



# Concepts of Sustainability, Motivations for Pest Management Approaches, and Implications for Communicating Change

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Impact and relevance are valued by both plant pathologists and the supporters of research and extension. Impact has been characterized as the “So what?” of research results, and in applied research in agriculture typically involves some change in human behavior. This might involve, for instance, avoidance of broad spectrum pesticides, use of economic thresholds, or adoption of a new cultural practice in disease management. Changes in human behavior often are slow and difficult, even when the potential benefits of change seem clear. Research and extension personnel working with farmers have discussed for decades the apparent slow pace of adoption of integrated pest management (IPM) and other less-pesticide-intensive management practices. The reasons why change is slow are numerous, but one aspect that warrants consideration is how changes in farm practices are communicated to farmers. Effectively communicating changes in pest management practices at the farm level requires a system of research and extension management that differs from that to which most biological scientists are accustomed (30). Fundamentally, how should new ideas and innovations be communicated to effect change, particularly when the change advocated potentially may conflict with existing paradigms and experience? What is the motivation for farmers to deviate from historical practices? How persuasive are concepts of environmental sustainability, integrated pest management, risk management, and economic gain in communicating the needs for change?

In addressing these questions, it is useful to understand some of the basic determinants of farmers’ decision processes and motivations to adopt practices. It is generally recognized (or assumed)

that integrated pest management practices have economic, social, and environmental benefits for those who implement these practices. At the same time, pesticide overuse is broadly claimed in the literature, especially in modern, mechanized agricultural systems in wealthy countries (21). The cost of overuse of pesticides is shared collectively by society in the form of pesticide resistance, chronic and acute health problems for farm workers and consumers, environmental contamination, impacts on nontarget organisms, and regulatory costs to governments (56). Not only is IPM viewed as an appropriate framework for achieving farm and environmental policy objectives, but also its adoption is increasingly becoming statutory (e.g., the European Union Thematic Strategy on the Sustainable Use of Pesticides) to reduce the social costs of pesticide use.

Researchers have discussed the perceived slow pace of IPM implementation and its possible causes in many contexts (10,15,60). It is clear that barriers to and motivations for less-pesticide-intensive forms of agriculture are multifarious and may vary regionally (43). A few of the explanations found in the literature suggest IPM adoption decisions can be explained in part by farmers’ personality traits (6), their goals and management disposition (4), and cultural factors (41). Economic factors influencing adoption may include economic lock-in (10), avoidance of risk (15,48), lack of efficacy to market demands (42), and more generally, a lack of fit to context (27,60). Other literature suggests that farmers’ ideological motivations are the most important source of their decisions, with moderating effects imposed by economic and market-related factors, and social processes restricting or increasing information availability (1,7,8,10,12,14,22,29,37).

It is clear that there is an important human dimension in the success or failure of IPM programs (6,60,61). Many contextualize farmers’ decision-making processes within the changing face of agriculture itself (7,12,14,54). It has been recognized for decades that agriculture has changed drastically during the course of the last century, and that the rural agrarian ideal does not resemble most current agricultural practices or communities (11,16,17,23,34,49). Modern farmers are not independent yeomen who have sole agency in their decisions, but rather are players within a much larger industrial system that includes many other interests and influences. Given the development of modern agriculture and the scale at which modern farms operate, there is ample reason to in-

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investigate the roles of an industry and its experts in influencing farmer choices and practices (51), as well as the importance of market factors such as consumer demand and international regulations (7,10,12,47,60).

Another commonly acknowledged influence on farmer choices is networks of knowledge and information about farming practices. Compared to conventional practices, alternative systems are frequently perceived as complicated, and experts are critical in aiding farmers in implementation (43). Sustainability in agriculture academic literature tends to incorporate ideas of best use of environmental resources with the least disruptive to these resources, leading to persistence over time and resilience (46). Other concepts of sustainability encompass broader ideas of economic and social ideals. IPM also has many definitions (5,32,57), although most share concepts of intentional coordination of multiple methods to suppress pests in a manner that is economical and minimizes impacts on nontarget organisms and the environment. The central concepts have been described as an “almost aspirational goal for pest management” (62), and it is clear that the particular expert called upon to aid in implementation can influence a farmer’s understanding of IPM and how its tenets are applied in practice (25). Thus, there is murkiness in what may constitute adoption, particularly when considering that IPM is a continuum of integration (32) and its application may be highly nuanced.

Kaup (29) notes that “farmers are ‘reflexive’ actors who actively negotiate between ‘expert’ and ‘local’ knowledges” including such sources as pesticide and fertilizer dealers, consultants, neighbors, and fellow farmers. Some of the literature on information sources pits the knowledge of agribusiness and extension agents against the experiential knowledge of farmers (7,10,29,37,38,47,60). These

works investigated the importance of farmers’ relationships to each other, and to agents of knowledge from both industrial and academic sources in influencing their decision-making processes. While industry experts from private consulting firms and seed, pesticide, and fertilizer dealers were shown to have strong influences on farmers (33,38), it was also found that “adoption decisions are often based on imprecise factors such as ‘what is considered to be socially and culturally acceptable by members of [potential adopters’] social group’” (47).

We present a case-study based on surveys and in-depth interviews with hop and mint farmers and industry specialists in Washington and Oregon that examines farmers’ decision-making processes with regard to disease and pest prevention, and barriers and motivations for adoption of IPM practices for arthropod pest and disease management. In this paper, we focus on findings that are relevant for framing communication with farmers and their advisers. Three primary themes emerged from the data that emphasize the importance of (i) personal relationships in effective communication, (ii) awareness of the diverse motivations for and basis of current farming practices, and (iii) respect for heterogeneity in views of sustainable pest management. We advocate that communication efforts are most effective when scaffolded by a relationship with farmers and their advisers that is informed by and evinces respect for the complexity of factors that underlie their management decisions.

### Research Field Sites and Methods

The research focuses on the two largest regions of hop production in the United States, the Yakima Valley in Eastern Washington and the Willamette Valley in Western Oregon (Fig. 1). The Yakima



**Fig. 1.** Commercial hop production. The hop plant produces annual shoots from a perennial root system, as shown in **A** and **B**. Shoots typically grow over 5 m from emergence in late winter to the summer solstice, and cones are harvested during mid to late summer (**C** and **D**). Nearly all commercial hop production in the United States is located in the Pacific Northwest.



Valley is a semi-arid region, reliant on irrigation for its abundant agricultural industries, which include hops and mint, grape vineyards, tree fruit, vegetables, and field crops such as wheat and corn. About 75% of all hop acreage in the United States is contained within the Yakima Valley, which grows 77% of the total U.S. crop. The average hop farm size in the region is 450 acres (59). Washington also produces about a third of all mint harvested in the United States, making it the largest mint-producing state in the nation, although the crop is not as concentrated in the Yakima Valley as are hops (Fig. 2).

