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Extending agroecology: Grower participation in partnerships is key to social learning

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Abstract

The extension of agroecology requires an alternative extension pedagogy. Agroecology is more than merely the promotion of new technologies or practices, but rather a fresh understanding of how to optimize the configuration of biological and technological components of farming systems informed by ecological principles. This necessarily requires a shift in roles among growers and extensionists so that they can actively participate in networks of social learning. Agro-environmental partnerships have emerged in California as the primary strategy for extending alternative, agroecological knowledge in conventional agriculture. Partnerships are an intentional, multi-year relationship among at least growers, a growers' organization, and one or more scientists to extend agroecological knowledge and protect natural resources through a field-scale demonstration. Partnerships have been particularly successful in perennial crop farming systems, and have played critical roles in helping California's almond and pear growers to reduce organophosphate use by over 75%. This study provides a cross partnership comparison of grower participation in partnerships and proposes a five-part typology to rank this.

Key words: agroecology, agricultural extension, agricultural partnerships, farmer participation, social learning, social networks, California

Introduction

Renewable agriculture requires an alternative approach to extension. Most extension services have operated with a 'Transfer of Technology' paradigm, when in fact it is these technologies that are used in unsustainable ways[1]. Most agricultural extension efforts have focused on increasing the adoption of new technologies to increase yields, with little regard for the impact new technologies and practices have on the entire farming system. Yet, simply inserting ecologically based practices into conventional agricultural extension systems has a very poor record of adoption[2,3]. Researchers and practitioners are increasingly articulating an agroecological framework for sustaining yields while conserving natural resources upon which agricultural production depends[4,5]. As an alternative agricultural paradigm, agroecology rests on alternative epistemological assumptions[6]. Successfully generating and exchanging agroecological knowledge requires a shift in actors' roles and participation.

Researchers have devoted considerable attention to the importance of farmer participation in agricultural extension in the developing world, focusing on the needs and perspectives as the end users of new knowledge[7–9]. To implement agroecological strategies, growers, extensionists and scientists have to conduct research and extension together through social learning processes, often referred to as 'partnerships'[10]. Most social science research into grower participation has been done in the developing world, although initiatives at the Wageningen Agricultural University in The Netherlands are an important exception to this[11]. Their work indicates that even in advanced capitalist agriculture, growers must actively participate in these social learning processes, and that these are more effective when organizations of growers facilitate a re-thinking of farming systems in light of specific, local ecological conditions[12]. This requires a fresh approach for growers accustomed to passively receiving expert knowledge from others, and for extension agents accustomed to the role of expert.

Agricultural extension is in crisis across many countries, chiefly due to trends toward privatization[13–15]. In the US, public extension services are institutionally located in agricultural universities. Extension service budgets in the states of Arizona, Oregon, Washington, Maryland, Texas, Colorado, Oklahoma and Alabama have all been cut during the past 3 years. Georgia has lost over 50% of its extension service. Likewise, the University of California Cooperative Extension (UCCE) service suffered serious budget cuts: 25% between 2001 and 2003. In addition, restructuring of professional incentives for extensionists more toward research has further removed them from field-based educational activities. Extension specialist McDowell[16], who has worked for decades in the US Cooperative Extension service, describes his institution as suffering from an 'identity crisis'. He notes a national pattern of agricultural interest groups 'taking extension hostage', meaning they have persuaded extension services to provide technical support for profitable yet resource polluting practices, a strategy that is unsustainable ecologically as well as socially and politically.

The publication of the National Research Council's Alternative Agriculture[17] accelerated the development of alternative models of extension in several regions of the US, based on co-learning and knowledge exchange rather than technology transfer. These initiatives explicitly assume that new practices can be developed that conserve natural resources and enhance grower economics, that scientists and growers have to learn from each other, and that knowledge exchange is accelerated through farm-scale joint research[18]. Prominent examples of these have been the Practical Farmers of Iowa[19], a team approach to extension in Wisconsin[20], soil conservation in Washington state[21], and California's agro-environmental partnerships. All of these evince a shift in roles—in social relations between growers, extensionists and scientists—to extend renewable agriculture and overcome the constraints of conventional extension pedagogies.

