Fragile Ecosystems: Pesticide Use in Conventional Agriculture

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May 2015
Abstract

In a continuing effort to master our environment, human beings have attempted to maximize the yield and efficiency of food production based on outdated reductionist and mechanistic understandings of land use. This has yielded the kind of modern industrial farms characterized by a reliance on pesticides, synthetic fertilizers, and monoculture that continue to produce most of the food in the United States. The eradication of pests is just one of the ecological wars being waged on these farms, the consequences of which have been the contamination of soil and water, loss of plant and animal biodiversity, pest resistance, increased vulnerability to pests, disease, and extreme weather. Scientific reports by the United States Department of Agriculture, the Environmental Protection Agency, the Fish and Wildlife Service, the Food and Agriculture Organization of the United Nations, and the National Academy of Sciences give insight into the severity of the problem from an ecological perspective, while sources on the social, historical, political, and philosophical development of this paradigm together will help to piece together a comprehensive image of the destruction of ecosystems through the use of pesticides. This interdisciplinary approach helps to illuminate how and why conventional agriculture has become so ecologically misguided yet (for a small few) immensely powerful and profitable. New policy should aim to reestablish farmland ecosystems by restoring soil health, promoting the presence of beneficial plants and insects and other local fauna, and utilizing strategies of integrated pest management including crop rotation and intercropping. Most importantly, efforts should be specific to the local environment and carried out by the community there. Among other benefits, the resulting ecological stability would decrease the need for intensive pest management measures, mitigate local environmental impacts, and galvanize the stability and productivity of the farmer’s crops and soil.
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Introduction: Agriculture’s War on Pests

Underneath the surface of any corn field or soy plantation exists a vast ecology of bacteria, fungi, worms, and insects that cycles nutrients and makes up the very structure of soil itself. Like all healthy and thriving ecological communities, the agricultural landscape depends on the interaction of a diverse variety of organisms from decomposers in the soil to top predators in the surrounding environment. Even before the widespread adoption of articulated ecological ideas, farmers benefitted from careful and cooperative management of the soil in maintaining reliably productive land—understanding, at least, that something had to be given back when taken away. But agriculture in the early United States, with its access to seemingly boundless expanses of arable land, presented new opportunities for expansion. Government agencies, particularly the USDA, supported the agenda of modernization through new agricultural technologies (specifically in helping to adapt pesticides and synthetic fertilizers from wartime technology) and facilitated the transformation from subsistence to profitable enterprise. These innovations would help to redefine our relationship with the natural world, especially in the way that we dealt with pests—with cheap, free flowing chemical inputs, farmers could undertake the complete eradication of pests as opposed to their control. Of course, pesticides are only one weapon in the arsenal of modern industrial agriculture. However, our relationship with pests and our approach to their management are perhaps some of the most revealing interactions about how we think about the world around us. The placement of my examination within an agricultural context further defines this perspective by describing how we feel about the natural world as a exploitable resource. The production of food is as especially salient yet controversial issue because, while it has become very political, is something our livelihoods are directly and universally founded upon. Our characterization of pests may serve as a microcosm, or an
exemplary acting-out, of a view of the world that is inherently ruinous. Pests are generally defined as any plant or animal that poses a threat, or sometimes just an inconvenience, to humans. In the life of the average American, this probably includes the dandelions in our lawns, the raccoons, opossums, or rats that get into our garbage, the moths and ants that infiltrate boundaries of our houses in spring—in other words, almost every living creature around us. We hate pests because they are dirty, disease carrying, and almost bizarrely resilient to our efforts to keep them out of sight. In agriculture, the fear of pests as a real threat may be slightly more legitimate than in the average household. Pest and disease outbreaks have the potential devastate crop yields if uncontrolled or unprepared for. In order to neutralize this threat, conventional agriculture advises an aggressive and uncompromising response—blanketing the entire landscape with potent pesticides, herbicides, and fungicides. Overall, this approach seems to be unnecessarily combative, uncooperative and shortsighted. More concerning, though, is that this might represent not just an overzealous reaction to the problem of pests, but a whole perspective of the world around us. Whatever our perceived role in this world is, it does not appear to be an ecologically conscious one. Again, agriculture promises a particularly accurate explanation of this perspective because it remains one of the most direct, and singularly most necessary, relationships human beings continue to engage in with the natural world.

In order to fully comprehend the seriousness and pervasiveness of the environmental threats posed by pesticide use, chapter one provides a variety of complied statistics from independent and government published studies. These document impacts such as losses in honeybee and other pollinator populations, the pollution of water and soil by agricultural chemicals and its effect on soil health and local water supplies, losses in plant and animal biodiversity and the number of threatened or endangered species associated with agricultural
areas. Next, chapter two describes what an agricultural ecosystem in the United States might look like. This chapter discusses the types of plants and animals found in this setting and how are involved in creating a healthy, stable, and productive community. From decomposers to predators, the crucial relationships between these organisms will be traced in order to give an accurate perspective of just how much diverse life is involved and at stake in agricultural ecosystems. Chapter three will provide a comprehensive history of pesticides within the context of the establishment and industrialization of agriculture in the United States. This timeline is made up of significant social, political, and economic, and ideological shifts in the nation’s early history. Chapter four attempts to tackle the daunting political aspect of pesticide use and other destructive practices in agriculture in the hopes of identifying obstacles to legislative change. This chapter identifies major political players, including vastly powerful private interests, less-than-upstanding politicians, and surprisingly complacent government agencies and organizations. Finally, chapter five provides my conclusion, which argues for ecological agriculture’s place in creating a sustainable form of food production. Solutions are proposed in the forms of federal agricultural policy change, community-based efforts, and personal (philosophical) reform.
Chapter 1. Quantifying the Damage of Pesticides

Unlike an oil spill or the clear cutting of a forest, the tragedies of pesticide use are not as easily noticed or appreciated. Apart from incidents of direct exposure in concentrated amounts (as the farmer sometimes is during application), the consequences of pesticides generally lack drama and immediacy. But the sheer volume of pesticides being used in American agriculture today guarantees that it will come into contact with every living thing on the farm at some point or another. That intersection can occur at any moment—from when the pesticide is sprayed and gets dispersed by the wind, when residues build up in the soil, or see into the ground, or become incorporated into nearby bodies of water through runoff by rain or irrigation. Even through predator-prey relationships.

Pesticides in the Bigger Picture. In combination with other conventional practices, pesticides exert their full ecologically destructive potential. In fact, the implementation of one of these practices often necessitates another. For example, in order to keep crops from being killed along with weeds during spraying, farmers use crops with genetically engineered pesticide resistance. Other example lies in the increased loss of nitrogen from soils that are intensively tilled. This necessitates more nitrogen fertilizer inputs. These dependent relationships indicate how just how vulnerable crops are under the modern industrial system and how easily farmers could get trapped in a cycle of extraction or depletion and the application of chemical inputs.

A Variety of Inputs. According to the Environmental Protection Agency’s most recent “Pesticide Industry Sales and Usage Report: 2006 and 2007 Market Estimates” released in 2011, eighty percent of all pesticides used in the U.S. in 2007 was in agriculture.¹ In this year, 442 million pounds of herbicides, 65 million pounds of insecticides, 44 million pounds of fungicides,

108 millions pounds of nematicide/fumigants, 25 million pounds of other conventional pesticides (making 684 millions pounds total) were used in the United States in this market sector alone.²

Using the USDA’s Agriculture Consensus records from 1997 to 2012, the continued trend of increased pesticide use (particularly of herbicide and insecticide) can be pieced together by looking at the sharp increase in millions of agricultural acres treated around 2002 and again around 2007 (Figure 1.1).³

These numbers show just how freely insecticides and herbicides have been used, and are increasingly being used, to combat the clearly significant threat that pests pose. But what exactly are farmers protecting their crops from? The USDA Natural Resource Conservation Service website lists a variety of different bacteria, fungi, protozoa, nematodes, arthropods, and

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³ USDA, Census of Agriculture 1992-2012
earthworms and their roles as either helpful or harmful in an agricultural setting. Some herbivorous arthropods (cicadas, crickets, maggots, and rootworms) can become pests in large numbers, while others known as “shredders” (millipedes, mites, and roaches) may begin feeding on crops if the presence of dead plant material as a food source is insufficient. Some nematodes (non-segmented worms) are root-feeding plant parasites, some cause disease. Pathogens and parasites “cause reduced production or death when they colonize roots and other organisms.”