The hop-growing region in Oregon is centered in Marion County near the state capital of Salem. The climate of this fertile region is maritime west coast, with mild, wet winters and warm, dry summers, which constrains the growing season and the cultivars of hop that can be grown there. The Willamette region grows a considerably smaller share of U.S. hops, and average farm sizes are less than half that of the Yakima Valley (58).

There are four primary pests that require management efforts on hop in the Pacific Northwestern United States: the hop aphid (*Phorodon humuli*), twospotted spider mites (*Tetranychus urticae*), downy mildew (caused by *Pseudoperonospora humuli*), and powdery mildew (caused by *Podosphaera macularis*) (Fig. 3). These pests occur in both Oregon and Washington, although pest incidence and damage to hops differ between the two states due to climate, cultivars produced in each state, and certain cultural practices such as irrigation methods and spring pruning (19,20). In Oregon, the mild, wetter climate generally favors downy mildew and hop aphid in most seasons. These pests are less problematic in Washington (e.g., 26). Powdery mildew and spider mites occur in Oregon, and may be damaging, although they tend to be more problematic in the semi-arid climate of central Washington (e.g., 19,20). Based on pest management surveys (described below), on average farmers in Oregon reported 1.9 insecticide applications and 1.4 miticide applications per season. The mean number of insecticide applications was similar in Washington (2.0), although miticides were applied more frequently in Washington (2.1) than in Oregon. For disease management, 5.1 fungicide applications were made for powdery mildew and 7.0 were made for downy mildew in Oregon. This was significantly fewer than the 7.7 fungicide applications made for powdery mildew in Washington, but far greater than the 1.1 fungicide applications made for downy mildew in Washington (Fig. 4).

### Online Surveys of Pest Management Practices

To obtain basic information on pest management practices, two surveys of hop growers were conducted between 8 October and 6 December 2010, with Institutional Review Board approval through Oregon State University. Contents of the surveys were related, but distinct, and sought to better understand growers' pest management practices, document awareness and use of online disease and

weather forecast tools for pest management decision making, document the impact of research activities on growers' awareness and decisions, and assist in planning future projects. The surveys also asked questions of how farmers' knowledge and use of IPM practices had been impacted by previous research and outreach activities.

The surveys were supported by grants from the EPA Pesticide Environmental Stewardship Program and the USDA-NIFA Regional IPM program. Electronic questionnaires were emailed to all hop farms in Oregon, Washington, and Idaho; data from Idaho are excluded from this article. The sampling frame was assembled from lists of growers provided by the respective commission offices in the three states. In cases where two farm operations were reported by the commission office but were known to be managed as one management unit (e.g., a father and son who had different farm names), a single questionnaire was sent and collected to represent the farm management unit. Both of the surveys comprised simple random designs. Nonrespondents were contacted at least once by email and once by phone to encourage their participation. Response rates for the surveys were 47.0 and 39.4%, respectively.

### In-Depth Interviews

In-depth assessments of individual farms and pest management practices were obtained from open-ended, recorded interviews with 28 individuals who work in the two industries, which took place during the summer months from 2010 to 2012. Qualitative methods are particularly useful for obtaining in-depth assessments at the level of individuals, because these methods allow respondents to indicate not only what they are doing but their rationale for the actions (39). Interviews generally lasted from one to two hours and included in-depth questions on several themes, including background history, life and community, general farm and pest management, crop-specific pest management, and workforce issues. The questions about the farm practices asked farmers to describe their operations, including size, crops grown, water use, and pest/disease management, including whether they employed IPM and what it entailed for them. They were also asked about major changes in practices in recent years, and why they made them. More detailed questions were asked about practices specific to hop and mint production, including their experiences with particular pests and diseases, how they handled them, and how they gathered information on both pests/diseases and treatment strategies. Although the general questions asked were similar, the nature of in-depth interviews is by design only semi-structured. The specific questions asked and direction of the conversation depended on the responses provided.

The research protocol was reviewed by the Washington State University Institutional Review Board, and was granted exempt status because it was deemed to be low-risk to participants.

Lists of Washington farm operators in the two industries were provided by the Washington hop and mint commissions. Farmers on the lists were contacted by letter, phone, and email after initial



**Fig. 2. A,** A mint field in central Washington produced under center-pivot irrigation. **B,** Mint plant affected by the two primary diseases in Washington, *Verticillium* wilt (**B**) and rust (**C**). Mint production in the United States is centered in the Pacific Northwest. The crop is produced for extraction of oils that are used for flavoring various foods, gum, and other products.



introductions facilitated by representatives of commodity commission groups or other researchers. Of 19 hop farmers contacted in Washington State, 12 agreed to interviews, representing a third of Washington's approximately 40 hop farms. Four mint farmers agreed to be interviewed out of eight contacted, representing about 30% of the 14 operators in Washington State. Mint farmers were only interviewed in Washington State, due to the bulk of Oregon mint producers being located in a different region of the state than the Oregon field site. In Oregon, farmers were contacted by an extension specialist from Oregon State University who explained the research, and those who agreed to be interviewed were then contacted via phone or email to set up interviews. Ten Oregon hop farmers were interviewed, representing 50% of the 20 farm units in the Willamette Valley. One hop industry specialist in each state was also interviewed for additional perspective on the industries. Six hop farm workers in the two states were also interviewed. Research with workers is not reported here. Interviews and data collection ceased when it became evident that new interviews were not revealing any novel information ("saturation").

All interviews were conducted in person by the first author. The sample was heavily male due to the structure of the industry, but a quarter of the participants were women ( $n = 7$ ), including several who are the main operators of their farms, as well as the wives of

male farm operators. Participants ranged in age from 30 to 65, with a mean age of 46. About 92% ( $n = 24$ ) of farmers had grown up on farms themselves, generally the same farms where they currently worked. Many of these farms had been owned and operated by their families for three generations or more. Farm operations ranged in size from 12 to 3,000 acres, with an average of 792. Yakima Valley farms tended to be larger than those in the Willamette Valley; the Yakima Valley farms averaged about 1,100 acres, whereas Willamette farms averaged about 375 acres. In order to help maintain the confidentiality of farmers, we categorized farms as small (<500 acres), medium (500 to 1,000 acres), and large (>1,000 acres). In contrast to the common assumption that the use of pesticide-intensive pest management strategies represents a consistent and exclusive worldview, many farms used multiple pesticide strategies, including specific plots or cultivars that were treated differently than others on the same farm. During the interviews, about 77% of farmers ( $n = 20$ ) characterized their pesticide strategy as conventional on at least some fields; 54% ( $n = 14$ ) self-reported using IPM to some degree (frequently in combination with more pesticide-intensive strategies on some crops or fields); 15% ( $n = 4$ ) had some amount of crop that was raised organically; and 15% ( $n = 4$ ) had third-party certification through the Salmon-Safe program (50).



