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Food Court

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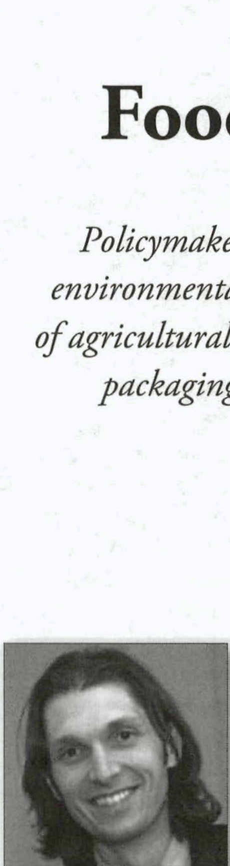
Food Court

Policymakers need to weigh the environmental and climate impacts of agricultural production, processing, packaging, and distribution



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Getting the average meal from farm to plate in the United States is no small task; a great deal of energy and material inputs goes into producing, processing, packaging, and distributing food. A commodity crop like corn, for example, could be cultivated in one state, say a Midwestern state like Iowa, shipped to a processing plant in Tennessee to take on an entirely new form like high fructose corn syrup, packaged in plastic in Pennsylvania, and finally distributed as ketchup to a supermarket chain in California. The modern food system is fossil fuel–intensive and often environmentally damaging, making the true cost of our food much greater than the price we pay at the supermarket. Only recently have environmentalists and environmental law scholars focused on the ecological impacts of food choices and considered how industrial food production has been responsible for significant greenhouse gases emissions.[1]

This article, focusing on produce and grain,[2] discusses the environmental and climate change impacts of food production, processing, packaging, and distribution, which ultimately contribute to both economic and social costs.[3] The article addresses environmental energy costs in the food supply. Figure 1 shows, for example, the significant amount of energy used in various aspects of food production, transportation, and processing.

Much of this article's focus will be on commodity crops. Along with wheat and rice, corn and soybeans constitute the world's most popular planted and consumed crops.[5] The United States is the leading producer of corn, growing nearly 40 percent of the world's total,[6] with more than half of that production coming from only 20 percent of U.S. corn growers.[7] In 2008 over 85 million acres of corn and more than 75 million acres of soybeans were planted in the United States,[8] and the crops "have faced increasing demand in the world market over the past ten years as they are sources of both human and animal food."[9]

Food, Agriculture, and the Environment

There is a closed-loop relationship between the current agriculture system and the climate crisis. With changing temperature and rainfall patterns, climate change may have a dramatic impact on food production and agricultural geography. Completing the circle, current agricultural practices are fossil fuel–intensive and contribute to greenhouse

gas emissions, accelerating this change in climate and rainfall patterns.[10] In the United States, food production alone accounts for 20 percent of overall fossil fuel consumption.[11] The American food system is dominated by industrial agriculture, though the organic food market has seen significant gains.[12] Despite the domination of industrial agriculture, both conventional and organic food production contribute to greenhouse gas emissions and ecological harm.

The Green Revolution dramatically transformed U.S. agriculture into high-yield, fossil-fueled, mass production in the 1940s.[13] The replacement of human labor with technological innovations, mechanized farm equipment, and other fossil fuel inputs were the primary changes resulting from the Green Revolution. The Green Revolution also led to the extensive use of chemical pesticides and synthetic fertilizers. The high-yield goals of the Green Revolution accelerated production of commodity crops, and, at the time, was essential in addressing concerns of food security and hunger. Between the start of the Green Revolution and 2000, commodity crop production increased threefold in order to keep up with population growth; the population grew from three billion to six billion people during that period. [14]

With increased use of chemical fertilizers and pesticides, consumers became concerned with the health and environmental impacts of conventional agriculture. Rachel Carson's *Silent Spring,* along with the growing environmental movement at the time, brought awareness and consciousness about the problems associated with agricultural chemicals, leading to consumer demand for food to be grown without harsh chemicals. Over the past 20 years, organic foods, and more recently industrial organic foods, have begun to enter the market. In response, Congress passed the Organic Foods Production Act in 1990 as part of the U.S. farm bill.[15] In order for a product to be called organic or carry the organic label, OFPA forbids the use of synthetic fertilizers and growth hormones and the addition of synthetic ingredients during processing, as well as the use of antibiotics in livestock.[16] In recent years the organic industry has shifted from small, local farms to large industrial ones. The organic market has quadrupled in the last decade, and the sales of organic food have grown from \$1 billion in 1990 to over \$20 billion today. [17]

Large corporations like Kraft, Coca-Cola, and Nestle, which have traditionally processed and supplied conventional foods, have seen this increase in organic trends and jumped on board by purchasing smaller organic firms. Figure 2 depicts major U.S. food processing companies that now own organic brands. Large-scale organic production increases greenhouse gas emissions and may also practice questionable agricultural methods,[18] which are legally organic but not necessarily sustainable.[19]