In order to spread awareness about invasive pests, the USDA’s Animal and Plant Health Inspection Service now hosts an educational website ("www.hungrypests.com") that features photos and videos of some kind of bug-man character who is apparently meant to embody the kind of unsavory mischief these insects have in store for us. The “Top Invasive Pest Threats” include a variety of exotic moths, beetles, snails, ants, flies, and two plant diseases. Although intended as a more accessible and engaging public educational resource, this site perfectly encapsulates the assumptions and anxieties underlying our approach to pest management. But this discussion is for a later chapter.

**On the Farm: Soil and Water.** With some idea of the sheer magnitude of the chemical warfare currently being waged on farms, as well as just a small sample of the diverse array of organisms being targeted there, the fact that pesticides often exceed their intended boundaries may be more meaningfully comprehended. In 1986, it was found that, “less that 0.1% of pesticides applied for pest control reach their target pest…thus more than 99.9% of pesticides used move into the environment.” More recent estimates put this number closer to less than

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4 Moldenke, “Soil Arthropods” (USDA)
5 Ingham, “Soil Nematodes” (USDA)
6 Ingham, “Soil Fungi” (USDA)
8 Pimentel, “Amount of Pesticides Reaching Target Pests: Environmental Impacts and Ethics”
5%. By way of wind and water, the reach of these non-target amounts is expansive and profound.

Depending on the permeability of the soil, residues are either absorbed or run off with rainfall or irrigation water. Within agricultural soils, pesticides undermine the stability, resiliency, and productivity of plants. One way is by disrupting nitrogen fixation, a process by which plants produce chemicals that attract *Rhizobium* soil bacteria to their roots, which then form nodules on the plant’s roots, converting atmospheric nitrogen into ammonia, fertilizing the plant. This symbiotic relationship only occurs through communication between the plant and the bacteria—this is what pesticides seem to interfere with.

One 2004 study using alfalfa seeds and *Sinorhizobium meliloti* bacterium found that the application of organochlorine pesticides pentachlorophenol (PCP) and methyl parathion at levels found in farm soils inhibited the nodulation receptors in plants by up to 90%. In another study published in the *Proceedings of the National Academy of Sciences* in 2007, alfalfa seeds inoculated with the same *S. meliloti* bacterium exhibited no nodule growth and a 17% yield reduction with exposure to PCP, and treated reduced nodule growth and a 50% reduction in yield when treated with methyl parathion. These results “indicate that pesticide residues in soil could not only reduce harvest yields, but also increase the need for synthetic fertilizers, thereby raising costs for farmers and contributing to environmental pollution.” In a Polish study, the use of herbicide and fungicide was found to damage and inhibit the growth of main and lateral

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9 Van Eerd, et al, “Pesticide metabolism in plants and microorganisms”
10 Potera, “Pesticides Disrupt Nitrogen Fixation”
11 Fox, “Chemical Communication Threatened by Endocrine Disrupting Chemicals”
12 Fox, et al., “Pesticides reduce symbiotic efficiency of nitrogen-fixing rhizobia and host plants” (PNAS)
13 Potera, “Pesticides Disrupt Nitrogen Fixation”
roots, hinder the development of root nodules, and impact the overall health and productivity of
the plant, and nutrient content of its yield—even in “normal field concentrations.”\textsuperscript{14}

Residues in particularly permeable soils quickly make it to the water table, contaminating
local sources of fresh water. In compacted soil, they are carried away with other runoff into
Nation’s Waters,” tested 186 streams, 5,047 wells, 700 streams, and 1,052 stream sites around
agricultural areas and found pesticide contamination in 97% of stream water, 61% of shallow
ground water, 92% of fish tissue, and 57% of bed sediment tested.\textsuperscript{15} While these scores alone
are enough to cause alarm, the EPA has set specific allowable “benchmark” concentrations for
such contaminants.\textsuperscript{16} Researchers determined that an “annual mean concentrations of one or
more pesticides exceeded a human-health benchmark in about 10 percent of the 83 agricultural
streams,” while 57% these samples exceeded benchmark concentrations for aquatic life, and 87%
of fish tissues exceeded the low benchmark concentrations for wildlife.\textsuperscript{17}

Furthermore, while these benchmark limits determine safe or tolerable concentrations to
diluted amounts in the environment, they do not account for other sources or processes that can
lead to exposure. The National Pesticide Information Center defines various indirect ways that
human and animals can be exposed to dangerous concentrations, including “secondary
poisoning” or “relay toxicosis” where a predator animal consumes the body of another animal
that was fatally poisoned.\textsuperscript{18} A process of “bioaccumulation can occur if residues build up faster

\textsuperscript{14} Neiwiadomska and Klama, “Pesticide Side Effect on the Symbiotic Efficiency
and Nitrogenase Activity of \textit{Rhizobiaceae} Bacteria Family”
\textsuperscript{15} USGS, “The Quality of Our Nation’s Waters: Nutrients and Pesticides”
\textsuperscript{16} EPA, “Human Health Benchmarks for Pesticides”
\textsuperscript{17} USGS
\textsuperscript{18} NPIC, “Ecotoxicology: Topic Fact Sheet”
than the organism can break them down and excrete them.” This means that, even if one animal has not ingested fatal concentration of the pesticide, a process of biomagnification can occur through the food chain, whereby animals build up toxic concentrations through their food source.

**Beyond the Farm: Pollinators and Endangered Species.** The same processes that carry pesticides throughout the agricultural landscape also help spread their destruction beyond its boundaries. Particulate residues are blown from spraying sites in a phenomenon called pesticide drift, blanketing surrounding land. Birds are exposed to toxic amounts of airborne residues through inhalation and sometimes mistake granular forms for a food source.

In 2000, the International Union for the Conservation of Nature charged agricultural activities with affecting 827 threatened bird species, 1,121 threatened plant species, and 92 threatened mammal species. These include agriculturally beneficial species, such as pollinators—43 of which the Fish and Wildlife Service currently lists as threatened or endangered. This list includes a variety of crucially important species of birds, bats, butterflies, moths, and arthropods. According to the Food and Agriculture Organization of the United Nations, these pollinators “affect 35 percent of the world’s crop production, increasing outputs of 87 of the leading food crops worldwide.” In fact, “crops that can experience declines in production – by up to 90 percent – if they lack pollination.”

The pollinators that receive the most attention, of course are bees. That is because, according to the USDA, they pollinate over 70% of the 100 crop species that provide 90% of the

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19 Ibid.
20 Best and Fischer, “Granular insecticides and birds: Factors to be considered in understanding exposure and risk”
21 IUCN, “Red List”
22 FWS, “Pollinators Federally Listed as Endangered or Threatened Species”
23 FAO, “Pollination Services for Sustainable Agriculture”
24 FAO, “AGP – What is pollinator management”
planet’s food. Bees are also on a precipitous decline, especially honeybees. The USDA claims “about 30 percent of honey bee hives in the United States have been lost each winter to diseases, parasites, poor nutrition, pesticide exposure, and other issues” since 2006.

According to the Department’s National Agricultural Statistics Service archives, this downward trend is not new (Figure 1.2).

