Agroecology in Action:
Social Networks Extend Alternative Agriculture
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Introduction & Chapter One
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Introduction
Re-thinking the ecology of industrial agriculture

Science consists not in the accumulation of knowledge, but in the creation of fresh modes of perception (Bohm 1993).

_Silent Spring_ upset American thinking about technology and the environment. Rachel Carson challenged society to think critically about the relationships between agriculture, science, and nature.¹ Agriculture serves as the fundamental metabolic relationship binding nature and society, and our agro-environmental problems are symptoms of the underlying ruptures between them.² Carson exposed the serious harm that the agrochemical production paradigm visited upon human health and the natural world. Over time, agriculturalists and their allied industries have generally responded in one of two ways: by dismissing these problems, or by learning their way out of them.

This book describes how some growers, scientists, agricultural organizations and public agencies have developed innovative, ecologically-based techniques and new models of social learning to reduce reliance on agrochemicals, and thus put agroecology into action. It describes the technical scope and geographic range of ecologically-based strategies and practices in American agriculture, analyzing in detail a set of specific agroecological partnerships in California. This book explains how agroecology has become the primary approach to addressing the environmental problems of agriculture, but its lessons have implications for any initiative to deploy ecology for environmental problem solving.

_Silent Spring_ was the first major book to raise serious questions about American industrial agriculture. Carson brought to public attention a most disturbing irony: the agriculture upon which we depend for sustenance was poisoning our environment and our very selves. Indiscriminate use of chemical technologies risked our planet and future generations. Carson made pollution visible, but also the inescapable ecological interdependence of society and nature. Her work led to the creation of the US

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¹ Carson (1962).
Environmental Protection Agency, the banning of the most hazardous pesticides, and more regulation on the use of many others. Less well known are the innovations in agriculture her work inspired.

Four decades after the publication *Silent Spring*, American society continues to wrestle with agricultural pollution. US agriculture has doubled its use of pesticides since its publication. Agriculture is the nation’s leading cause of non-point source water pollution. Surface, ground, and coastal waters are seriously impaired, not just by pesticides, but by nitrogen fertilizers as well -- Carson never anticipated the scale and impact of nutrient pollution. Farmworkers and rural communities continue to suffer from pesticide drift. The indiscriminate use of agrochemicals threatens the future of earth’s biological diversity. Agriculture has extensive negative environmental impacts, and these directly threaten rural communities, and the health of American society.

Carson sparked the modern environmental movement by making normative claims on society, inspired by an ecological vision. The scientific discipline of ecology assumed much greater social prominence as a result of her work and subsequent political advocacy. In the final chapter of *Silent Spring*, Rachel Carson described “the other road” of ecologically based pest alternatives, the “extraordinary array of alternatives,” based on ecological science. “Much of the necessary knowledge [of alternatives] is now available but we do not use it.” Since *Silent Spring*, ecology has proposed many more environmentally responsible practices, but they lack the immediate incentive of economic appeal inherent in most other technological innovations. Environmental critics of agriculture (including the National Research Council) have repeated Carson’s refrain identifying existing alternatives and decrying their lack of adoption. The greatest obstacle to ecologically-based alternative practices has not been a shortage of ideas, but more the dearth of practical educational initiatives – also known as “extension” – to help producers learn about them.

Agroecological strategies and practices require more sophistical knowledge, demand specialized labor, and in some cases may entail more economic risks for growers, yet they hold out the greatest hope for reducing agriculture’s environmental impacts. Despite the potential social benefits they offer, American agriculture’s publicly funded scientific institutions have rarely embraced them, and when they have it has often been under duress. Generally, over the past two decades, agroecological strategies

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3 Throughout this work, the term “pesticide” is used to refer to insecticides, herbicides, fungicides and rodenticides. For national trends, see Aspelin (2000), page 4.9. Much of this increase is due to the greater reliance on herbicides in the Midwest farm belt.
4 In 1991, the U.S. Congress funded the US Geological Survey to conduct a major survey of US water quality, the National Water-Quality Assessment Program (NAWQA, pronounced “naw-qua”). NAWQA’s research focuses on more than fifty major river basins. For a national overview, see U.S. Geological Survey (1999).
5 See Carpenter et al. (1998), and Howarth et al. (2000).
7 See Colborn et al. (1996), and Hayes (2005).
8 Carson (1962), 263.
9 National Research Council (1993), but see discussion below.
have first been requested by growers or growers’ organizations. The dominant, publicly funded agricultural science institutions, the land grant universities and “Cooperative Extension Service,” continue to operate out of a “Transfer of Technology” paradigm, delivering technologies to “end users,” despite incontrovertible evidence that it is these technologies which are environmentally problematic substances, chiefly agrochemical fertilizers and pesticides.

The search for alternatives
Many are the stories of agriculture’s environmental problems, but this book is about initiatives to create solutions. It describes how agroecology has emerged as the primary conceptual framework for addressing modern agriculture’s economic and environmental crises. Agroecology can only be effectively put into action when networks of growers and scientists learn together about the local ecological conditions shaping farming. Agroecology cannot be “transferred” like a chemical or mechanical technology; it must be facilitated by social learning, which I define as: diverse stakeholders participating as a group in experiential research and knowledge exchange to enhance common resource protection. Agroecological initiatives require a collaborative network to facilitate this social learning.

Since agriculture manipulates for human benefit the interactions of plants, animals, and the resources they need, ecological relationships are always present in farming even when modern industrial technologies dramatically alter them. Over the past two decades, farmers and scientists have begun deploying agroecology for economic and environmental problem solving. Many authors are beginning to use this term, but no previous work addresses the social relations necessary to support the extension of agroecology and its practical application.

Social learning processes using agroecological strategies and practices have become the chief strategy for extending more “sustainable” alternatives within conventional agriculture over the past twenty years. The social learning model required to put agroecology into action relies more on knowledge exchange than the delivery of technology and static expert knowledge. Producers, growers, farmers, their organizations, and scientists must be able to work collaboratively to share the different kinds of knowledge they bring, whether derived from the farm, laboratory, or marketplace. Those managing the farm must develop new skills of observation and decision making, but expert scientists must recognize this as practical, local knowledge.

These extension activities have been much more successful with the help

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10 For an analysis of social learning for environmental protection, see Woodhill and Röling (1998).
11 Both Röling and Wagemakers (1998) and Hassanein (1999) investigate social learning processes and networks in sustainable agriculture, but they do not explicitly use agroecology as a framework for investigating extension processes.
12 My understanding of the centrality of knowledge questions in sustainable agriculture draws from Jack Kloppenburg’s (1988) groundbreaking work First the Seed: The Political Economy of Plant Biotechnology, and his (1991) article on the de-/re-construction of agricultural science for alternative agriculture. Neva
of a growers’ organization, one committed to growers’ needs and leadership, but capable of scientific competence and projecting a positive vision for agriculture. As this book demonstrates, in many cases growers and farmers have developed agroecological strategies and practices before agricultural scientists, and in some cases, despite the resistance of publicly funded institutions. In America, agroecological practice has usually led theory, and varied kinds of growers’ organizations have assumed new roles in facilitating the exchange of this knowledge through partnerships.

This study describes and analyzes key US agroecological initiatives: their origins, organization, networks, practices, and impacts. The book describes initiatives from every major region of the US, but with special emphasis on original field work in California. By surveying diverse agroecological initiatives, this book explores the operational meaning of agroecology in the US. In general, agroecological initiatives have been more successful in states with sustainable agriculture programs hosted by a land grant university, although these programs have had uneasy relationships with their parent agricultural research institution. California’s diverse specialty crop agriculture has given rise to 32 partnerships in 16 different cropping systems, and the analysis of these suggest important lessons for agroecological practice with relevance across all forms of agriculture in the industrialized world. These California initiatives use what they call the “agricultural partnership model” to guide their extension activities, an approach differing in important ways from conventional technology transfer. I restrict my use of the term “agroecological partnerships” to initiatives using alternative extension practices at a field scale, whether in California or elsewhere. These 32 partnerships form a coherent phenomenon, facilitating comparative analysis about the practice of agroecology in a specific regional context. This study carries important programmatic implications for any effort to help industrialized agriculture protect environmental resources, but it also raises questions about the character and practice of agricultural science. To interpret these efforts and controversies, I will draw from Science & Technology Studies, and in particular, the conceptual framework of Bruno Latour.