**Fig. 3.** Signs and damage caused by the primary diseases and arthropod pests of hop in the Pacific Northwest. **A and B,** Shoots affected by downy mildew. **C,** Hop cones severely damaged and discolored by twospotted spider mite. **D and E,** Hop cones with extensive powdery mildew. **F,** Sooty mold development on a cone associated with honeydew from hop aphid.

(Salmon-Safe is a designation that applies to the entire farm, not just specific fields or crops. This designation was primarily adapted to Willamette Valley agriculture, and no hop or mint farms in the Yakima Valley were certified as Salmon-Safe at the time of interview. Salmon-Safe is described by the certifying organization as encouraging “the adoption of ecologically sustainable agricultural practices that protect water quality and native salmon”).

Most participants were interviewed alone, generally in their farm offices or private residences, although in two cases participants chose to be interviewed in cafes. The interviews were based on a series of questions common to all interviews, but allowed for follow-up questions based on the answers given. Concepts and definitions of conventional pest management, IPM, sustainable, and other terms were not defined during the interviews to remain agnostic. Self-reported use of IPM (or other ill-defined production systems) may be appraised optimistically by individuals (e.g., 52), and this is a potential source of bias in this research. However, defining or imposing constraints on these concepts would introduce different biases into the answers provided and was avoided to better elicit the attitudes, perceptions, and viewpoints of the target audience.

Interviews were digitally recorded, transcribed verbatim, and analyzed and coded using qualitative analysis software (HyperRESEARCH, Researchware, Inc., Randolph, MA). Transcripts were coded for both anticipated themes and unanticipated themes that arose repeatedly throughout the interview sample, using a

grounded theory orientation. Initial coding focused on broad themes, and subsequent rounds of coding added more detailed categories related to the larger themes (9). Field notes regarding the interview settings and respondents were generally recorded within 24 hours of the interviews, and were included in the analysis. After initial analysis, the findings were discussed in depth with other researchers on the project who had extensive experience working with hop and mint farmers in the two regions, in order to confirm that findings were consistent with their experiential observations. Analysis was further checked for consistency with the results of the surveys of hop and mint farmers discussed above. All names of individuals and companies reported herein are pseudonyms in order to preserve the confidentiality of participants.

## Relationships with Experts

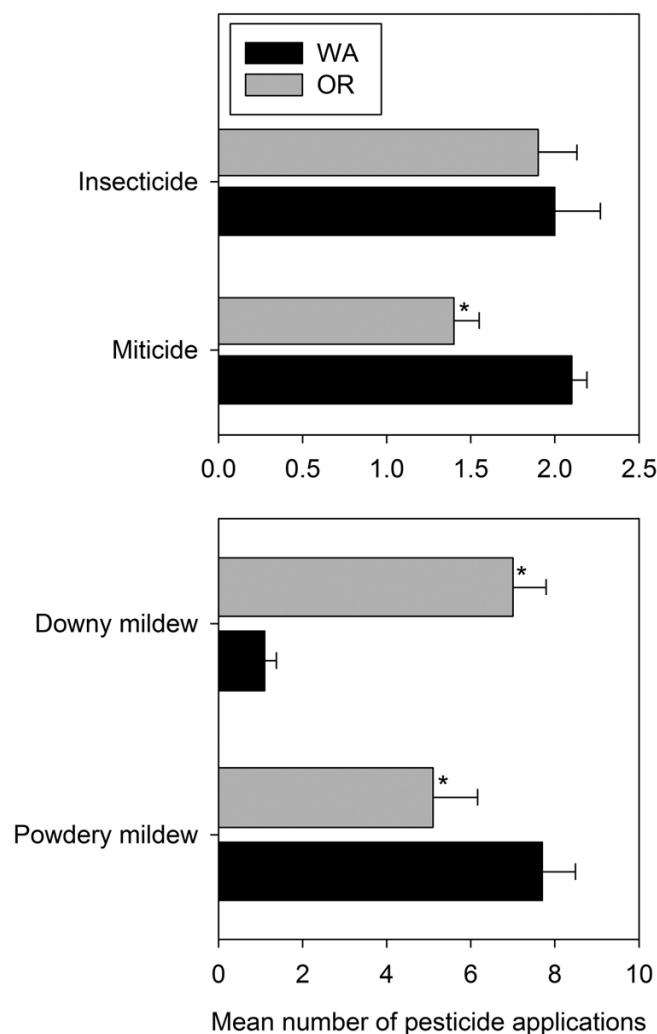
A recurrent theme that emerged during grower interviews was the importance of relationships with experts in making strategic and tactical pest management decisions. For most farmers, certain IPM principles were not innately understood, nor had they learned them from previous generations. Thus, their adoption required both information and support from various specialists. More conventional farmers also needed information to help them navigate the evolving field of pesticides, spray schedules, and national and international regulations. Farmers had numerous sources of information available to them regarding best practices, each with its own intrinsic biases. Among these sources were crop consultants who worked for pesticide distributors, independent crop consultants, university specialists, industry agencies such as the hop and mint commissions, and independent in-house research; but this information was tempered with experiential knowledge gained firsthand or from mentors such as fathers or uncles.

This finding was also supported in the electronic surveys, where monitoring for arthropod pests and diseases was reported to occur at least weekly for 96% of the farms (Fig. 5). For 80% of farms, an external adviser or consultant conducted monitoring. These individuals ranked highly in importance to pest management decisions, with 71.4% of respondents indicating that treatment decisions for disease management were often or frequently influenced by the recommendations of external advisers. However, 32% of respondents also reported that they personally conducted pest monitoring as a supplement to or in lieu of external advisers.

It was clear from the interviews that specialists often represented competing interests, and thus could apply pressure to a farmer to adopt one practice or another. Regional differences as well as a farmer's personal experiences and beliefs appeared to influence who they relied upon most for information. Equally important to farmers were relationships with individual consultants, and their experiences of mutual trust, respect, and efficacy vis-à-vis a particular “expert.”

In general, farmers highly prized their own experiential and multi-generational knowledge, and treated all experts with some skepticism. Many farmers explained in interviews that they felt they had learned more from their fathers' generation than from either academics or field men. Washington hop farmer Don Ackerman discussed the need to “be careful” with pesticide and fertilizer company consultants, whose motives were questionable. He explained, “You always got to keep in the back of your mind, these chemical companies are telling you something because they want to sell. And, you know, so you just – you keep that in the back of your mind.” When asked, “Who do you listen to [instead]?” he replied, “Your gut. Your grandfather, you know, your father.” Medium-sized Washington hop farmer Wade Martin expressed a similar skepticism of consultants: “There's a lot of chemical reps that come by and say, ‘Well, I think this will work.’ And you hate to be the guinea pig, because if it works, it's great, but if it doesn't...” When asked what sort of process he did use to make decisions, he responded, “It's mostly experience.”

