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Bridging scientific and experiential knowledges via participatory climate adaptation research: A case study of dry farmers in Oregon

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Abstract

In western Oregon's Willamette Valley, small fruit and vegetable growers have traditionally relied on irrigation to produce their crops. However, they are increasingly experiencing issues with water availability and access due to precipitation pattern changes associated with climate change. In 2016, the Dry Farming Collaborative (DFC) was developed as a participatory model for facilitating research, social networks, and resource-sharing among agricultural stakeholders to test the efficacy

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Author Note

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of dry farming as an adaptation strategy. Dry farming differs from irrigated cropping systems in that growers do not irrigate their fields and instead utilize a suite of practices to conserve soil moisture from winter rains for summer crop growth. To better understand how to meaningfully engage stakeholders in participatory climate adaptation research, this study explored how the participatory process facilitated the adoption of dry farming as a climate adaptation strategy among participants. Drawing on interviews with 20 DFC participants, including farmers, gardeners, and researchers, results indicate that the integration and use of different knowledge systems within the participatory research process made it easier for participants to integrate dry farming into their operational contexts. Processes designed to encourage interactions and information-sharing between participants and nonhierarchical researcher-grower relationships facilitated the exchange of these knowledge systems among participants, thus providing them with the trusted and salient information they needed to adopt new practices. Results indicate that these features could be useful for enacting future participatory climate research projects that lead to the adoption of effective adaptation strategies.

Keywords
Dry Farming, Participatory Research, Climate Adaptation, Small Farmers

Introduction

In western Oregon's Willamette Valley, many small fruit and vegetable producers traditionally have depended upon irrigation to produce their crops during the hot, dry summers. However, due to a changing climate in the region, small farmers are likely to experience more drought conditions, changes to peak flows associated with earlier runoff and reduced snowpack, and more extreme rain events (May et al., 2018). For many producers, this means that access to water during the growing season will be limited, especially for those who have junior water rights or no water rights (Li et al., 2019). While this challenging context may be unique to farmers in Oregon's Willamette Valley, many of these changes, especially access to water, will also be experienced by those in other parts of the globe (Alexandratos & Bruinsma, 2012).

In response to these changes, some Oregon farmers are adopting dry farming methods as a climate resilience strategy to cope with the reduced water supply available for irrigation. Dry farming and various associated techniques have deep historical and varied cultural roots. Desert farmers and Indigenous Peoples around the world have developed techniques for farming with minimal irrigation or rainfall (Nabhan, 2013). Dry farming differs from traditionally irrigated cropping systems in that farmers do not apply irrigation to their fields. Instead, they select a site with deep soil and good water-holding characteristics and utilize a suite of management practices to conserve soil moisture from winter and spring precipitation to be used for summer crop growth. Some of the practices that support dry farming include early soil preparation and planting; the selection of drought tolerant, resistant, or early-maturing cultivars; lower planting density; cultivation or surface protection to prevent crusting and cracking of the soil surface; diligent weed control; and improvement of soil health over time with practices such as cover cropping, rotation, and minimizing soil disturbance (Garrett, 2019).

In order to facilitate information-sharing as Oregonian growers began experimenting with dry farming, Amy Garrett, an associate professor in the Oregon State University Extension Small Farms Program, created the Dry Farming Collaborative (DFC). Dry farming is not a yield maximization strategy and as such has not gotten much attention from industry and academia over the past century. Dry-farming techniques have mainly been passed down from farmer to farmer, so facilitating knowledge-sharing to build trust, respect, and inform research efforts was key in the collaborative's inception. The DFC has since evolved into a multifaceted participatory research effort that facilitates networking, on-farm research, and resource-sharing among farmers, gardeners, agricultural professionals, and university researchers interested in dry farming.

To better understand whether and how participatory research can support farmers in adopting climate adaptive methods, this paper seeks to understand whether and how the DFC's participatory

process facilitates the adoption of dry farming as a climate resilience strategy among participants. Important findings regarding this process may then be applied to similar participatory efforts in the future. Calls for participatory research such as this have been increasing, with the goal of creating usable science for farmers, ranchers, and others on the frontlines of climate change (Ballard & Belsky, 2010; Meadow et al., 2015). These efforts have arisen out of concerns about the traditional "top-down," loading-dock style of research in university extension and elsewhere. In the top-down style, research agendas are designed and studies are led by university researchers with farmers simply receiving the results and integrating them, if possible, into their operations (Prokopy et al., 2015). However, the results are oftentimes not usable or relevant for farmers, or at least not all types of farmers.

In contrast, participatory research emphasizes the coproduction of knowledge and seeks to bring together a plurality of knowledge systems that come from multiple stakeholders (Bezner Kerr et al., 2018; Meadow et al., 2015; Prokopy et al., 2017). In an effort to make science "work" for more types of farmers, participatory research has been championed as a solution to the flaws in these traditional methods, as it allows for more direct stakeholder involvement in shaping research agendas (Meadow et al., 2015; Yorgey et al., 2017). However, it is important to understand what aspects of research projects on participatory climate adaptation help effectively engage producers and create knowledge that is useful to stakeholders.

In this paper, we will first review the relevant literature regarding the role different epistemologies play within agricultural knowledge systems. We will also review previous research that has shown how participatory research efforts can facilitate a mutual process of knowledge exchange, particularly in climate adaptation contexts. The methods section then describes the DFC and this research project in more detail, including the participant sample and the data collection and analysis methods used. The results and discussion sections examine the findings from the in-depth interviews, which illustrate how different forms of knowledge were used and valued by participants, and the ways specific elements of the participatory process facilitated the exchange of those different knowledge systems between participants. The conclusion section describes how these results can inform future participatory research projects and offers some recommendations for future outreach and research.