Over the past 15 years, agro-environmental partnerships have become the primary vehicle for facilitating agroecological strategies in conventional California agriculture to address agricultural pollution[22]. Thirty-two partnerships have created networks of growers, scientists and agricultural organizations to extend agroecological knowledge to protect environmental resources, reduce pesticide use and reduce input costs. Agro-environmental partnerships incorporate traditional participants in agriculture, but configure them into intentional and dynamic networks to learn how to optimize ecological relationships in farming systems. Partnerships facilitate social learning among growers, which I define as: participation as a group in experiential research and knowledge exchange to enhance common resource protection[23].

This paper reports original research into the development, impact and social organization of agro-environmental partnerships in California. These represent an innovative, semi-privatized approach to organizing extension activities guided by agroecological principles. Agro-environmental partnerships demonstrate the critical importance of grower participation in social learning about these strategies, and the essential, facilitating role growers' organizations have played in fostering participation. Successfully extending agroecology requires the design of alternative extension pedagogies, based on fostering social networks of active participation in social learning by scientists and growers.

This paper begins with an introduction to California's hyper-specialized agriculture and the implications of this for the practice of agroecology. A description of California's agro-environmental partnerships, and their impacts, follows. The next section describes growers' roles in creating and maintaining these partnerships. The paper concludes by analyzing the social networks that order grower participation in partnerships, and proposing a five-part typology for interpreting their social learning models.

Methods

This paper reports qualitative research into the social relations among partnership participants, and how they negotiated research and outreach activities. Using in-depth interviews among growers, their consultants and scientists, it highlights the critical role of grower agency and participation in partnership viability, although it does not attempt to quantify the impact of these partnerships on growers. It describes reductions in agrochemical usage in several commodities that have hosted the most active partnerships, although it presents no evidence of an exclusive, direct cause/effect relationship of partnership activity on agrochemical decision making by participants.

Three years of field interviews in California provided the data sources for this research. The primary sources of information are semi-structured interviews with 32 partnership leaders. This is supplemented by: personal interviews with 97 other participating growers, managers, scientists and grower organization staff; 13 focus groups with 84 participating growers, extensionists, scientists and grower organization staff; and participant observation at 34 partnership-related meetings. Data from this field work were analyzed and reported more fully in a dissertation[24].

Agroecology in California

Agroecology prescribes agricultural and ecosystem management strategies based on the discipline of ecology, and it marks a convergence between the agricultural and ecological sciences[25]. Fifteen years ago Altieri[26] proposed three chief characteristics of agroecology:

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

More recently, he has described agroecology as optimizing agroecosystem processes (see Table 1), which

Table 1. Elements of agroecology.

Agroecosystem processes (Altieri[5])	Practices promoted by California's agro-environmental partnerships
Organic matter accumulation and nutrient cycling	Cover crops, application of compost, manures, chipping tree prunings, crop residue management
Soil biological activity	Cover crops, application of compost, manures, crop residue management
Natural control mechanisms (disease suppression, biocontrol of insects, weed interference)	Removing ecologically disruptive agrochemicals from the farming system, bio-diversification to attract and retain beneficial insects, cover crops
Resource conservation and regeneration (soil, water, germplasm, etc.)	Protection of streams with buffer strips, efficient use of irrigation water (no attention paid to genetic resources)
General enhancement of agrobiodiversity and synergisms between components	Managing components of farming systems to capture synergistic benefits

correspond rather well with the practices promoted by California's agro-environmental partnerships[5]. Note that Table 1 only reports the processes which growers and scientists can use as tools in designing farming systems; extending agroecology requires specific adaptation of these processes to local ecological conditions and distinct production systems.

California agriculture is among the most hyper-specialized and commodified in the world[27,28]. For this reason, farmers here prefer the term 'growers'[29]. Most California growers identify themselves primarily by the primary commodity crop they grow (e.g., an almond grower or a winegrape grower), and they purchase virtually all inputs (including many that growers in other places produce on their farm, such as compost). Extension agents also work among a restricted number of crops. Partnerships have thus emerged within the context of commodity-specific social networks. Participants in each partnership build on commodity-specific knowledge, and their consideration of agroecological strategies is restricted to optimizing their commodity-specific farming system. Growers and extensionists conceptualize bio-diversification and attempts to capture synergistic benefits only within the context of monocultural, single commodity production practices.