While many farmers were suspicious of paid consultants and prioritized their own experience and knowledge, most still did rely on experts to some degree. For most farmers interviewed, the consult-



**Fig. 4.** Mean number of pesticide applications made per season reported by hop growers during 2010 for disease and arthropod pest management in hop yards in Oregon and Washington. Asterisks indicate a significant difference between Oregon and Washington based on a one-sided *t* test.

ant of choice was someone with whom a long-term relationship had been established, and who the farmer believed to be trustworthy, knowledgeable, and effective at addressing his or her needs versus an outside agenda. In Washington, this generally meant pesticide and fertilizer dealer field men, while Oregon farmers tended to have more established relationships with independent consultants and university specialists. Farmers generally chose consultants who were able to aid them in the pursuit of their chosen strategies, but the relationship with a specific individual was equally important to most farmers. An expert's ability to communi-

cate effectively and in a way that both acknowledged and respected the farmer's own knowledge was vital to his ability to maintain trust.

For Washington farmers, of whom three-quarters tended to rely heavily on pesticide and fertilizer dealer consultants, the type of conflict of interest discussed above by Don Ackerman was a common concern, yet one they could live with if they trusted the individuals. Medium-sized hop farmer Ted Fitzgerald said that he got most of his information from several large pesticide and fertilizer dealers in the area, even though he was aware of the inherent con-

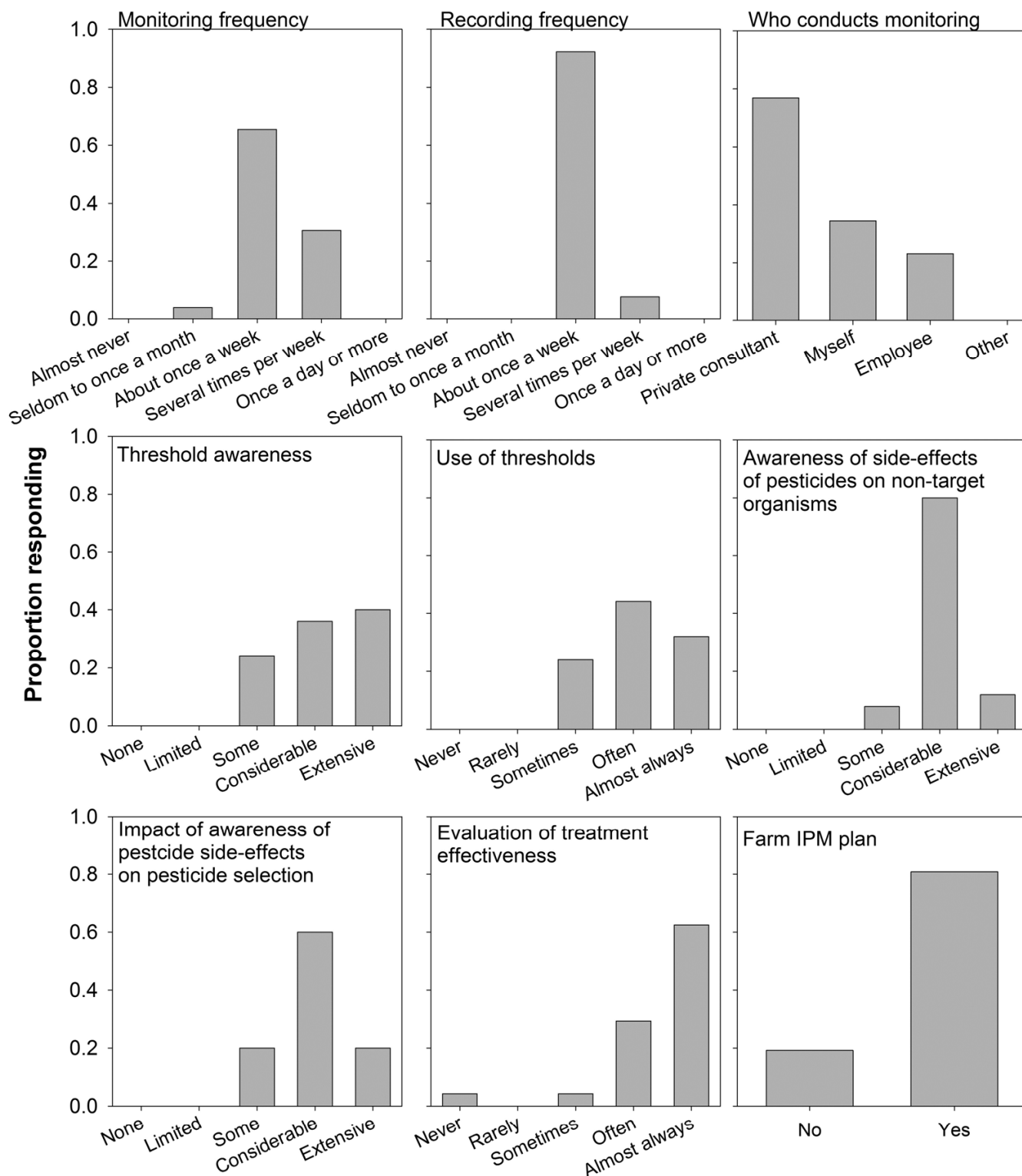


Fig. 5. Reported self use of various integrated pest management principles and tactics among hop growers in Oregon and Washington based on surveys conducted during 2010.



flict of interest: “You have the guys selling you the chemicals, telling you about the new chemicals.” However, he went on to say, “They do a very, very good job, and I value their opinion highly. It’s just that that conflict is always there.” A number of Washington farmers expressed trust in pesticide and fertilizer dealer consultants for similar reasons, generally believing them to be both knowledgeable and trustworthy. Large Washington hop farmer David Edstrom expressed his belief that such consultants were at the cutting edge with regard to pesticide technology: “Anything that has to do with technology, its pace of change is so quick, that you know, you have to do that full-time, or you have to get a consultant, people who are on the very leading edge knowing what’s going on.” Mint farmer Andy Keller expressed no reservations about trusting his pesticide and fertilizer dealer consultant to keep him up to date on best practices for his large farm, explaining, “We buy all of our chemicals from a fertilizer chemical rep... The field man that works for the company is knowledgeable.” Medium-sized hop farmer Alex Simon similarly trusted a longtime consultant to know what was best: “Our crop manager is one of the local representatives from Valley Ag, which is a chemical company that’s based out of Yakima. And he’s had years and years of experience in hops and he’s worked with us for a really long time.” For these farmers, a combination of trust and results made pesticide and fertilizer dealer consultants worth the possible conflict of interest.