Literature Review

Epistemologies within Agriculture

Understanding how different epistemologies are used by stakeholders is an important part of shaping successful participatory climate adaptation research. Epistemologies, or what and how we know, cannot be separated from the practices and sociomaterial conditions that give rise to them (Carolan, 2006a). Previous research has shown that knowledge itself is a form of social relation and only has meaning in a social context—when it comes from a source that is trusted and seen as legitimate (Carolan, 2006b; Ingram et al., 2016). Therefore, epistemologies are important for shaping perceptions and behaviors within agricultural contexts (Carolan, 2006a). In U.S. agriculture, peer-reviewed, scientific studies have traditionally been framed as the basis for trusted knowledge, and the goal of the Cooperative Extension Service has been to funnel this knowledge from university scientists to farmers. This type of knowledge arises through the use of the scientific method and is validated by replication and an extensive peer-review process.

However, farmers, particularly small-scale alternative-style farmers, do not always see this type of knowledge as trustworthy, reliable, or applicable to local realities (Carolan 2006b). Therefore, farmers do not rely exclusively on scientific knowledge when making management decisions. Instead, they often rely on other forms of informal, place-based knowledge. For instance, research shows that much of the knowledge involved in farming is embodied and gained through lived experiences in a body in the world: feeling soil, watching crop growth, experiencing the weather (Carolan, 2009). Furthermore, farmer-to-farmer exchange of their embodied and experiential knowledge has consistently played a critical part in helping farmers transition to sustainable practices (Bell, 2004). For instance, Šūmane et al. (2018) found that a diversity of knowledge

sources, including other farmers' local, experiential knowledge gained through networking, was necessary for farmers transitioning to sustainable and resilient agricultural systems. In addition, in a study of farmer knowledge exchange, Wood et al. (2014) found that farmers preferred learning from others' direct farming experience. Of course, experiential knowledge is often combined "in the field" with farmers' scientific knowledge as well. Scholars have pointed out the substantive similarities between these two forms of knowledge, such as the fact that they are both empirical in nature and can have both local and abstract applications (Agrawal, 1995; Watts & Scales, 2015). In this way, experiential knowledge gained from interactions with other local farmers is just as important as scientific knowledge, and oftentimes it is even more trusted and salient for farmers.

Participatory Processes in Climate Adaptive Research

Participatory research efforts are one way to facilitate a process of knowledge exchange that can break down boundaries between scientific knowledge and local, experiential knowledge. We know that more conventional approaches to agricultural outreach and extension have often relied on top-down information transfer (Jackson-Smith et al., 2018). Therefore, participatory research is part of a suite of practices designed to respond to and counteract a top-down model of information delivery. It is designed to cultivate strong network ties to improve the ongoing dialogue between farmers (or other stakeholders) and scientists (Roncoli, 2006). Indeed, "participatory processes emphasize decentralization, transformation, empowerment, integration of local knowledge and application of research to locally relevant management scales" (Wilmer et al., 2018, p. 2). The increasing popularity of participatory methods, which are a form of collaborative science, is grounded in many of the schools of thought associated with coproduction of knowledge. This coproduction of knowledge can encourage greater engagement by nonscientists, particularly on the topic of climate science (Meadow et al., 2015), and encourage the creation of tools and information that might be utilized by agricultural stakeholders (Prokopy et al., 2017).

Participatory research integrates nonscientist stakeholders in the process of scientific research, from problem definition to data analysis and interpretation (Allen, 2018). The idea behind these participatory processes is to bring together scientists and those who use science to increase the likelihood that knowledge and information will be accepted and utilized by the relevant decision-makers. One critical aspect of maintaining and supporting these scientist-stakeholder partnerships is an iterative approach that relies on repeated interaction, the production of usable and understandable scientific information, and the incorporation of diverse disciplinary knowledges for understanding the world (Lemos & Morehouse, 2005), which can include local and indigenous knowledge systems.

In the context of adapting to a changing climate and improving management decisions, it has been found that participatory models can be effective ways to encourage natural resource managers in responding to global change (Roncoli, 2006). Indeed, these methods can foster the development of network ties that can lead to greater collaboration and joint action (Bodin & Crona, 2009; Wood et al., 2014). Furthermore, researchers have found that "stakeholder networks and participatory processes have been proposed as venues and mechanisms for repeated knowledge sharing, dialog, and learning about climate change adaptation" (Bartels et al., 2013, p. S46), and such sustained interactions can lead to mutual trust *and* the development of information that is locally relevant. Overall, there is evidence that participatory efforts can lead to sharing across epistemological boundaries, the creation of new knowledge, and enhanced network learning, as well as guide action taken in response to this new knowledge (Jackson-Smith et al., 2018; Wilmer et al., 2018).

In seeking to understand whether and how the DFC's participatory process facilitated the experimentation with and adoption of dry farming by participants, this paper explores how its structure supported the exchange of different forms of knowledge in a way that enhanced trust and salience among participants.

Applied Research Methods

Context of Study

The DFC is a group of growers, researchers, extension educators, plant breeders, and agricultural professionals partnering to increase knowledge and awareness of dry farming management practices with a hands-on participatory approach. The initial purpose of the group in 2016 was to facilitate information exchange as more growers started to experiment with dry farming. Since then, the DFC has evolved into a multifaceted participatory research project with growers all over the maritime Pacific Northwest. As of 2020, more than 50 DFC members have actively engaged with the group's research. DFC members are encouraged to experiment on their own with dry farming and share their lessons learned, as well as participate in larger participatory research projects to help answer common questions that align with their operation and interests. Some of the research projects that emerged from the onset focused on crop varietal and site suitability for dry farming. A study was also conducted to evaluate the ability of fungal inoculants to enhance drought tolerance. Each research project was developed through consultation with DFC growers and led by different researchers involved in the group who set up its own terms with the DFC growers who volunteered to participate. Participants in variety trials and the fungal inoculant study were provided seeds or transplants, instructions for setting up trials, and data sheets to fill out and submit after harvest was complete.