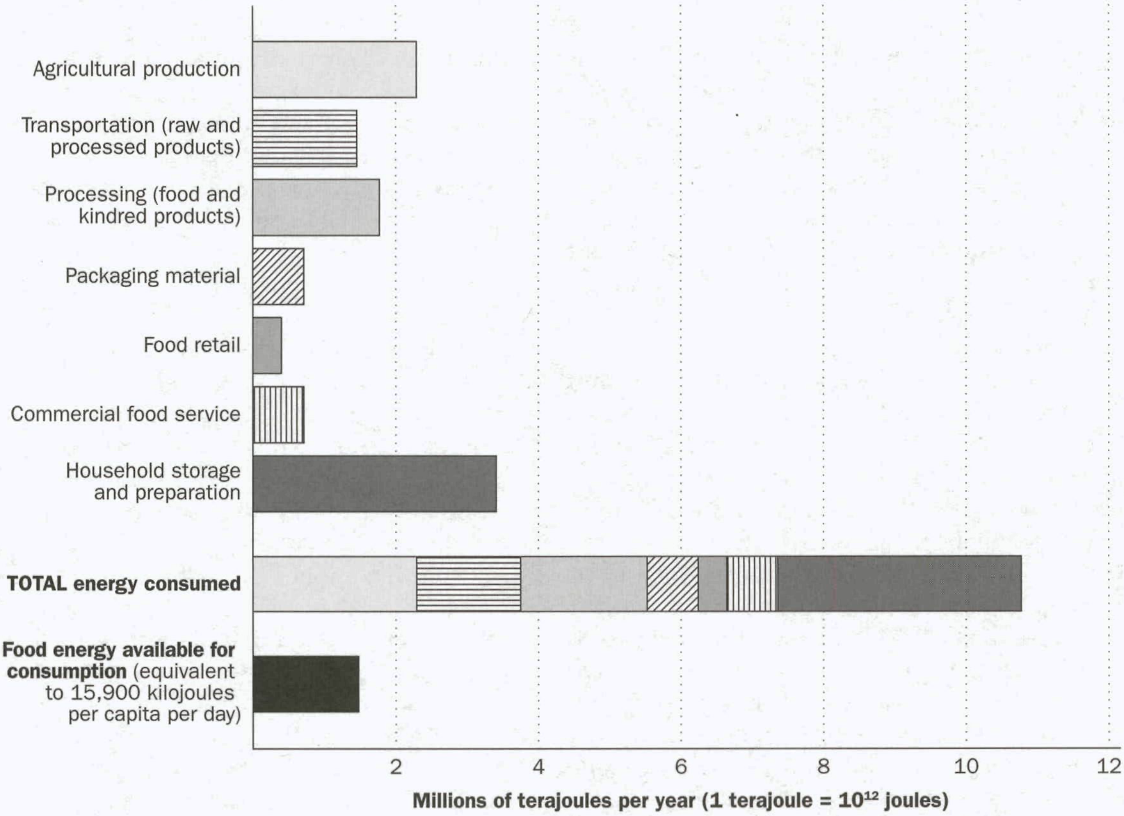
Industrialized Food Production and Cultivation

The dominance of the industrialized food system drives current farm cultivation practices. The cultivation stage is when seeds are planted, soil tilled, and crops tended, watered, and harvested. Large mechanized farm equipment and irrigation systems are used to produce enormous crop yields, contributing significant greenhouse gas emissions, degrading the soil, and reducing access to water. In addition, petroleum-based chemical pesticides and nitrogen fertilizers used in industrial agriculture increase its ecological footprint. Finally, both conventional and organic industrial crops are planted as monocultures, which can have grave impacts on soil health and water quality, as well as lead to a continued increase in the use of pesticides and fertilizers. It is a self-reinforcing system in which each innovation and input increases the reliance on further interventions and, ultimately, the ecological costs of modern food production.

Mechanized Cultivation and Irrigation

As population has increased, food production

Figure 1
Life-Cycle Energy Use in Supplying U.S. Food



has also increased, as has the size and scope of farms. Millions of acres of the two leading crops in the United States, corn and soybeans, are planted each year.[20] The massive area it takes to grow such a large amount of commodity crops requires the use of industrial machines and large irrigation systems, which creates significant carbon emissions, and soil and water degradation.

Carbon Emissions. Industrial agriculture is based on high-yield crops, which, due to the immense size of farms they are grown on, are difficult to plow, till, and water in a traditional way by human labor or livestock (absent significant labor costs). According to historian Walter Prescott Webb, new technologies like the John Deere plow and mechanized harvesters (not to mention the Colt six-shooter, barbed wire, and other agricultural implements) helped farmers control the Great Plains and increase production during the rise of industrial agriculture in the 19th century.[21] As the industrial agriculture model became dominant, the energy costs of simply tilling became substantial. To till one hectare of land today with a 50 horsepower tractor, the petroleum input is 306,303 kilocalories, or 30.3 liters of gas.[22] These petroleum inputs by farm machinery are directly linked to the carbon emissions going into the atmosphere. In addition, the manufacturing of farm machinery contributes to greenhouse gas emissions. While there are negligible emissions associated with transporting the tractors from the manufacturing plant to the farms,[23] the manufacturing of tractors takes a great deal of energy. On average, roughly 12.8 kilograms carbon dioxide equivalent of greenhouse gas is emitted to manufacture just one kilogram of a tractor.[24] If calculated out, using the average weight of a 92 kilowatt tractor, it takes 187 barrels of oil consumed, or the annual greenhouse gas emissions of 15.8 passenger vehicles, to produce one tractor.[25]

In addition to the energy and carbon emissions from the manufacturing of large machinery, irrigation requires a significant amount of fossil fuel energy for pumping and delivering water to crops.[26] Generally, irrigation water is from wells or surface reservoirs located on the farm, or surface reservoirs from off the farm.[27] Fossil fuels are the primary source of energy for powering the pumps required to distribute the water.[28] Each year, pumping irrigation water accounts for an estimated 15 percent of the total energy expended on farms.[29]

