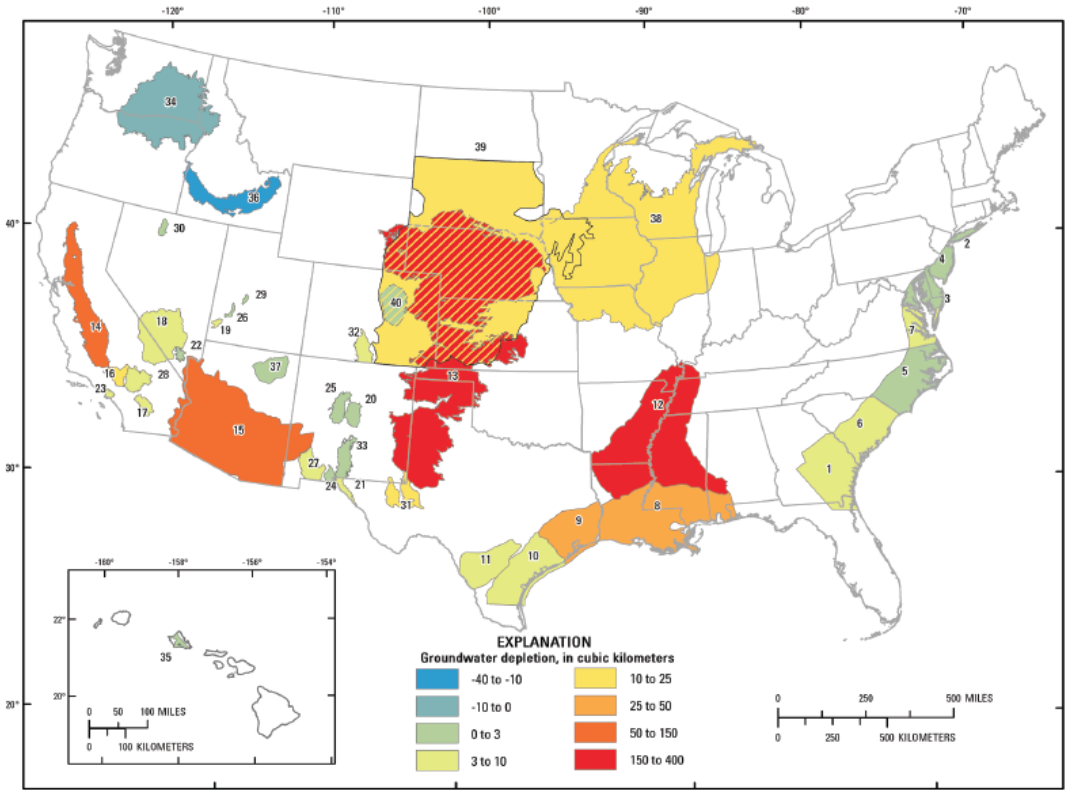


Figure 9. Crop Irrigation Is Depleting Aquifers across the Country[65]



The hatched region marks overlapping aquifers. Zone 13 is the Ogallala Aquifer in the High Plains, where scientists fear that groundwater resources may be exhausted within the next 30 years.

those ecosystems and potentially harming local wildlife.[66] Many rural families also draw their household water supply from wells that connect to the same aquifers used by industrial farms. As these reservoirs are depleted, underlying saltwater deposits can leak into the aquifers, raising saline and mineral content to undrinkable levels.[67] In California's Salinas Valley, for example, which produces more than half of the lettuce grown in the country, saltwater intrusion has forced farms to close their wells and experiment with irrigating their fields with treated sewage.[68]

Pesticide Overuse

Growing huge fields of the same crop or the same few crops year after year allows pests and crop diseases to flourish. Biodiversity has been one of the strongest natural strategies for pest control. Because pests—which can be weeds, insects or fungi—are usually adapted to feed on only a few types of plants, fields with more plant species variability deter invasive creatures by offering them a limited food supply. Conversely, fields with a single type of crop allow pests to flourish.[69] We already have at least one history lesson about the dangers of single-crop farming: the Irish Potato Famine. Because 19th century Ireland became so reliant on a single variety of potato, a deadly crop disease was able to spread through fields all across the country, and almost one million people died from poverty and starvation.

In the U.S., the current strategy to protect single-crop farms from similar disease is liberal pesticide usage, which poses its own risks to human health and the environment. Pesticide use was more than 2.5 times higher in 2008 than in 1960.[70] Because these chemicals typically kill more species than the single invasive fungus, plant or insect that is the intended target, natural predators of the pests may also be killed, increasing the farm's long-run dependence on pesticides.

Chemicals that have been designed to kill pests may also hurt people. According to EPA research, the commonly-used insecticide chlorpyrifos impacts brain development.[71] Other studies link this pesticide to autism, lower IQ, ADHD, and reduced motor skills in children.[72] The World Health Organization (WHO) has linked the herbicide glyphosate, the most widely-used agricultural chemical in U.S. history, to cancer.[73] In addition, a study at UC Berkeley found that when women were exposed to high levels of a certain type of common agricultural pesticide while pregnant, their children scored up to 7 points lower on IQ tests.[74] Farm workers and their families face a higher risk of ill effects due to their increased pesticide exposure.