Each year after all data were submitted, a data analyst would then compile and illustrate the data to share at meetings and conferences. For example, the DFC winter meeting has taken place after each growing season since the group formed in 2016. This is typically a full-day event attended by approximately 60 DFC members who are actively dry farming or interested in dry farming. The agenda is a combination of short formal and informal presentations, roundtable discussions, seed swap, brainstorming, networking, and a potluck or meal prepared with some dry-farmed produce. Results, successes, and failures from the previous growing season are shared by DFC growers and researchers at this meeting, as well as ideas and suggestions for future research and invitations to participate in various trials in the coming growing season. Results and information about dry farming are also shared yearly at in-person and virtual field days hosted at Oregon State University's Small Farms Program's trial plots and/or on members' farms. The field days are an opportunity for those interested in dry farming to see dry-farmed crops up close, learn about trial results, network, and exchange information.

Another significant part of the DFC is the Facebook group (with over 950 members in 2020), which is a public group and discussion forum open to anyone interested in dry farming globally. Most of the group is from the Western U.S., although there is growing international interest. DFC growers and researchers post pictures and sometimes do live video walk-throughs of their plots, inquire about varieties that work well, and share events, articles, and stories relevant to farming with fewer resources.

Data Collection and Analysis

In the summer of 2018, a qualitative research project was initiated to better understand the DFC's participatory process and how it helped participants to introduce dry farming to their operational contexts. This study was approved by the Oregon State University Institutional Review Board and was funded by the U.S. Department of Agriculture (USDA) Northwest Climate Hub. Gabrielle Roesch-McNally along with Melissa Parks worked together with DFC founder Amy Garrett to design the research project to fulfill both the DFC's needs and to explore the utility of participatory research for adapting to climate change. Over the course of the summer, Roesch-McNally and Parks conducted interviews with various members of the DFC and conducted participant observation at several dry farming field days where members and prospective members were in attendance. Both Parks and Roesch-McNally led the collection and analysis of the data but included Garrett in the process of data assessment and analysis.

Overall, we conducted 17 semistructured interviews with 20 farmers, gardeners, and researchers in the DFC. Some interviews were conducted with multiple participants at once. Informed consent

was received verbally from all interviewees, as per the Oregon State University Institutional Review Board guidelines. Participants were offered the choice to have their names and farm information remain anonymous. Some chose to do this, and others approved the use of their first name in reporting out the results. All interviewees were given a transcript of their interview and were given time to ensure that they felt their responses were complete and accurate. Overall, Parks and Roesch-McNally spoke to half of the growers and researchers involved in the DFC's trials and research projects. Purposive sampling was used to recruit members in different regions of Oregon. Farmers who had been actively involved in the DFC's research projects since its inception were also purposefully recruited because they had consistently participated in the DFC and were thus able to speak to the research and collaborative process. While this sampling method restricts the generalizability of the results, given that interviewees were selected by Parks and Roesch-McNally rather than selected at random, the large sample size allows for some broader generalizations to be made about the group.

Key topics discussed in the interviews that informed this study included participants' feelings about and experience with the practice of dry farming, as well as their involvement in the DFC. They were also prompted to describe the functioning of the DFC and to evaluate what they appreciated about the collaborative and what they thought could be improved. The interviews were audio-recorded and ranged from 36 minutes to over two hours in length. Participant observations were also conducted at three dry farm field days over the summer and at the 2019 winter meeting. At each event, Parks and Roesch-McNally participated while taking notes and photographs, focusing on the interactions between attendees and the functioning of the events. All interviews and fieldnotes were transcribed and coded for themes using NVivo qualitative analysis software.

The coding process followed a grounded theory approach, following an open, axial, and selective coding approach (Charmaz, 2006). The coding process began with an initial meeting between Parks, Roesch-McNally, and Garrett to discuss the main themes that arose during interviews and to outline the preliminary codebook. Subsequently, the interviews were coded separately by both Roesch-McNally and Parks utilizing the same codebook. These two then met again to qualitatively discuss their findings and further refine their coding, focusing on an iterative and grounded dialogue to achieve coherence of themes (Charmaz, 2006). The themes that emerged for the purposes of this paper included successes and challenges with the practice of dry farming and the DFC group; processes of research design, development, and data collection; processes of knowledge exchange; the role of scientific or expert and experiential knowledges; and the cultivation of trust and mutual respect. All three authors then met to discuss the major conclusions and directions for publication. Finally, our preliminary analysis was ground-truthed by sharing at the DFC's 2019 winter meeting to gain insight on the findings from DFC participants themselves. Overall, the initial results shared were corroborated by those in attendance and the conclusions were seen as valid and helpful in guiding future work. This feedback was gathered in an ad hoc way, but we encouraged participants to reach out if they had additional feedback, reflections, or critiques. No such effort to contact us was made by any participants beyond the conversations had at the winter meeting.

Study Population

Seventeen interviewees were located in the Willamette Valley, located between the Coast and Cascade mountain ranges, the most populous region of Oregon. It is characterized by hot, dry summers and cool, wet winters (Taylor & Hannan, 1999). Two interviewees were located in the drier, more mountainous region of southern Oregon, and one was located along the milder coastal region of northwest Oregon, which borders Washington (see Figure 1).