Agro-environmental Partnerships in California

This section describes the origins of pioneering partnerships and explains why partnerships have been more effective among perennial crops. The agro-environmental partnership model has been the chief strategy for extending alternative, agroecological knowledge in California over the past decade, with over 500 growers, 92 public scientists and extensionists, and 84 private entomologists/crop consultants participating. These growers experimented with agroecological practices on over 9800 hectares, while managing a total of over 97,500 hectares[24]. I define an agro-environmental partnership to be an intentional, multi-year relationship between at least growers, a growers' organization, and one or more scientist to extend agroecological knowledge and protect natural resources through field-scale demonstration. This extension model contains traditional elements and participants, but deliberately configures them to more effectively promote agroecological knowledge. Partnerships create opportunities for actors to negotiate their respective goals for agricultural research, education and production, and they facilitate a more comprehensive response by growers and scientific actors.

The almond Biologically Integrate Orchard Systems (BIOS) partnership is the best-known and most studied partnership in California[30,31]. At the request of two brothers who farmed almonds—one with organic and the other with conventional methods—UCCE extensionist Lonnie Hendrix launched a multi-year, whole-farm comparison documenting the ecological relationships on the organic farm that made it more profitable while dramatically reducing agrochemical use[32]. The non-governmental organization Community Alliance with Family Farmers (CAFF) expanded this into regional programs of field-scale comparisons by groups of growers who conducted on-farm research based on collaboration among growers, private entomologists, CAFF staff and university researchers.

BIOS promoted a holistic, farming systems approach. Instead of substituting one or two ecologically based practices for a harmful technology, BIOS promoted the re-design of farming systems based on agroecological principles, but encouraged the grower to make changes on a timetable of his or her own choice. BIOS helped growers 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.

CAFF parlayed BIOS's early and dramatic success in agrochemical reductions into a broader agenda for a change that included state policy initiatives as well as constructive engagement with commodity organizations (marketing orders), such as the Almond Board of California[30]. It proposed BIOS-like partnerships as an alternative model for conducting extension, based on populist and environmental conservation values. This partnership model has three main components:

(1) a *structure* of local management teams;
(2) a *process* of grower outreach; and
(3) a *goal* of reducing agrochemical use by adopting integrated farming practices[33].

CAFF insisted that what they had demonstrated to be successful in almonds could be replicated for other commodities. The example of BIOS and the advocacy of CAFF stimulated legislators, public agency officials and private philanthropic foundations to fund and create funding programs for a total of 32 partnerships between 1991 and 2003.

Growers who do not wish to transition to organic production have found partnerships to be an attractive way to learn more about alternative practices. The voluntary nature of partnerships facilitates the active contribution of growers and private consultants pre-disposed to experimenting with agroecological approaches. They participate because they think they can cut costs while farming more in keeping with their environmental values. Scientists and extensionists engage in partnerships because their contribution can have a greater impact and they stand to learn from skilled growers. Partnerships enhance or create an interactive network to extend and evaluate alternative practices on a field scale. Partnerships are sufficiently flexible to allow various goals to be pursued in different partnerships, and by different participants within the same partnership.

The entrance of growers' organizations such as CAFF and the Almond Board into extension activities is a remarkable new development in California agriculture, and is one factor distinguishing the agro-environmental partnership model from conventional extension models using integrated pest management (IPM) strategies[24]. California growers have always been highly organized, and have funded university research for many years, but not extension activities. The combination of the retreat of public extension services plus increasing environmental regulatory pressure has induced these organizations to help growers develop more resource conserving practices.

The two primary public funding programs have been the University of California's Biologically Integrated Farming Systems (BIFS) and the Department of Pesticide Regulation's Pest Management Alliance (PMA) program. They sponsored ten and eight partnerships respectively. The Pew Charitable Trust funded partnerships in California and elsewhere, and later established the Center for Agricultural Partnerships that funded two additional projects in California. Yet growers or growers' organizations initiated nine partnerships, independent of these major funding programs[24]. This indicates the degree of grower interest in alternative practices.