In the fight against pests, genetically modified seeds, some of which are engineered for herbicide resistance, facilitate spraying without fear of killing the crop and also reduce the need to till fields to keep weeds down.[75] Since genetically modified organisms (GMOs) were introduced to agriculture in the 1990s, they have become standard for many of the most common U.S. crops. By 2007, 91 percent of soybean fields contained herbicide-resistant plants grown from genetically modified seeds.[76]

Pesticides and GMOs were initially intended to address the problems that threaten crop yield, but in some cases they have created new dangers. Even as GMO seeds have reduced the need for insecticide to control the European corn borer and other pests, they have facilitated increased use of herbicides that have harmed human health and led to the emergence of herbicide-resistant weeds, which now infect 60 million farm acres.[77]

Intensive Animal Farming Threatens Public Health

The increase in agricultural specialization has resulted in animals being raised by the thousands in densely packed complexes**.** These factory farms have spread in tandem with specialized crop farming, as heavily subsidized commodity crop production has

lowered the cost of animal feed enough that livestock farmers began buying feed instead of growing it themselves.

Vertical integration within the livestock industry—led by mergers between many farms and meatpackers—created the first intensive animal farms, which in turn pressured smaller farmers to follow their lead.[78] The largest of these farms, categorized by the EPA by herd size, are known as concentrated animal feeding operations (CAFOs), and they operate by raising animals in confinement and feeding them grains instead of allowing for room to graze.[79] CAFOs and other factory farms are responsible for a host of public health and environmental concerns, including increased antibiotic resistance and polluted waterways.

Antibiotic-Resistant Disease

When tens of thousands of animals are raised in close quarters, exposed to each other and their manure, diseases can spread quickly. To prevent this, operators of farms with many animals in close quarters often feed daily doses of antibiotics to their animals. Routine doses of antibiotics are also used to help animals reach slaughter weight more quickly, increasing production without increasing food requirements. For these reasons, antibiotic usage has become widespread on farms with densely packed animals.[80]

Many antibiotics are used to treat both humans and livestock. In the U.S., roughly 70 percent of medically important antibiotics sold are used on food animals, rather than people.[81] The routine use of antibiotics on animals results in the emergence of antibiotic-resistant bacteria that can affect human health. When livestock are fed routine doses of antibiotics, bacteria that are vulnerable to this medication are killed, and just a small number of bacteria with natural resistance survive. They are able to reproduce, and also to share genetic information enabling antibiotic resistance with other strains of bacteria. Antibiotic-resistant bacteria do not stay on the farm, and the infections they cause are not limited to farm animals. Bacteria can travel from animals to people through contaminated meat, on the clothing of farmworkers, and through contaminated air and water.[82]

The Centers for Disease Control and Prevention (CDC) has identified 18 bacterial strains as either "urgent," "serious," or "concerning" because of their degree of antibiotic resistance. According to the CDC, the overuse and misuse of antibiotics—including in animals—is the single most important factor leading to antibiotic resistance around the world.[83] Already, antibiotic-resistant infections kill at least 23,000 Americans each year.[84] The United Nations, the World Health Organization, the CDC, and other public health and medical organizations have all described the growing threat of antibiotic resistance as one of the gravest dangers facing public health.[85] If antibiotic resistance continues to develop, common infections and diseases that have been treatable for decades may once again be dangerous or even fatal.

Water Pollution

Another problem with keeping lots of animals in a confined space is that they produce large amounts of waste in a small area, with no safe way to dispose of it. Food and Water Watch found that animals raised on factory farms created 738 billion pounds of waste in 2012.[86] Too often, this waste results in water pollution.

Farms often store manure in lagoons for rudimentary processing or in piles or silos until it is time to spread it on fields. Farms can apply for federal conservation funding toward construction of manure storage facilities. However, this effectively creates a subsidy for meat production practices that pose threats to human health. Additionally, manure storage facilities can fail, polluting waterways and making people sick. In Wisconsin, for example, farms spilled 1.6 million gallons of manure in

Manure lagoons in North Carolina, like the one pictured here, were flooded after Hurricane Matthew in October 2016, overflowing and polluting the surrounding areas. Photo: Bob Nichols, USDA Natural Resources Conservation Service

2014 alone, including one instance when 16 people became sick after liquid manure from a nearby farm spilled into a town's well.[87] More recently, the heavy rainfall and flooding caused by Hurricane Matthew in October 2016 caused at least a dozen North Carolina hog lagoons to overflow.[88]

The main method of disposing of manure—spreading it on fields to use as fertilizer—is itself a major source of water pollution. Land application is the cheapest and easiest way to get rid of manure, but factory farms produce so much waste that there can be more of it in a region than crops need as fertilizer. In four Maryland counties, for example, chicken production operations generate manure that contains four to eight times more nutrients than crops in those counties need as fertilizer.[89] The excess nutrients, especially phosphorus, are easily washed off fields by rain or melting snow.

Nutrient pollution from farms can result in high nitrate levels that make water unsafe to drink. Exposure to nitrate has been linked to increased risk of thyroid cancer.[90] Water polluted with nitrates can also cause "blue baby syndrome," which can be fatal to infants, particularly at levels above the EPA-mandated limit of 10 milligrams per liter.[91] The Des Moines Water Works, Iowa's largest water utility, says that nitrate pollution has driven up the cost to treat drinking water drawn from the Raccoon River for 500,000 people.[92] In 2015, the utility sued three counties for allowing agricultural pollution to raise nitrate levels to five times the EPA limit.[93]

Excess nitrogen and phosphorus from manure can trigger algal blooms that threaten public health. For example, Lake Erie regularly experiences severe blooms fed by agricultural pollution.[94] Algal blooms frequently contain cyanobacteria, which can cause stomach and

respiratory issues.[95] In 2011, microcystin, a toxin produced by cyanobacteria, covered swaths of Lake Erie's western basin, reaching levels 50 times greater than recommended for safe recreation; two people reported symptoms associated with algae exposure.[96] In 2013, the 2,000 residents of Carroll Township were told they could not use their tap water due to contamination from an algal toxin as dangerous as cyanide.[97]

Nutrient-fed algal blooms also can turn lakes and estuaries into "dead zones" that develop after algae die and begin to decay. This depletes oxygen from the water, threatening fish populations and other marine animals.[98] A huge dead zone caused by agricultural runoff into the Mississippi River forms each summer in the Gulf of Mexico, threatening aquatic life, local seafood, and recreation in the region.[99] The Chesapeake Bay, the nation's largest estuary, which once supported thriving oyster populations and fisheries, has also been suffocated by algae blooms triggered by agricultural runoff.[100]

The Broader Public Health Impacts of Industrial Farming

Industrial farming practices, including large animal operations and the intensive production of commodity crops, have contributed to two of the country's biggest public health threats: obesity and climate change.