An anonymous demographic survey of interviewees showed that 11 were women and 9 were men. Of those who responded to the survey, 14 individuals identified at least in part as White, while one identified as Native American and two as Hispanic. Their ages ranged from 29 to 72 years old. All 15 interviewees who farmed were small-scale

fruit and vegetable growers, meaning per the USDA's definition that they made less than US$350,000 a year in gross cash farm income (Hoppe, 2018). Of the nine farmers who shared their gross cash farm income on the survey, three made less than US$10,000, five made US$10,001–US$50,000, and one made US$50,001–US$100,000. Another notable aspect of participants was their education levels. Seventy-nine percent of survey respondents held a bachelor's degree or graduate degree, and several mentioned their scientific backgrounds in interviews. This indicates a potential aptitude for, or at least interest in, scientific research among many of the participants, which may have contributed to their desire to participate in the DFC. For further information on participants, including a detailed breakdown of who were farmers, gardeners, and researchers, see the Appendix. Finally, most participants chose to use their real first name for this publication, except where noted in the Appendix.

Results

The results overall indicated that participants were able to successfully integrate dry farming into their operations. The use of multiple forms of knowledge by participants was a major factor that facilitated this. Furthermore, the integration and exchange of multiple knowledges was supported by key aspects of the DFC's participatory process. The following subsections explore key themes uncovered during the data analysis including the most common forms of knowledge used by participants and how participants, including farmers, gardeners, and researchers, used these forms of knowledge to apply dry farming to their operational contexts. Subsequently, the key aspects of the participatory process that facilitated the development and exchange of these forms of knowledge are described. These aspects include the existence of multiple avenues for information exchange and opportunities for networking, as well as the cultivation of mutual trust and respect among participants, especially between researchers and farmers and gardeners.

Scientific and Experiential Knowledges: A Conceptual Framework

In an attempt to understand how multiple forms of knowledge were integrated into the DFC's process, a conceptual framework was developed to tease apart the differences between two common forms of knowledge described and utilized by participants (Figure 2). Overall, these two knowledges tended to arise from distinct sources and experiences. 'Scientific knowledge' was primarily knowledge which was more strictly derived from the scientific method. This type of knowledge was often gained by interacting with more distant information sources, such as the media, or by reading research reports written by scientists they did not know personally. However, this category also included knowledge gained from the DFC researchers' scientific experiments and expertise. This type of knowledge tended to be more generalized and less locally specific. Some examples of this knowledge include data from dry farming variety trials which were aggregated by the DFC researchers, data generated from testing soil in a laboratory, or information about global climate change as communicated in popular articles summarizing scientific

Figure 1. Map of Interview Locations

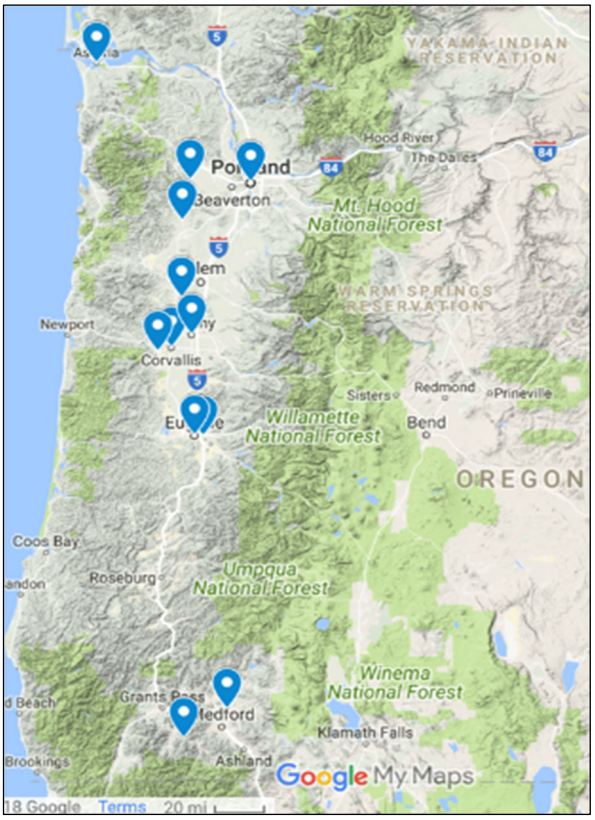
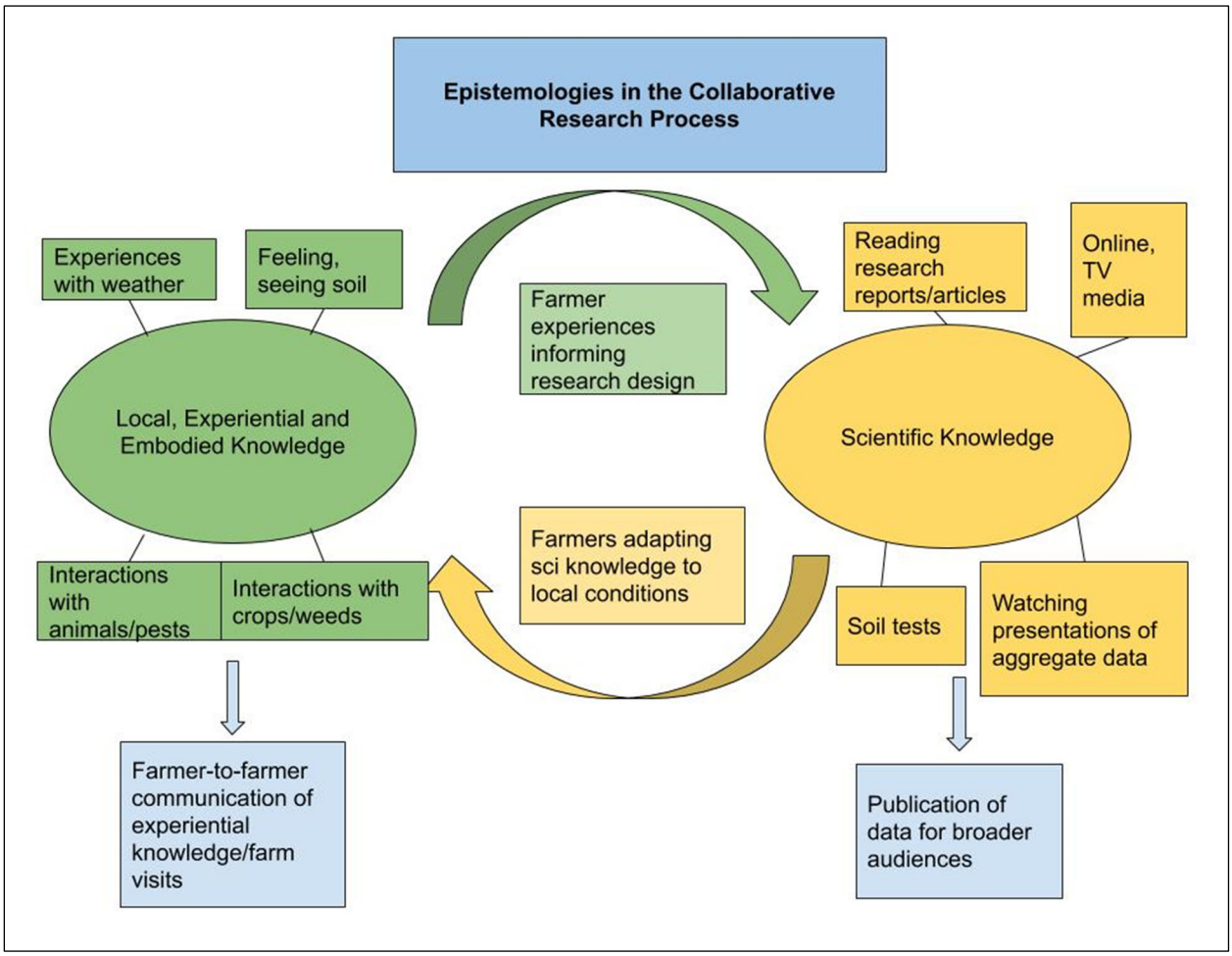