The 32 partnerships have addressed alternative production systems in 16 crops. Perennial crops, perennial crop growers and organizations of perennial crop growers all appear to be more disposed to partnership activities. Three-quarters of all partnerships have been in perennial crops, and only perennial crops have hosted two or more partnerships. Over half the partnerships have been in just five crops (winegrapes, walnuts, pears, almonds and prunes). Several factors favor partnership development in permanent crops: the cropping system, social relations within the commodity; and economic pressures on California agriculture.

The perennial character of these crops is very important. Perennial crops do not require the same degree of disturbance that annual crops do, and biocontrol strategies have been relatively more successful in them. Perennial crop growers have added incentives to invest time in learning about perennial crops because they represent a multi-decade investment of capital and labor.

Secondly, perennial crop growers have a long history of cooperative organization, more so than growers who grow annual crops or raise agricultural animals[29]. Agro-environmental partnerships build on this tradition. Perennial crop growers have a long history of successful commodity organizations and cooperative marketing efforts, rewarding collective activities. This is true across most commodities, and especially true with local winegrape organizations. Commodity organizations exist at the pleasure of a majority of growers, and have to continually prove their worth to their members to justify the assessments they collect from growers on each pound of crop. Partnerships are a new way so that they can add value to their organization and further strengthen grower support for them.

Thirdly, over the past few decades, there has been a trend in California agriculture away from low value extensive crops toward high investment perennial crops[34]. This has been driven by increased demand for fruit and nut crops plus growers' needs to capture improved returns per acre from their land. This has resulted in attracting somewhat more educated and entrepreneurial growers, with new capital and expertise, and in some cases, more education. This is especially true in almonds and winegrapes, and to a lesser extent in walnuts.

Assessing the Impact: Examples from Pioneer Partnerships

Agro-environmental partnerships impact a commodity's practices through three general stages: discovery, agronomic feasibility and economic viability. The first stage consists of initial research into why some growers have had success with agroecological methods. Hendricks's whole farm comparison study in the late 1980s performed this function in the almond farming system, but some partnerships have not been able to move beyond this stage because a system of alternative practices has not yet been assembled for that crop.

The second stage demonstrates the agronomic viability of new methods. Most partnerships have developed effective practices, but they require more (expert monitoring) labor or are more expensive. Growers participating in partnerships at this stage are motivated to learn about new methods when they are subsidized or supported, but few are willing to spend much more for them once the partnership has ended.

The third stage depends on widespread circulation of knowledge about practices among growers of a specific commodity, after they have been demonstrated to be economically viable. The more successful partnerships have created manuals to help growers make the transition to an alternative farming system. CAFF worked with the Almond Board to create the Almond BIOS manual[35]. The Lodi Woodbridge Winegrape Commission developed a manual to assist its member growers in understanding and managing winegrape farming systems under local conditions[36]. A statewide organization, the California Association of Winegrape Growers, built upon and expanded this approach[37]. The prune partnership assembled its findings into a manual as well[38].

During the 1990s, California's annual use of agricultural pesticides fluctuated around 200 million pounds, roughly a quarter of the US total[39–43], so for political reasons at the very least, partnerships have documented pesticide reduction as a result of their activities. Four commodities evince significant commodity-wide progress in pesticide reduction, as documented by California's Pesticide Use Report database, attributable in part to agro-environmental partnership activities: pears, almonds, stone fruit and winegrapes[44].

These four commodities have had the most active, far-reaching and successful partnerships. The first three have documented dramatic reductions in organophosphate (OP) pesticide use. Agro-environmental partnership activities are not the only reason for pesticide reductions in these commodities. Pesticide resistance, weather and the economics of new 'softer' pesticides are also critically important factors, but partnerships have helped all of these commodities and provided the social relations necessary to support widespread learning about alternative practices and how to use them successfully.