Ultimately, agroecological initiatives seek to engage broader society in support of this new approach to farming. Without supportive scientific and economic policies, agroecology will remain a subordinate, marginal practice. Taken as a whole, this study addresses critical, contemporary issues at the nexus of food, environment, and health by describing how public policies shape the social context in which agroecological partnerships try to improve environmental management.

Organization of the book
The first chapter opens with three vignettes tracing the secondary impacts of *Silent Spring* on the development of agroecological solutions to environmental and production problems in pear, winegrape, and almond farming systems. These provide insight into

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Hassanein (1999), his doctoral student, substantially shaped my understanding of the critical role of knowledge and power relations in social networks for sustainable agriculture.
the diverse ways that growers, applied and research scientists, and growers’ organizations have created networks to solve interlocking environmental and production problems. This chapter then recounts how Carson’s vision impacted agricultural regulation and science. She initiated a public outcry about pollution that led to strengthened pesticide regulations, although the US government has never created a comprehensive framework to address agriculture’s environmental impacts. Agroecological initiatives have emerged to meet air and water pollution prevention goals that cannot be achieved through regulatory enforcement, in large part because of the diffuse character and ecological contexts of agriculture. Carson critiqued the contemporary practice of science as well, and agroecology has emerged as the primary scientific paradigm to guide new approaches to farming. This chapter will also introduce Latour’s circulatory model of science, which will serve as an interpretive tool for understanding the scientific controversies underlying research and extension in agroecology.

The second chapter narrates the development of two pioneer agroecological initiatives in Wisconsin and Iowa. Networks of intentional rotational graziers and a partnership between the Practical Farmers of Iowa and the Leopold Center at Iowa State University developed new models of farmer-scientist relationships in the American Midwest during the 1980s. These land grant universities were relatively (albeit modestly) responsive to the expressed desire for new, more sustainable forms of production, and they expressed this through the creation of new programs. Constructively engaging scientific institutions has been a fundamental challenge for agroecological initiatives, because conventional agricultural science has deployed reductionist logic and resisted taking a systems approach. This chapter introduces the land grant universities, describing the controversies surrounding the operational understanding of their products, clients, and extension processes. Agroecological initiatives have emerged on the margins of these institutions, but nevertheless, need their expertise to grow.

The third chapter describes and analyzes the evolution of the agroecological partnership model in California. Although the original almond production techniques were developed by a grower, the pathbreaking BIOS almond partnership emerged from his interactions with an extensionist, a research scientist, and a staff member from a non-governmental organization. Acting together, these pioneers parlayed this partnership into a model for other commodities and for new granting programs. This has come to be known as the “agricultural partnership model” which is a loosely-held set of assumptions about how various participants can work together to solve problems. Factors both internal and external to agriculture favored the expansion of this model over the past decade. This chapter presents data on the progress three commodities have made in reducing pesticide use and improving their overall environmental performance, and surveys national patterns of the partnership phenomenon.

Opening with a narrative of how a group of Washington State growers worked together and partnered with others to create more sustainable forms of farming, the fourth chapter describes the partners and their motives for association. Partnerships
require active participation by growers, scientists of all kinds, and agricultural organizations. This chapter reports on the characteristics of participating growers and how they interpret the value of partnership activities. Agricultural scientists are configured in a hierarchy according to their primary type of scientific activity and economic sponsor, yet partnerships require the participation of diverse types of scientists, and successful partnership leaders have found ways to provide incentives for all of them to contribute. Partnerships mark the entrance of agricultural organizations into extension activities, and they do so as intermediaries between growers and the public, represented by markets and regulatory agencies concerned about pesticides and pollution.

New technologies and management techniques have shaped the ecology of farming systems, and the narrative opening the fifth chapter illustrates how they pose challenges yet present opportunities for using agroecological strategies in almond farming systems. Partnerships use agroecological principles to guide the development and deployment of specific techniques to manage crops, animals, pests, nutrients, soil, and water; some partnerships capture synergistic benefits by managing these farming system components. This chapter presents a five-part analysis of the agroecological strategies of California’s agroecological partnerships.

Using the scientific support necessary to implement codling moth pheromone mating disruption in pears as a case study, chapter six describes the social networks shaping partnership development. Successful partnerships have not created new relationships so much as intensified existing ones, weaving disparate relational threads into a common whole. The networks they constitute facilitate the generation and exchange of knowledge to better manage crop and non-crop organisms – and their ecological relationships – in farming systems. This chapter describes how strategic choices shape different configurations of networks, and how partnerships shape the development trajectory of agricultural research and extension.

The seventh chapter presents a model of what agroecological partnerships must have to successfully impact a commodity production system. Its opening narrative explores the full range of initiatives one California winegrape partnership has undertaken. It describes the essential components of a successful partnership: the human participants, the scientific knowledge, dynamic social networks, and supportive off-farm institutions. It illustrates the value of Latour’s model for understanding the scope of partnership activities.

The final chapter looks at the future of agroecology, and opening with a narrative about a potato partnership in Wisconsin, it shows how partnerships must be able to link to the larger public. The chapter draws conclusions about the significance of agroecological partnerships to address environmental problems, and summarizes the key principles that have made partnerships successful. This book explains the origins and accomplishments of these partnerships, but also suggests what additional work must be done to fulfill the alternative, ecological vision of Silent Spring. Ultimately, ecological knowledge from the farm must flow outward to engage the public, and this chapter identifies the kinds of agricultural scientific and economic policies that must
emerge to support them. Without such an integrated effort, agriculture in this country faces a dubious future.

Each chapter begins with a narrative of how partnership participants have come together to realize the possibility of alternative agricultural production practices, before turning to a social science analytical approach for the balance of each chapter. Michael Pollan’s *The Botany of Desire: A Plant’s Eye View of the World* inspired this descriptive approach. The narratives convey the dynamic interaction between plants, animals, and people. They provide an entrée into the socio-ecological world of farming. Collectively they describe an extensive cast of characters, but that is itself essential to this story. There is no one law, program or scientific expert driving these changes, and different partnerships follow their own paths to distinct ends. These networks are largely self-created and markedly less hierarchical than conventional extension. Readers will find a *dramatis personae* in an appendix at the end of the book.

Three years of field interviews, primarily in California, provided information about these partnerships. These consisted of more than 135 personal interviews, 13 focus groups with 84 persons, and participant observation at 32 meetings. All quotes are from these interviews unless indicated otherwise. Additional source materials for the narratives and social science analysis are documented thoroughly in the methodological appendix of my dissertation, upon which this book is based.  