![Graph showing the decline in honey colonies from 1980 to 2013.](image)

**Figure 1.2**

The causes of this trend are various and complex and still being understood. But the action recommended by the USDA gives insight to some of the biggest factors at play. Major themes here seem to habitat destruction, lack of diverse food sources and nesting sites, and pesticide exposure. The 2008 Farm Bill includes the Environmental Quality Incentive Program (EQIP) in an effort to get farmers involved in the creation of pollinator habitat. Farmers are advised to protect and enhance abundant and diverse native flower habitat, reduce unnecessary or reckless

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25 NRCS, “More Information About Pollinators” (USDA)
26 NRCS, “Conservation Work for Honey Bees” (USDA)
27 NASS Annual “Honey” Report (USDA)
28 NRCS, “How NRCS Is Helping Pollinators” (USDA)
pesticide use, and plant hedgerows or windbreaks; in order to avoid destroying underground nesting site, they are also instructed to minimize tillage.\textsuperscript{29}

\textit{Pest Resistance.} The development of resistance to pesticides is yet another serious threat. According to the FAO, 520 species of insects and mites, 150 plant diseases, and 113 weeds were confirmed pesticide resistant in 1995.\textsuperscript{30} The International Survey of Herbicide Resistant Weeds documents 524 herbicide resistant weed species from 1980 to 2014.\textsuperscript{31} This particular consequence is one that illustrates just how completely and blindly we rely on agricultural technologies such as pesticides, and how at the same rate we are compromising the stability of everything we are a part of, and the very thing we require to live and thrive.

\textbf{Chapter 2. The Agricultural Ecosystem}

Like the conventional farm, the agricultural ecosystem is an entirely manmade site. Modifying the earth for any kind of cultivation is an inherently destructive, or at least disruptive, kind of relationship. The first to apply “the ecological critique of industrial agriculture” was Aldo Leopold.\textsuperscript{32} Instead, he proposed “a scientifically informed ago-ecology” as a way of engaging with cultivation in an ecologically sensitive way.\textsuperscript{33} These manmade plant and animal communities are merely artificial replications “deliberately designed to imitate the structure of a natural biotic community.”\textsuperscript{34} This definition both prioritizes the healthy ecosystem while giving humans an active role in it. This crucial understanding is what Wendell Berry says is often missing from “the conservationist mentality,” which either sees nature as scenes of pristine

\textsuperscript{29} NRCS, “How Farmers Can Help Pollinators” (USDA)
\textsuperscript{30} FAO, “Dimensions of need: An atlas of food and agriculture”
\textsuperscript{31} ISHRW, “Herbicide Resistant Weeds on United States”
\textsuperscript{32} Callicott, \textit{Beyond the Land Ethic}; page 277
\textsuperscript{33} Ibid., page 279
\textsuperscript{34} Ibid., page 279
beauty or tragic scenes of man’s greed and destruction in need of rescuing.\textsuperscript{35} Instead, we must have an idea of our day-to-day involvement with the world around us and be able to conceive of an engagement of “kindly use.”\textsuperscript{36} The agricultural ecosystem must be able to reconcile these ideas and understand that just because agricultural ecosystems are inherently disrupted ones does not mean they cannot or should not be healthy. In the process of defining our place within the larger biotic community, there is one crucial thing we must realize: “Humans, like all other organisms, have competitors for our food and shelter, predators that attempt to eat us, and parasites that feed in or on us.”\textsuperscript{37} The only difference is that we have given these competitors a special name: pests.

\textit{Ecology Revisited.} First, it will be useful to outline just exactly what an agricultural ecosystem looks like. Descriptions such as these are usually reserved for more the more interesting or exotic plants, animals, and climates than cornfield in the rural Midwestern United States. But ecological stability is important everywhere. Whether is holds pristine wilderness, a breathtaking view, or supports human cultivation, every ecosystem must be respected according these principles in order to thrive.

Most farms in the United States exist in grassland or cleared deciduous forest biomes. In Midwestern states, the climate tends to be warmer and dryer, featuring a variety of grasses, shrubs, and flowers that support grasshoppers, spiders, snakes, mice, rabbits, prairie dogs, deer, foxes, coyotes, and a variety of birds including sparrows, quails, hawks, and owls. Eastern states feature cooler temperatures, more precipitation, and a variety of deciduous trees occupied by squirrels, skunks, deer, foxes, black bears, and a similarly wide variety of birds. Each individual

\textsuperscript{35} Berry, \textit{The Unsettling of America}, page 30
\textsuperscript{36} Ibid.
\textsuperscript{37} Winston, \textit{Nature Wars}, page 1
is a member of the population of its species. When members of different populations interact, they create the communities of agricultural ecosystems. But when farmers clear hundreds of acres of these landscapes for cropland, much of the native flora and fauna disappears. If they are not intentionally eradicated, or poisoned by agricultural chemicals, they are driven away. Suddenly, the ecosystem is much more sparse and imbalanced. As some populations leave, others take their place and become more dominant. Eventually, the same ecosystem is almost unrecognizable.

**New Communities.** Some warn that with increasing population pressure in the coming decades, agricultural landscapes must adapt to accommodate wild species diversity and ecosystem services, which “will require farmers, agricultural planners, and conservationists to reconsider the relationship between production agriculture and conservation of biodiversity.”[^38] They are calling for “a new paradigm, ecoagriculture, defined as integrated conservation-agriculture landscapes where biodiversity conservation is an explicit objective of agriculture and rural development, and the latter are explicitly considered in shaping conservation strategies.”[^39] This concept begins to define the kind of relationships farmers must develop within their agricultural communities in order to be responsible and concerned members.

Another defining characteristic of ecological health in this context is the centrality of soil in the food web. To the farmer, the bacteria, fungi and other microbes working invisibly away beneath the surface are not just necessary components of the soil, but direct actors on the success of their crops. And from the same perspective, disease carrying or root-feeding nematodes and arthropods pose direct threats. Faced with this conflict, many choose to strike back in full force.

[^38]: Scherr and McNeely, “The Challenge for Ecoagriculture,” page 1
[^39]: Ibid.
A World Within the Soil. The USDA acknowledges that, “although the effect of pesticides on soil organisms varies, high levels of pesticide use will generally reduce food web complexity. An extreme example is the repeated use of methyl bromide which has been observed to eliminate most soil organisms except a few bacteria species.”  

Most soil organisms, including earthworms and even burrowing mammals, live within the top three inches of soil—well within reach of harmful exposure. Surface-dwelling animals, including everything from mice, ants, ladybugs, beetles, and spiders, and hornets, are even more vulnerable. The invaluable nutrient cycling and pest management services provided by decomposers, parasites, and predators such as these disappear along with their populations.

In wiping out beneficial insects or even in the successful eradication of a target pest, pesticides actually help facilitate the creation of new pests as “previously innocuous insects may suddenly explode into pest status.” Still another outcome is pesticide resistance, which insects are especially adept at developing thanks to “enzyme systems that originally may have evolved to detoxify chemical defenses that occur naturally among plants.” The United States Department of Agriculture’s Natural Resource Conservation Service website acknowledges:

“A fundamental dilemma in pest control is that tillage and insecticide application have enormous effects on non-target species in the food web. Intense land use (especially monoculture, tillage, and pesticides) depletes soil diversity. As total

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40 Ingham, “Food Web and Soil Health” (USDA)
41 Moldenke, “Soil Arthropods” (USDA)
42 Mark L. Winston, Nature Wars: People Vs. Pests, page 15
43 Ibid., page 13
soil diversity declines, predator populations drop sharply and the possibility for subsequent pest outbreaks increases.”

The promotion of such an ecologically sensitive perspective on soil health and pest management on the part of a government agency seems promising. Unfortunately, this not seem to permeate all of the Department’s initiatives.

**Redefining Pests.** Lost in the desperate battle for complete eradication have been the beneficial aspects of our relationship with these fellow agricultural populations. These benefits are not reserved to specific “ally” species that provide us with some clear and direct service. The USDA explains that wherever “a healthy population of generalist predators is present, they will be available to deal with a variety of pest outbreaks.” But only if they have an adequate and continuous food source, such as that provided by “a healthy and diverse food web.” Some bacterial decomposers can even break down pesticides and pollutants in the soil, thereby helping to undo the damage we have already done. A stable ecological system that permits and takes advantage of these benefits requires less work, less expensive inputs, and increased longevity of its soil.