This trust in dealer company field men contrasted sharply with the way that many Washington farmers viewed university specialists. Despite his concerns about conflicts of interest with pesticide and fertilizer dealer field men, Ted Fitzgerald felt they achieved clear results that were useful to him, versus academic researchers who were out of touch with the real needs of a farmer:

[University researchers are] figuring this stuff out that really is not – as far as pest management goes, as far as anything goes, it’s not commercially viable. It’s not helpful to us... A couple years ago, there was a bunch of money plugged into a computer model to help us predict how severe mildew was going to be in a particular area at a particular time. Well, you know, in the end that computer model didn’t tell me anything more than I could figure out if I went outside and licked my finger, and put it up into the air. And it just – it just didn’t help... And there was a ton of money invested, and it just isn’t viable.

Peter Moore, whose large hop farm mostly used IPM, expressed similar reservations about the usefulness of university research:

I see a lot of the times, okay they may take on this research but then what they’ll do is they’ll have this little controlled plot on a research station and it’s not being farmed the way that the industry’s farming... You know, it’s just like well, then your data is flawed. Because if you’re not going to farm it properly then, you know, how can you say that this worked or didn’t work? ... And then looking at stuff in labs I think is great but I’ve just – it’s, huh, you have so many – you have, you know, exponentially more variables out in the field.

Eric Lang, whose medium-sized hop farm also used IPM, gave a clear explanation of his problems with university researchers and their inability to respond to and address the real issues farmers faced:

I have worked with a researcher from one of the state institutions out here that is very, very good with beneficial insects, but does not have any type of appreciation for the real world at all.... It started to make my reputation with the handlers suffer, because the plots that I was working with, with him, they looked terrible. And he couldn’t understand how that was damaging my reputation. And I had to discontinue that relationship. And he was not happy with me, but once again – I mean, he was – he couldn’t see the connection with what the marketplace was demanding.

For these farmers, personal relationships and belief in a consultant’s respect for their real needs and existing knowledge, versus pursuit of his own independent agenda, mattered most. In this case, it also meant that farmers had less information and understanding of practices such as IPM even when they used them. According to their self-reports during the interviews, 82% of Washington farmers used pesticide-intensive practices to some degree on their farms, almost half (47%) reported using IPM tactics, and 17% had some organic crops. Farmers who relied primarily on pesticide and fertilizer dealer consultants frequently had a difficult time articulating the meanings of IPM however, and expressed a poor understanding of IPM practices. Ted Fitzgerald, for instance, asserted that, “I think every hop farm here is – has some kind of integrated pest management program. And some may do things a little bit differently than others, but everybody has to have some kind of an idea.” Yet when asked how IPM was different from conventional practices, he said, “I don’t know if I can answer that,” and immediately changed the subject. Medium-sized hop farmer Wade Martin gave a similarly vague answer when asked if he used IPM: “I’m not really sure [laughter]. When they talk about integrated pest management, it’s kind of, hmm.” In Washington, trust in pesticide and fertilizer dealer consultants, coupled with frustration and suspicion with university specialists, contributed to a high likelihood of using conventional practices, and confusion regarding the meanings and practices of IPM.

In Oregon, the informational climate was different, although practices differed only slightly. During the interviews, 60% of Oregon farmers still indicated they used conventional pesticide practices to some degree, 54% reported using IPM, and just 9% had any organic crops. But Oregon farmers tended not to have strong relationships with pesticide and fertilizer dealer consultants, and to rely more on independent consultants and university specialists with whom they had developed trust. Less than one-third of the Oregon growers relied on pesticide and fertilizer dealer consultants as their primary sources of information. Pat Oster and Ben Albert ran a medium-sized hop farm in Oregon that relied exclusively on independent consultants and university specialists for information. When asked whether they relied on pesticide and fertilizer dealer consultants, Pat replied, “No, we don’t use them.” Ben went on to add, “They’re salesmen.” Medium-sized Oregon hop farmer Tom Mitchell relied heavily on a university extension specialist, but was distrustful of the knowledge base of even independent consultants, complaining, “Remember, some of these consultants are maybe a year out of school and they don’t have the experience.” Small hop farmer Bill Nelson did turn to pesticide and fertilizer dealer consultants from time to time, but also relied heavily on an independent consultant and a university specialist, and felt he knew how to manage his pesticide consultants. He complained about farmers who weren’t savvy enough to handle them properly, however:

Some of them just follow [the pesticide and fertilizer dealer consultants], ‘cause they don’t know, they don’t feel comfortable reading the reports themselves, they’re nervous. I think fear is hugely used by companies... They scare them, “Well, you know, if you don’t spray your grass for rust, you know, you might make it, but you know, it’s only \$15 an acre, and you know, do you really want to worry about it for the last three weeks?” You know, that kind of stuff, it happens all the time. I mean, I hear it – I mean, I get bombarded with it. They don’t anymore, ‘cause I yell at them. I mean, I tell them, ‘Come on.’

As in Washington, in Oregon trust in an expert was directly connected to how much practical knowledge farmers believed him to have, as well as the degree to which he was perceived to respect their needs and experience. Several farmers had developed important relationships with local university specialists there for this reason. Small hop farmer Greg Daniels, who also relied on independent consultants, explained why he thought the input of university specialist Brian Sumner was critical to Oregon hop farmers:

What he says works... He gets instant results. I mean, he has really helped us in that way... Because some of the, you know, researchers or doctor-type people, you can't seem to get anything out of them and even though we give them direction nothing seems to happen, and Dr. Brian makes things happen.

Small Oregon hop farmer Chris Bernard had similar reasons for relying heavily on Dr. Sumner: "He is out on the fields on a regular basis... so he knows what's going on. He is able to communicate really well with I think all growers." His perceived respect for farmers and responsiveness to their needs meant that Oregon farmers relied heavily on this single individual in their decision-making processes.

This relationship of trust also meant that many Oregon farmers were better educated about the practices associated with IPM, which Dr. Sumner and other university specialists advocated. Compared to their Washington counterparts, they tended to give clearer explanations of their practice when asked for details. For instance, small hop farmer Paul Barnes, who relied on Dr. Sumner as well as independent consultants and the Oregon Hop Commission for information, gave this description of his farm's IPM practices:

The pest management and disease management are based on past experiences, weather models, weather forecasting – there is a lot of things that go into play. And we are very proactive on the soft chemicals, the biofungicides... So it's just softer chemicals and more, a lot more knowledge now about predator mites and things like that that help with our spray decisions.

While farmers in Washington and Oregon tended to choose different experts as their main consultants, in both cases their decisions were influenced heavily by their relationships with the individuals themselves. Farmers took pride in their own experience and knowledge, and expressed clear preferences for experts who respected them, listened to their concerns, and effectively addressed their needs. While to some degree their preferences reflected their chosen pesticide strategies, this was not always the case. However, the specialists did generally have their own agendas, whether selling pesticides or promoting IPM and organic practices. For farmers, openness to a specialist – and their particular agenda – was directly related to the degree of respect and efficacy they perceived, and had much to do with the specialist's ability to communicate with farmers and respond directly to their concerns.