With the increasing demand for organic products, more and more organic acreage is being put into production. Large organic farming operations share the same energy needs for cultivation and irri-

gation as do conventional farms. Earthbound Farm, which was originally 2.5 acres, is now a 40,000-acre farm.[30] Journalist Barry Estabrook describes the Earthbound spinach field:

> To step into an Earthbound Farm spinach field is to be overwhelmed by the incomprehensible vastness of it all. It looks identical to hundreds of operations that stretch across the valley floor, stopping only at the base of the faraway, hazy mountains. An area big enough to accommodate a dozen football fields is carpeted with symmetrical strips of tiny, perfect baby spinach plants with just enough space between the rows to allow for the passage of a mechanical harvester.[31]

What Estabrook describes is a sight similar to any found throughout the country on either a conventional or industrial organic farm. Like conventional fields, massive organic fields like Earthbound's spinach field cannot be cultivated or watered by hand (or not, at least, without very high cost), so they require the same fossil fuel-intensive machinery and irrigation systems as conventional agriculture.

Soil Degradation. The use of large farm equipment contributes to soil degradation because the heavy equipment compacts and disturbs the soil, and over-tilling of crops causes soil to erode.[32] In addition, the large amount of water applied to fields from the irrigation systems adds to the likelihood of erosion. Degraded soil has a reduced capacity to function properly.[33] Farmers rely on soil health and quality to stay in production; however, every year millions of acres of productive land are abandoned due to degradation.[34]

Industrial agriculture involves tilling by large machines, and due to the fact that organic farming does not use chemicals to kill weeds, increased tilling is often employed, potentially leading to overtillage and increased soil degradation. In addition, compaction from heavy machinery used in agriculture causes runoff, erosion, and flooding which can prevent water from infiltrating down to recharge the aquifer.[35]

After soil is degraded by overtilling and compaction from large machinary, it is more likely to erode, especially with the increase of water on fields, and the erosion diminishes essential nutrients, micronutrients, and organic matter in the soil.[36] According to a study by the National Resources Inventory of the USDA, 1,700 megatonnes (Mt=million metric tonnes) of agriculture soil in the United States was eroded in 1997. Wind accounted for 760 Mt of this erosion, and 960 Mt was due to sheet and rill (caused by water).[37] This amount of eroded soil would "fill a freight car train loaded to capacity that would encircle the *planet* about seven times."[38] Professors Martin Heller and Gregory Keoleian calculated that at the current rate of topsoil erosion, "2.5 cm of topsoil [is] lost from all U.S. cropland every 34 years."[39] They explain that, when soil is supplemented with large amounts of fertile organic material, which does not happen in normal industrial farming practices, 2.2 cm of soil can rejuvenate in about 30 years.[40] However, it is estimated that under current farming conditions it could take anywhere between 200 and 1,000 years to regenerate 2.5 cm of soil[41]

Water Quality and Access

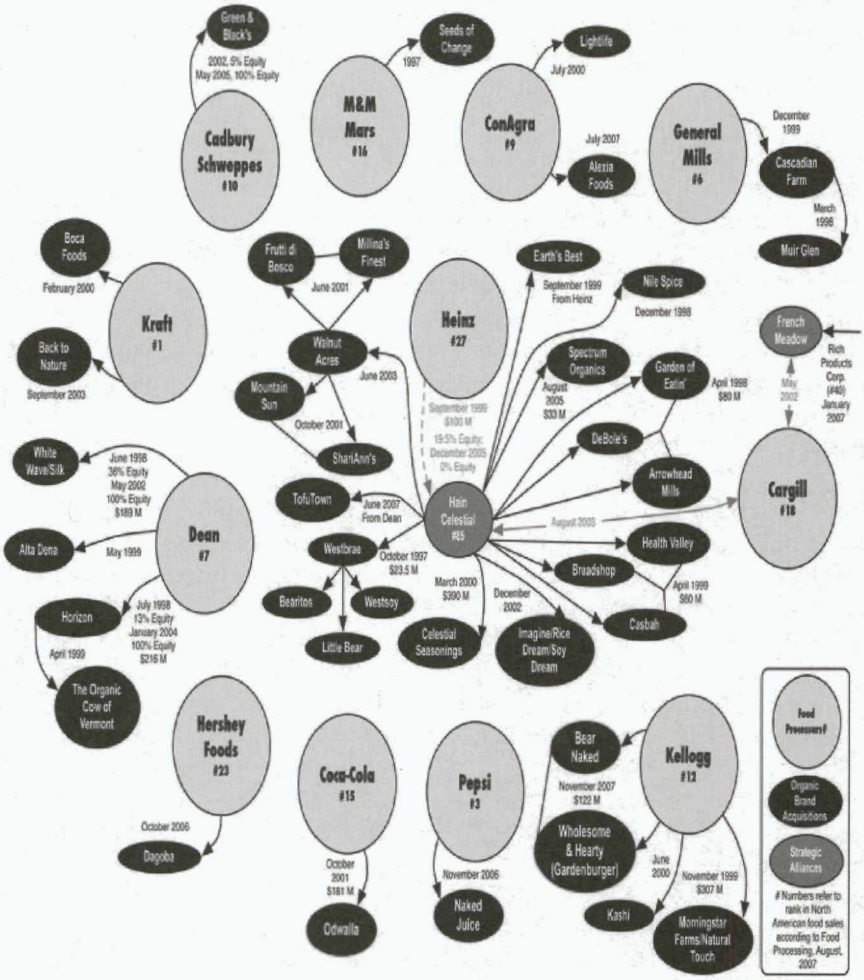
Commodity crop production impacts both the quality and quantity of U.S. waters.[42] Agricultural irrigation constitutes over one-third of the fresh water used in the United States, making it the largest use in the nation.[43] On average, it takes 1,000 tons of water to grow one ton of grain, with rice using the most water, and corn using the least.[44] The use of enormous amounts of water by large irrigation systems is particularly problematic because so few states have adequate regulation of groundwater withdrawals.[45] Because in some areas of the United States property owners risk losing their water rights if they do not use their entire allotment, "farms will use their whole water allowance even though they could easily use less or install efficient irrigation."[46] As an example, the Ogallala Aquifer is a critical water resource for agriculture in the Midwest, as it covers eight states — Wyoming, South Dakota, Nebraska, Colorado, Kansas, Oklahoma, New Mexico, and Texas.[47] The aquifer receives little recharge, and the water table drops each year due to unregulated and unsound irrigation practices.[48] Estimates suggest that within the next decade or two the Ogallala aquifer will be so low that using it for irrigation will become prohibitively expensive.[49]

