Beating the Heat: A Statewide Assessment of Drought and Heat Mitigation Practices (and Needs) with Oregon Farmers and Ranchers

Oregon State University
Extension Service

A STATEWIDE DROUGHT AND HEAT NEEDS ASSESSMENT WITH OREGON FARMERS AND RANCHERS

JUNE 2023

Oregon State University Extension Services prepared this report per section 17 of SB 5561. The results presented here are intended to provide insights to the state legislature on what farmers and ranchers are currently doing to manage drought and heat and how to best support them in mitigating these pressures moving forward. These results are also intended for farmers and ranchers, in the hopes that they may glean useful insights from other producers actively working to manage drought and heat.

Lead Author: Berit Dinsdale, Ph.D.

Project Supervisors and Co-Contributors: María Zamora Re, Ph.D. and Abigail Tomasek, Ph.D.

Acknowledgments

In addition to the farmers and ranchers that made this assessment possible, the authors also would like to thank the following individuals and their associated organizations for their time and assistance:

Ashley Rood, Megan Kemple, and Andrew Collins-Anderson, Oregon Climate and Agriculture Network (OrCAN)

Brittney Deming, Friends of Family Farmers (FoFF)

Lisa Kilders, Clackamas SWCD

Ellen Hammond, Jefferson SWCD

Michelle Smith, University of Oregon School of Law

Kelly Delpit, Sustainable Northwest

Greg and Malia Kupillas, Pacific Hydro-Geology Inc.

Finally, a big thank you to all of the OSU faculty and staff that contributed to this project for their outreach, insights, and support.

Oregon State University
Extension Service

Title Page by Lauren Chase, Oregon State University

Executive Summary

INTRODUCTION

Farmers and ranchers across Oregon are increasingly facing challenges related to extreme drought and heat. While emergency funds have been made available to producers impacted by these pressures in recent years, their recurrence indicates the need for both pre-emptive and longer-term solutions. The Oregon State Legislature requested that Oregon State University Extension Services conduct a statewide needs assessment with Oregon farmers and ranchers to pursue this goal. This report provides an overview of what actions are already being taken by producers to manage drought and heat and what resources and support they need to become more resilient in the face of these challenges.

PROJECT OVERVIEW

This project began in the spring of 2022 with an evaluation of drought and heat-related projects already in progress and the identification of prospective collaborators. The team then worked to recruit and interview 59 farmers and ranchers over the next seven months. Project participants spanned all regions, commodities, and operation sizes in Oregon. This process resulted in a generalized assessment of current drought and heat-related mitigation practices, obstacles, and resource needs. The results of this assessment are presented here.

IRRIGATION INFRASTRUCTURE AND MANAGEMENT

Irrigation Systems in Use. Project participants had mostly already adopted the highest efficiency irrigation systems possible for their operation's needs. Obstacles to upgrading to higher efficiency systems for those who had not were predominantly related to cost, the need for overhead for frost and heat protection, and a lack of compatibility of higher efficiency systems with certain commodity types (i.e., pasture forage, sod, grass seed). Water storage was also an essential component of many producers' systems. Costs to develop storage, permitting obstacles, and a lack of water were all challenges to increasing water storing capacity. Assistance with upgrading systems, financial support to integrate remote monitoring and automation, and moderated energy rates were suggested as potential pathways to support producers.

Irrigation Management Strategies. As participants face water curtailments, many have to make difficult decisions about allocating their limited water supply. For some producers, this has meant allocating water to only the highest-value fields. In contrast, for others, it has meant spreading more limited water over the entire operation. Producers also increase water applications in extreme heat events, which poses obvious problems when drought conditions accompany heat. Participants with groundwater rights are also digging deeper or drilling new wells to access water tables when permitted. Costs and regulations are the main obstacles to pushing limited groundwater resources further.

Off-Farm Irrigation Infrastructure. In central, eastern, and southern Oregon, off-farm infrastructure improvements were recommended to manage drought pressures. However, there was a lack of consensus among producers regarding the relative costs and benefits of decreasing evaporative losses by replacing irrigation ditches with buried pipe. On-going large-scale reservoir and water storage projects are being discussed in eastern Oregon. Producers expressed frustration, however, at the speed of the projects' progress and the perceived lack of compromise from government groups.

SOIL, COMMODITY, AND ECOSYSTEM STRATEGIES

Ecosystem Management. Silvopasture, riparian restoration, and enhancing ecosystem biodiversity were all approaches used by participants to engender increased on-farm resilience to drought and heat. Ecosystem management was also seen as a pathway to avoiding wildfire hazards.

Soil Management. One of the most common approaches to increasing on-farm resilience was soil health management through reduced or no tillage, composting or mulching, soil moisture monitoring, cover cropping, and rotational grazing. Obstacles to these practices often involved accessing equipment or necessary materials and interpreting soil-related data to inform appropriate actions.