But all of this hinges on the presence of numerous and diverse native species. As discomforting it might be, this means we need to learn how to live more cooperatively bugs and weeds. We also need to become more comfortable with imperfections. The perfectly straight rows of corn associated with conventional farming today are no fantasy—fields appear stripped clean of any plants or residues apart from the planted crop. The images below provide an

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44 Moldenke, “Soil Arthropods” (NRCS, USDA)
45 Moldenke, “Soil Arthropods” (USDA)
46 Ibid.
47 Ingham, “Soil Bacteria” (USDA)
example of the difference in plant variety and density between conventionally managed Iowa cornfields (Figure 2.1, 2.2)\textsuperscript{48, 49} and those planted according to organic, polycultural principles (Figure 2.3, 2.4).\textsuperscript{50, 51}

This kind of mixed cropping can be used for a variety of different purposes, from nitrogen fixation, increase moisture retention, prevent erosion, and pest management. Organic agriculture and mixed cropping are just two ecoagricultural strategies that have proven effective at

\textsuperscript{48} San Martin, “Intensive agriculture – Corn field”
\textsuperscript{49} Nemec, iStockphoto
\textsuperscript{50} Fuhrer, “Season Grass and a Warm Season Broadleaf”
\textsuperscript{51} Ibid., “Corn and Hairy Vetch”
maintaining wild plant and animal biodiversity.\textsuperscript{52} Another powerful visual testament to the sterility of conventional fields is NPR’s recreation of David Liittschwager’s \textit{One Cubic Foot} project to document biodiversity around the world. The original images are packed with creatures of all shapes, sizes, and colors, while this one (attempting to depict the diversity of an Iowa cornfield) is decidedly sparse (Figure 2.5).\textsuperscript{53}

The widespread adoption of alternative methods of pest management has “been hampered by our commitment to pesticides, our psychological attitudes toward pests, short-term economic concerns, the complexity of nonchemical management techniques, and a lack of comprehension about our impact on the rest of nature.”\textsuperscript{54} Navigating this complex intersection of personal, social, economic, and political issues toward an effective and accessible solution will not be easy. It will not likely happen with the development of a new technology or with a legislative change, but will require a deep reexamination of the values and motivations behind our approach to farming and where they came from. For this, we turn to history.

\textsuperscript{52} Buck, et al., “Scientific Assessment of Ecoagriculture Systems,” page 20
\textsuperscript{53} NPR, “Organisms found in an Iowa cornfield”
\textsuperscript{54} Winston, \textit{Nature Wars}, page 16
Chapter 3. Pesticides in U.S. Agricultural History

Massive, mechanized, synthetic, and genetically modified, the farms producing most of the food in the United States today are distinctly modern institutions. Though humans have been practicing agriculture for about ten thousand years, the last century alone has produced some of the most significant and transformative innovations in the way we cultivate the earth.

Biotechnology’s most recent major breakthrough has been the genetic modification of crops to introduce traits like increased yield and pest (or pesticide) resistance. Since their commercial introduction in 1996, GM crops have been cited as just one indication of the corruption of modern industrial agriculture from anything perceived as natural. They were quickly integrated into its arsenal and, in 2014, 93% of all corn planted in the United States was of a genetically engineered variety.\(^{55}\) While specific technologies such as GM crops have only been made

\(^{55}\) USDA, “Genetically engineered varieties of corn, upland cotton, and soybeans, by State and for the United States,
possible with recent scientific advancements, the overall state of our agriculture as one that readily seeks out and adopts these new technologies as quick fixes for the degraded land and vulnerable crops has been a long time in the making.

From the very beginning of the settled existence that agriculture necessitated, humans ran into new kinds of conflicts with the natural world. Increasingly dense populations—engaged in the production and storage of a variety of fruits, vegetables, and fibers as well as raising domesticated animals—provided concentrated food sources for opportunistic creatures of all kinds, whether they sucked blood, munched leaves, or scavenged garbage. The imbalance of ecosystems caused by the transformation of habitats and import of foreign plants and animals through trade only created more opportunities for these populations to flourish to the point of becoming problematic. To Mark Winston, “pests provide an excellent paradigm to understand how our attempts to have dominion over nature have backfired” because throughout history it has often been our very own activities that “have exacerbated pest situations far beyond their natural significance.”

**The Flaws in Our Machine.** Agriculture is a relatively new form of subsistence in the grand scope of human history. In fact, we have spent over 99 percent of our existence as a species hunting and gathering our food. To historians, this indicates that there is no guarantee of it being truly successful or sustainable in the long run. Looking to the past, this scenario is not terribly hard to imagine. A classic example of the catastrophic potential of agricultural failure is preserved in the remnants of sophisticated irrigation systems created by ancient Mesopotamian

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56 Winston, *Nature Wars*, page 1
57 Stoll, *Larding the Lean Earth*, page 18
civilization. Devastating plagues of locusts are frequently referred to in Biblical writing. Extreme weather patterns and pest and disease outbreaks have left cultivators at nature’s mercy for centuries. Famine has devastated, and continues to devastate entire nations, especially in arid or otherwise inhospitable climates. More recently, mounting concerns about climate change and its potential consequences for food security continue to remind us of how fragile and flawed our source of livelihood is.

Still, there are unmistakably more sustainable and less sustainable ways of producing food. Since the very beginnings of agriculture in the United States, we have tended toward the latter to some degree. The specific geologic, economic, and social conditions of this history helped set the practical and ideological stage for the conventional agriculture of today. In some ways, the story begins with the origins of the country itself; the same spirit of opportunity and development that would guide the European colonization of North America influenced agricultural ideas for years to come.

The Origins of Our Destruction. Far different from their long established and densely populated places of origin, the seemingly endless abundance of North America captivated early colonists. On their long journey to the New World, they brought with them assumptions about what an established society—or, more specifically, what inhabited land—was supposed to look like. From this point of view, early settlers saw what they believed to be pristine and undisturbed wilderness, open for the taking and ripe for cultivation.

The first window of opportunity opened for American agriculture’s destructive potential was possibility of almost boundless expansion to the West. No longer concerned about limited space, farmers had little incentive to carefully manage the health of their soils. After intensive

58 Ibid.
tilling practices took their toll, it was actually more cost effective for farmers to emigrate than to rest and fertilize their fields. Furthermore, there was an extreme shortage of labor in the still sparsely occupied early America, making it more labor intensive for farmers to maintain land on their own. This opportunity for cheap exploitation was one the settlers had never experienced before, but which they readily took advantage of. As early as 1820, the soils of the early states along the East coast were showing signs of severe depletion.\textsuperscript{60} As Steven Stoll puts it in his account, these “colossal imbalances between labor and land in the New World became a catalyst for mechanical innovation and a rationale for waste.”\textsuperscript{61} In other words, it produced the first recognizable characteristics of what would become modern industrial agriculture.

Although this cycle was a widely implemented among early American farmers, its destructive potential was recognized early on. The term “‘skim and scratch’ described a casual cultivation, conducted with the least possible effort, intended to take what was easily available and leave the rest.”\textsuperscript{62} To those who condemned the practice, this vocabulary differed from their preferred terms of “cultivating” or “improving” land—in fact, many farmers who elected to stay put rather than emigrate adopted the term “improvement” to define their dedication to maintaining the health of their land.\textsuperscript{63} Some improvers believed their mission as farmers to be the claiming of land from wilderness and transforming it, refining it, to serve the purpose of human livelihood. Others were more concerned about the conservation of land and used to term to refer to the creation of highly managed but stable natural agricultural environments. Overall, they recognized the importance of sustainability in a permanent agriculture and its importance to an enduring society. Improvers notoriously “disdained frontiering”; they saw their own practice

\textsuperscript{60} Stoll, \textit{Larding the Lean Earth}, page 19
\textsuperscript{61} Ibid., page 34
\textsuperscript{62} Ibid., page 35
\textsuperscript{63} Ibid., page 20
not only as a way to increase yields and profits, but suggestive of “a hierarchy of land use in which rich sod represented the maturity of American civilization.”64 The conservation of land was thus a moral project.