Obesity

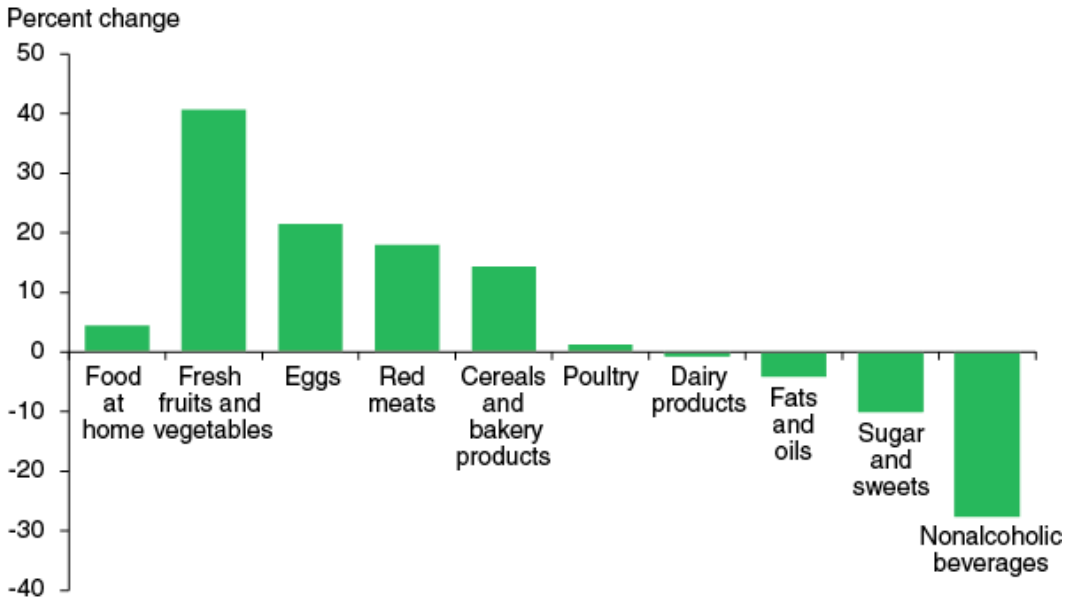
The overall distribution of crops and animals raised on U.S. farms bears little resemblance to what nutritionists suggest people should be eating to maintain optimal health. (See Figure 6, p. 14.) The most recent federal guidelines define a healthy diet as one that includes a variety of fruits, vegetables and whole grains, and limits the consumption of added sugars and saturated and trans fats.[101] This doesn't square with what is grown and produced on U.S. farms. A majority of crop acreage now produces either corn or soybeans—which are primarily used as animal feed or processed into foods like high fructose corn syrup and soybean oil—while fruits and vegetables comprise just 2.5 percent of all harvested acres in the country.[102] Specialized agriculture and federal policies that incentivize farms to plant a limited variety of grains encourage the production and consumption of unhealthy junk foods, which in turn have contributed to increased rates of obesity, heart disease and other health concerns.

The least healthful foods have historically received higher subsidies than more healthful foods. A 2013 U.S. PIRG report found that corn sweeteners (such as corn syrup and high fructose corn syrup), corn starch, and soy oils—common junk food ingredients that are all made from corn or soybeans—received $19.2 billion in agricultural subsidies between 1995 and 2011.[103] In contrast, apples received $689 million, just 4 percent of what was spent on corn sweeteners, corn starch and soy oil.

This may be part of the reason that fruits and vegetables have gotten more expensive compared to other foods. According to the USDA, fruits and vegetables became 40 percent more expensive from 1985 to 2014, while fats and sweets became cheaper.[104] (See Figure 10.)

The foods subsidized by the federal government have measurably harmed Americans. According to the Centers for Disease Control, 38 percent of the population is obese, a 65 percent increase over less than 30 years.[106] This increased prevalence of obesity, and the related spread of heart disease, diabetes, stroke and more, is inextricably linked to agricultural policy and practices. A recent study found that people who eat more food containing subsidized commodities tend to have greater risk of suffering from diabetes, heart disease or stroke.[107] Specifically, the quarter of the population that eats subsidized foods most often is 37 percent more likely to be obese

Figure 10. Fruits and Vegetables Became 40 Percent More Expensive between 1985 and 2014, while Fats and Sweets Became More Affordable over That Same Period (adjusted for inflation)[105]



than the quarter of the population that eats subsidized foods least frequently.[108] In response to these findings, one researcher concluded, "through commodity subsidies that encourage poor diet we are, in part, paying for our own demise."[109]

Climate Impacts

Many aspects of U.S. industrial agriculture contribute to global warming. Between the overuse of nitrogen fertilizers, agricultural soil management, and methane emissions from cattle and manure, the EPA estimates that the agricultural sector was responsible for roughly 9 percent of U.S. greenhouse gas emissions in 2015.[110] This figure does not account for emissions from the combustion of biofuels or the release of nitrogen or carbon stored in soil, suggesting that the actual impact is even greater.