Figure 2. The Use of Scientific and Experiential Knowledges by Participants in the Dry Farming Collaborative Research Context



research. In contrast, local, experiential, or embodied knowledge was gained through direct participant interaction with the soil, crops, animals, or weather, or through direct communication with another participant about their own local, experiential knowledge. This included information about which crop varietals grow best under dry-farmed conditions, specific mulching or planting techniques, and embodied knowledge about soil health.

Uses of Experiential and Scientific Knowledge in Dry Farming

When it came to applying dry farming techniques on their properties, a pattern emerged whereby local, experiential, and embodied knowledge of dry farming techniques was utilized simultaneously with more generalized scientific knowledge. While participants liked having access both to generalized scientific information, such as the aggregated data analyzed and communicated by the DFC researchers, and others' experiential knowledge, these two forms of knowledge were valued for different reasons and incorporated in different ways. Their own and others' on-the-ground experiences with dry farming were seen primarily as critical to the dry farming process. When asked what it takes to be a successful dry farmer, Teresa[1] expressed this sentiment,

[1] For more details on each participant, including their role in the DFC, farm size, and length of time farming, see the Appendix.

> I feel like part of that's just really feeling almost at one with your ecosystem. . . . I think also part of it's just like if you've done this enough times and you've planted plants at these times and they do well, your instinct is like 'this is when I should plant this because it's probably gonna do well,' and sometimes I think we do that instinctively without really being able to quantify it, but it's almost just like there's a smell in the air, you know, there's these birds have shown up, there's a feeling, and you can't exactly explain what it is but it's like, I know the day it's spring and it's not necessarily when the calendar says it's spring... and I feel like dry farming has a little bit of that going on.

This idea that experiential, embodied knowledge of dry farming was critical to being successful was brought up in 10 of the 17 interviews. Furthermore, eight participants expressed that communication with others who have that knowledge was also critical, especially if you did not yet have it yourself. For instance, John expressed this when he said,

> [To be successful] you have to have experience farming, and you also probably have to have examples of seeing people who have done it successfully, and to know what they've done and, you know, what mistakes they've made, and how they've corrected those.

On the other hand, scientific knowledge was used mostly as a starting point from which they could then develop their own specific strategies. Given that many participants had never dry farmed before, they needed somewhere to start. The DFC's aggregated data and guidelines describing specific variety yields, planting dates, soil preparation, and appropriate soil characteristics helped to provide them with a starting point. As one participant put it, "having access to the data, to the research is super valuable." However, since this knowledge was not locally specific to participants' regions or farms, nor was it embodied, it needed to be complemented with the local, experiential, and embodied knowledge described above in order to be successful or useful to growers.

The lines between these two forms of knowledge began to further blur in the DFC because researchers were often farmers, and farmers were researchers as they were conducting their own trials and collecting their own data. This aspect was one that participants highly appreciated. As Harry put it,

> I don't feel like what we're doing is proper science in that I could ever publish anything, but I think that by paying attention to things, and every year tweaking and changing and trying to learn from your experience. . . . I think everyone's personal experience is really important, I'm not such a big fan of like . . . one set of practices that I think everybody should do, I think what's better for us is that we all are finding our own ways. . . . The great thing about [the DFC] is that scientists can come in and say "well you know these farmers have done trials, we can use that as the basis for our studies."