Following the first great depression in the United States in 1819, the improvement movement began to take hold as a way to increase production and profits from fixed means. Old practices such as soil restoration and crop rotation once again rose to importance for farmers. An influential and innovative public figure during this time was James Madison, who criticized the greed of exploiting the earth’s resources for the exclusive benefit of human beings over all other creation. Furthermore, he “pointed to the key ecological factor in all perpetual cultivation—the ability of farmers to return the nutrients they take.”65 Improvement farmers did this by fertilizing their fields with animal manure, taking particular pride in the diverse herds of livestock that became a central fixture on their farms. By doing this, farmers were able to create an efficient, almost closed loop system that encapsulated their ethic of farming—resourceful, self-sufficient, and low waste. The ideas and practices being put forth here represent an early holistic understanding of landscapes and an ethic for conservation years before the science of ecology or the establishment of public land reserves.

The introduction of guano as a manure substitute, the first marketed agricultural input, marked the next major development in the legacy of industrial agriculture. From this point forward, “the biological foundation of American society became a one-way transfer of material from some point of extraction or production to the farm where it went into the crops, and from there to consumers.”66 This innovation not only accommodated the destructive emigration cycle

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64 Ibid., page 85
65 Ibid., page 39
66 Ibid.,
of farming already prevalent, but also helped to define agriculture in the mechanistic and reductionist terms that would be key in its industrialization.

**From Food to Factory.** New technologies in agriculture are so significant and potentially disastrous because they redefine our very relationship with the natural world. “Fertilizers, pesticides, reapers, and harvesters constituted vaulting achievements in the ability of farmers to make food and fiber from sunlight and soils, but they stood for the abandonment of an idea.”\(^{67}\) The particular idea in this example is the looping of nutrients within the farm and, more broadly, the idea of the farm as its own functioning landscape or ecosystem.

In 1840, a German chemist named Baron Justus von Liebig published *Chemistry in Its Application to Agriculture*, in which he identified the three chemical nutrients required for plant growth: nitrogen, phosphorus, and potassium. As Michael Pollan explains, this “NPK mentality” (as it was later referred to by English agronomist Albert Howard) “fostered the wholesale reimagining of soil (and with it agriculture) from a living system to a kind of machine: Apply inputs of NPK at this end and you will get yields of wheat or corn on the other end.”\(^{68}\) It demonstrates the negative side of reductionist science that seeks to isolate and simplify variables.

Chemical and biological methods of pest control in agriculture have been implemented and recorded for thousands of years, up until around the time of the collapse of the Roman Empire. They included everything from sulfur, various herbs and oils, garlic, pomegranate, seeds soaked in leek and cucumber extracts, the introduction of predatory ant colonies in orchards.\(^{69}\) A renewed interest in pest control was not piqued until many years later with the dramatic growth of agriculture from subsistence to commercial enterprise, now characterized by

\(^{67}\) Ibid., page 209
\(^{68}\) Pollan, *The Omnivore’s Dilemma*, pages 164-7
\(^{69}\) Winston, *Nature Wars*, pages 5-6
expanded acreage of only one or very few crop varieties, increased application of manure and fertilizer, row planting, and the mechanization of planting, weeding, harvesting, processing and transportation in international trade.\textsuperscript{70} This growth, of course, brought more pest problems. The first use of modern chemical pesticide was the result of an accidental discovery by a European grape farmer, who sprayed a mixture of copper and lime at the edges of his fields to discourage people from stealing his crop, only to notice that it inhibited the infection of the grapes by fungus.\textsuperscript{71} This combination remains the most commonly used fungicide, but in the years following this discovery, other inorganic compounds of arsenic, antimony, selenium, sulfur, thallium, zinc, and copper were developed.\textsuperscript{72}

Of course, the true “modern era of synthetic organic pesticides” did not commence until World War II and the race to develop chemical warfare.\textsuperscript{73} The tropical and sub-tropical climates in which this war was being waged were home particularly dangerous insect- vectored diseases, including malaria, sleeping sickness, dengue, and relapsing fever.\textsuperscript{74} The development of strong insecticides would therefore be crucial for any hope of success. But the same method promised to be effective in wiping out human enemies as well. Both sides began extensive testing in their clamor for the upper hand, each making crucial advances that would lead to development of modern pesticides, but the first major breakthrough was made by Paul Mueller, a Swiss chemist in the United States, who was testing a compound that “proved highly toxic to virtually all insects, and at extremely low doses”—dichlorodiphenyltrichloroethane (DDT).\textsuperscript{75} Another chemical innovation lending itself to combat at this time was the use of ammonium nitrate in

\textsuperscript{70} Ibid., pages 6-7
\textsuperscript{71} Ibid., page 7
\textsuperscript{72} Ibid., pages 7-8
\textsuperscript{73} Ibid., page 8
\textsuperscript{74} Ibid.
\textsuperscript{75} Ibid.
making explosives, but after the war, the government found itself with a huge surplus on their hands. It also conveniently happened to be a potent source of nitrogen for plants, so USDA agronomists advised its redirection to farms as fertilizer.\textsuperscript{76} The export of these technologies (along with innovations in high-yielding varieties of rice and wheat developed through an “international agricultural research system” funded in large part by the Rockefeller and Ford foundations) to developing countries experiencing food insecurity would come to be referred to as the Green Revolution.\textsuperscript{77}

The widespread adoption and active dissemination of these new agricultural chemicals was undoubtedly revolutionary. It not only helped change the practice and philosophy of farming, but the larger political and economic role of farming as well. It even changed the farmer’s relationship to managing pests. The advent of cheap and highly effective pesticides, sprayed liberally according to the schedules recommended by the companies selling them, created a “post-World War II generation focused on complete pest eradication” rather than control.\textsuperscript{78} This dependence on inputs in place of management techniques and reliance on chemical companies for resources and information is a dynamic that continues to exist and has trapped farmers in a cycle of destructive production on increasingly degraded and fragile land.

\textbf{Chapter 4. Agricultural Policy and Political Powers}

Government agencies have historically supported technological innovations in agriculture as opportunities to modernize, boost production, and get ahead in the global economy. In 1862, Congress established the United States Department of Agriculture and, from the very start, it was

\begin{itemize}
\item Pollan, \textit{The Omnivore’s Dilemma}, page 41
\item IFPRI, “Green Revolution: Curse or Blessing?”
\item Winston, \textit{Nature Wars}, page 9
\end{itemize}
so singularly devoted to modernizing farmers that “its experts eventually embraced any machine or chemical that promised increased production regardless of how technological change would affect farm families or the environment.”79 As it became more profitable, expanding from subsistence and local markets, farming became even more enmeshed with economic and political interests. The get-rich-quick craze of the merino wool industry in the early twentieth century represents a major turning point in this transformation. This was the first attempt by farmers to read the market and specialize their production in response. They were no longer raising diverse varieties of plants and livestock, but became growers of wool, specifically. Now farmers had a stake in the economy, which necessitated political involvement. Farmers supported their first industrial policy when they formed coalitions to lobby for the passage of a tariff bill to protect the value of the sheep they had invested in. In yet another transformation, farmers themselves became consumers because they were no longer producing the feed to raise their sheep. With this new dynamic “emerged the rudiments of industrialism, defined by a profound interdependence between agrarian and factory production.”80 After all this, farmers were finally ready to enter the world of manufacturing under the watchful and calculating eye of the USDA.