Soil Management

Nitrous oxide occurs naturally in fertile soil as a byproduct of organic matter decomposition, but tilling and removal of protective buffers on cropland releases this powerful greenhouse gas to the air, contributing to global warming.[111] The over-application of nitrogen fertilizer causes the release of additional nitrous oxide to the atmosphere. Atmospheric nitrous oxide concentrations have increased more than 6 percent since 1980, and recent research suggests that agricultural uses are the primary cause.[112] In the United States, the agricultural industry was responsible for almost 80 percent of nitrous oxide emissions in 2014, largely due to soil erosion and the overuse of chemical fertilizers.[113]

Livestock Emissions

Agriculture is also a major source of atmospheric methane, another greenhouse gas. Cows naturally produce methane during digestion, and the eventual decomposition of manure, from cattle and other animals, also releases methane gas. These sources of emissions are a natural result of raising livestock, but industrial farming practices exacerbate the problem. As discussed in "Intensive Animal Farming Threatens Public Health" (p.20), livestock are increasingly being raised in confined feeding operations,

which do not encompass nearly enough land to absorb the billions of pounds of manure produced. Therefore, many farms mix this solid waste with water and store it in lagoons before spraying it on fields. The EPA has identified this liquid storage—which produces greater methane emissions than solid manure—as the primary reason that greenhouse gas emissions from manure have increased almost 65 percent in the last 25 years.[114]

Biofuels

While biofuels such as ethanol and biodiesel are generally thought of as a carbon neutral energy source, recent research suggests that the entire process—from growing large fields of corn to processing it and burning it for energy—is a net contributor to greenhouse gas emissions.[115] The presumed benefit of biofuels comes from the carbon dioxide that plants remove from the air through photosynthesis. However, a study of emissions from 2005 to 2013 indicates that the carbon-capturing benefit of photosynthesis from growing corn was less than the additional emissions that occurred from ethanol refining and use.[116] Between contributing to crop specialization and not offering the climate benefits that were initially expected, corn ethanol is a harmful and unnecessary use of agricultural land.

Factors That Have Led to Harmful Farming Practices

American agriculture and food production have been shaped by an array of forces, including technological advances, bank lending that helps finance farm operations, evolving consumer food preferences, and public policies that explicitly address farm practices. Most of the policies that currently influence U.S. agriculture fall under the umbrella of the Farm Bill, which regulates issues as varied as crop insurance, land conservation and food stamps.[117] Historically, federal agricultural policy has been used to support farm incomes, prevent overproduction, and encourage land conservation. At the same time, some of these federal farm policies have encouraged specialization and the rise of large farms with damaging industrial agricultural practices.

Crop Insurance Influences Farmers' Behavior

Crop insurance is one of the most damaging and most generously funded federal agricultural policies, receiving $90 billion over the current 10-year funding period.[118] Crop insurance programs, introduced with the 2014 Farm Bill, replaced direct payment subsidies, under which farmers were paid for growing commodity crops, regardless of output. Direct payment subsidies shaped American agriculture in the 20th century, but were criticized across the political spectrum for being a wasteful and unnecessary use of taxpayer money.[119] However, the crop insurance program provides little improvement. It continues to encourage specialization in commodity crops and incentivizes farmers to grow on unsuitable or environmentally vulnerable land, all at the taxpayers' expense.

Typically, insurance is an arrangement in which regular payment of a premium ensures receipt of some amount of compensation in the event some unlikely mishap or disaster occurs. In many cases, that is not how crop insurance works. Instead, many types of federally subsidized insurance have become a predictable annual source of income for farmers—regardless of need.

The most basic policy, called catastrophic coverage, protects farmers from extreme weather or other events that may lower their yield below expected levels. With this policy, federal subsidies pay farmers 55 percent of the market value for any crop that produced less than half the expected yield.[120] Farmers can choose to pay more for fuller coverage or for a policy that also insures them against financial losses if crop prices fall.[121]

Rather than simply providing vulnerable farms with financial stability, federally subsidized insurance payments have become a reliable source of supplemental income. Farmers regularly receive more money in insurance payouts than they initially spent on premiums, resulting in a system closer to a subsidy—which is what crop insurance supposedly replaced—than to any traditional insurance program.[122] Between 2011 and 2014, the average farmer received more than two dollars back for every dollar spent on crop

insurance.[123] Because there is no payment cap, the largest farms can receive payouts that offer much greater economic benefit than the emergency cushion that insurance is intended to provide.[124]

Crop insurance policies offer the highest payouts with the greatest ease to farmers who grow commodity crops and who specialize in just one or two crops.

Insurance policies are more readily available for farmers who grow commodity crops. For example, while multiple types of insurance for corn are offered in nearly every county nationwide, fruit and vegetable insurance is often only available in a small number of counties, and farmers will rarely have the option to choose between different types of insurance programs for these crops.[125] That is part of the reason why more than 85 percent of corn and soybean cropland in the U.S. is insured, while just 54 percent of vegetable acres are covered by insurance.[126]

Crop insurance has long been more readily available for farmers who grow just one or two crops, putting operators of diversified farms at a disadvantage and effectively discouraging diversification.[127] Until the 2014 Farm Bill, "whole farm" insurance programs—policies that covered all crops on a farm without requiring a separate policy for each crop—offered limited subsidies and payouts and required more paperwork than single crop policies.[128] A new whole-farm policy option available since 2015 has begun to make it easier for farms with numerous, diverse crops to obtain coverage, but because it is so new its impacts on farmers' planting decisions are not yet known.