As this shows, farmers in the DFC expect scientists, and not just those in the DFC, to learn as much from them as they do in return. They appreciate that their own experiential knowledge is being translated into scientific knowledge to discover broader patterns and best practices, while simultaneously the scientific knowledge they are given can be bent and tweaked by their own experience when conducting trials and incorporating dry farming into their operational context. The incorporation of both of these forms of knowledge is front and center in the DFC, and it is part of what makes it successful, according to participants.

Finally, a blended reliance on scientific and experiential knowledges was also observed in participants' assessments of soil health. Soil type and health is critical in dry farming since it is necessary for the soil to hold moisture from winter rains throughout the hot, dry summer. While many participants had their soil scientifically tested by a lab to determine features such as nutrient levels and pH, most were also using embodied measures to assess their soil health. For instance, most farmers used the visual health of their plants and tactile or

visual interactions with the soil as indicators of soil health. For instance, when asked how she assessed soil health in her garden, Janice said,

> By looking at it, by digging in it, a lot, you know, just a lot of observational stuff, soil tests for nutrient levels and pH, and observing not only the soil but the plants that are growing.

Similarly, Kevin said,

> I don't know how I define soil health, it's just like, I feel soil health by touching the soil. I see soil health by, you know, put a shovel in and a lot, tons of worms in there and dung beetles and, you see it in the plants.

These trends illustrate that embodied knowledge of the soil such as touching and seeing the soil and the plants growing from it was commonly relied on to assess soil health.

In contrast, scientific knowledge about soil health was valued as a complement to this in that it could illuminate factors that may not be readily discernible, or simply confirm what they felt to be true. For instance, Nate describes his interaction with Andy, a soil scientist who was also a gardener and researcher participating in the DFC,

> Andy came and took some soil for some tests and stuff, and I learned so much from the hour I got to spend with him. It was valuable and interesting to see how a soil scientist goes about evaluating and looking at what is present. He has been on a LOT of ground and to have him say, "your soil is some of the better stuff that I have worked on, there are a lot of worms out here," it is really fortifying, it sort of cinched it for me like, yep, we are going to keep doing this because it makes sense and it's not just my own sense of it.

This quotation provides one example of how participants valued scientific expertise by illustrating how a participant incorporated scientific knowledge delivered from a soil test and a DFC researcher into their management. While Nate had his own sense of the health of the soil, the knowledge he gained from interacting with Andy made him feel more confident in his approach and helped put his own embodied knowledge into a scientific context.

Processes of Knowledge Exchange in the Dry Farming Collaborative

One of the ways that participants negotiated their own experiential, embodied knowledge with the scientific information shared by researchers and other more distant sources was via the process of exchange and the network of DFC participants. Sixteen participants described the importance of talking with and relating to other participants who were also experimenting with dry farming, often in an in-person field day or winter meeting setting. They also described the importance of their relationships with the researchers, which nonresearcher participants described as collaborative and nonhierarchical.

Participants described this process of exchange as one of community-building and cooperation with others in the network, which for them has become an iterative learning experience. Participants often highlighted the importance of those in the DFC, both researchers as well as farmers and gardeners. They expressed that all groups were working toward a "common interest" in a symbiotic way. This idea that there are blurred lines between the researchers and farmers was aptly described by John, who said,

> Yeah, I think that the line [between researcher and farmer] gets, it's blurred quite a bit. . . . It's kind of a nontraditional kind of a group, in that respect . . . and I think that's useful in a lot of ways.

Participants also greatly appreciated being a part of this farmer-to-farmer exchange where they could share their experiences of dry farming and trying new varieties or soil amendment practices. Through this exchange they were able to boost their effectiveness with the practice by learning from one another and sharing their own knowledge and experience. For example, Anne describes this exchange in her effort to share a dry farm tomato variety that she helped to discover,

> I brought one variety of tomato into the program which was a tiny cherry tomato called Champagne Bubbles that was just absolutely fantastic flavor but 100% of them split and turns out if we don't water it then they don't split. And they're even better! So some of the farmers are using that variety that we brought, and Amy [Garrett] is growing some.

To this end, the participants appreciated the ways in which their knowledge and experimentation of dry farming could fit into the group research effort where there is both freedom to experiment and the pleasure of learning from one another, as explained by Harry,

> They're [the DFC] just doing iterations until each person arrives at a method that works for them, I think that's the most valuable thing for each other and for the future too. I think when I come to these meetings what I really love is hearing people and talking to people who have been paying attention, have lots of ideas, they're forming all these like hypotheses in their heads, and we just share that.

Eighty percent of participants also discussed a preference for knowledge delivered in-person through events such as field days and the winter meeting, while 40% also utilized online resources and the Facebook group. Overall, there was a general appreciation of the many ways that the network facilitated learning and sharing among participants. According to Darlene, there is such power that comes from participating in a group and learning from each other. When asked whether or not she would be participating in the DFC next year, she said,

> Definitely. It's something you could do on your own but there's so much you can learn from other people. . . . I enjoy being with other people, I enjoy learning from them.

While there was a deep appreciation for and desire to learn from other farmer or gardener participants, it was also clear that they valued the expert knowledge that was shared by the researchers. Many of the terms that farmers used to describe this relationship between researchers and nonresearcher participants suggested that it was collaborative, iterative, or not "top down." For example, when asked whether he thought that researchers and farmers were partners in the DFC, Andrew said,

> That's a good way to present that question . . . partners. . . . I think that they're trying to learn from each other and it's a mutually beneficial relationship . . . with the people learning from each other, becoming better, more efficient at what they're doing and what they're pursuing for the greater good of dry farming and how it can be implemented on a larger scale.