**The Militarization of Food.** With growing profitability, the powerful potential of agriculture beyond a source of human sustenance and livelihood was becoming apparent. The USDA has made its national agenda for agriculture clear. Earl Butz, the Secretary of State for Agriculture during the Nixon administration, notoriously pushed farmers to “regard themselves not as farmers but as ‘agribusinessmen,’” ordering them to “‘get big or get out.’”81 And as former Assistant Secretary Richard E. Bell has explained, “‘…true agripower…generates

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79 Stoll, *Larding the Lean Earth*, page 212
80 Ibid., pages 118-19
81 Pollan, *The Omnivore’s Dilemma*, page 52
agridollars through agricultural exports.”

But most alarmingly of all is Butz’s statements that

“Hungry men only listen to those who have a piece of bread. Food is a tool. It is a weapon in the US negotiating kit.”

Wendell Berry argues, “this militarizing of food is the greatest threat so far raised against the farmland and the farm communities of this country.”

Food, or hunger rather, has proven to be the ultimate persuasive political weapon. It has justified destructive practices and masked the intentions of international development projects and food aid initiatives. Clearly, this threat reaches far beyond American farming communities.

Despite the fact that we have (by no accident) a substantial and growing food surplus, anxieties about food security continue to subdue criticism of destructive agricultural practices and put off policy reform. The justification is often that the negative externalities are a necessary evil of what is really at stake—feeding the world. As Wendell Berry puts it, “projected rates of population growth have become the all-purpose threat and justifier of the apologists of the agricultural establishment” and “the hunger of these future millions is now the foundation of policy in the Department of Agriculture.”

The controversy of the Green Revolution has to do with much more than the floodgate of agricultural chemicals it bore unto the world under the justification of scientific advancement. And much more than the fact that we are still struggling to correct the reckless approach to pest management it helped install. It also has to do with the political and economic motivations underlying efforts to address hunger. While food aid and research and development projects may appear to be wholesome and well intentioned, they also make for an undeniable selling point, and a powerful way to create dependence and indebtedness. Furthermore, the technologies being promoted and exported may not be the

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82 Berry, The Unsettling of America, page 34
83 Patel, Stuffed and Starved, page 99
84 Berry, the Unsettling of America, page 9
85 Ibid., page 59
miracle solutions to hardiness and productivity they have talked up to be. Raj Patel points out that, “in order to work, the seeds required almost perfect growing conditions, which demanded irrigation, fertilizers and pesticides,” and “the expunging of native biodiversity, so that rows of the new seed might take its place.”\textsuperscript{86} In this way, the Green Revolution didn’t just develop and export new agricultural technologies, but a new way of farming altogether—one that depends on chemical inputs and the companies that sell them.

Innovations since then have built directly upon this model. Patel argues that the propagation of genetically engineered crops, making new promises of extraordinary resilience and productivity, “presents itself as a feel-good solution for politicians who’d rather not face the more profound, persistent and difficult questions of politics and distribution.”\textsuperscript{87} The danger of GM crops, such as the “Golden Rice” that is planned to halt blindness in children suffering from vitamin A deficiencies, is their use as publicity stunts, as miracle solutions that prevent real discussions of the systemic problems creating such malnutrition in the first place. But there are also significant ecological dangers. Bt crops, for example, have a built-in insecticide produced by the soil bacterium \textit{Bacillus thuringiensis}. For the first few years, these crops allow farmers to drastically cut down on the amount of insecticide they have to spray. But after a while, the ecological niche left by the targeted pest being wiped out is taken up by a new secondary pest, and farmers suddenly have to spray exponentially more than they did on their conventional fields. So-called “RoundUp-ready” crops, on the other hand, are engineered with pesticide resistance, so that more pesticide (RoundUp, of course) can be sprayed to more effectively

\textsuperscript{86} Raj Patel, \textit{Stuffed and Starved}, page 130
\textsuperscript{87} Ibid., page 146
eradicate pests. The ultimate result, Patel argues, is “deskilled” farmers and “the collapse of an entire farming system.”

**Business Opportunities.** Clearly, government agencies are not the only ones who capitalize on the threat of hunger. Immensely powerful “agribusiness conglomerates” dominate the production and distribution of food in America—the ten largest companies controlling half the world’s seed supply, and 90 percent of the pesticide market. “According to a 1999 report, at least 22 food, agriculture, or food chemical firms ranked among the ‘top 100 corporate criminals of the decade’ on the basis of the size of the fines they had paid for violating federal laws.” Yet, agricultural policy is made with close communication with these food and chemical companies. Lobbying is done by arranging campaign contributions, staging media events, harassing a public official’s critics, and most importantly forming close personal connections through meetings and social occasions. Revolving-door politics (from lobbyist to public servant and vice versa) is another way that food and chemical company interests are represented and is a practice particularly common in the USDA. One example of just how absurd and problematic this process can be is the career of Michael Taylor. While he began as a lawyer and counsel to the FDA, he eventually moved directly to position at King & Spalding, a private-sector law firm representing one of the leading agricultural biotechnology companies, Monsanto. Taylor then returned to the FDA as Deputy Commissioner for Policy, helped issue some industry-friendly policy on food biotechnology, was investigated then exonerated of conflict-of-interest charges, moved on the USDA as the administrator of its Food Safety and Inspection Service, then returned to King & Spalding, and finally ended up as Vice President for

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88 Ibid., page 148
89 Ibid., pages 109-12
90 Nestle, *Food Politics*, page 170
91 Ibid., page 95
92 Ibid., page 101
Public Policy at Monsanto.\textsuperscript{93} Yet another way for these companies to exert their power is through the courts. Many times, this means waging legal war against private citizens. Even if the defendants have a chance of being successful, it comes at such enormous financial burden that they are forced to settle or comply in some other way. Most of the effect of lawsuit is intimidation, to warn those looking to criticize, defame, or investigate companies, or even the industry in general, of the consequences. In the 1990s, “veggie-libel” food-disparagement laws were created in response to an herbicide scare in apples.\textsuperscript{94} Through lobbying by the food industry, 13 states were convinced to adopt them; the one enacted in South Dakota “specifically prevented people from saying that generally accepted agricultural practices (such as the use of pesticides, no doubt) might make foods unsafe.”\textsuperscript{95} This is just a small example of how private interests and government continually work to weaponize and politicize issues of food in ways that have massive health, environmental, and social consequences.

\textit{Government Regulation}. The negotiators of agricultural policy have always maintained a somewhat tumultuous, push-and-pull relationship. At times it has been unclear exactly who the Department of Agriculture is representing and who their regulatory policies are meant to protect. Apparently, “America’s farmers had long been making political trouble for Wall Street and Washington” and united with the labor movement in the 1890s in a common cause to check the power of corporations.\textsuperscript{96} At some point, this opposition broke down and “by the end of World War II, a period during which government and food producers worked together in the national interest, farmers and food producers had come to view USDA as their department and its

\textsuperscript{93} Ibid.
\textsuperscript{94} Ibid., page 162
\textsuperscript{95} Ibid., page 163
\textsuperscript{96} Pollan, \textit{The Omnivore’s Dilemma}, page 50
secretary as *their* spokesman.”97 Together, food producers, USDA officials, and members of the House and Senate Agricultural Committees became known as the “agricultural establishment”—“an entity so strongly united in purpose that it could ensure that any federal policy related to land use, commodity distribution, or prices would promote the interests of food producers.”98 But as the category of “food producers” became more stratified, farmers’ interests became distinct from those of the food and chemical companies that were cashing in on processing, transporting, and chemically treating food. In the aftermath of the Great Depression, New Deal programs aimed to support farmers by creating a grain reserve out of the surplus corn they had produced. However, other food producers using corn as their input were not happy about this policy that cut them off from cheap supply. Over the next few decades, this support system for farmers was slowly dismantled. It took its final blow in the 1973 farm bill, in which then USDA Secretary Earl Butz replaced loan programs with direct subsidy payments to farmers, who could now price their product as cheaply as they wanted and be reimbursed for the difference in price loss.99 This is where big grain buyers like Cargill and Archer Daniels Midland (ADM) took interest and, beginning in the 1980s, were even given an in on the process of shaping future farm bills, which increasingly reflected their interests.100