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Chapter One
Rachel’s dream: agricultural policy and science in the public interest

Optimizing eco-rational technologies
Doug Hemly’s great-grandfather planted pear trees on Randall Island about 15 miles south of Sacramento shortly after the California Gold Rush, making this the longest continually cultivated perennial crop production region in the state (figure 1.1). The codling moth (Cydia pomonella) had plagued the fruit grown by his great-grandfather, his grandfather, and his father, so Doug had become accustomed to pesticides, although he had never really liked using them. During the 1970s Hemly and his father had actively cooperated with University of California (UC) researchers to develop ecologically informed strategies for using pesticides, timing their application carefully and using the least amount possible. This approach controlled the pest populations, but relied to the greatest possible degree on the beneficial action of predatory and parasitic insects. With the help of UC scientists, Pat Weddle had developed protocols for carefully tracking the peaks and valleys of population dynamics following the principles of Integrated Pest Management, or IPM. Weddle, a professional entomologist and consultant, or pest control advisor (PCA), advised Hemly about pest management for years. Their approach worked well until the bugs got uppity.14

Pesticide resistance develops within a population when repeated applications cull its most susceptible members, allowing only the fittest to survive and reproduce. Synthetic pesticides intervene in the ebb and flow of insect populations, a technological mimic of Darwin’s natural selection. The codling moth is a particularly robust pest, having demonstrated resistance to lead arsenate in the 1920s and DDT in the 1950s, in the latter case after less than ten seasons. After World War II, the chemical industries adapted the organophosphates (OPs), originally designed as weapons of war, to use against insects. Scientists and growers discovered they could use one OP, azinphosmethyl (Guthion), with their pear IPM strategies. By spraying it conservatively and precisely, growers managed their codling moth populations for thirty years, until 1991 when it stopped working. They applied the maximum legal rate -- four sprays of three pounds per acre of Guthion – and still failed to stop the pest from eating into Hemly’s income. When azinphosmethyl lost its efficacy against the codling moth, Weddle knew they had a problem.

He contacted Stephen Welter, a professor and researcher at the UC Berkeley entomology department specializing in plant-insect interactions and the management of insect populations in agroecosystems. Weddle himself had received an MS from that department, inspired by Silent Spring and attracted to the ecologically informed initiatives undertaken by its faculty. Welter and his graduate student John Dunley

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14 Named individuals were the most important sources of information for these three vignettes. For a complete discussion of the California case studies, see the methodological appendix in my dissertation (Warner, 2004). California’s Pest Control Advisors are described more in chapter 4.
devised a new methodology to assess resistance, and confirmed that codling moth populations in the Sacramento River pear district were now effectively immune to this pesticide.\textsuperscript{15}

Fortunately, some Australian scientists had developed a novel product that releases a chemical mimicking the sex pheromones female codling moth release to attract the male for mating. Isomate dispensers appear like plastic twist-ties, and over a period of months they release their 0.0028 fluid ounces of synthetically produced pheromone into the orchard air, frustrating mating (see figure 1.2). In theory, flooding the orchard with artificial pheromones could disrupt the pest’s reproductive cycle, but no one had ever done this in a commercial orchard. Because mating disruption technology is not lethal to insects, it would have to be deployed fully and consistently throughout the orchard when the codling moth is in flight. A failure to completely blanket the orchard with pheromones could result in an economic disaster.

Weddle had experimented with an earlier pheromone product on one orchard block, but used the regular OP application to kill any additional codling moths that flew in from adjacent orchards. This proved effective, but at twice the cost. Weddle had over 20 years of applied IPM experience, but the technical skills this experiment required were daunting. Welter thought the product could work but only if the entire contiguous block of pear trees were managed to disrupt codling moth mating. He agreed to work on the project but only on the condition that Hemly secure full cooperation from all the adjacent growers. Hemly spoke to the four other growers in the Randall Island area, three of whom agreed readily and one reluctantly, and they developed coordinated management strategies to put all their 760 acres into pheromone mating disruption.

The Randall Island Project was widely considered a success by 1994, and began receiving awards and national recognition. This project was one of the most successful field scale ecologically based IPM projects of the 1990s.\textsuperscript{16} Randall Island growers reduced Guthion applications by over 75% with reduced fruit damage in one season. The first year, Isomate cost $220/acre plus labor to apply, but by the late 1990s, the price of the product dropped and the growers figured out how to use only half as much by applying it more efficiently. At $50/acre, all the major pear growers in Sacramento County were using it. Participants had hoped to completely eliminate the need for OPs, but had to settle for dramatically reducing them.

The project’s success built on the first IPM research in pears. During the early 1970s, pear growers in the Sacramento region had used as many as 14 active ingredients (most of which were hazardous). This attracted the attention of early pear IPM researchers, then funded by the United States Department of Agriculture, which began funding IPM projects after the pesticide controversies stirred up by \textit{Silent Spring}. Pat Weddle recalls a flood in the Sacramento River Delta during the early 1970s in an area where some of the IPM trials were underway:

\textsuperscript{15} Information on codling moth resistance from Dunley and Welter (2000).
\textsuperscript{16} This according to Benbrook (1996), a leading scientific critic of environmentally harmful pesticide use.
Where they were using the chemically intensive program, those orchards defoliated during the flood. Where they were using the IPM program, they did not defoliate. You could drive down the river and see it. The Farm Advisor would say, there’s a chemically intensive block and there is an IPM block... everybody could tell. It was a real eye popper. It made a lasting impression on what you could do if you could somehow manage pesticides in a way that was less disruptive.

High pesticide use stimulated OP resistance in codling populations, but the early IPM work provoked interest in alternative practices among a network of leading growers as well. According to Weddle, “the Delta pear growers seemed to be that progressive core of people that were having enough trouble and were paying enough attention to the new possibilities.”

The Randall Island Project relied upon professional IPM-oriented entomologists like Weddle to develop field monitoring protocols to track the behavior of the insect pest. The extra work these practices entailed did require extra compensation. In the words of Pat Weddle, ecological agriculture is information intensive, site specific, and labor intensive to monitor. Since Hemly was a member of the California Pear Advisory Board, a grower supported organization to foster marketing and facilitate research, he was able to arrange funding from them to help offset early additional costs of the pheromone products. In 1992, the same year Hemly, Weddle and Welter began testing pheromones, Jean-Marie Peltier, the board’s executive director, initiated the Pear Pest Management Research Fund. This was financed jointly by growers and canners (e.g., Gerber, Del Monte), and generated about $150,000 annually to subsidize pheromone products. Contributing canners recognized that reducing the environmental and public perception risks of high pesticide use added value to the fruit they bought from growers, and merited a higher price from their customers. Although invisible to anyone documenting the on-farm development of pollution prevention practices, this joint research fund was critical to Randall Island Project success.

By the late 1990s, Randall Island Project growers were down to four pesticides: oil, pheromones, one OP, and a miticide. Reduction in codling moth pesticide use allowed beneficial insects – formerly killed by OPs – to control some other pests that had required treatment. They were able to fulfill the vision of IPM of creating the right conditions in their farming systems to take advantage of bug vs. bug strategies, better known as biological control. The rate of pheromone adoption at the end of the decade was quite steep because its economic advantages were undeniable. Pear growers in other regions of California noticed the success of the project and began demanding access to it as well. California Department of Pesticide Regulation records show that the California pear industry reduced OP use 75% between 1994 and 2002.

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17 The former two are compatible with organic production. Mites are arthropods closely related to spiders that are not members of the class insecta. Miticides are pesticides used to control them.

18 As documented by the PUR database. For details of this database, see below. For information on OP reductions in the California pear industry, see the section on partnership impacts at the conclusion of chapter 3.
An agroecological imagination in almond growing

When Glenn Anderson returned to the family’s farm, he knew he wanted to do things differently. He had grown up in California’s Central Valley, 100 miles south of Sacramento, but developed a certain dis-ease – physically and emotionally – with the ecological and economic implications of modern dairy production. He had dropped out of farming in the 1960s, and moved to Hawaii, where he took courses in tropical agriculture, and Pacific Island ecology. He had begun reading Rodale’s *Organic Farming and Gardening Magazine*, and in class, he inquired if organic agriculture could be put to use. His instructors told him that simply wasn’t possible because chemical farming was the wave of the future. During the 1970s, Anderson traveled around the Pacific Islands and concluded that organic agriculture was not only possible, but necessary. When he took over the family farm back near Merced in 1980, he was convinced he could find another way to farm. His older brother had found almonds to be profitable, so Anderson set out to plant an orchard. Glen wanted to farm organically, but he didn’t know how and had never met a scientist or extensionist (applied scientist/educator) who could help him.