The California almond industry has documented the greatest volume reduction of OP use, from almost 500,000 pounds in 1992 to just over 100,000 pounds in 2000. Much of this reduction is attributed to growers switching to pyrethroid pesticides (less hazardous to mammals and somewhat less disruptive of beneficial insects, but acutely toxic to aquatic organisms); however, partnership activities have also played an important role[45]. The size of this voluntary reduction has generated more research into the almond industry's pesticide use records than any other commodity[46–48]. Stone fruit growers have reduced OP use, in part by switching to 'softer products' as have almond growers, but OP use has not declined as dramatically in this commodity[49]. Stone fruit growers and their organizations have not invested the same scale of effort into partnership activities as have almond growers, but they have to cope with greater cosmetic concerns.

Pear growers reduced OP use faster than any other commodity in the history of California agriculture by substituting pheromone mating disruption products, from over 110,000 pounds in 1998 to 25,000 pounds in 2002. Codling moth resistance to OPs began to appear in the Sacramento region in the early 1990s, and gave a strong impetus to develop the ecological knowledge necessary to make this new pest management strategy effective. Partnerships fostered networks of expert scientific knowledge critical to the successful use of pheromones necessary to support this OP reduction, and to take advantage of biocontrol opportunities in less disrupted farming systems.

Winegrape growers are fortunate to have a crop with few cosmetic concerns, generally lower pest pressure, and many alternatives to OPs to treat their pests, so winegrape partnerships have focused their attention on the entire farming system, more than other commodities. Campos and Zhang[50] and Arounsack et al.[51] have documented reductions of problematic pesticides in three regions where winegrape partnerships have been active.

In sum, agro-environmental partnerships have played a substantial role in reducing pesticide use in these commodities, but they are not the only factor. Weather is the most important factor shaping pest populations and pest management[48], but partnerships have extended critical information about ecologically informed alternatives to OPs and other disruptive pesticides.

Grower Participation in Partnerships

Other researchers have documented the benefits of grower participation in extension, but this research investigated 32 distinct cases. Individual partnerships form the unit of analysis, and this is the first time grower participation across partnerships has been compared in this way. What follows is a presentation of various expressions of grower agency, roles and participation in partnerships. This will be an important background for interpreting the various networking strategies discussed in the final section.

Partnerships structure grower participation, consciously or not. Growers' participation is uneven across partnerships. Some partnerships are organized and substantially directed by growers, while others are operated 'for' growers by extensionists and organizations. Growers have been crucial to the establishment and maintenance of the most active and successful partnerships. The importance of grower participation is not directly proportional to the amount of time they contribute to the management of the partnership, but rather the legitimacy they confer on their activities in the eyes of their peers.

Growers have expressed their leadership by identifying problems, proposing collaborative solutions, initiating partnerships, forming organizations, directing existing organizations to address agro-environmental issues, providing a template of new practices, recruiting growers, and assisting with management team leadership (see Table 2). Only in a few partnerships have growers taken a leadership role in all

Table 2. Growers' roles in establishing partnerships.

Phase	Activity	Number ($n = 32$)
Partnership genesis	Identify an environmental problem affecting local growers	26
	Defining the problem and supporting a collaborative solution	20
	Developing or sharing a template of practices for the partnership	11
Recruitment of growers	Leading growers enroll >50% of other grower participants	7
Role on management team	Helping lead the management of partnership activities	8
	Contributing to management team efforts	19

Source: interviews with partnership leaders; $n = 32$ with all partnerships reported.

Table 3. Expressions of participation by leading growers, by numbers of partnerships.

Phase	Activity	Number ($n = 32$)
Research	Contributing to formal scientific research	8
	Leading (proposing) the research and development of new practices	15
	Contributing to making the new practices practical	28
	Consenting to others conducting research on property	29
Outreach	Leading outreach activities (organizing field days)	7
	Contributing to outreach (hosting field days, speaking, inviting others)	23
	Serving as a template/mentor grower	14
	Sharing grower knowledge/experience with other growers	30
	Choosing and applying practices from a menu of options, and assuming the risks (versus practices chosen by others)	24
Evaluation	Contributing to a formal evaluation forum (committee, focus group, survey, interviews)	21

Source: interviews with partnership leaders; all partnerships reported.

of these activities. They generally do not contribute to the day-to-day management of the partnership itself, but their participation ensures that scientists' research will be of practical use, and persuades other growers of its viability. Other growers attend to the authority of their peers who have invested their time and taken economic risks on agroecological practices. Growers identified production problems and sought out collaborative solutions in 11 of the partnerships.