As industrial farms increase across the United States, groundwater is being used unsustainably, reducing water tables to the point where other consumers may no longer be able to use the water.[50] In addition, commodity crops, like corn, are grown in states that do not have adequate water resources to support this sort of intense irrigation.[51] This results in diverting water from waterbodies far from the growing fields, sometimes causing water disputes.[52]

Pesticides and Fertilizers

Approximately 500,000 tons of 600 different types of pesticides are used annually in the United

Figure 2



States.[53] In fact, in 1997 about 98 percent of the corn acreage planted in the top 10 corn-producing states received commercial fertilizer.[54] The increased use of pesticides and nitrogen fertilizers contributes to the carbon footprint (as well as other forms of pollution) as synthetic pesticides are made from fossil fuels, and fertilizers are derived from natural gas made from fossil fuels.[55] Chemical pesticides and fertilizers also greatly impact soil, water, and air quality.

Carbon. For better or worse, pesticides "prevent pest damage to potentially a third of the nation's crop, help food preservation, and result in cheaper food production."[56] Today the growth of chemical use has been an "integral part of the technological revolution in agriculture that has generated major changes in productivity techniques, shifts in input use, and growth in output and productivity," and has resulted in the use of more chemicals and less manual labor.[57]

Many pesticides are powerful toxins that persist in the environment.[58] The most widely used pesticides, those containing synthetic chemicals, are produced primarily from fossil fuels[59] and contain ingredients like refined oil and kerosene. Depending on the type of pesticide, it is estimated that it "takes the equivalent of a gallon of diesel fuel to make one pound of active ingredient of pesticides."[60]

In the past, animal manure and other farm refuse were used as nutrient sources, but today commercially manufactured chemical fertilizers are the major source of applied plant nutrients.[61] Nitrogen fertilizers were first introduced into industrial agriculture after World War II; their use has shifted soil fertility from "a total reliance on the energy of the sun to a new reliance on fossil fuel."[62] Fertilizers are petroleum-based, and the energy needed to fix nitrogen into fertilizers is supplied by fossils fuels.[63] California organic farmer Jason McKenny estimates that "[t]he production of nitrogenous fertilizers consumes more energy than any other aspect of the agricultural process."[64] This is a bold statement, considering all the inputs in the agricultural process; however, it takes the "energy from burning 2,200 pounds of coal to produce 5.5 pounds of usable nitrogen."[65]

Soil. The increased use of pesticides, as well as herbicides and insecticides, used on crops significantly impacts soil health. Pesticides, including ones banned years ago like DDT, can linger in the soil for decades and kill important biota that nourish and aerate soil.[66] Creatures like earthworms and microorganisms nourish the soil, and soils are more productive when these important biota are present.[67] Many herbicides and insecticides kill these biota.[68] Chemical inputs also degrade soil structure, hindering water and gas relationships between plants and soil.[69] Severely degraded soil can take decades, centuries, or millennia to fully recover.[70] The increased amount of nitrogen added to soil from synthetic fertilizers destroys the soil biodiversity by

> diminishing the role of nitrogen fixing bacteria and amplifying the role of everything that feeds on nitrogen. These feeders then speed up the decomposition of organic matter and humus. As the organic matter decreases, the physical structure of soil changes.[71]

Soil becomes less efficient at absorbing and retaining water, air, and other essential nutrients.[72] In addition, fertilizers make soil more acidic, which causes declines both in soil humus content and crop output.[73] The large amount of chemicals applied to crops today clearly hinders the soil that the crops need to flourish. As a result, more chemicals are applied because soils are degraded and lack nutrients to crop productively, creating a vicious cycle.