A few years after starting his orchard, Anderson went to the “Ecofarm” Conference where he heard about organic farming principles in vegetable crop production from instructors based at the (then named) Agroecology Program at UC Santa Cruz, and he said to himself, “that will surely fit an almond orchard.” He began experimenting with leguminous cover crops and enhancing the ecological activity in his orchard. He drew from his study of ecology and the general principles of organic farming to guide his orchard management, relying on a diversity of organisms (cover crops, beneficial insects) to provide fertility and pest control instead of chemical technologies. At the end of the decade, he compared financial records with his brother and they discovered that Glen’s costs were lower and profits were greater than his brother’s conventional, chemical-intensive operation. If this were true, why were so many almond growers using so many chemicals?

Together the brothers approached their local UC Cooperative Extension Farm Advisor (a publicly funded extensionist), Lonnie Hendricks, about conducting a whole farm comparison study. Anderson and Hendricks both knew the director of the Sustainable Agriculture Research and Education Program (SAREP, located near the UC Davis campus), who readily agreed to fund the study. As Anderson recalls,

At first [Hendricks] wondered, “What the heck are these guys bringing to me? They’re a little bit, especially the younger brother, they’re odd.” But as we did that, I really threw myself into it. I was very, very interested and excited about the possibility of doing this. And after the first year, Lonnie began to bring people around to say, “Just a minute. Take a look at this.” And of course, his colleagues said, “You’ve got to be out of your mind, Lonnie. You’re comparing just two orchards. I mean, that’s not sound science. Anything can happen in that circumstance. Where’s your replication?”
Hendricks himself had grown up on a pear orchard and observed the advent of the chemical revolution. His father had used traditional practices such as cover crops and mineral oils, but Hendricks also recalls his family wearing gas masks as a farm hand sprayed parathion out of a tractor exhaust pipe. They watched birds die as a result, and his father grew skeptical of pesticides. As a new Farm Advisor in the early 1960s, Hendricks read *Silent Spring*, and he felt it “made sense,” although the work did not appeal to many of his Cooperative Extension colleagues. He expressed his opinion when asked, but didn’t want to rock the boat too much.

As Hendricks began to talk about the curious results of the Anderson brothers study, SAREP scientist Bob Bugg and Rick Reed, the program officer for the Community Alliance with Family Farmers (CAFF), were looking for a working example of ecological farming. Bugg and Reed had concluded that to advance the missions of their respective organizations, they needed to do more than critique conventional chemical practices, they needed to promote viable alternatives to it. When Reed and Bugg visited the Anderson orchard, they recognized what they had been looking for, and formed a partnership with Anderson and Hendricks.

They did not set out to promote organic agriculture, but rather to help conventional growers re-imagine their orchards as ecological systems. They wanted to help any grower recognize the practical economic and environmental benefits that could gained by farming according to ecological principles. If the conditions in an orchard merited a pesticide, they encouraged a grower to use one, but only if the grower was truly sure it was both economically and ecologically justified. While visiting Glenn Anderson’s orchard, Bugg named this project the Biologically Integrated Orchard System, or BIOS. Many people have observed that this was a brilliant name because, in the words of Glenn Anderson, it “resonated really broadly for all the right reasons.” Hendricks then sent out a letter to the 800 almond growers in Merced County, inviting them to further participate in this study with the Andersons. Eighty growers came to their first meeting.

BIOS promoted a holistic, farming systems approach. Instead of substituting one or two sustainable practices for a harmful technology, BIOS promoted a system redesign based on agroecological principles. BIOS worked with growers to help them perceive the potential interactions between components of their farming system, and the impact that alternative management practices with one component could have on the overall farming system. BIOS practitioners mentored growers as they applied ecological principles to the specific conditions of their orchards.

BIOS differed from conventional Cooperative Extension programs and their practice of technology transfer. Facilitating the acquisition of agroecological knowledge requires a different approach to social relations than transferring technology. It requires a social learning or co-learning model, in which leaders facilitate the exchange of learning experiences of all participants in practical research. BIOS developed local leadership around management teams consisting of growers, professional entomologists, Farm Advisors, and research scientists. This became known as “the BIOS model” or the agricultural partnership model of extension.
The first years of the Merced BIOS partnership demonstrated that this approach was possible and could be profitable. It required more effort, but could be a more satisfying way to farm. CAFF developed a plan to expand BIOS to other counties and commodities, and to advocate with state and university leaders for more programs like BIOS. CAFF staff were able to stimulate the creation of a larger, Biologically Integrated Farming Systems program at SAREP. They developed a strategic partnership with the Almond Board of California to promote this ecologically based approach to agriculture, lending credibility to this approach. Inspired in part by BIOS, the California Department of Pesticide Regulation funded a program to help commodity boards conduct their own partnership activities to reduce pesticide use.

California almond growers achieved what appears to be the greatest volume of voluntary OP pesticide use reduction in US history. Winter dormant season OP use fell from a high of almost 500,000 pounds in 1992 to just over 100,000 pounds in 2000. BIOS and the Almond Board of California played crucial roles in educating growers about alternatives. Annual variation in weather, the economic advantage of new, “softer” pesticides, and regulatory pressure pesticides were also important factors, but they do not by themselves fully explain the scale of this reduction. The extent of OP reduction varies by region, but counties with BIOS programs had the greatest reductions.\textsuperscript{19}

Agroecological partnerships have demonstrated that commercial scale monoculture can be substantially informed by ecological principles, if the requisite social relations are cultivated.

Cultivating quality

About the same time that Hemly and Weddle began to notice the worrisome signs of pesticide resistance, a group of winegrape growers in adjacent San Joaquin County began devising an even more ambitious partnership. Located just north of Stockton, the Lodi area is the second oldest commercial winegrape region in California, with some of the operations dating back five generations of continuous winegrape growing to the 1860s. A century later, Napa wine makers created their reputation by pursuing quality and promoting it through aggressive marketing. In contrast, the Lodi region had an established reputation for growing inferior winegrapes used only for cheap wines, and growers here were reputed to suffer from an inferiority complex. As the Napa growers continued to pursue and expand the premium wine niches, other regions could move up to fill the mid-price range. Because of its geographic setting near the cool breezes of the Sacramento Delta, the Lodi region had the potential to produce much better wines than its neighbors further south in the San Joaquin Valley. To enter the quality wine market would require grafting over most of their vines to varietal grapes -- an expensive gamble – but maintaining the status quo would result in a slow but inevitable economic decline.

\textsuperscript{19} See Epstein et al. (2000; 2001), Zhang et al. (2004), and Elliott et al. (2004); I analyze and interpret this data at the end of chapter 3.
Randy Lange and John Ledbetter led a small group who wanted to emulate some of Napa’s success in the Lodi area, but at that time, the State of California was suffering from yet another budgetary paroxysm. They realized that to achieve their goal, they would need scientific resources, and that they could not rely on their traditional sources, the UC Farm Advisors. UC simply was not investing in field-based research to help the practical needs of agriculture as they had in previous generations. Lange, Ledbetter and their consort were going to have to take matters into their own hands. They were going to have to fund their own research and extension program to add value to their product by distinguishing the quality of their wine and the quality of their environmental stewardship.

They built on a history of regional cooperative marketing dating back over a century. In 1986, they petitioned the Federal government to create the Lodi American Viticultural Area. In 1990, Lange and Ledbetter lobbied the State Legislature to amend the laws governing commodity organizations – previously requiring statewide agreement among growers -- so that local crush districts could become their own winegrape commissions.20 Lange, Ledbetter, and 25 other growers put up $5000 each of their own money to campaign for the creation of the Lodi Woodbridge Winegrape Commission. Their original impetus was to foster applied research, but a significant number asked for help with marketing as well, which proved to be a popular selling point during the run up to the election. The commission was established by a majority vote of the region’s winegrape growers in 1991.