Most partnership leaders ascribe significant importance to the contribution of 'leading growers' to the overall success of the project, even if only one or two growers play a leadership role. The distinction between leading growers and enrolled growers is crucial to understanding different expressions of grower participation. The term 'leading growers' distinguishes their role from others because it indicates they have researched integrated farming systems and actively engage others in discussions of these practices. Leading growers have a vision of agriculture that does a better job of stewarding environmental resources, and they translate that into a vital model. They recognize that they are more likely to attract the attention of researchers if they are organized into a group, and are independently motivated to try new practices (see Table 3). For example, in the Lodi winegrape partnership, several leading growers persuaded their neighbors to accept a mandatory per-ton 'self-tax' on their winegrapes to fund specialized, local research and education projects, and marketing efforts[52]. The importance of grower participation in establishing and orienting partnership activities cannot be overstated. In 11 partnerships, leading growers were designated template growers, meaning they have a farming system for other growers to emulate, or mentor growers, indicating they will help less skilled growers learn about new techniques. Glenn Anderson of the almond BIOS partners exemplifies a template grower.

The term 'enrolled growers' indicates that their participation in the partnership was solicited by someone else, whether a leading grower or an extensionist. Enrolled growers manifest less initiative than leading growers, and play a less influential role in partnerships, because they are recruited to a partnership already designed by others. Thirty partnerships formally enrolled as growers, and their participation is reported in Table 4. Enrolled growers are expected to dedicate a field or block for experimenting with a new practice, learn more about pest or fertility monitoring, and share this information with other growers and extension actors in a structured way. Enrolled grower participation is necessarily less active than that of leading growers.

Some partnerships explicitly try to facilitate growers re-thinking on their farm management decision-making process. Many of these partnership strategies, such as having the grower select from a menu of options and

Table 4. Expressions of enrolled grower participation, by numbers of partnerships.

Partnerships expected enrolled growers to	Number ($n=30$)
Enroll by	
Engaging in a structured research and social learning process	30
Dedicating a block for alternative practices for >1 year	29
Dedicating comparison blocks	25
Learn by:	
Participating in agroecological pest, soil, water and fertility monitoring	29
Sharing with other growers in a structured way	26
Selecting from a menu of agroecological pest, soil, or irrigation management techniques	18
Experiment with:	
Agroecological pest management techniques	29
Agroecological soil and irrigation management techniques (e.g., cover cropping, conservation tillage, irrigation monitoring)	20
Integrate farming systems by:	
Evaluating the impact of system components (e.g., the impact of fertility and water management on pest pressure)	22
Creating farming system management plans (with extensionists)	15

Source: interviews with leaders of partnerships that formally enrolled growers ($n = 30$).

collaboratively developing a farm management plan, were originally promoted by BIOS. The manuals emerging from partnerships, described above, are an attempt to formally expand the range of menu options, beyond that of conventional wisdom. Engaging growers with a menu of options demands additional effort from partnership leaders, but it facilitates more active learning on the part of growers and does appear to result in better farming decisions over a time.

Many participating growers report they now make decisions on a multiple criteria basis. Many leading growers in partnerships insist that agroecologically based farming can cost the same or less, but only if the entire farming system is evaluated. For all its technical sophistication, California agriculture has tremendous variability in its practices, suggesting that growers have greater flexibility in their operations than many realize. Facilitating the development of farm management plans can help growers recognize the value of monitoring data and incorporate it into adaptive decision making. This is fundamentally different than technology transfer.

Engaging Networks

The highly specialized, narrowly defined roles of growers, consultants and scientists in California agriculture are incompatible with a facile assumption about participation from the 'Farmer First' development literature[1]. Core principles of power dynamics and social learning still apply, but the highly specialized division of labor here is profoundly different than in the developing world. California agriculture is among the most technologically advanced in the world, and consultants, scientists, growers and farm workers have narrowly conceived roles. Successful partnerships have provided growers new and multiple perspectives on farm management, and helped them develop a more complete framework for understanding the ecological dynamics of their farming system.