The USDA has not been the only one to grant such concessions. In 1977, Congress expanded the jurisdiction of the agricultural committees of both houses to have control over “policies and programs related not only to agricultural production, marketing, research and development but also to a wide range of new areas: rural development, forestry, domestic food assistance; some aspects of foreign trade, international relations, market regulation, and taxes”—

97 Ibid., page 97
98 Ibid., pages 97-8
99 Ibid., pages 52-3
100 Ibid.
quite far-reaching influence for agriculturalists.\textsuperscript{101} Even the White House seems to be at the mercy of food companies: over the decades-long controversy of the Food and Drug Administration’s food pyramid, many specialized food industries thought it was unfair to suggest any kind of hierarchy of nutritional value. Philip Morris, for example, wanted to protect the products of its Kraft cheese subsidiary by being able to label them low in fat. They directly requested that the White House prevent the FDA from blocking these claims, and in response, the White House refused to accept the FDAs proposal until they raised the daily allowable fat limit.\textsuperscript{102} In response to criticism “governments have gone to great lengths to ensure that interventions in the food system can be seen as functioning in the national interest.”\textsuperscript{103}

Being a believer and active promoter of modern industrialized agriculture, the USDA was initially very hostile to the organic movement that was gaining popularity in the 1970s. But when the EPA declared Alar (a common growth-regulated chemical used in conventional orchards) to be a carcinogen in 1990, the resulting panic forced the world to be more wary of biotechnology and to pay more attention to non-chemical methods.\textsuperscript{104} That same year, Congress passed the Organic Food and Production Act (OFPA), which gave the USDA jurisdiction in establishing national organic standards, officially and uniformly defining organic food and organic farming for the first time.\textsuperscript{105} Of course, the following decade was spent battling over the particulars of this definition according to opposing the interests of organic farmers and agribusinesses.

Of course, we must recognize the progress that has been made. The USDA now recognizes and admits to the destructive nature of the agriculture they had been promoting for so

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\textsuperscript{101} Ibid., page 98  \\
\textsuperscript{102} Nestle, \textit{Food Politics}, page 256  \\
\textsuperscript{103} Ibid., page 22  \\
\textsuperscript{104} Pollan, \textit{The Omnivore’s Dilemma}, page 154  \\
\textsuperscript{105} Ibid.
\end{flushright}
long. They now embrace more holistic and less toxic approaches, including organic farming, polyculture, and integrated pest management. Mark Winston acknowledges that, “our scientific concepts of pest management are evolving toward multidisciplinary techniques that view pests as normal components of ecosystems that can be best controlled through integrated management techniques rather than brute eradication.” But, he argues, we are still lacking in philosophical progress on the issue:

“…our thinking about pests and the practice of pest management has taken place in the context of our broader thinking about the role of humans in nature. Attitudes have ranged from our divine right to manipulate nature for our own ends to an environmental ethic that views humans as caretakers of Eden. Pests are a part of this larger issue, and our decisions about managing them tell us much about ourselves, about how we view nature, and about the problems that develop as we attempt to fit the earth into a mold that is of increasingly human design. We may need to conduct particular battles against pests, but out battles have lately escalated into a costly war on nature itself, and in the end it is a war we are bound to lose”

Chapter 5. Shifting Perspectives and Restoring Ecosystems

One of the reasons pest management provides such an illuminating look into the state of our agriculture is because, in terms of required technology and scientific understanding, solutions are so apparent and alternatives so accessible that our continued misuse is indicative of how complex and embedded environmentally destructive behaviors can be. Although conventional

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107 Ibid., page 18
methods of pest preventions have been defended as a necessary evil for adequate levels of food production, their history in the United States is relatively short and has been widely acknowledged as extremely problematic for decades—at the very latest, since Rachel Carson’s *Silent Spring* in 1962. In looking at the supporters and challengers, the victims and the beneficiaries, its fixture as part of a primarily political and economic institution is clear.

By taking a closer look into the agricultural pesticide industry, the degree to which private interests control public perception, government policy, and food production as a whole is undeniable. The hope is that a deeper understanding of the influence behind this industry might offer an opportunity to disassemble the framework of corruption, contradict misinformation, transform attitudes, and reclaim farming as a responsible and ecologically sound endeavor. But considering the complacent role that government agencies such as the USDA have assumed with powerful food and chemical companies, often representing their interests over those of farmers and consumers, seems to offer little hope for solutions through legislative reform. Wendell Berry argues that this kind of “big” solution through policy would never be the answer anyway. Solution will not come from government agencies, or any kind of organization or institution, he argues, because the corruption of land suggests an inward corruption. Therefore, the solution must come from the individual, enforced from within by one’s own ethic and discipline, not imposed by policy. From there, a private solution will turn into public solution as the individual engages with their community. In many ways, Wendell Berry echoes the sentiments of early American improvers, emphasizing independence and self-sufficiency and the active engagement with a specific place, saying, “the healthy farm sustains itself the same way that a tree does: by belonging where it is, by maintaining a proper relationship to the ground. It is by this standard of health or independence that one recognizes the absurdity of a farm absolutely dependent upon a
complex of industrial corporations, which are in return dependent upon the actions of foreign
governments and politicians whom the farmer did not vote for or against and cannot
influence."

In proposing solutions, he says “the first necessary public change is simply a
withdrawal of confidence from the league of specialists, officials, and corporation executives
who for at least a generation have had almost exclusive charge of the problem and who have
enormously enriched and empowered themselves by making it worse.” After investigating the
trends of federal agricultural policymaking in the USDA, there is not much confidence for a real,
effective solution left to give up. Berry offers a crucial perspective of personal responsibility and
participation within a person’s specific place or community. These principles all tie in to
ecological understandings of agricultural solutions for protecting biodiversity, restoring soil
health, and empowering local farmers to maintain their livelihood and escape the destructive
cycles of land use.

Why Organic Is Not the Answer. The obvious alternative to industrial agriculture is
often assumed to be simply “organic.” It’s true, pesticides themselves are poisoning landscapes,
causing ecological stability, sterilizing soils, and compromising crop health. But our use and
reliance on them indicates a deeper problem. This is precisely why, as Mark Winston argues,
our philosophical comprehension of pest management needs to come to the fore of changing
practices and policies. Maybe then, more people would be aware that the organic producers
supplying most supermarkets are no less industrialized than their chemical-laden counterparts.
And that sometimes, both conventional and organic fields lie next to one another on the same
farm, owned by the same company. With more of a philosophically driven understanding of pest
management, we might realize that sustainability is not necessarily about remaining chemically

108 Berry, *The Unsettling of America*, pages 183-4
109 Ibid., page 219
pure. At one point in time, organic agriculture represented such a philosophy. During its rise to popularity in the 1970s, it was built around “the ecological premise that everything’s connected to everything else” and “sought to establish not just an alternative mode of production (the chemical-free farms), but an alternative system of distribution (the anticapitalist food co-ops), and even an alternative mode of consumption (the ‘countercuisine’).”\textsuperscript{110} Today, organic agriculture is an $11 billion industry, and the fastest growing market sector in agriculture. Big food and chemical companies have responded to this opportunity and created their own version of organic where “the same factory model is at work in both fields, but for every chemical input used in the farm’s conventional fields, a more benign organic input has been substituted in the organic ones.”\textsuperscript{111} What was originally intended to be a distinct departure from industrial agriculture now easily fits into the exact same “chemico-mechanical conception of growing food” as the conventional approach.\textsuperscript{112} For this reason, solutions cannot simply focus on the symptoms of the way we think about farming (i.e., the externalities of pesticide use), but must address the more profound flaws in our system. Similarly, the problems that pesticides cause are not felt in isolated incidents, but ripple throughout a larger ecological framework, being magnified and transformed in ways that we may never fully comprehend.