Ledbetter saw part of the reason for wanting to fund regionally focused research and outreach was because leading growers in the region had come to the conclusion that sustainable pest management was the wave of the future: “Farmers are consumers, too. We get our food from the same supermarkets everyone else does. We drink the same water and breathe the same air. We have children and we can read. That’s all it takes to make me want to look for alternatives to pesticides.”21 The Lodi Woodbridge Winegrape Commission began its IPM program in 1992 to “identify and implement sustainable strategies that will reduce conventional pesticide and fertility inputs while maintaining or improving the grower’s net income.”22 The commission’s five-point plan included using cover crops, improving soil health, monitoring for pests, pulling leaves to improve grape quality and reduce the risk of grape disease, and using the least hazardous and disruptive means of pest control. This program assumed that implementation of these practices would require addressing all those who participated in shaping decisions about a farming system: the grower, the professional entomologist, and the winery. Pest control consultants would need to focus on monitoring the entire insect complex, not just pests, and the commission worked with wineries to help them

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20 Crush districts were established by the State Legislature in the 1880s. Some correspond to county boundaries, but those in the San Joaquin Valley do not. The Lodi district includes southern Sacramento and northern San Joaquin Counties. For more information on local and state wide agricultural districts and organizations, see below.


22 From Culver (1993).
clearly define acceptable pest damage levels so that growers would spray only when necessary to protect the quality of the winegrape flavor and not for cosmetic reasons.\textsuperscript{23}

In 1995, Cliff Ohmart took over leadership of the IPM initiative. Ohmart had received his PhD in entomology at UC Berkeley in 1978 from the same department where Pat Weddle had trained and Stephen Welter taught. He strengthened the IPM program in quantity and quality. Ohmart obtained a grant from SAREP to integrate the grower-to-grower outreach model first developed by BIOS into the commission’s organizational structure and identity. For demonstration vineyards, Ohmart selected 43 growers who put up the original seed money to start the commission, and they owned or managed more than half of the district’s vineyard acres.

Leading growers fully bought into this outreach model, and were able to take advantage of the existing social relations among the 650 growers in the district. During the late 1990s, growers already familiar with IPM approaches applied those techniques more consistently throughout their vineyards, and those new to IPM were exposed to repeated encouragement to monitor their vineyards and make pesticide decisions based on site-specific data and economic thresholds.

The commission is widely credited within the California winegrape industry as creating the most comprehensive working model of a regional, grower-supported initiative to promote sustainable practices. Ohmart facilitated a change in how growers approach their farming systems by taking a region of predominantly conventional growers and helping them transition to using “sustainability” as the primary criteria for evaluating their practices. Growers do not understand themselves primarily as stewards, but have incorporated stewardship into their collective identity. His leadership is broadly perceived to be integral to the commission’s overall success. While the commission advertises the quality of Lodi winegrapes, Ohmart travels as an ambassador of sustainability, describing how the commission has worked with growers to improve viticultural quality and environmental quality. The entire district has profited from this initiative, and the same growers are now considering how to launch an eco-label to further add value and engage the wine-consuming public in their project.

The California winegrape industry has invested more in partnerships than any other commodity. Four regional winegrape partnerships have worked particularly close to help local growers recognize agroecological alternatives to pesticides (see figure 1.3). The Lodi partnership has been the longest running and most visible of these. This partnership inspired a statewide winegrape growers’ organization and a winery trade organization to develop the Code of Sustainable Winegrowing Practices. This is a comprehensive, objective, and transparent guide to growing winegrapes and producing wine in a way that is “environmentally sound, economically feasible, and socially equitable.” Its sponsors have conducted 75 workshops around California, and reached over 900 winegrape growers managing 120,000 vineyard acres (over 20% of the state total). The code represents the most sophisticated program to date by any commodity-

\textsuperscript{23} For a description of the early Lodi partnership activities, see Culver (1993).
specific group of growers to educate themselves, and to present themselves to the public as environmentally responsible. Yet the Lodi Woodbridge Winegrape Commission still has an advantage lacking among most other groups: it has invested years of effort to develop a social network that provides peer support for managing vineyards in the most environmentally friendly way possible.

Putting ecology into action
Most of *Silent Spring* narrated the apocalyptic implications of hazardous, invisible, carcinogenic biocides, but Carson concluded it with a story of hope. She described how a few entrepreneurial scientists developed ecologically based pest management strategies. This chapter describes the impact Carson’s work had on both political and scientific institutions shaping conventional agriculture, and how they, in turn laid the foundation for agroecological partnerships, such as the three above. Throughout this work I use the word “institution” to mean both patterns of social behavior as well as human organizations necessary to support them.

Carson made pesticide pollution a political issue, and appealed to the public interest as justification for doing so. Individuals have a right to protection from poisons introduced by others into the environment. She made normative claims: only those able to understand the ecological hazards of pesticides should be allowed to purchase and use them. Regulatory institutions should be independent of political influence and provide safeguards for the public. Government should fully support the development of safe, ecologically based alternatives. These were the key elements of her public testimony before Congress in 1962, and were reflected in the famed Environmental Defense Fund lawsuits. *Silent Spring* started the public debate that resulted in the creation of the Environmental Protection Agency. 24

The USEPA was created with a whole cluster of environmental laws, but two of them stand out for the purposes of this story. 25 Congress passed the Federal Environmental Pesticides Control Act in 1972, which transferred responsibility for pesticide registration and regulation to the USEPA, in large part to address charges that the US Department of Agriculture suffered from a pro-pesticide bias. 26 Congress assigned the USEPA responsibility for pesticide evaluation and registration, but regulatory enforcement of pesticide use was still in the hands of the states, with USEPA supervising.

In the same year, Congress passed the Federal Water Pollution Control Act Amendments, better known as the Clean Water Act. This set the ambitious goal that all surface waters be “fishable and swimmable” by achieving “zero pollution discharge” from point sources. This act gave USEPA responsibility for setting standards for toxins

25 For analysis of US environmental policy initiatives shaping agriculture, see Andrews (1999), pages 170-2, 236-7, and 304-8. The Federal EPA is identified hereafter at USEPA to distinguish it from the California EPA, or CalEPA.
26 Bosso (1987) provides a detailed history of how US policy has handled pesticides.
in surface water, and allowed citizens to bring lawsuits to compel enforcement. In 1974, Congress passed the Safe Water Drinking Act to protect public health by regulating the nation's public drinking water supply. American cities and industry have made impressive progress in controlling point source, or end-of-pipe, water pollution. Agricultural nutrients are now clearly the greatest source of non-point water pollution.

The US has never had an explicit, systematic environmental policy for agriculture, despite its large and widespread impacts. Congress has never shown much interest in regulating the environmental impacts of agriculture, in large part because it has found the persistent cultural myths about family farmers, and the national virtues they exemplify politically useful. Key Congressional leaders have protected agriculture from environmental regulation, even as this sector is increasingly responding to the wishes of vertically integrated transnational corporations. Congress has never given the EPA a clear mandate to address agricultural pollution, even as evidence of its water quality impacts has become incontrovertible.

The agricultural practices shaping the quantity, media, and impacts of pollution are distinct by crop, region, and specific ecological context, frustrating consistent regulation and enforcement. The kind of agriculture (annual crops, perennial crops, animal husbandry) determines the kinds of pollution (nutrients, soil erosion, agrochemicals) most likely to leak out of the farming system into the broader landscape. Local soil, moisture, and geological conditions have a tremendous effect on the severity and scope of pollution, and operation-specific management practices can result in highly variable environmental impacts, even within the same kind of cropping or animal production system. Agriculture can pollute several environmental media: air, surface water, and groundwater quality, often simultaneously, and sometimes from different activities. Environmental impacts may be temporally or spatially distinct from the activities that cause them, as is the case with surface and ground water pollution.