From these data, we propose that the first principle for effective communication of change in farming practices is *relationships with farmers and their advisers*. Respect for farmers' knowledge and experiences, recognition of their situation-dependent constraints and goals, and responsiveness to their individualized needs enabled both the university specialist and private consultants to earn credibility and value in farmers' decision processes.

### Motivations for Adoption of Specific Practices

Many federal granting programs have implicit or explicit definitions of sustainability and support research and extension activities to achieve shifts in production practices. Are these policy objectives and aspirations salient and generally convincing to farmers? In this section, we explore the diversity of farmer constructs of sustainability and their motivations for adopting certain production systems.

While sources of information could help influence a farmer's practices, they were not the sole basis of their decisions. Both ideological and economic factors often also impacted a farmer's pesticide strategy. Yet there was significant variation in their motivations and attitudes regarding the practices they pursued. Rather than suggesting that all sustainable or conventional producers held common sets of beliefs, the interviews illustrated a wide range of economic and personal motivations for their choices. Kloppenburg et al. (31) argued that despite "'sustainability' having achieved

canonization as a kind of cultural shorthand for 'the green and good,'" its meaning is still disputed on the ground, symbolizing entirely different things for different actors. We do not attempt to define sustainable in this research and remained agnostic during the interviews to avoid prejudicing participants. Constructs of sustainability espoused in the interviews therefore are individually based and undefined, but nonetheless provide some perspective of how individuals viewed themselves and the goals they were pursuing.

In the electronic surveys, most respondents reported a relatively high degree of awareness and use of various IPM principles and tactics (Fig. 5). "Considerable" or "extensive" awareness of economic thresholds for pests was reported by 72% of farmers, and 76% intended to use thresholds in their decisions to make treatments. They also reported broad awareness of the side-effects of pesticides on beneficial arthropods (considerable or extensive awareness reported by 95.8% of respondents), and 83% said that this awareness had an influence on the choice of pesticides used. The level of conservation of beneficial organisms was considerable or extensive on 71% of farms. IPM plans had been developed for 84% of the farms. The order of IPM self-reported in the surveys could be broadly classified as level I, as defined by Kogan (32), or in some cases intermediate to levels I and II.

During the interviews, approximately a third of farmers expressed clear personal preferences for production techniques that were less pesticide-intensive, and used the type of moralistic language documented in previous research (7,28,44,55). Mark Harris, a small-scale hop farmer in Oregon, explained his recent move toward IPM as part of "trying to take a more sustainable approach." He described his motivation as, "It's the ground that takes care of you; you better take care of it," and went on further to explain:

I just don't think it's good business practice to farm with a beaker in one hand. You know? I just don't like it. It's not good for you, it's not good for me, it's not good for the kids, it's not good for anybody.

Peter Moore, whose pest management on his large hop farm in Washington was mainly IPM-oriented with some organic fields, similarly professed an ideological preference for sustainability: "I have a certain moral code, you know, and just I, I want to be a good steward to the land... You know, it's just kind of an overall belief." Kyle Anderson, whose medium-sized Washington hop farm used a combination of IPM and organic practices, talked similarly about the intrinsic benefits of sustainability: "[The bulk of our acreage is] being farmed under what we would say is sustainable practices... We do it because we think it's the right thing to do."

However, it was more common in interviews for farmers to profess economic motivations behind their choices to pursue less pesticide-intensive practices, including desires to cut back on pesticide costs and financial incentives in the form of marketing. For those who pursued IPM in particular, lower input costs were often a major incentive. Bill Nelson was slowly moving toward IPM on his small hop farm. He explained that although the result of IPM was that he used fewer pesticides, his motivations were mostly about saving money:

The goal isn't to use less, the goal is to maximize the use of each chemical, so in a roundabout way we use less. But that's not the goal – I mean, my goal isn't to be organic or to not put that stuff on the hops. My goal is to maximize the return of the investment on that chemical that I just put on the hops... But the bottom line is we use less.

Alex Simon, a medium-sized Washington hop farmer, gave a similar explanation for moving toward IPM: "It just makes sense. You know, we don't want to waste money spraying if we don't need to." For Kyle Anderson, the farmer introduced above who uses both IPM and has organic production, these types of economic concerns coexist with his personal preference for sustainability:



I think we probably spray fewer pesticides than the average. So it does save – it saves us money on our chemicals... I feel like it gives us more control over the cost.

Marketing concerns were also among the top factors motivating farmers' choices of lower-impact practices, particularly organic and Salmon-Safe. Tom Mitchell, a medium-sized Oregon hop farmer, had pursued Salmon-Safe certification on his farm, explaining, "You know it was a step mostly for marketing." Craig Lambert, whose medium-sized Washington farm had a small amount of organic hops, expressed similar motivations for pursuing the strategy. His aim was, "Taking our base, what we have right now, and making it as profitable as possible. And one of the ways is converting some of the acreage to organics, and try to develop some niche markets." Oregon hop farmer Chris Bernard described multiple motivations for pursuing Salmon-Safe certification, including both personal and market concerns: "It takes a certain amount of visibility and third-party verification in order to be able to use it as not just to make you feel good, which is really a good reason to be doing it, but to be able to then use it for marketing as well."

As these quotes suggest, for farmers in Washington and Oregon, sustainable practices are motivated not by personal ideologies alone, but generally by a combination of personal beliefs and economic concerns. While some profess the kinds of moral and environmental attitudes that have been documented by previous researchers, for many, sustainable practices were a cost-cutting or marketing tool that happened to also use less pesticides. For these farmers, sustainability is both about pesticide practices and about economic viability, and their receptivity to different practices is not entirely predetermined by their own cultural beliefs.

An important principle for communication of changes emerges from these discourses: *the motivation for adoption of specific practices are heterogeneous*. Farmers who self-identified as users of IPM or pursued third-party certification systems commonly gave economic motivations for doing so, discussing the cost of pesticide inputs as well as niche markets for certified sustainable products as incentives for choosing the techniques. On the other hand, many farmers who did not self-identify as users of IPM cited the productivity of their farms and called upon moral or environmental language to argue that their strategies were sustainable, often drawing explicit comparisons with harsher pesticide practices of previous generations as justifications. The implications for communicating change are that change agents need to be aware of and speak to numerous factors when advocating change, and recognize that motivations for change may be highly situated.