Water. Farming practices harm water quality when soil, loaded with pesticides and nitrogen fertilizers, erodes into water systems due to overproduction and over-tilling. EPA "has identified siltation associated with erosion in rivers and lakes as the second leading cause of water quality impairment."[74] Agricultural chemicals easily leach into groundwater when rain or irrigation water comes into contact with farm fields.[75] In addition, surface water can become contaminated when groundwater naturally flows into surface water.[76] According to EPA, farming practices account for 70 percent of the pollution in the nation's rivers and streams.[77] EPA reported that "runoff of chemicals, silt, and animal waste from U.S. farmland has polluted more than 173,000 miles of waterways."[78] A 2006 U.S. Geological Survey study stated:

> Pesticides or their degradates were detected in one or more water samples from every stream sampled. One or more pesticides or degradates were detected in water more than 90 percent of the time during the year in agricultural streams, urban streams, and mixed-land-use streams. . . . Organochlorine pesticides (such as DDT) and their degradates and by-products were found in fish or bed-sediment samples from most streams in agricultural, urban, and mixed-land-use settings — and in more than half the fish samples from streams draining undeveloped watersheds.[79]

Chemical runoff from pesticides and fertilizers also results in a "build-up of excess nutrients in waterbodies that create algae blooms, which use up oxygen and essentially suffocate fish and shellfish populations."[80] One of the largest "dead zones" lies in the Gulf of Mexico, where the Mississippi River deposits high-nutrient runoff from midwestern farms.[81] Agricultural runoff can impact both local water sources as a direct point source pollutant, as well as harm waters thousands of miles away when it flows down river.

Even organic farms, which often use animal manure to fertilize crops, pollute surrounding water and land. As synthetic fertilizers, animal manure is high in nitrogen and phosphorous. A 1992 study showed that farms throughout the United States had manure-based nitrogen levels that exceeded potential plant uptake, and many areas showed excess levels of phosphorous.[82] The excess nitrogen and phosphorous levels, when not absorbed by plants, runs off into area streams and pollutes groundwater just the same as chemical fertilizers. This runoff can also contribute to the dead zones and excess nitrogen in water.

Air. Nitrogen fertilization contributes to emissions of the greenhouse gas nitrous oxide, which is a large contributor to climate change[83] by impacting the first and second layers of the atmosphere, the troposphere and stratosphere.[84] When nitrogen oxide is emitted from agricultural soil it increases tropospheric ozone, a component of smog, and impacts human health, natural ecosystems, and ironically, agriculture.[85] Nitrogen oxide from agricultural practices can be transported through the air over long distances and deposited around the world, impacting water and land ecosystems.[86] This widespread exposure to nitrogen oxide can cause "eutrophication, loss of diversity, dominance by weedy species and increased nitrate leaching or NO*x* fluxes."[87] Pesticides pollute air through runoff and airborne pesticide "drift" and can act as a means of transport, further polluting land and water.[88]

Monoculture

Monoculture is the planting of a single crop as opposed to a variety of diverse crops,[89]and the practice has increased dramatically worldwide.[90] It is estimated that the amount of crop diversity has de-

creased dramatically in recent years.[91] Today there are over 50,000 varieties of corn grouped together into hundreds of races; however, U.S. commercial production "relies almost exclusively on the cultivation of a handful of hybrid varieties from two of these races."[92] This "sameness," as Helena Norberg-Nodge refers to monoculture, is beneficial to the transnational food corporations like Cargill, but "in the long term a homogenized planet is disastrous for us all."[93] Norberg-Nodge writes, "It is leading to a breakdown of both biological and cultural diversity, erosion of our food security, an increase in conflict and violence, and devastation of the global biosphere."[94] Traditionally, farmers grew a variety of diverse crops and continuously rotated their crops.[95] This diversity allows crops to adopt a resistance to pests, and if one crop is impacted by pests and disease, the entire year's harvest will not be lost.[96] Monoculture, on the other hand, greatly reduces the biodiversity of farmland and

> [p]art of the instability and susceptibility to pests of agroecosystems can be linked to the adoption of vast crop monocultures, which have concentrated resources for specialist crop herbivores and have increased the areas available for immigration of pests. This simplification has also reduced environmental opportunities for natural enemies. Consequently, pest outbreaks often occur when large numbers of immigrant pests, inhibited populations of beneficial insects, favorable weather and vulnerable crop stages happen simultaneously.[97]

A single monoculture crop, planted continuously and in great volume, is more susceptible to pest infestations and disease, and it impairs soil quality and accelerates soil erosion.[98] Genetically uniform crops are more vulnerable, as seen in 1996 when "the fungal disease known as Karnal Bunt swept through the U.S. wheat belt, ruining over half of that year's crop and forcing the quarantine of more than 290,000 acres."[99] The crop failed because farmers had planted only a few varieties of wheat with low resistance to the disease.[100]

Loss of diversity and increased risk of pest infestation and disease due to the planting of monocultures, in turn, requires the application of more chemical pesticides to kill the pests.[101] Monocultures also require increased application of nitrogen fertilizers because the lack of diversity impoverishes the soil and reduces its ability to naturally retain nitrogen.[102] This vulnerable soil lacks nutrients and loses its capacity to retain moisture, and therefore becomes more sensitive to drought and erosion.[103] Monocultures are perpetuated only by adding large amounts of fertilizer and pesticide. It has been shown that "rotating crops provides better weed and insect control, less disease buildup, more efficient nutrient cycling and other benefits."[104] Unfortunately, monoculture practices are encouraged by modern agroeconomics, as farmers receive greater government payments for growing high-erosion monocrops.[105]

Food Processing

Commodity crops like corn, soybeans, alfalfa, and wheat — which are cultivated with large machines and irrigation systems, pesticides, and nitrogen fertilizers — do not go directly to the consumer. Cultivation is only the first of many steps to get processed and packaged foods (think macaroni and cheese, and TV dinners) on American plates. The next stage in the food system, for both conventional and organic agriculture crops, is processing — a stage that produces greenhouse gas emissions. This section discusses the emissions associated with food processing, focusing on the emissions from processing plants as well as the wastewater pollution problems associated with processing facilities.