Decisions about agricultural practices in the US are made by two million farm operators. Each of these factors presents a significant obstacle for typical environmental

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28 As Andrews (1999) points out, once point sources (discharge pipes) were effectively regulated, agriculture became a leading source of water pollution, contributing as much as one third, even though it represents roughly a quarter of the US land use. Aspelin (2000, page 3-21) estimates total US land area to be 1.9 billion acres, and crop land to be 460 million acres, ranking third behind grassland pasture and range (589 million acres) and forest (559 million acres). His primary data sources were the USDA and EPA.
29 For a discussion of how this myth has guided policy, see Browne et al. (1992). For a broader discussion of US agricultural policy and its dynamics, see Browne (1988; 1995; 1998). The political reluctance to address environmental problems in agriculture continues despite the fact that agriculture is among the most heavily regulated economic activities in the US.
31 Regulating agriculture is seen by many as impinging on land use decision making, a process that has been jealously guarded by local governments at their domain. Land use planning is known as the “L-word” at the EPA because of the political conflicts that surround any Federal effort to address it (Rosenbaum 1994).
regulatory strategies, confounding the regulatory uniformity required of an equitable process. 32

From a national perspective, nutrients such as nitrogen and phosphorus create agriculture’s most extensive environmental problems in streams and ground water. 33 When nutrients borne by rivers reach estuarine and coastal waters, toxic algal blooms, marine mammal deaths, habitat destruction, and shellfish poisoning can result. “Problem areas occur on all coasts, including those of California, Florida, Louisiana, Maryland, Massachusetts, New York, North Carolina, Texas, and Washington, but problems are particularly severe along the mid-Atlantic coast and the Gulf of Mexico.”34 The Farm Belt’s regional discharge of massive amounts of nitrogen through the Mississippi River has created a hypoxic, or dead, zone covering up to 7700 square miles in the Gulf of Mexico. On the Eastern seaboard, nutrients from farms and confined animal feeding operations flow into estuaries causing algal blooms and outbreaks of Pfiesteria piscicida, a dinoflagellate causing fish lesions and fish kills, and perhaps posing a threat to human health.35

Nitrate threatens human health when they contaminate groundwater drinking supplies because they can affect the blood’s ability to carry oxygen, especially when an infant’s digestive tract converts it to nitrite, causing “blue baby” syndrome. Rural water supplies are susceptible to nitrate contamination from agriculture, especially shallow wells.36 For example, in Central Washington’s Columbia Plateau, nitrate concentrations in about 20% of wells exceed the drinking water standard, and the highest rates were found where fertilizer use is greatest. Nitrate concentrations in shallow wells here are among the highest in the nation. Agricultural fertilizers are the leading cause of nitrate pollution, followed by cattle feedlots and food processing discharges.37

Even as Silent Spring provoked new environmental policies, US agricultural pesticide use grew dramatically, reaching one billion pounds per year in 1976 and fluctuating around that level ever since.38 California’s specialty crop agriculture has

32 Rosenbaum (1994).
35 Although this organism and its threat to human health is poorly understood, it appears that exposure to waters where toxic forms of Pfiesteria are active may cause memory loss, confusion, and a variety of other symptoms including respiratory, skin, and gastro-intestinal problems.
38 Source: Aspelin (2000, appendix). These crude figures do not reflect the changes in type of pesticides (insecticides, herbicides, fungicides, etc.) over time. Aspelin estimates agricultural pesticide expenditures from 1961 to 1997 to have risen from $1.5 billion to $4.2 billion (in constant dollars), a rise from 2% to 4.5% of total US agricultural expenses. Benbrook (1996) drew from USDA agrochemical use surveys and estimated total pesticide use to be about 600 million pounds in the US in 1992. For more on California pesticide use, see the discussion of the Pesticide Use Reporting system in chapter 3.
used a disproportionate amount of the nation’s total pesticides, roughly 20-25%. The banning of DDT created a great irony: many growers compensated by switching to organophosphate pesticides. These insecticides do not bioaccumulate and threaten top predators as did DDT, but they are acutely toxic, and increasing reliance on OPs meant greater acute health risks to growers and farm workers. California’s San Joaquin Valley has the maximum concentration of many pesticides among all of the US watersheds studied by the US Geological Survey: pesticides were detected in 69% of the groundwater samples collected from the eastern San Joaquin Valley. A companion report on the Sacramento River found that watershed to generally be in better shape, although it did find that agricultural streams here have some of the nation’s highest concentrations of the insecticide diazanon.

Twenty years after USEPA’s creation, attention within the agency began to focus on agriculture’s environmental problems. The USEPA was initially created with a legislated shotgun marriage of existing media (air, water) and category (pesticides, solid waste) programs. William Reilly, USEPA Administrator for the first President Bush, directed his staff to undertake regional analyses of environmental problems to determine gaps they needed to address. Integrated analysis of environmental indicators in several regions indicated that agriculture merited priority attention, and USEPA launched place-based agricultural initiatives. Under Reilly’s tenure, USEPA also emphasized public sector/industry partnerships to promote voluntary pollution prevention. This shifted attention from end-of-the-pipe pollution management to the reduction or elimination of potential pollutants, especially hazardous or toxic materials. These administrative initiatives nudged USEPA to address agriculture’s problems, but staff knew they had to do so in a low-key, non-confrontational way.

During the Clinton administration, the US Department of Agriculture set new goals for implementation of IPM, but the passage of the Food Quality Protection Act in 1996 was the most important agricultural regulatory initiative of that decade. As chapter 3 narrates, this law created new concerns in the agricultural community about the loss of chemical technologies, but also new funding sources for agroecological partnerships. As chapters 3 and 4 explain, when USEPA staff encountered BIOS and other partnerships, they discovered that by investing in them they could achieve agency goals with carrots – not merely sticks.

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39 Aspelin (Aspelin 2000; Aspelin and Grube 1999) estimates US pesticide use between 800 million and one billion pounds. California’s proportion of insecticides is much greater than 25% because over half of all US pesticides are now herbicides, intensively used in the farm belt.
40 See chapter 2 of Wright (1990).
41 For information on the environmental contamination of California, see the following NAWQA reports: US Geological Survey (1998) on the San Joaquin Valley, and U.S. Geological Survey (2000) on the Sacramento Valley. USGS found the levels of organochlorine pesticides, PCBs, and nutrients in the San Joaquin River to be among the highest in the nation. This river flows through most of state’s top agricultural production counties.
42 For more on the environmental impacts of diazanon, see chapter 3.
43 See Andrews (1999), pages 262-266.
44 See Gottlieb (2001).
Essentially all industrial farming operations pollute, and comprehensive enforcement is impossible. Laws such as the Clean Water Act and Food Quality Protection Act provide a framework for environmental regulatory agencies at the Federal and state levels, but their limited resources leave all but the most egregious environmental offenses unaddressed. Agriculture’s widely distributed and independent decision makers, managing varied farming systems in highly variable ecological contexts frustrate regulatory enforcement models. For these reasons, developing incentive systems of collaborative voluntary innovation hold more promise.

The emergence of agroecology

Silent Spring challenged scientific institutions as well as public officials. Carson was one of the first in the Cold War era to openly criticize publicly funded scientific institutions for disregarding the public good. Although she did not use the word “ecology,” she advocated an approach consistent with its principles. Silent Spring inspired many students of the 1960s and 1970s – such as Pat Weddle -- to put ecological concepts into action. Some of these became scholars who have developed applied sub-disciplines of ecology, such as agroecology and conservation biology, to redress environmental problems. Both of these sub-disciplines make implicit ethical claims on the organization of society along ecological principles.