California growers make decisions in dialogue with others. In addition to university-generated research, they draw on the knowledge expertise of fellow growers, private scientists and growers' organizations. Extending agroecology requires engaging these social influences on grower behavior. This section describes how partnerships facilitate enhanced knowledge exchange between growers, private consultants and agricultural organizations.

California's hyper-specialized farming systems plus its relatively strict pesticide regulations have given rise to the Pest Control Advisor (PCA), a state licensed, privatized extensionist combining specialized university-generated expertise with practical, field-based experiential knowledge. More than anyone else, they are able to observe regional trends in pest pressure and propose a menu of tactics that can control them, and they often have the most influence on decisions to apply pesticides. Many large growers rely heavily on the counsel of PCAs to make pest management decisions, and some draw on the expertise of two or even three.

Over 80% of all PCAs work for agrochemical sales companies, and receive from them base pay plus a commission on all materials they sell. Critics refer to these as 'chemical company PCAs,' but they prefer to be known as 'affiliated PCAs.' Affiliated PCAs provide a seamless package of expert advice plus pesticide sales, delivery and application, depending on the needs of the grower, but the 'value' of the recommendation is folded into the price of the agrochemicals. A small minority of PCAs are independent consultants who contract their services for monitoring and consulting directly with the grower. Independent PCAs are paid on a per acre basis. Many report earning less money as independent PCAs, but having superior job satisfaction.

Twenty-seven partnership leaders reported enrolling a total of 84 PCAs as formal partners, 38 of them independent PCAs. This is a disproportionately high number of independent PCAs, and they have played important leadership roles in some partnerships, in terms of both the applied science, and overall group leadership. Twenty-one partnership management teams included one or two PCAs, enhancing the credibility of partnership activities among other PCAs. Both kinds of PCAs report they participate in partnerships because it offers them the opportunity to

Table 5. Social learning and relationships between leading and enrolled growers.

Social learning type	Relationships between leading and enrolled growers	Social learning occurs?	Number ($n=32$)	Growers came into this role by:	Comments
Incubation	Leading growers all learn together as a group; other growers only learn later	Yes, within the group	5	Leading growers volunteered for it	Often used for initial field-based research
Entrepreneurial learning	Leading growers develop alternative practices and promote them through an organization for other growers, formally enrolled or not	Yes, within group and publicly	3	Leading growers volunteer for it, and promote participation by others	Only found in winegrape partnerships
BIOS model	Leading growers provide template, and enrolled growers adapt; social learning occurs	Yes, within group and publicly	15	Extension actors negotiate roles with both kinds of growers	Also known as the BIOS-inspired BIFS model
PMA model	Enrolled growers receive practices from extension agent; others learn by observation	Yes, publicly	7	Invitation from extensionist	Inserting alternative practices into conventional extension model
Reduced Risk Research	Only enrolled growers; no evidence of social learning by growers	No	2	Invitation from extensionist	Consent to pesticide trials

sharpen their skills, develop professionally and 'improve the system' of pest management.

Partnership leaders report mixed success working with PCAs. They praise PCAs who actively participate for helping to make partnership practices economically feasible, but they report most affiliated PCAs express skepticism and passively resist pesticide reduction goals. PCAs apparently contributed less than growers, but their participation was nevertheless essential to partnerships' honing agroecological pest management techniques.

Many growers and their consultants do perceive partnership practices to carry increased risk without offering a sufficient return. Some partnerships try to re-configure risk perception by introducing a broader array of knowledge about risks. Additional research into the role and re-configuration of risk agroecological practices would help agro-environmental partnership participants understand the dynamics of partnership activities.

Networking Growers Through Social Learning

Differences in farming systems and social relations across commodities have given rise to multiple forms of social learning. Table 5 reports five major types of social learning, shaped by relationships between leading growers, enrolled growers and extensionists. In general, the first three types evince more active discovery learning and dynamic knowledge sharing between actors.