Policies available solely for commodity crops offer higher levels of financial protection. Programs like Price Loss Coverage and Agriculture Risk Coverage programs provide coverage for up to 85 percent of revenue, 85 percent of yield and 95 percent of input cost.[129] These so-called "shallow loss" policies are only available to commodity crop producers.[130]

The combined effect of federal crop insurance rules that disproportionately benefit farms producing just one or two commodity crops is the overproduction of crops like corn, soybeans and wheat. Overproduction lowers prices for food manufacturers and consumers. The fact that these grains are so cheap and readily available may be one reason for the nation's growing obesity problem.[131] In addition, cheap and abundant grains effectively subsidize large animal feeding operations, which create a host of environmental and public health problems, and have encouraged the expansion of animal operations.[132]

A second major problem with crop insurance is that it incentivizes farmers to grow crops on unsuitable, or even vulnerable, land, rather than leaving it uncultivated and better able to provide environmental benefits. Crop insurance is structured so that farmers know that they can still profit from cultivating land that is likely to give them a poor yield because taxpayer-subsidized insurance payments will replace their "lost" crops.

In some places, farmers are planting crops on seasonal wetlands and receiving annual insurance payouts when their yield unsurprisingly suffers due to excess moisture. For example, 65 counties in North Dakota and South Dakota received 14 consecutive years of "excessive moisture" insurance subsidies between 2000 and 2013.[133]

Elsewhere, acres under cultivation have expanded into places with dry or nutrient-deficient soil that lowers crop yield and is at risk of erosion.[134] The USDA estimated that one-third of new cropland in the late 1990s—in the years immediately after the 1994 Crop Insurance Act, which increased insurance funding by tens of millions of dollars—could be categorized as "highly erodible."[135] Even after the 1994 program was disbanded, the

practice of farming on unsuitable lands has increased; between 2008 and 2012, the amount of marginal farmland, defined as having "severe to very severe limitations on cultivation," has increased at twice the rate of planting on well-suited lands, a risk that farmers would be less likely to take if they did not have subsidized crop insurance.[136]

Beyond the direct cost to taxpayers that stems from planting on fields that are poorly suited for agriculture, tilling, spraying and irrigating these lands can lead to an array of environmental problems discussed earlier in this report.

Overall, policies like crop insurance (and commodity payments, before 2014) reduce financial risk for farmers.[137] While insurance is a valuable tool that ensures a farmer won't be wiped out by a single bad year, it also enables farmers to specialize in just one or two crops because they don't need to hedge against risk by growing a more diverse selection of crops. Shallow loss programs offer particular encouragement for specializing in commodity crops and expanding farm size.

Conservation Programs Fail to Offset Damage from Harmful Policies

In response to environmental concerns about U.S. agricultural practices, federal Farm Bills have included conservation programs since 1985.[138] The structure and content of these programs have varied over the years, but they typically require farms to implement certain sustainable practices in order to receive federal subsidies. These programs incentivize farmers to avoid over-working and over-watering their fields with the intention of limiting erosion, soil depletion, water

Construction of this poultry litter storage facility in Hazlehurst, Mississippi, was funded by the USDA's Environmental Quality Incentives Program. Photo: Judi Craddock, USDA NRCS via Flickr, CC BY 2.0.

pollution, and many other environmental and public health concerns discussed earlier in this report. However, these policies are inconsistently enforced and some of the current programs treat the symptoms rather than the causes of farming-related environmental problems.

Requirements that farmers comply with erosion and wetland conservation standards before receiving loans, disaster aid, or crop insurance are inconsistently enforced. In the late 1980s, the early years of the program, up to 5 percent of farms were tested for conservation compliance.[139] Compliance checks have decreased steadily in the years since, with just 0.6 percent of farms receiving spot-checks in 2006.[140] This decline in enforcement efforts has occurred at the same time as an increase in soil erosion rates.[141] The budget for these conservation programs was cut by $4 billion in the 2014 Farm Bill, making it unlikely that enforcement has increased since the mid-2000 data were reported.[142]

Other conservation programs within the Farm Bill provide direct funding for remediating the problems created by industrial farming, but do not address the causes of the problems. The Environmental Quality Incentives Program (EQIP) is an optional program that provides funding to farms for conservation initiatives. However, the largest use of these funds has not been particularly conservation-oriented: manure storage.[143] As discussed in more detail in "Intensive Animal Farming Threatens Public Health" (p. 20), one of the largest concerns about industrial livestock farming is that it results in huge volumes of manure in a concentrated area, which can emit methane and pollute waterways. EQIP funding can be used to install anaerobic digestors and build manure storage facilities, which can reduce these risks. However, because farmers can receive this funding, they have few incentives to change their practices, and can instead expand into larger industrial confinement operations.

Financial Forces and Technological Innovations Encourage Industrial Farming

Federal policy has not been the only factor that has encouraged farm consolidation and specialization. Since commercial fertilizer production began in the early 20th century, farmers have turned to technological improvements to replace more labor-intensive and therefore costlier farming methods. These advances include faster and more powerful tractors that can plow a bigger field in a day. For example, a modern tractor is 50 times more powerful than a team of six horses.[144] Technological improvements also include plants that are genetically modified for pesticide resistance and cheaper herbicides that make it more attractive to spray chemicals than to invest in other pest control methods.[145] These technologies allowed farms to expand in size. They also encouraged farmers to specialize in just one or two crops that had government-guaranteed income that could cover the cost of investing in expensive new equipment and technologies. In turn, purchasing equipment tailored to producing a single crop more quickly or at lower cost facilitates subsequent expansion of the farm, because each additional acre requires less effort to cultivate.