Agroecology prescribes agricultural and ecosystem management strategies based on the discipline of ecology, and as Stephen Gliessman argues, it marks a convergence between the agricultural and ecological sciences. Like conservation biology, agroecology is a value-laden science that proposes ecologically-based concepts for solving socio-environmental problems, meaning they both assume the merit of environmental resource conservation. Agroecology asserts that farms should be managed as a functional system, and that sound farming decisions must be guided by an understanding of the structure and function of natural ecosystems. It carries with it an explicit criticism of agricultural scientific perspectives that pay attention only to individual components of farming systems, or reductionism, and ignore their impact on the dynamics of that system.

Miguel Altieri proposed three chief characteristics of agroecology:

1. A systems framework of analysis;
2. A focus on both biophysical and socio-economic constraints on production;
3. Use of agroecosystem or region as a unit of analysis.

More recently, he has described agroecology as optimizing agroecosystem processes, which correspond rather well with the practices promoted by California’s agroecological partnerships (see Table 1.1). The term agroecology was created in

45 This split occurred during the early decades of the 20th Century for reasons mostly related to the development of academic disciplines, but over the past two decades this artificial barrier has begun to erode, at least in some university departments (Elliott and Cole 1989; Gliessman 1998).
46 For a discussion of conservation biology as a value-laden science, see Meffe and Carroll (1994).
47 Altieri (1989).
48 Altieri (2002).
Mexico among ecologists, agronomists, and ethno-botanists as an agricultural development framework in opposition to the Green Revolution. In its original form, agroecology helped peasants improve their indigenous farming practices as an alternative to high input, chemically-intensive agriculture.

Agroecology in advanced industrialized countries necessarily draws more from ecological sciences than from traditional, indigenous ethno-botanical knowledge more typical of the developing world. Over the past 50 years, industrialized US agriculture has discarded the ecological wisdom inherent in integrated animal/crop farming systems. Here growers must learn to manage nutrients in ecologically informed ways, and devise alternatives to essentially ecologically irrational technologies (e.g., OPs). An agroecological or farming systems perspective identifies nutrient loss and non-target pesticide impacts as consequences of leaky, poorly assembled, and brittle systems.

Coping with these as symptoms is essentially a holding action, and authentic solutions require rethinking the design and management of agroecosystems based on principles derived from the study of natural ecosystems.

Agroecology proposes deploying ecologically based practices, adding biological diversity to farming systems, and managing their interactions for synergistic benefits for the farmer and society (see figure 1.4). Ideally, nutrients would no longer leak from the system because they would be circulated back to other organisms, such as manures serving as plant fertilizers. “Pest” populations would not explode to economically damaging levels because the niches they exploit would be occupied by diverse organisms, or their populations would be regulated by predators or parasites. For example, instead of repeatedly applying herbicides to control weeds on an orchard floor, a grower would plant cover crops, creating improved soil health, and reduce soil and water erosion. This approach to farming requires a different mode of perception, and the ability to recognize the potential benefits of managing components for superior outcomes for the entire system. Thus, agroecology’s integrative, whole systems approach exists in fundamental tension with reductionistic scientific practices and perspectives.

Agroecology is becoming a primary scientific paradigm to guide alterative agriculture, partially replacing the term “sustainable agriculture” within the academy. Sustainability is a compelling albeit slippery term, and continuing debates about and differing interpretations of its precise definition make it difficult to use without having to continually define it. Many sustainable agriculture initiatives in US agriculture have in practice been narrowly focused, on single practices within farming systems. I prefer the definition of Patricia Allen et al.: sustainable agriculture is “one that equitably

50 Altieri (1998).
51 Jules Pretty (1998) counted more than 80 different definitions of sustainable development subsequent to the 1987 Brundtland Commission report introducing the term, and he argues that it should never be identified exclusively with a technology or policy (which it frequently has), but rather an overarching set of goals. Neva Hassanein (1999), 2-6, describes the difficulty of using the term sustainable agriculture in the US.
balances concerns about environmental soundness, economic viability, and social justice among all sectors of society.” In practice and program, however, collaborative progress toward this comprehensive and ambitious framework to sustainability has been difficult to achieve.

One does not have use the term ecology to recognize ecological relationships and the benefits of manipulating them. Growers and their consultants appear comfortable using products and practices described by the stem “bio-“. Partnership leaders have assiduously avoided using any terms with the stem “eco-“, even though they regularly take advantage of ecological relationships between organisms. This example is but one of the discursive framing strategies used by leaders of these agroecological initiatives.

For the purposes of this study, I consider the terms holistic resource management, alternative agriculture, biointensive IPM, and integrated farming systems to fall under the broader umbrella of agroecology. These will each be discussed in subsequent chapters. Organic agriculture has also grown in recent years, although the US federal organic certification program has also led to contradictory outcomes. In its ideal form, organic agriculture is organized along agroecological principles, although in practice, this is rarely the case. Regenerative agriculture and natural systems agriculture are other terms similar to agroecology.

By framing the initiatives described by this book with the science of agroecology, I hope to show how participants are using applied ecology to undertake socio-environmental problem solving in agricultural production. Agroecology is concerned about the broader social and economic context of farming, but attends primarily to questions of agricultural production. Authentic sustainable agriculture encompasses all questions of food consumption, while I have limited my investigation to agricultural production. Questions of social equity, economic viability, and public policy lurk in the background of this book, and will reappear in the final chapter to inform its conclusions.

Latour’s tool for interpreting scientific controversy
To understand agroecology’s critical stance toward the broader field of the biological sciences, I will draw on Science and Technology Studies, or STS, which now informs

53 Many sustainable agriculture initiatives in the industrial world leave unaddressed questions about social equity, especially regarding farmworkers. Much debate of the term “sustainability” turns on whether a practice or initiative can promote ecological sustainability (resource protection) without simultaneously addressing economic and social relations. For example, Patricia Allen critiques “sustainable agriculture” because it has largely been defined as “a natural/technical process, rather than a social one; a relation between people and nature versus a relations between people and nature” (Allen 1993, 5). Some argue that any initiative must simultaneously address all three, but I leave that particular issue for further debate elsewhere.
54 For a discussion of the discursive framing, see Warner (2006c).
56 See Guthman (Guthman 2004b; 2000).
many studies of controversies within scientific institutions. STS emerged to critique the overly idealized depictions of scientists and their activities. Bruno Latour’s (1987) *Science in Action: How to Follow Scientists and Engineers through Society* broke open new ways of understanding the role of scientists in society. Latour and other STS scholars insist that science must be studied in action, as a variable, contingent, creative and at times controversial cultural practice, not as plodding conformity to a static, trite formula to accumulate increasingly larger data collections. From an STS perspective, science is not so much the pursuit of “truth-to-be-revealed” as a social project weaving together knowledge work, organisms, technologies, theoretical arguments, and public representation. Latour insists that to truly understand science, one has to follow scientists through society and observe them as (social) *actors*, in *action*, and this book derives its title from his work. He developed a methodological approach that analyzes scientists’ engagement with the social world, not only discrete activities in a cloistered laboratory.\(^{57}\)

STS investigates how actors use science knowledge to form networks and persuade other people, organisms, and technologies to collaborate.\(^{58}\) Networks emerge as actors realize they are better able to feed and grow by associating with others, human and nonhuman, through a process Latour describes as “enrolling.” Knowledge, therefore, serves as an incentive, piquing the interest of the scientist and others with the possibility of rewards. Latour refined his theory of hybrid social/scientific networks in *Pandora’s Hope*, proposing a “circulatory system of science” (figure 1.5). According to Latour, “there are five types of activities that science studies needs to describe first if it seeks to understand in any sort of realistic way what a given scientific discipline is up to: instruments, colleagues, allies, public, and finally, what I will call *links* or *knots* so as to avoid the historical baggage that comes with the phrase ‘conceptual content.’”\(^{59}\)

For Latour, scientific knowledge is more powerful and more persuasive as it flows through society. He rejects the portrayal of science as an activity that is more real because it is “pure,” isolated from contaminating social interests; instead, he proposes science as a beating heart at the center of a circulatory system of arteries and veins, pumping knowledge as though it were oxygen through tissue. Latour proposed this model as a tool to understand science generally, but I prefer its adaptation by Margaret FitzSimmons for understanding the circulation of ecology in society.\(^{60}\) After introducing the dynamics of the five loops, we will test Latour’s interpretive tool with the controversies surrounding the work of Rachel Carson.