In the Incubation type, growers learn together, and minimize distinctions between those who initiate the partnership and those who join it later. The emphasis here is on formal and informal learning through collaborative research by scientists, PCAs and growers. Field days may be held, but there is little emphasis on outreach. Non-enrolled growers learn about partnership practices at a later time. Growers initiate these partnerships for themselves and each other. This model has been used more for initial field-scale agroecological research, the discovery stage described above.

The second type of configuration, Entrepreneurial Learning, consists of leading growers forming a co-learning relationship like the first type, but in addition they take the practices they develop and promote them to other growers through an organization. Social learning here takes place among leading growers, but they realized the benefits that could be captured by helping neighboring growers to improve their practices, and they wanted to formalize this educational process by creating an organzation. An initial emphasis on facilitating learning by leading growers subsequently gives way to broader outreach in the region. All three examples of this model occur in the winegrape industry. Local winegrape partnerships have deployed this model to focus more attention on their identified research needs, draw on the resources of existing local organizations to aide marketing, and to help 'bring along' other growers to enhance the reputation of regional growers as environmentally responsible (this is a phrase common only to the winegrape partnerships).

The most common configuration among partnerships is the BIOS model, in large part because the BIFS program tried to institutionalize this approach. In this, extension actors identify one or two template growers and propose their farming systems as examples for other growers. In some cases, the extensionist has provided expert knowledge and guidance to the leading grower during previous years, and a partnership provides a structure for further promoting these practices. This configuration facilitates variable combinations of research and outreach, and they often are conducted simultaneously. Clear results are extended broadly, and scientific uncertainties are communicated as such. In this configuration, outreach is targeted to enrolled growers, who receive concerted attention and resources in the form of farm visits, access to new products and cost sharing for resource conservation tools like cover crop seeds. Other growers are invited to field days and encouraged to learn about agroecological practices at field days and put them to use on their own farm. In almost all of these cases, enrolled growers selected from a menu of practices, and were expected to share the results of their experimentation. Social learning activities are focused on the extension actors and the leading and enrolled growers, and to a lesser extent on other growers and PCAs.

In the PMA model, UCCE extensionists test a suite of agroecologically informed practices in field-scale conditions on the orchards and farms of cooperating growers. Growers may make practical suggestions as to making the program work, and their observation and experience may be important contributions to the partnership, but their fundamental role is hosting the research and demonstration site. Scientists and extensionists run the management team and evaluate the results of experiments. Growers do not propose practices, nor do they select them from a menu, and they do not make substantive contributions to the management team. This model does not readily facilitate initiative or leadership from growers, and generally has fewer leading growers than other models. The organizers of partnerships with this configuration did not speak of intentionally excluding growers, nor did they report them making any important contribution.

Two partnerships were configured so as to have virtually no participation from the growers in research or outreach, and are thus labeled Reduced Risk Research. In practice, these partnerships worked closely with PCAs, and the operational definition of grower participation consisted of consenting to research being done on their fields. Neither of these partnerships exhibited social learning, and are included here for contrast.

Conclusion

To successfully extend agroecology, growers and extensionists must be able to create networks of social learning. They create these networks to apply agroecological principles to specific farming systems. Four of the five types of networks detailed above manifest the kind of knowledge exchange necessary for agroecological learning. Participation in these networks necessarily varies by the character of a crop's farming system, progress in developing agroecological knowledge and the social relations among a commodity's growers.

Agroecological principles have demonstrable application to the monocultural farming systems in California. The agro-environmental partnerships deploying them have made a substantial contribution to the reduction of hazardous agrochemicals in almonds, pears, stone fruit and winegrapes.

Extending agroecological knowledge requires an alternative to the transfer of technology pedagogy. Agroecology requires more dynamic interactions to support learning by growers, extensionists and scientists about the ecological relationships between technological and biological components of farming systems. Knowledge exchange between growers can often be equally important as knowledge exchange between extensionists and growers.

Substantial progress has been made in researching agroecological principles. Extending agroecology requires a pedagogy that engages network growers and their consultants in social learning.

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