Financial forces have magnified the impact of these technological advances. The Farm Credit Act of 1971 made it easier for banks to offer loans to farms.[146] Low interest rates in the 1970s, coupled with technologies that enabled farmers to cultivate larger fields, encouraged many farmers to take out loans to buy neighboring land and expand their farm size.[147] A decline in crop and land prices in the early 1980s triggered many farm bankruptcies. In response, banks pushed remaining farms to expand. Between 1982 and 1992, the total number of farms nationwide declined by 14 percent, even as the number of farms larger than 1,000 acres increased by 9 percent.[148] In addition, new financial tools have increased contracting options that can mitigate risk

for a farmer specializing a single crop. These influences are part of the reason that fruit and vegetable farms, which have not received the same federal support over the decades as grain crops, have also become larger. Farm size has not increased as dramatically, however, as it has for commodity crops.[149]

Renewable Fuel Policies Promote Harmful Farming Practices

The federal Renewable Fuel Standard (RFS) program, which seeks to replace a portion of the U.S.'s fossil fuel usage with renewable energy sources, and other subsidies have provided additional incentive for farmers to convert wetlands and grassland to crop fields. The RFS requires the U.S. to produce and use roughly 15 billion gallons of "conventional" biofuel—largely corn ethanol—by 2016.[150] Tax credits for adding ethanol into fuel reached new levels in the mid-2000s.[151] Farmers responded in two ways.

First, farms that were originally growing a more diverse array of crops switched to growing corn alone to take advantage of the economic incentives.[152]

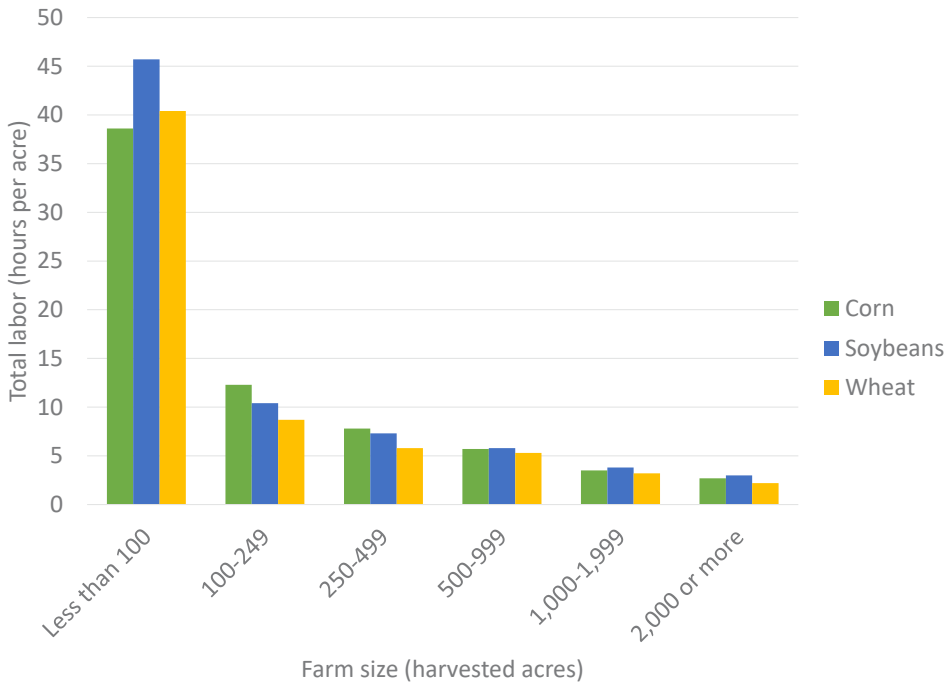
Second, higher corn prices encouraged farmers to expand onto environmentally vulnerable lands. Between 2008 and 2011—the years following the 2007 expansion of the RFS program—more than 8.4 million acres of formerly uncultivated land was planted with corn.[153] Although federal policy supports corn ethanol because of an expectation it would reduce greenhouse gas emissions, the practice of destroying wetlands and grasslands to plant corn for use in biofuels has a net negative impact on the climate.[154]

Much of the land that has been converted to cornfields previously had been identified as environmentally vulnerable. From 2008, soon after the expansion of the RFS program, to 2012, farmers converted an estimated 1.5 million acres from the federal Conservation Reserve Program—a conservation initiative that pays farms to leave their most vulnerable property uncultivated—to corn cultivation.[155] The corn these acres could produce was worth more than the conservation payments the farms were receiving. As a result, the RFS and other incentives for corn ethanol have encouraged farmers to focus on a commodity crop and to increase the acreage planted in that crop.

Larger, Specialized Farms Require Less Labor

Another factor supporting bigger farms is that bigger fields require far less labor per acre. Mechanization and synthetic fertilizers and pesticides allow fewer people to farm the same amount of land. This has enabled farmers to expand their acreage without having to hire and pay a large number of staff.[36] The USDA has found that on average, the largest corn fields require just 7 percent as much labor per acre as the smallest corn fields (Figure 5).[37]

Figure 5. Hours of Labor per Harvested Acre, by Farm Size and Crop Type[38]



There are benefits to this level of efficiency, but it has also weakened farming communities. With less labor required for each acre of land, farm populations have dropped. Nearby towns have also declined, unable to support stores, churches, schools and fraternal organizations. Rural communities themselves, in many cases, have become unsustainable, lacking the civic institutions needed to retain and attract the next generation of farmers.

A New Vision for Farm and Food Policy

The environmental and public health problems created by our agriculture system are, in part, the result of specific policy decisions. Revising those policies will change how our food system operates, and has the potential to better protect public health and the environment.