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\(^{57}\) This field is vast, but for some introductory literature, consult Latour (1987; 1999; 1999).

\(^{58}\) To broaden STS’s analytical framework, Michel Callon worked with Latour and John Law to develop actor-network theory (ANT). At its core, ANT posits that science and scientists cannot be understood in isolation from their material and cultural worlds. Michel Callon (1986; 1989) developed the initial concepts and language of ANT. For a review of ANT literature, see Latour (1999) and Whatmore (1999). My work does not deploy ANT, but rather a more practical understanding of socio-ecological networks.


\(^{60}\) FitzSimmons (2003) applied his theory to ecology and the Ecological Society of America’s Sustainable Biosphere Initiative.
In the first loop, which FitzSimmons titles “nature,” humans investigate natural phenomena, which in turn shape human social behavior. Farmers have observed the natural world since the beginning of human civilization, and more recently, scientists have joined them in the field, armed with the scientific method, statistics, and devices to make obscure phenomena visible. They discover how plants (crops, weeds, cover crops) and animals (livestock, insect pests and their natural enemies) behave in association in an environment of variable light, heat, water, and soils, and together they develop insights for improving agriculture. Knowledge circulates from the field to university laboratory and then back out to the field. Scientists organize and categorize their discoveries in the world, and make them available for scholarly argument.

The second loop, what FitzSimmons titles “scientific colleagues,” describes how scientists assemble facts and construct institutions devoted to knowledge. Scientists attempt to validate their discoveries by organizing knowledge into disciplines, sub-disciplines, specializations, and scientific communities that will amplify, feed, and validate further investigations. Peer approval is critical for the reproduction of science. Without the imprimatur of colleagues, resources dry up, disciplines wither, and lines of scientific investigation fail.

Latour names the third loop “alliances,” and FitzSimmons renames it “allies,” but for my purposes, it is best labeled “clients.” This loop reflects the patrons that scientists have always had. These are the people and groups that can put knowledge yielded by scientific discovery to practical use. Knowledge contained by the academy is feeble compared to that put into economic action. Agriculture may request specific help on problems from scientists, or scientists may need to persuade growers of the commercial potential of their research.

Latour labels the fourth loop “public representation,” although he is quick to dissociate this from the stigma of “public relations.” He insists that society ultimately has a say in the conduct of science, however distorted or stereotypical its understanding may be. The public is located just outside the edge of this loop. Pumping knowledge through it requires very different skills than laboratory investigations, but it too is science, just as much as is statistical sampling. This loop holds opportunities as well as dangers. Scientists may be celebrated for their innovation, or their credibility may suffer attack for making public knowledge from the field and laboratory, as Carson herself discovered. Scientists discount the importance of this loop to their peril, as evinced by public squeamishness about transgenic crops.

Scientific knowledge circulates by the pumping of the heart. Without “links and knots,” or scientific content, there would be no other loops; they would die instantly. But the heart does not exist in isolation: it exists to distribute knowledge throughout the entire system. This conceptual core becomes stronger the faster it circulates knowledge through the other four loops, in turn strengthening the power of science within society.

Carson captured the public’s attention by describing the ecological folly of indiscriminate agrochemical use. She critiqued the practice of scientists who thought of their work as exclusively serving their immediate, economic clients: actors in loops two and three were only concerned with each other’s interests, and not ecological or social
consequences. Carson diffused knowledge from loop 1 to loop 4, mobilizing the public to act on behalf of nature; in other words, she circulated knowledge from society to reduce the hazards of irrational pesticide use. For her efforts she was savagely attacked by industry and elected officials, and the integrity of her scientific work was assailed. Carson was dismissed as an irrational, emotional woman, and her science work judged illegitimate. Her critics were wrong, of course, and her arguments about the public significance of the scientific consequences of irresponsible chemical use carried the day, in large part because she circulated her findings to the public, which recognized the interdependence of all these loops even when most agricultural scientists did not.

Using insights from Latour’s understanding of science as practice, we can improve Altieri’s conceptual model of agroecological interactions of systems components by adding a feedback loop, circulating knowledge back to the humans who make management decisions (Figure 1.6). Agroecology in Action investigates how people have successfully circulated this knowledge back to farming decision makers for social and environmental benefits. In so doing, they collectively carry forward Rachel Carson’s dream.

Conclusion

The three partnership vignettes that opened this chapter fulfilled Carson’s dream of agricultural alternatives, inspired by an alternative vision of nature-society relations. They demonstrate how an ecologically informed conventional agriculture can do a better job protecting environmental resources. Silent Spring has had ripple effects through every institution shaping the agriculture/environment interface in the US. Carson made agricultural pollution a political issue and laid out an alternative path, one informed by ecology. She challenged public officials and scientists to better safeguard the public interest. Agricultural pollution is particularly intractable, even though it now is the greatest source of non-point pollution. The diversity and variability of its origins and consequences have resisted regulatory and scientific initiatives to control it.

Legislative and regulatory responses to Silent Spring are more widely known than those of scientific institutions, but these too have been important. Scientists are now proposing agroecology and its integrated systems approach as the best framework for preventing pollution and protecting environmental resources while ensuring an economic return for growers. The scientific institutional obstacles facing this integrated farming system approach – and public interest strategies to surmount them – is the chief topic of the next chapter. Latour’s model of science will serve as a guide for interpreting the controversies we will encounter.
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Table 1.1 Elements of agroecology

<table>
<thead>
<tr>
<th>Agroecosystem processes (Altieri 2002)</th>
<th>Practices promoted by California’s agroecological partnerships</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organic matter accumulation and nutrient cycling</strong></td>
<td>Cover crops, application of compost, manures, chipping tree prunings, crop residue management</td>
</tr>
<tr>
<td><strong>Soil biological activity</strong></td>
<td>Cover crops, application of compost, manures, crop residue management</td>
</tr>
<tr>
<td><strong>Natural control mechanisms</strong> (disease suppression, biocontrol of insects, weed interference)</td>
<td>Removing ecologically disruptive agrochemicals from the farming system, bio-diversification to attract and retain beneficial insects, cover crops</td>
</tr>
<tr>
<td><strong>Resource conservation and regeneration (soil, water, germplasm, etc.)</strong></td>
<td>Protection of streams with buffer strips, efficient use of irrigation water (no attention paid to genetic resources)</td>
</tr>
<tr>
<td><strong>General enhancement of agrobiodiversity and synergisms between components</strong></td>
<td>Managing components of farming systems to capture synergistic benefits</td>
</tr>
</tbody>
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figure 1.1
Map of California’s Central Valley
(missing)
Figure 1.2

Doug Hemly shows off one of the pheromone mating disruption device he uses to control codling moth in his pear orchard; the synthetic pheromones are released from the plastic “twist-tie,” which is attached to the tree with a modified bread bag clip.

Figure 1.3. UC IPM Advisor Lucia Varela (to the right of the table) explains the finer points of insect identification to growers using microscopes at a Sonoma County Grape Grower Association IPM field day. Farm Advisor Rhonda Smith (far right) discusses pest management with a winegrape grower.
Figure 1.4 Interactions between systems components (from Altieri 2002)

Figure 1.5 Latour's circulatory system of science
Interactions between farming system components and farm management decisions (modified from Altieri 2002)