## Contestation over the Meaning of Sustainability

Not all farmers shared a single vision of what was best for their land, however, or of which practices were truly best. Although some consumers and others may place organic farming at the extreme end of the sustainability continuum, for many farmers there were considerable questions regarding the true value of this practice and of other sustainability certifications like Salmon-Safe. For some, a lack of information or understanding may have contributed to their uncertainty regarding whether organic was possible for their crops. But a number of others were quite well informed about organic and Salmon-Safe, and still believed them to be of questionable benefit to either land or consumers. Pesticides were considered an important and legitimate component of their production systems, and were viewed as wholly consistent with their constructs of sustainability and IPM. They frequently argued that organic pesticides weren't better than many of the modern conventional pesticides on the market, and that organic food wasn't any healthier for consumers. Many pointed to the improvements in pesticide technology since their fathers' and grandfathers' days to argue that current conventional practices already represented a huge leap forward in safety and sustainability. Many of the farmers who resisted sustainable practices were not uneducated or uncon-

cerned about their land, but rather felt they were stewards who had done research on the issues and believed themselves to be following the best practices for the long-term viability of their land and farm operations. Many clearly resisted being characterized as lacking concern for their land and environment, and this often translated into resistance to certain practices entirely.

Alex Simon, who reported use of IPM principles, dismissed organic as a marketing tool that was not any safer for consumers:

The whole organic thing is, I don't know, it's kind of a marketing gimmick. 'Cause a lot of people, when I've talked to them, that aren't in the agricultural field, they go, "Oh, I like organics because there's no pesticides on them." Which is wrong. They use organic pesticides on organic products. And people don't make that distinction. And there's, you know, cyanide and arsenic are organic. It doesn't mean I want to eat them.

Washington hop farmer Eric Lang gave a similar assessment of organic practices:

I really think there is a lot of misconception in the public about the difference between organic and conventional. There are some differences. I am not going to discount that. I think organic is probably a little bit healthier and cleaner and whatnot, but I'll tell you what, there is some stuff that is labeled as organic that is really nasty. And I don't know how it got an organic label. And there are some very, very benign products that you can apply in a conventional orchard or hop yard and stuff that can't be applied in organic.

Greg Daniels, a small hop farmer in Oregon, expressed nearly identical concerns:

I personally think organic is just a marketing thing. They put on more sprays that we do.

Interviewer: And what do they spray?

Oh, I don't know. Soaps and oils and anything that's organic. You know? I don't know. And, you know, copper and sulfur – is that any better for you than one shot of a fungicide or a pesticide? I doubt it. I don't know. I think it's just marketing. People will pay double for organic, so they do it. I don't think it's any better for you to eat an apple that's got all kinds of soap and stuff on it versus one spray.

While organic was often dismissed for using pesticides that aren't really safer, farmers also frequently discussed the technological improvements in conventional pesticides, which allowed them to be more targeted and thus lower impact. A number of farmers believed that modern pesticides were milder than those used by their fathers and grandfathers. For them, conventional practices already represented significant improvements from those of their parents' era. Washington hop farmer David Edstrom took this point of view:

I've handled, you know, chemicals. There are some chemicals that make you sick. They're a lot better now on what chemicals that are used. There used to be some very, very bad stuff out there that isn't there [now].

Oregon farmer Mark Harris expressed a similar understanding:

When I was young it was like the nuclear approach. Yeah, like ground zero with the chemicals they had in the '60s and early '70s. It was like – I mean, they would go over and spray with the airplane, and the little birds that would go to drink out of the puddle at the end of the road would be dead-cold the next morning. I mean, this stuff was nuclear.

For farmers like these, comparisons with the "nuclear" approach of the past gave them reason to believe that modern conventional techniques were both benign and sustainable. They often expressed the same sense of environmental concern or stewardship for the land as farmers who were more clearly committed to following

practices like organic and IPM, and openly resisted the common understandings of “alternative” farmers as more concerned about the environment. Barbara Winslow, whose husband operates a small conventional hop farm in Washington, staked her claim to sustainability on these grounds:

You know, they go on and on and on about chemicals like we’re poisoning the land and stuff. And [sighs] we, like my husband says, farmers are the original ecologists or whatever. They’ve been farming this land for a hundred years and they want to farm it for another hundred. They’re not going to trash it.

Greg Daniels also used history and continued productivity as his claim to being a responsible steward:

For anyone else to come out here and tell me I’m not a good steward of the land – I would kick them off of here. Because that’s our livelihood. We are good stewards, and we’ve been here almost a hundred years, and the land is more productive now than it was.

These farmers made it clear that sustainability had multiple meanings, and that multiple practices could fit within its umbrella, including their fairly routine use of pesticides as evidenced in the electronic surveys (Fig. 4). However, in the electronic surveys, most respondents also reported adoption of basic aspects of lower level IPM such as regular monitoring of pests, awareness and use of economic thresholds, and consideration of side-effects of pesticides on nontarget organisms (Fig. 5). Far from lacking concern for the environment or the future, “conventional” farmers like Greg and Barbara situated their practices within the same sorts of moral attitudes and social concerns as did organic farmers and users of higher level IPM, and resisted being characterized as lacking environmental concern. Being sustainable for them did not mean using a specific set of pesticide techniques, but rather implied a combination of concerns including affordability, effectiveness, and what was most likely to allow them to continue to farm their land into the future. For many, personal beliefs and values combined with experiential, professional, and academic knowledge to inform decisions that all farmers, regardless of the strategies they pursued, believed to be in the best interests of both their farms and the larger society.

A principle interrelated to the previous two is found here: *communication of change in value-laden terms may contribute to a sense of alienation from both the practices and the experts that espouse them*. This is, in a sense, the reciprocal of the first principle. Whereas evincing respect for farmers’ knowledge and experiences builds credibility and rapport, framing communication in moralistic or environmental language may implicitly suggest a lack of concern for these considerations and ultimately undermines respect for farmers’ individual values, constraints, and goals.

## Conclusions and Implications for Communicating Change

Although much research on farmer decision-making has been focused on farmer attitudes and ideological orientations, we find a number of other structural and social factors play important roles in influencing their pest management decisions. These influences not only provide incentives for and against specific practices that compete with farmers’ personal preferences, but also impact farmers’ understanding of the meanings of practices, including those associated with sustainable agriculture. The outcome of this multifaceted process is a complex and contested understanding of what is and isn’t best for farms, communities, and the larger environment.

Of particular importance are farmers’ contested meanings of sustainability and the implications for communicating the adoption of less-pesticide-intensive practices. Farmers’ views of sustainability and best management practices may be heavily influenced by preferences for experiential sources of knowledge, their current use of

lower level IPM tactics, and beliefs in the improved safety of current practices compared to those of past generations. The boundaries between different types of farming practices can be viewed as permeable, and the orientations that accompany them are multiple and inconsistent. While for some, production approaches such as IPM, organic, and third-party certification systems are connected to a clear belief in the environmental and moral correctness of these techniques, for many others the motivations for – or against – such practices are quite different and unstable. There is not a clear set of values or worldviews underlying decisions to adopt or reject a given practice (14,35). Even more, farmers contest the very meanings of sustainability. Many expressions may be used to imply greater sustainability of agricultural systems over traditional or prevailing production systems (46), although concepts of sustainability are complex, often imprecise, and highly case-sensitive. While some farmers agreed with the academic understandings of sustainability and IPM as best practice, many others question whether such strategies are truly environmentally or morally superior, and draw upon different sources of knowledge and experience to argue for the long-term sustainability of a variety of farming practices. In navigating a minefield of information, market forces, experience, and personal ideologies, farmers develop their own understanding of the meaning of sustainability. Their basic conceptualizations of sustainability both influence their decisions and justify them after the fact. Their choices of production techniques are not always uniform across a farm, and cannot be readily categorized as sustainable, IPM, conventional, or otherwise. We find that individuals who might be labeled as more conventional farmers have rich conceptions of sustainability and are no less concerned for the long-term persistence and resilience of their land than are those who might be characterized as sustainable. These individuals often actively resist being characterized with potentially value-laden terms such as “conventional”.