High Fructose Corn Syrup, Commodity Crops, and the Farm Bill

Today, most food found in grocery stores is loaded with hydrogenated fats, salts,[106] and most commonly, high fructose corn syrup, a substance found in virtually every processed food.[107] Most of these ingredients, like HFCS, are "basically a clever arrangement of carbohydrates and fats teased out of corn, soybeans and wheat — three of the five commodity crops that the farm bill supports."[108] Every year about 530 million bushels of corn are turned into 17.5 billion pounds of HFCS in processing facilities.[109] Author Michael Pollen writes, "Today there are hundreds of things processors can do with corn: They can use it to make everything from chicken nuggets and Big Macs to emulsifiers and nutraceuticals."[110] Soft drinks are the most common place to find HFCS, but it also shows up everywhere at your Fourth of July cookout, from the ketchup and mustard to the hot dog and buns.[111]

Why have we chosen commodity crops to be transformed into highly processed additives and ingredients? As commodity crops, grains like corn were what the first processors focused their efforts on.[112] Author Richard Manning explains that "[n]o one took say, carrots or tangerines or broccoli to a mill and attempted alchemical transformation. Chemically, those items are too complex to lend themselves

to reconstitution. They are food."[113] Unlike vegetables and fruits, grains are generally not consumed immediately as food, but need fermenting, baking, or grinding.[114]

More recently, the processing of commodity crops has been accelerated by the policies in the U.S. farm bill that encourage large-scale, high-yield commodity production. Industrial farming and food processing is sustained through government subsidies on commodity grains. The farm bill's role has shifted from its original intent of supporting farmers to subsidizing industrial agriculture and supporting the growth of cheap and plentiful soybeans and corn.[115] Agricultural subsidies within the U.S. farm bill create incentives for farmers to produce large amounts of commodity grain, in particular soybeans and corn.[116] The monetary incentives to grow these crops put new fields into production whenever possible and boost crop yields through increased use of pesticides, herbicides, and monoculture.[117] With the excessive amounts of corn and soybeans, and other commodity crops being produced, there is a need to process all this grain into new products. The government subsidies in the farm bill drive the industrial agriculture system, which in turn drives the processing of commodity crops.

Greenhouse Gas Emissions and Air Pollution

Air pollution, in the form of a number of greenhouse gases, is considered one of the most threatening environmental hazards associated with the industrial food system. With over 20,000 companies processing food in the United States,[118] a great deal of greenhouse gases is released into the atmosphere by processing plants. Major air pollutants involved in food processing plants include sulfur dioxide, carbon monoxide, ozone, carbon dioxide, and nitrogen dioxide.[119] Emissions from food processing can be classified into three categories: direct emissions, indirect emissions from electricity, and other indirect emissions.[120] Direct emissions are from sources owned by processors, including boilers, heaters, cookers, vehicle fleets, and wastewater treatment.[121] Other key contributors to energy use and carbon emissions within the plant include processing equipment, like ovens, dehydrators, retorts and pasteurizers, coolers and freezers, compressed-air systems, air-handling systems, and lighting.[122] Indirect emissions, the second category, come from the use of purchased electricity.[123] And finally, the category of other indirect emissions include "emissions that occur as a result of food processing activities but from sources not owned or controlled by the manufacturer" such as "ingredients, freight, equipment manufacture, solid waste disposal, contractor, [and] employee business travel."[124]

In addition to sulfur dioxide, carbon monoxide, ozone, carbon dioxide, and nitrogen dioxide emissions from processing plants, some plants use products that contain volatile organic compounds, also a greenhouse gas.[125] VOCs are used as flavorings, dyes, inks, adhesives, and other surface coatings.[126] The greenhouse gas emissions from processing plants contribute substantially to climate change.

Wastewater Pollution

In addition to increased greenhouse gas emissions from the processing facilities themselves, wastewater is another environmentally damaging cost of food processing. On average, large food processing facilities produce about 1.4 billion liters of wastewater annually.[127] The wastewater from processing facilities "is high in suspended solids, and organic sugars and starches and may contain residual pesticides."[128] These solids include "organic materials from mechanical preparation processes, that is, rinds, seeds, and skins from raw materials."[129]

Food Packaging

As food processors grew in size early in the 20th century, "they relied increasingly on the innovation of product packaging to keep their commodities clean and fresh."[130] Packaging "maintains the benefits of food processing after the process is complete, enabling foods to travel safely for long distances from their point of origin and still be wholesome at the time of consumption."[131] But environmental damage can result from the materials used in food packages and, arguably worse, the disposal of the packaging.

The Tellus Institute has described the three categories of costs in the production and disposal of food packaging in an equation:

Full cost of packaging production and disposal =
Environmental costs (pollutant costs) of packaging production +
Conventional (monetary) costs of disposal +
Environmental costs (pollutant costs) of disposal[132]

Applying the equation to the production of a plastic ketchup bottle, the pollutant costs of packaging production include the materials, like the chemicals and petroleum, used to make the bottle. There is the monetary cost to the consumer to dispose of the bottle, either by recycling or municipal waste. Finally, the environmental costs, such as air and water pollution associated with disposing the ketchup bottle, are added. Even without specific numbers plugged into this equation, one can see

that the full cost of food packaging is a great deal more than the price at the supermarket.