In addition, Lucas articulated that this approach is the heart of the DFC and an intentional part of its design by saying,

> Yeah, I'd say they're very much partners and I believe that Amy [Garrett] has sort of driven that point home a lot of time in the meetings, she tries to stress that academic researchers are equal to the farmers, and I think it's a really important concept that is not appreciated in the world of University Extension … [which is] too often sort of a delivery of knowledge rather than a collaboration.

Furthermore, Yadira describes having access to university experts as,

> [Something] that is unique about this collaborative … [for example,] somebody else who is super interested in winter squash varietals would be super stoked to spend time with Alex [Stone] and her group because that is what she does and someone who is crazy interested in data collection would be super stoked to talk to Amy [Garrett].

Finally, 72% of the growers described the importance of this partnership as a means of knowledge sharing. This was brought about by the fact that they needed to, and were responsible for, collecting data to benefit the whole group.

Janice noted that,

> I know that some of the growers were active in helping develop some of the [research] protocols. I mean that's being a partner, and they're taking our data at face value, which is like, my data is nasty data. I mean, I didn't trust it very much but you know they were having us collect data, they weren't coming out and doing it, and so that's being a research partner right there for sure.

This illustrates that this participatory process has enabled the farmers and researchers to feel like they are collaboratively working toward a shared common goal, which in this case is the development of more resources and data that will help growers in adopting dry farming techniques in the region.

Facilitating Knowledge Transfer: Cultivating Trust and Mutual Respect

The DFC was designed and functions as a nonhierarchical group, a feature which appears to have facilitated the development and exchange of both scientific and experiential knowledge by enhancing trust and mutual respect among participants. Primarily, this nonhierarchical approach has facilitated broad buy-in among participants, where each recognizes that they have a role to play in delivering results and in moving the project forward. This kind of commitment is articulated well by Teresa, who noted,

> When I say I'm going to host a trial on my farm, I agree to do that to the best of my ability, like that I'm gonna honor the guidelines that are set up so that the data I'm submitting is useful and valid, you know, that I'm gonna not cheat and water my plants or, if I do, I hate to even use the word cheat because I know sometimes people do water, but I'm gonna be honest about that.

Nate further notes that the lack of hierarchy makes him feel like there is space for his ideas to be heard and respected, which will build more buy-in over time:

> It doesn't feel like an ivory tower, it doesn't feel exclusive or like there is some clique to it or something, so I think as long as that spirit is kept up then the sky's the limit, everyone is going to come in who wants to do it and there will be more and more momentum.

Further, Jane clearly articulates that trust is more or less a given in the context of sharing among farmers and researchers in the collaborative:

> You know, I don't question. I'm just assuming being researchers, if I ask a question, they're gonna give me an honest answer. It's never crossed my mind that they're gonna give me a bad answer. And it goes the other way too, if they ask me a question, I try to give them honest feedback.

The vast majority of participants (80%) intimated that this mutuality, where their knowledge systems and expertise are shared in such a way to give both parties, growers and researchers, equal footing, has fostered a learning network that is iterative and respectful. There was no real discussion of trust being broken by any of the participants; however, two participants suggested that expectations or communication were sometimes unclear, and one noted that this had resulted in more work for them. However, this was not a common sentiment and, on the whole, most people we interviewed felt very positive about the trust that had developed between researchers and growers. Even this farmer who suggested that communication had broken down at points was still very much committed to the DFC.

It seems that one of the reasons that this commitment to the project remains is because of the trust and mutual respect that has been fostered through the collaborative approach. One of the reasons for this, as described by participants, is that participants felt that the leadership in the project, particularly Garrett, had fostered a respectful tone that generated interest and buy-in. The DFC was purposefully designed to be participatory in nature so that the growers and researchers were on an equal playing field, so to speak, with no one person or set of people being the sole decision-makers. In this way, the more traditional, one-way delivery of

expert information that is common in university extension is complicated by this nonhierarchical and collaborative structure. Andy, one of the researchers who is also experimenting with dry farming on his property, suggested that Garrett is the glue that holds this thing together, noting that,

> She really is basically the Dry Farm Collaborative in one person, and who has kept it going, who keeps it going. Her personality and her style really are collaborative, I think that's a good name for it, and she finds out what people can do what, and gets the best out of everybody.

This sentiment is echoed by Harry, who said,

> What I appreciate about the way that Amy [Garrett] is running things is that she gives us a lot of room to do our own things and explore. I know it must probably feel like herding cats at times, but I think it's really essential. I think if it was very prescriptive, honestly for me, I'd keep dry farming, but I probably wouldn't be a part of the collaborative.

Many participants commented on the importance of Garrett as a leader, the tone she set, and her commitment to the group. While she encouraged others' involvement and incorporated their diverse ideas, she was not seen as the sole decision-maker, making her a leader whose main role was to facilitate group cohesiveness rather than dictate its functioning. In this way, the group was largely nonhierarchical in its decision-making. However, some concerns did arise about the sustainability and long-term viability of the group if Garrett ever decided not to provide leadership for the DFC anymore. There are many real challenges associated with maintaining group cohesiveness and spreading leadership around in such a way so as to limit the importance of any one individual. Nonetheless, it is clear that without this collaborative process being established from the start, it is quite possible that the participants would have a very different experience. This might have had consequences for the ways different forms of knowledge were shared and utilized by the group and in driving further experimentation and adoption of dry farming methods among participating farmers and others in the broader network.

Discussion

Our results illustrate how DFC participants were able to integrate dry farming into their operations, in part by relying on different forms of knowledge and through the exchange of that knowledge. Participants primarily relied on their own local, experiential, and embodied knowledge as well as scientific knowledge to integrate dry farming into their operational contexts. For instance, participants drew on scientific knowledge in the form of soil tests conducted by laboratories and a soil scientist's expertise to understand the health of their soil, but they also jointly relied on their own embodied knowledge of the soil to measure its health. By interacting with the soil, the plants growing from it, and the organisms living in it, mostly through touch and sight, they came to know the health of the soil with their bodies (Carolan, 2009).