Overlaid on and moderating these effects are relationships with experts who may influence a farmer’s practices, as well as the depth of understanding of those practices. We found that farmers were valenced to advisors who both complemented and helped shape strategies that were not necessarily either monolithic or consistent across their farms. The presence of a specialist IPM advisor working closely with a small group of farmers is often considered necessary for successful adoption of IPM (40). Yet, while farmers relied heavily on experts for information to help them make their decisions regarding pesticide strategies, a sense of trust and respect for their own experience and concerns was vital to their willingness to call upon and listen to a particular expert. For some “conventional” farmers, awareness of being judged as nonsustainable or lacking environmental concern contributed to frustration with and resistance to less-pesticide-intensive pest management strategies.

There are limitations to how broadly to interpret the results of this case study given the structure and size of the hop and mint industries and market factors such as forward contracting. The structure of the study was a single-point assessment of what farmers and industry members *say* their attitudes, motivations, and constraints are, which might be quite different from the way they actually *behave*. The survey data provide some support for the qualitative data, although clearly with imperfect triangulation to all farm practices. With these cautions, however, we suggest the following principles have important implications for communicating change and warrant consideration.

Chiefly, framing contrasts of production practices as simple dichotomies or in a moral or environmental context may be problematic both for making sense of farmers’ decisions and for helping to inform their future choices. While certain individuals *may* be motivated by moral stances, for those who are not, it does not appear to be sufficiently compelling to affect their decision to adopt different practices. While farmers who have already adopted certain practices may make use of moral discourses, such understandings are seldom the sole motivating factor. For others, who resist both new practices and being characterized as lacking concern for their land and environment, the suggestion that some practices are morally or



environmentally superior may contribute to a sense of alienation from both the practices themselves and the experts *themselves* whose goal is to promote them. Decisions to adopt a set of practices emerge from a complex web of both cultural and structural influences and constraints. Thus, specialists may seek to either avoid all moral language or, ideally, offer recommendations based on situated knowledge of the goals and constraints significant to an individual and promote practice in terms that align most clearly with an individual's paradigm. There are likely many pathways toward agricultural sustainability (46), but successful communication toward an appropriate pathway requires rapport, trust, and relationship between farmers and specialists.

Previous studies have suggested that farm management style and production goals are associated with adoption of biologically based practices (e.g., 4), but with a high degree of variance (35). In their study of the ideological stances of farmers, Fairweather et al. (14) question "the direct and unqualified causal attribution of environmental and social degradation to conventional practices, while establishing alternative practice – be it framed as organic, local, small-scale, agroecology, dialogic, and so on – as the solution to such ills." They further contend that this framing has the problematic outcome of "overstating the homogeneity of conventional practice, especially in relation to its environmental impacts" (14).

The case studies presented here suggest that communicating changes in pest management practices in value-laden moral and environmental terms are not necessarily the most salient to farmers, and that the intrinsic value of these practices is inadequate to encourage their adoption. Such approaches ignore important determinants of intention to act, such as perceived and actual behavioral control (2), which often are situation-dependent. Rather, incentives to adopt new farm practices should be communicated in a personalized context. For many farmers, the most convincing arguments appear to be those that focus on other factors, namely economic viability and efficacy, particularly when supported by direct observation and experience. In communicating these benefits, discussions should be framed to evince respect for farmers' experiential knowledge and with consideration of their production goals and constraints.

The interview data suggest this is best achieved through relationships with a trusted adviser, a lesson private consultants have learned well (45). Diverse media and communication formats are helpful for creating awareness and improving knowledge in some cases (13), but with trust lacking no form of communication seems satisfactory, and consequently research impacts will be elusive. Trust is easier to destroy than to create, a fundamental mechanism of human psychology that Slovic (53) terms the "asymmetry principle". Developing trust requires personal relationships that take time and resources, both of which are increasingly scarce for extension activities, and may be impossible with large audiences. In the United States and other developed countries, this role has progressively been filled by private consultants (33), and some authors suggest delivery of certain types of information is best left to the private sector (3). Private consultants are consumers of information from extension agents and others (24) and perhaps the ultimate integrator of information for their clients. However, potential issues of "double risk asymmetry", a compounding of risk avoiding behavior, are possible if intermediaries impose their own aversion of risk into their recommendations (18).

The data presented here provide general guidance for framing persuasive and effective communication of change of farmer behavior. The framework of this communication is built on relationships, trust, respect for farmer experience, and tailoring recommendations to individuals and their unique needs and objectives. Communicating changes in production practices seems destined to fail unless structured as a two-way process, where both researcher/extension agent and farmer have something to contribute. It is an understatement to say that affecting change can be complicated, and clearly communication strategies are but one of many considerations in developing and transferring IPM. We do not wish to make light of the importance of credibility of the recommenda-

tions and practices promoted, intrinsic characteristics of a particular pest and crop, institutional policies, and other context-specific factors. Rather, these factors themselves provide motivation for developing professional rapport and participatory research approaches that leverage (and inform) farmer experience (36). In this framework, researchers and extension personnel can learn much about farmers' situated pest management decisions and the fit of IPM innovations researchers wish to see adopted. An ancillary, but critical, outcome of these relationships is development of trust from our clientele and holism that only they can bring to applied research.

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Dr. Gent is a research plant pathologist with USDA-ARS in Corvallis, Oregon. He received his B.S. degree in crop and soil science from Oregon State University, and his M.S. and Ph.D. in plant pathology from Colorado State University under the mentorship of Dr. Howard Schwartz. He is also courtesy associate professor in the Department of Botany and Plant Pathology, Oregon State University, Corvallis and Honorary Faculty at the University of Tasmania, Australia. His current research is focused on the epidemiology, population biology, and management of powdery mildew and downy mildew diseases on hop and other crops. In everything he does, David attempts to approach and integrate his research within a farming systems context to develop and deliver practical disease management approaches that can be adopted by growers. He enjoys collaborations with colleagues across the United States and internationally, interacting with and serving growers, and helping to solve real-world problems.