Virtually all packaging materials impact the environment in some manner. Depending on the type of packing materials used, the manufacturing, use, and disposal of packaging materials may contribute to greenhouse gas emissions in the form of carbon dioxide, the release of toxins, like vinyl chloride monomer, and the scarring of landscape from the extraction of raw materials used in packaging.[133]

The primary packaging materials used in food production are glass, metals (aluminum, laminate, and metalized films, tinplate, tin-free steel), plastics (polyolfins, polyesters, polyvinyl chloride, polyvinylidene chloride, polystyrene, polyamide, ethylene vinyl alcohol, laminates and co-extrusions), paper, and cardboards.[134] Plastics are by far the most common packaging material, and arguably the most harmful to the environment. Aside from e-waste, plastics are the fastest growing portion of municipal waste[135]; "Americans trash more than forty million plastic Pepsi bottles a day."[136] Flexible plastic wrap is one of the most common packaging materials, constituting about two-thirds of all food packaging, and is made from low-density polyethylene, sometimes with a chemical abbreviated as DEHA, which is added to make the wrap more flexible and adhesive.[137] During the production stage of packaging, plastics are known to be particularly hazardous to workers and the environment. [138]

All the packaging must go somewhere. Author Heather Rogers writes, "Tossed as soon as it is empty, sometimes within minutes of purchase, packaging is garbage waiting to happen."[139] Most household solid waste ends up in landfills, and of the 250 million tons of municipal garbage produced each year, two-thirds ends up in landfills, while only one-third is recovered in recycling or composting programs.[140] Rogers explains that "[t]he rate of climate change is perhaps the broadest barometer of environmental health and is closely linked to trash; the more that gets thrown out, the more pollution-causing processes are relied on to make replacement goods."[141]

Food packaging — such as soda cans, milk cartons, cardboard boxes, and ketchup bottles — represents the majority of the packaging waste going into landfills.[142] Over 50 percent of all paper (though not all of it packaging), which is an easily recyclable material, ends up as garbage, accounting for half of the discards of all materials in U.S. landfills.[143] Only 5 percent of all plastic is recycled, and two-thirds of all glass and half of aluminum beverage cans end up in the trash.[144] The recycling rate of PET plastics (polyethylene terephthalate), the most widely collected type, was 19.9 percent in 2002, with 3.2 billion pounds of PET bottles being buried or burned.[145] Water bottles with the No. 1 recycling code[146] are recycled less then soda bottles with the No. 1 recycling code.[147] With Americans consuming so much bottled water (13 billion liters in 2003, and only 11 percent being recycled[148]), a great deal of plastic is being trashed.

When materials like plastic are not recycled properly, they end up in landfills, where they cause significant environmental impacts. First, with an increase in the amount of packaging being trashed, there are more collection trucks on the roads releasing more carbon dioxide into the atmosphere.[149] Second, incinerators release large amounts of toxins into the air, which contaminate soil and water.[150] According to the United Nations Environment Program, as of 2000, "Municipal waste incinerators were responsible for creating 69 percent of worldwide dioxin emissions."[151] Even in facilities with proper filtration equipment, "dioxin cannot be destroyed or neutralized because it is generated through the very process of incineration."[152] Dioxins are formed when diverse packaging materials, like paper and plastic, are burned together.[153] When the plastics are burned in incinerators, the remaining ash can also "contain heavy metals like lead, mercury, cadmium and other toxic substances that can leach once buried in landfills."[154] The dioxins can travel through the air and be dispersed on the land and into water on a global scale.

Landfills produce what is known as "landfill gas," the emissions of decomposing waste, which consists primarily of methane, another large contributor to climate change.[155] In fact, EPA suggests that "[m]ethane is of particular concern because it is 21 times more effective at trapping heat in the atmosphere than carbon dioxide."[156]

Plastic is the most environmentally hazardous packaging material when not recycled because, like all synthetics, it cannot be safely returned to the environment and will stay intact for an unknown number of years, with estimates ranging from 200 to 1,000 years.[157] The Container Recycling Institute has estimated that if the number of bottles ending up in incinerators were recycled, "an estimated 6.2 million barrels of crude oil equivalent could have been saved, and over a million tons of greenhouse gas emissions could have been avoided."[158]

Despite national recycling initiatives, few food packages get recycled and curbside recycling programs are at risk, due in part to increased costs and municipal budget cuts.[159] In addition, "[r]ecycling experts link the drop [in recycling] to the rising number of beverages consumed away from the

home — in offices, parks, cars, and other places that lack a handy recycling bin."[160] Food is now made to be convenient — wrapped in a plastic, ready to be microwaved in a minute, and eaten with one hand. Convenient foods can be eaten on the run, and ultimately the packaging ends up in trash cans and then landfills, increasing greenhouse gas emissions and environmental impacts.

Food Distribution

The food supply chain has become increasingly global, with food being produced and shipped all around the United States and the world. The use of the fossil fuels in transporting food products increases the climate change impacts of the food system tremendously.

Food Miles

Food miles are the "distance food travels from where is it produced to where it is consumed. Food miles have increased dramatically in the last couple of decades, largely as a result of globalization."[161] On average, food travels between 1,300 and 1,500 miles before it is consumed.[162] Depending on distribution channels, for example, food moving anywhere within the United States and Canada may first travel through Los Angeles.[163] As author Dale Allen Pfeiffer explains, "[e]ven food distributed within North America is first shipped to L.A. So pears and apples from Washington, right next to the Canadian border, make a longer journey to reach Toronto than carrots from California."[164] Because most food is moved by truck, train, or plane,[165] all of which are currently fueled by fossil fuels, transportation increases carbon emissions.