The U.S. needs a food system that provides adequate, nutritious food, and that does so while minimizing environmental and public health damage, limiting the use of taxpayer money, and ensuring the nation's ability to produce abundant food for generations to come. Agricultural practices used to feed the nation today should not compromise the ability of farmers to feed the nation in the future because topsoil has washed away or water is not available to irrigate crops. Raising animals for meat, eggs and milk should not rely on practices that reduce the effectiveness of antibiotics critical for treating infections in people and for animals on the farm. Boosting agricultural yields should not be achieved with methods that contribute to global warming and make future agricultural production more difficult and uncertain. And the least-nutritious food produced by our agricultural system should not be artificially cheap due to taxpayer subsidies, adding to the nation's obesity problems and raising health care costs.

The U.S. has abundant agricultural capacity, and better practices mean the nation could produce plenty of food while protecting clean water, improving public health, and reducing global warming pollution. Changes in public policy can help reshape the food system to reduce its environmental and public health impacts, now and in the future.

End Subsidies that Encourage Farm Specialization and Intensification

Current crop insurance programs subsidize production of commodity crops and encourage practices that increase soil loss, water pollution and pesticide use.

Crop insurance should be reformed to function as a safety net rather than a predictable subsidy. Subsidies for the purchase of crop insurance should be phased out, except for farms that implement practices to help protect public health and the environment. Excessive insurance coverage encourages farmers to plant commodity crops instead of other crops, and to maximize the total acreage planted regardless of field and soil suitability.

The Renewable Fuel Standard should be wound down and eventually ended. It incentivizes farmers to grow even more corn, reducing crop diversity and destroying important habitat, all to produce a fuel that may create just as much global warming pollution as gasoline does.[156] Because the development of sustainable biofuels remains important as the nation seeks to cut its climate pollution, a low-carbon fuel standard would be a better approach. Such a standard establishes targets for lifecycle climate

pollution reductions from transportation fuels and would promote biofuels made from more diverse sources.

Require Practices that Reduce Soil Loss and Water Pollution

In exchange for any crop insurance subsidies, taxpayers should receive environmental and public health benefits, not harm. By following best practices, farmers can reduce soil loss from fields, preserving that resource for the future, and cut nutrient and sediment pollution that taints drinking water, contaminates food, and harms aquatic ecosystems.

Some of the best practices that farmers participating in subsidized crop insurance programs could be required to adopt include:

- Crop diversification, in which farmers plant not just one or two crops year after year, but instead rotate through a sequence of three or four different crops to help improve soil fertility. For more on the benefits of crop rotation, see text box "Research at Iowa State University Shows the Benefits of Crop Rotations" (p. 34).

- Planting cover crops such as rye, winter peas or buckwheat, which can be planted after a crop has been harvested and before the next marketable crop is planted. Cover crops can reduce soil loss, improve moisture retention and increase yields of corn and soy subsequently planted on those fields.[157]

- Maintaining conservation buffers. These narrow strips of permanently vegetated untilled land can prevent up to 75 percent of sediment and 50 percent of nutrient and pesticide pollution if properly set up around agricultural fields.[158]

Some federal subsidy programs already require farmers to follow these best practices. However, there is substantial opportunity

Conservation buffers, such as these hedges alongside Iowa's Bear Creek, help prevent sediment and agricultural chemicals from contaminating water. Photo: Lynn Betts, USDA Natural Resources Conservation Service.

Research at Iowa State University Shows the Benefits of Crop Rotation

From 2003 to 2011, researchers at Iowa State University conducted an experiment to study the differences between sustainable and conventional farming. They compared three different farming techniques: a standard two-year corn and soy rotation with pesticides and chemical fertilizer used in similar quantities as conventional industrial farms; a three-year corn, soy and oat rotation that received occasional, limited applications of cattle manure, synthetic fertilizer and pesticides; and a four-year corn, soy, oat and alfalfa rotation that was treated with the same minimal doses of fertilizer and herbicide as the three-year rotation.[161] Counter to the common argument that environmentally conscious farming methods limit production, the three- and four-year rotations produced slightly higher yields than the conventional plot, while also requiring significantly smaller amounts of herbicide and fertilizer and reducing groundwater toxicity by 2,000 percent.[162] Time and money spent on labor did increase in the three- and four-year scenarios, but overall profits remained constant. Between the decreased chemical use, improved water quality, increased output, and decline in specialization, introducing three- or four-year crop rotations dramatically reduced the negative impacts of intensive crop farming.

to expand the use of, and funding for, conservation methods.

- The USDA should increase enforcement efforts to confirm that farmers are complying with conservation requirements. The limited data available suggest compliance may be low. According to the most recent data available, from 2006, just 0.6 percent of farms that were required to institute erosion and wetland conservation measures as a condition of receiving loans, disaster aid or crop insurance received spot-checks to confirm they were complying.[159] Soil erosion rates increased at the same time that enforcement was scaled back.[160]

- Data on conservation programs need to be more publicly accessible to ensure that farmers are complying and that the programs are delivering environmental benefits.

- Beyond rewarding those farmers who follow best practices, farms that create water pollution through improper manure storage or the over-application of manure or chemical fertilizers should be held responsible and be required to repair their damages.

In addition to crop insurance and conservation funding reform, a variety of policy and market responses are needed to end the excessive manure production that is at the root of significant water pollution, including:

- A moratorium on new or expanded factory farms,

- Transitioning to raising livestock on rotational pasture,

- Changing incentives to help farmers address the cause of excess manure production from factory farms, rather than just funding manure storage facilities or anaerobic digesters that deal with the consequences of the problem.

Maintain the Effectiveness of Antibiotics

Ensuring that antibiotics remain effective for treating infections in humans requires limitations on how and when antibiotics can be used in animals, and can be supported by reforming policies that influence how farmers choose to raise animals.