When it came to dry farming itself, local, experiential knowledge derived from their own experience or the experiences of others in their area was highly valued and trusted, whereas scientifically aggregated data provided by the DFC researchers was seen as interesting and broadly helpful, but less applicable to local realities and limited in its ability to help individuals select varieties or troubleshoot issues in their specific context. These results support previous research showing that local, experiential knowledge and extensive farmer-to-farmer knowledge-sharing are critical for successfully implementing sustainable practices (Bell, 2004; Smith et al., 2017; Šūmane et al., 2018; Wilke & Morton, 2017). This type of experiential knowledge may be more trusted and useful for growers because it is more localized and embodied, rather than generalized and derived from distant sources. With increased vitriol in the efforts to engage farmers in tackling the problem of climate change, building this trust and usability of data is more important than ever.[2]

[2] The #TimberUnity movement in Oregon is a great example of how farmers, ranchers, and forest landowners derailed bipartisan

Furthermore, the results show that there were specific aspects of the DFC's participatory process that allowed for and encouraged the exchange of these two forms of knowledge in a way that supported the process of implementing dry farming techniques. Specifically, the nonhierarchical organization of the collaborative as well as the trust and mutual respect that were cultivated between researchers and growers allowed for open scientific knowledge and data sharing, cultivating the kind of coproduction of knowledge that drives action and knowledge exchange (Meadow et al., 2015). Since participants trusted the group's leadership and knew them personally, they were more willing to incorporate the information they received from them. In this way, scientific knowledge was made less distant and took on an important characteristic of experiential knowledge—it was gained from a local, known, and trusted source.

In addition, providing ample spaces and opportunities for networking and information exchange allowed for local, experiential, and embodied knowledge, such as specific experiences with dry farming strategies, to be shared between participants. This was key as it was an aspect of the collaborative that was highly desired by participants and has been shown to make the information gained more trusted and salient (Wood et al., 2014). Not only this, but these exchange opportunities facilitated the sharing of experiential knowledge with researchers, which in turn allowed researchers to incorporate this knowledge into the DFC guidelines and process. This latter aspect added to the trust and mutual respect which were cornerstones of the group, as participants felt as though their experiences and knowledge were valued.

Conclusions

By exploring the use of different forms of knowledge and participatory processes in the DFC, this study has shown how creating space for multiple forms of knowledge to be exchanged and acted upon while building mutual trust and respect can be critical parts of successful collaboration efforts with growers. Participatory research projects, especially those regarding climate adaptation, should not assume that the generation of scientific data is the number one priority of participants, nor that the communication of this data is what they need most. If scientists wish to work with agricultural stakeholders to produce usable science from the bottom up, or to gain buy-in to advance mitigation and adaptation actions, local, experiential, and embodied knowledge must be taken into consideration and not forsaken for "hard line" scientific data (Finucane, 2009) or scientific perspectives on the "correct" course of action, since growers' experiential knowledge is often blended with scientific knowledge "in the field" (Watts & Scales, 2015).

In participatory research it is critical to encourage farmers to collect their own experiential "data" and share their experiences with one another while cultivating trust between researchers and participants so that scientific knowledge can be successfully integrated. While every participatory context will be different, in the DFC trusted and respected leadership gave credence and legitimacy to participants' lived experiences and influenced their persistence with experimenting with and adopting dry farming techniques. Future research should examine whether the presence of these aspects is beneficial in other participatory research contexts as well, especially those pertaining to climate change adaptation and mitigation. Additional research could also explore the role of strong leadership in these efforts and how leaders can facilitate trust and mutual respect. This research could also be expanded to examine whether leaders affect overall group cohesion, especially when or whether that leader is no longer active. Overall, participatory climate adaptation research can be beneficial for growers and researchers alike, particularly when it is grounded in the needs and experiences of those the science is intended to reach.

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efforts to accomplish climate mitigation legislation, two years in a row (Schlarb, 2020).

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Appendix. Details on the Study Participants

Name or Pseudonym	Farmer, Gardener, or Researcher	Farm Location (ecoregion)	Farm Size (acres)	Length of Time Farming at Current Location (years)	Length of Time in DFC (years)
Andrew	Farmer	Klamath Mountains	60	4	3
Anne	Farmer	Willamette Valley	15	19	3
Darlene	Farmer	Willamette Valley	106	9	3
Harry	Farmer	Willamette Valley	2	7	3
John*	Farmer	Willamette Valley	UNK	4	2
Kevin	Farmer	Willamette Valley	60	4	3
Kimberly	Farmer	Klamath Mountains	26.5	7	1
Nate	Farmer	Willamette Valley	15	4	3
Paul	Farmer	Willamette Valley	12	11	3
Rene	Farmer	Willamette Valley	15	19	3
Teresa	Farmer	Coast Range	18	8	3
Jane*	Farmer	Willamette Valley	40	22	2
Yadira	Farmer	Willamette Valley	15	4	3
Harriet	Gardener	Willamette Valley	<1	12	1
Janice	Gardener	Willamette Valley	<1	3	2
Amy	Researcher	N/A	N/A	N/A	3
Ana	Researcher	N/A	N/A	N/A	2
Alex	Researcher/Farmer	Willamette Valley	UNK	3	1
Andy	Researcher/Gardener	Willamette Valley	<1	UNK	3
Lucas	Researcher/Farmer	Willamette Valley	3	UNK	3

* Pseudonyms
Note: UNK=Unknown