\textit{Solutions from Ecoagriculture.} This new agricultural “paradigm” embodies the kind of fundamental shift modern agriculture would have to undergo to be ecologically informed. For one thing, it does not aim for a singular goal, such as productivity or profit, but looks to simultaneously uphold conservation, biodiversity, and rural development. Researchers focus on issues such as food security, crop domestication, habitat restoration, agroforestry, integrated pest

\footnotesize\textsuperscript{110} Pollan, \textit{The Omnivore’s Dilemma}, page 143  
\textsuperscript{111} Ibid., page 159  
\textsuperscript{112} Callicott, \textit{Beyond the Land Ethic}, page 268
management, and community leadership. Much different than national institutions of agriculture currently installed in the United States (including both the USDA and the monopoly of big food and chemical companies), ecoagriculture seems to be much more adaptable to a community scale. In this way, it provides a unique opportunity for small farmers to organize, support each other, and take back responsibility for the way they engage with their land. Ecoagronomists also offer insight into ecologically informed solutions for specific agricultural problems that will help to restore health and stability to landscapes by counteracting the damage done by conventional methods.

In maintaining biodiversity, agricultural landscapes must be recognized as critical habitat with pieces of land designated exclusively for surrounding wildlife. The strategy found to be most effective for maintaining biodiversity is the maintenance of hedgerows. “Ecoagricultural landscapes are land-use mosaics consisting of the following:

- ‘Natural’ areas (high-quality habitat niches to ensure ecosystem services that cannot be provided in areas under production)
- Agricultural production areas (productive, profitable, and meeting food security, market, and livelihood needs)
- Institutional mechanisms to coordinate initiatives to achieve production, conservation, and livelihood objectives”

The shape and quality of these areas determine their success—High quality patches include native vegetation, and are compact, and less exposed to the agricultural matrix. The second most effective strategy for maintaining biodiversity is organic agriculture, as “several studies have

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113 Ibid., pages 8-9
demonstrated that the application of agricultural chemicals significantly reduces soil biodiversity, while the reduction or elimination of those chemicals results in higher below-ground biodiversity.”\textsuperscript{114} Mixed cropping is another top strategy, which illustrates the need for farmers to adopt diverse cropping systems based on polyculture over conventional ones on monoculture for the complete health of the landscape. Ecoagriculture acknowledges that the conservation of biodiversity doesn’t just involve setting aside habitat, but “includes maintaining the biological processes (e.g., predator—prey and plant—pollinator relationships) that produced those organisms and of which those organisms are a part.”\textsuperscript{115}

Perennial grains offer major breakthroughs for the reduction of pesticides and soil erosion. Because they cover the land year-round, they hold the soil in place—making them up to six times more effective at preventing erosion than annuals—and block sunlight from getting to sprouting weeds. Agroforestry is another important ecoagricultural solution, defined as “a type of land use with the simultaneous aim of promoting human welfare and environmental resilience.”\textsuperscript{116} Planters must fully engage with ecological processes by recreating successional phases akin to the succession of natural ecosystems so that trees producing different agroforestry products (AFTPs) and providing different services can fill niches in the farming system—“A domestication strategy results in the formation of three populations: the genetic resources population, the selection and breeding population, and the production population.”\textsuperscript{117} Livestock can be added to no-tillage systems to help to increase plant biomass and soil biota by adding manure and hoof action. Of the 8% of plants with edible parts, only about 0.04% percent have been domesticated for food; the domestication of wild species offers considerable gains in

\textsuperscript{114} Scherr and McNeely, \textit{Farming with Nature}, page 29

\textsuperscript{115} Ibid., 23

\textsuperscript{116} Harvey, “Designing Agricultural Landscapes for Biodiversity,” page 149

\textsuperscript{117} Leakey, “Domesticating and Marketing Novel Crops,” page 95
introducing biodiversity and strengthen the agroecosystem by incorporating native species.\textsuperscript{118}

Integrated pest management (IPM) describes a broad set of strategies for maintaining a threshold level of pest populations below seriously damaging, from creating habitat for natural predators, planting hedgerows and cover crops, intercropping, creating beetle banks and other shelters, setting traps, or even introducing sterile male insects to the pest population. But the biggest breakthrough of IPM is that it is in its application of holistic ecological approaches.

Most important, though, are the themes of community leadership in ecoagriculture. A major concern for development projects with funds or leadership imposed from outside groups is misunderstandings of a community’s needs and resources and the failure to apply local knowledge according to the specific environment in favor of broad, generalized approaches. It is important to identify what has and has not worked in the past and, most importantly, to remember that there will be no universal answer across people, farms, or local environments.

\textit{Policy Recommendations.} Reform is needed on a personal, community, and national level. Again, policy reform alone will not be able to address the fundamental flaws of our relationship with the land, but there are a handful of policies and standards in place that seem plainly unjust. Through the process of industrialization, most small-scale farmers have been pushed out by the necessitation of new and prohibitively expensive input products and technology, which come along with new standards of production and sanitation. The small number of farmers who now remain are overseen by, and at the mercy of, billion-dollar multinational corporations that exert their power through the promise of abundance made by their patented, genetically modified seeds through binding legal contracts. Anyone who opposes these giants by breaking such a contract or speaking out against them in any way must

\textsuperscript{118} Ibid., page 86
face a storm of litigation of financially incomprehensible proportions. This economic monopolization of the industry affords them considerable political power. By altering the process and content of agricultural policymaking, they ensure legislation that facilitates their goals and the crops they produce—mainly corn and soybeans. They sell us propaganda about the advancement of food production through ingenious innovations in technology developed by scientists and trained professionals in order to guarantee food security in the face of an ever-growing and hungry population. Worst of all, government actors facilitate this monopolization by tailoring legislation and subsidizing these specific stable crops. The incredible expansion of productivity in agriculture might be considered an accomplishment but, as Wendell Berry argues, “this ‘accomplishment is not primarily the work of farmers—who have been, by and large, its victims—but of a collaboration of corporations, university specialists, and government agencies. It is therefore an agricultural development not motivated by agricultural aims or disciplines, but by the ambitions of merchants, industrialists, bureaucrats, and academic careerists.”

Therefore, reform is needed to keep these companies out of the policy-making process to make agricultural policies for farmers and about farming, not profit. Subsidies must move away from staple crops such as corn and soybeans, which are now the main fuel of the industrial agriculture machine, and toward diversifying agricultural landscapes. Subsidies could be redirected to farmers including high-quality natural areas for native wildlife, and those implementing IPM techniques.

Researchers in ecoagriculture maintain that community-based approaches will need government support as well, and “without legislation and policy frameworks that enable local communities and small-scale producers to own and derive benefits from their resources, their

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119 Berry, The Unsettling of America, page 33
willingness and capacity to implement ecoagriculture is severely compromised.”\(^{120}\) Instead of broad federal policy, state policy might be better suited to help organize initiatives based on local needs. But no matter what “initiatives should emerge from and be driven by community representatives themselves, based upon innovations that meet their inherently linked livelihood goals and objectives. Local land-use systems and decisions are often founded upon long-term accumulation of knowledge and experimentation about what will and will not work.”\(^{121}\) Ecoagricultural approaches will require more work than conventional mechanized ones, but farmers will have the opportunity to “reskill” and forge a more involved and rewarding relationship with their land. Finally, for farmers feel secure that there will be a market to support them, consumers must also take an interest in ecoagriculture, including buying local products and getting involved with local policymaking. We all need to take responsibility to make farming for and about farming, guided by principles of what it truly is—a cooperative relationship between human beings and the land.

\(^{120}\) Bumacas, et al., “Community Leadership in Ecoagriculture,” page 303

\(^{121}\) Ibid., page 289
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