Specific reforms needed to protect the effectiveness of antibiotics include:

- The Food and Drug Administration should restrict the use of antibiotics in livestock production to treat animals diagnosed with an illness or if needed to control an identified disease outbreak. The routine use of antibiotics on factory farms for growth promotion and disease prevention should be banned.

- Until adequate restrictions are put in place, Congress or the USDA should require uniform labeling of meat products so that consumers, at the point of purchase, know if antibiotics were used for purposes other than treating an infection. Human drugs of last resort, such as colistin and vancomycin, which are the last line of defense against life-threatening infections, should not be used at all in animal medicine. This recommendation is consistent with the World Health Organization's recent guidelines on restricting the use of medically important antibiotics in animal agriculture.[163]

- Industrial farms' use of antibiotics should be tracked in a publicly available online registry that includes the types, doses and purposes of antibiotics administered farm-by-farm. In the Netherlands, detailed information about antibiotic use has been important to reducing the use of antibiotics in animals. (See "How Denmark and the Netherlands Reduced Antibiotic Use in Livestock" text box for details.)

- Administration of antibiotics to animals on factory farms should be overseen by a qualified veterinarian who has been to the farm or ranch and assessed the animals, not called in by an off-site veterinarian.

Current farm policies subsidize practices in animal feeding operations that raise the risk of disease and thus lead farmers to feed routine doses of antibiotics to animals. Those subsidies should end, particularly funds from the Environmental Quality Incentives Program that are spent helping farmers build manure storage facilities. It doesn't make sense to spend millions of taxpayer dollars subsidizing construction of manure storage facilities at factory farms when the livestock raised in those confined systems are a significant source of antibiotic-resistant bacteria that threaten public health.

Align Federal Policies with Dietary Recommendations and Consumer Preferences

Federal agricultural policies should better match dietary recommendations that call for greater consumption of fruits and vegetables, changes that would improve health and reduce obesity. In addition, farm policy should better align with growing consumer preferences for food grown sustainably and without pesticides.

Current federal dietary guidelines recommend Americans eat more fruits, vegetables and dairy products than we currently do, and less meat, grains, fats and sugars.[170] However,

How Denmark and the Netherlands Reduced Antibiotic Use in Livestock

Efforts by the Danish and Dutch governments have significantly reduced the overuse of antibiotics in those countries. The Danish ban—which was phased in gradually during the 1990s and has been fully in place since 1999—prohibits the use of antibiotics on farm animals for any reason other than curing illness.[164] Danish farmers, scientists and government officials worked together to change their practices. In the pork industry, for example, many farmers began waiting longer before separating newborn pigs from their mothers, which helps them naturally strengthen their immune systems.[165] This ban has decreased the use of antibiotics on animals by a large margin. Even though Danish meat production increased 15 percent from 1994 to 2014, the use of veterinary antimicrobials declined by 44 percent over this time.[166]

The Dutch approach, while newer, has also been successful in limiting the misuse of antibiotics. In 2009, three years after a less ambitious E.U.-wide restriction on some uses of animal antibiotics and immediately after the discovery of an antibiotic-resistant infection spreading through the Netherlands, the Dutch agricultural ministry decided to set stronger limits on antibiotic use.[167] Dutch farmers were required to reduce antibiotic consumption by 20 percent by 2011, 50 percent by 2012, and 70 percent by 2015 (from 2009 levels).[168] These national targets were then translated into more specific goals for each herd, supported through inspections, improved reporting of antibiotic use, and potential disciplinary action for veterinarians. As a result, antibiotic use on farms fell. From 2009 to 2014, the amount of antibiotics used on Dutch farms was cut by 59 percent.[169]

federal programs historically have provided more support to the foods of which we should eat less, and less support to fruit and vegetable growers.[171] Changes since 2014 have made it possible for more fruit and vegetable farmers to obtain crop insurance, but federal crop-support policies still fail to reflect the priorities of dietary guidelines.

Agricultural policies also do not reflect Americans' changing food preferences, as expressed by their purchasing patterns. A growing number of consumers prefer food grown without pesticides. From 1997 to 2014, purchases of organic food—crops grown without the use of most pesticides and animals raised under natural conditions without hormones, antibiotics or non-organic feed—increased more than 10-fold, to $39 billion.[172] The vast majority of Americans at least periodically purchase organic food, and yet as taxpayers they end up supporting pesticide and antibiotic use and suffering from the environmental and health consequences. Despite consumers expressing preference for the practices that the organic label requires, the federal government is currently working to weaken regulations for organic meat.[173] Production of organic food should receive increased support in federal policy.

Conclusion

For decades, the nation's agricultural policy and farm system have been designed to maximize farm output. With the help of generous subsidies for a subset of farm products, production of some crop and animal products soared. In the short term, this approach has been very successful, but many of the practices used to maximize our current output threaten our future farming ability.

This boost in farm production has created other costs, too. Intensive use of fossil fuels and fertilizers and changes in farm practices have created extensive water pollution, harmed the climate, led to excessive use of pesticides, and destroyed habitat. Off the farm, in many cases antibiotics are no longer reliably effective for treating disease in people. In addition, loss of topsoil and depletion of groundwater will reduce the future productivity of the nation's farms.

It is time for a change in our agricultural policies and priorities, away from a near-absolute emphasis on maximizing production and toward ameliorating the problems caused by the intensification and specialization of farming. Developing a more balanced agricultural system will require extensive changes throughout our food production system. Those reforms will threaten established interests and reshape farming in the U.S., but also create opportunities to build more vibrant rural communities. Accepting those challenges is essential because the threats generated by current farming practices cannot be ignored any longer.

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