Food miles may be similar regardless of whether or not the product is conventional or organic. Some may believe that organically grown means locally grown, and that local products are organic. This is not necessarily the case, because "[a] food may be Certified Organic, but it is not necessarily locally grown."[166] This can lead to consumer confusion, as it can be difficult to find the food with the least carbon footprint. Marion Nestle writes about her predicament in a New York City Whole Foods store:

> I found peaches, corn, and tomatoes from New Jersey, and apples from New York, but all were conventionally grown. I looked hard for local organic foods but found only one (some red cabbage from New York State), unless you consider organic corn and tomatoes from Vermont as 'local'. On that particular midsummer day, hardly any of the produce was grown locally, and hardy any of the local produce was Certified Organic.[167]

Many organic foods, particularly industrialized organic foods, travel the same great distances as conventional products to get to a store. With the rise in the organic market, both conventional grocery stores and high-end stores like Whole Foods are carrying more organic products from all around the world in order to meet the demand.

Importing Food

Generally speaking, the calculation of food miles only accounts for food traveling within the United States and does not consider imported foods, in which case, the number grows significantly. Food in the United States is increasingly grown in other countries, "including an estimated 39 percent of fruits, 12 percent of vegetables, 40 percent of lamb, and 78 percent of fish and shellfish in 2001."[168] Furthermore, "[t]he typical American prepared meal contains, on average, ingredients from at least five other countries."[169]

However, despite the large amounts of energy used in the long miles food travels, transportation is arguably the least energy-intensive step in the entire food system. Rich Pirog, who was the first to analyze food miles, has shown that transportation is actually the lowest of all fossil fuel usage in the food system, at about 11 percent.[170] Production and processing, Pirog suggests, account for much more — 45.6 percent of fossil fuel use.[171] Scientists at the Landcare Institute in New Zealand explain that "localism is not always the most environmentally sound solution if more emissions are generated at other stages of the product life cycle."[172] This is not to say we should not be concerned with where our food is coming from, but that buying local alone will not solve all the environmental problems associated with the food system.

Conclusion

The current food system, including conventional and organic food, contributes to environmental degradation and climate change. The production stage relies on fossil fuel-intensive machinery and irrigation systems that harm the soil, water, and air. Harmful pesticides and fertilizers are used extensively, and the dominant monoculture practices pollute natural resources. To the extent that organic products are grown without synthetic pesticides and fertilizers, they are less harmful to the environment. But if they are produced with the same machinery, irrigation, and monoculture as conventional prod-

ucts, organic products present the same environmental issues. Processing, especially of commodity crops, increases greenhouse gas emissions and environmental impacts of the food system because processing facilities use energy derived from fossil fuels, and they pollute water systems. Packaging is a large part of both the conventional and organic system, and is environmentally damaging, in particular when food packages are not properly disposed of. Finally, distribution, although it may not be the most intensive stage of fossil fuel use, does increase the carbon footprint of the entire system.

Notes

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2. Although the production of livestock is a significant contributor to the carbon footprint and environment impacts, it will not be discussed here.

3. At the outset, we must recognize the difficulty scientists have had in evaluating the environmental costs of the life-cycle of food, given the food system's geographic diffusion, the inability to disaggregate all commodity production from food (e.g., ethanol), and the complexity of import and export systems. Martin C. Heller & Gregory A. Keoleian, *Assessing the Sustainability of the U.S. Food System: A Life Cycle Assessment*, 76 Agricultural Systems 1007, 1009 (2003); Karin Anderson & Thomas Ohlsson, *Life Cycle Assessment of Bread Produced on Different Scales*, 4 International Journal of Life Cycle Assessment 25, 25 (1999).

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6. Kimbrell, Andrew, *A Blow to the Breadbasket: Industrial Grain Production, in* Fatal Harvest: The Tragedy of Industrial Agriculture 100 (Andrew Kimbrell ed., 2002).

7. *Id.*

8. Darrel Good, *Weekly Outlook: Corn and Soybean Acreage*, ACES News (Jan. 20, 2009), *available at* http://www.aces.uiuc.edu/news/stories/news4630.html.

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10. Mary Jane Angelo, *Corn, Carbon, and Conservation: Rethinking U.S. Agricultural Policy in a Changing Global Environment*, 17 Geo. Mason L. Rev. 593, 600 (2010).

11. Czarnezki, *supra* note 1, at 75, citing Dan Imhoff, Paper or Plastic: Searching for Solutions to an Overpackaged World 102 (2002).

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17. Czarnezki, *supra* note 1, at 80, citing Organic Trade Ass'n Executive Summary, Organic Trade Association's 2007 Manufacturers Survey, *available at* http://www.ota.com/pics/documents/2007ExecutiveSummary.pdf (stating that organic food sales accounted for 0.8 percent of total food sales in 1997, and 2.8 percent in 2006).

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21. Czarnezki, *supra* note 1, at 9.

22. David Pimentel & Marcia H. Pimentel, Food, Energy, and Society 60 (3rd ed. 2008), citing David Pimentel & Marcia H. Pimentel, Food, Energy and Society (1979).

23. *Id.* at 119.

24. *Id.* at 118-19, citing C. Wells, Total Energy Indicators of Agricultural Sustainability: Dairy Farming Case Study (2001).

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