Commodity Management. Adapting planting and harvest times, transitioning to new varieties, and transitioning to new crops are all strategies being implemented by producers. Participants also noted utilizing non-irrigation techniques such as shading and intercropping to manage heat pressures. Other strategies included experimenting with new cultivation strategies (i.e., dry farming), using weather stations to make management decisions, reducing or limiting production size, or leaving or stopping farming. The main obstacles associated with commodity management included loss of income, cost of shading equipment, and untenable risk to transition to new production systems.

DATA AND FUNDING

Data Resources and Needs. Data resources for producers were primarily OSU and OSU Extension Services and farmer-to-farmer information networks. Data needs focused on translating climate and moisture-related data into actionable items, researching drought and heat-resistant varieties, and context-specific data informed by financed on-farm trials. Producers also noted a disintegration of farmer-to-farmer networks, which limited community-based information exchanges.

Funding Resources and Needs. While funding programs were extremely well utilized, producers noted that funding systems could be challenging to navigate, and application processes were often extensive and had slow turnaround times. Participants also suggested that more grants be made available for those already exhibiting efficient water use rather than only be provided to those seeking to improve efficiency. It was also recommended that services be expanded to improve application assistance and turnaround times and that cost-share parameters be updated to account for inflation and increased losses due to drought and heat.

ADDITIONAL OBSTACLES AND PATHWAYS FORWARD

Conflicting Uses. Project participants suggested conflicting uses with wildlife, recreation, and urban users were an obstacle to on-farm drought and heat resilience. It was also common, however, for participants to express concern about preserving wildlife habitat and protecting vulnerable species. Participants suggested more straightforward and transparent communication on the data used to make decisions and ongoing mediated conversations and planning.

Inclusion and Applicability. Farmers and ranchers appreciated being included in this assessment and suggested the ongoing inclusion of agriculturalists in policy-making and more nuanced and context-specific research and policies. Potential next steps could include the creation of locally-based teams with farmers/ranchers and experts from various disciplines (e.g., soil health, crop health, water quality and irrigation, and the social sciences) to address locally-specific drought and heat-related problems and solutions.

Other Policy-Related Issues and Potential Solutions. In addition to concrete actions such as increased cost-sharing and relaxed water-related regulations, participants suggested clear and honest communication, mediated talks and workgroups between stakeholders, and ongoing multi-organization collaborations to achieve on-farm drought and heat resilience.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction and Project Overview

"They say the next World War will be fought over water, and I kind of believe it."

– Central, Fruit, Small

Introduction

In December 2021, the Oregon State Legislature, in a special session, passed SB5561. Under section 17 of this bill, the legislature allocated funds to Oregon State University (OSU) to assess on-farm strategies that farmers and ranchers use across the state to contend with drought and heat. The request also entailed identifying additional support and resources needed to help farmers and ranchers increase their resilience to these pressures moving forward.

The request for this project arose following multiple years of moderate to extreme drought conditions across many parts of the state (NIDIS & NOAA, 2023), as well as the unprecedented heat dome of the summer of 2021, which resulted in extensive crop damage and loss (USDA (a), N.A.). Although the heat dome has been described as an anomaly (McKinnon & Simpson, 2022), its impact, compounded by longstanding heat and drought pressures, raised concerns among many producers and policymakers about the future and fate of Oregon agriculture. These concerns continue to be well-founded, as evidenced by the recent declaration by the Oregon Water Resources Department that over 56% of Oregon is still experiencing moderate to extreme drought conditions despite the above-average spring-time precipitation in many parts of the state (Oregon Water Resources Department, 2023). As such, the need for this assessment has become even more vital since it was first proposed in 2021.

Under the leadership of Dr. Lauren Gwin (OSU Extension Services), this project commenced in the spring of 2022 before being transferred to Dr. Abigail Tomasek (OSU Extension Soil and Water Quality Statewide Specialist), Dr. María Zamora Re (OSU Extension Irrigation and Ag Water Management Specialist), and Dr. Berit Dinsdale (Postdoc Researcher) in the summer of 2022.

Following the transfer of the project, the new assessment team spent the first few months designing the project and organizing the necessary steps into three distinct phases: Phase I involved developing project methods, identifying pre-existing drought and heat-related projects, and cultivating inter-organizational collaborations, Phase II focused on recruiting project participants and conducting interviews to gather pertinent data, and Phase III encompassed analyzing the collected the data and reporting the assessment outcomes.

How to Read This Report

A few considerations should be noted before reading this report. First, this account does not aim to provide a drought and heat impact assessment, but rather it is intended to serve as a descriptive account of how individuals are currently addressing drought and heat pressures, actions they would like to be able to take moving forward, and proposed solutions to address these challenges. Second, this report should be viewed as a first step towards understanding farmer and rancher experiences with drought and heat rather than a comprehensive endpoint. Developing an in-depth understanding of farmer activities and needs for all commodities, regions, and scales in Oregon will require ongoing assessments that are less generalized moving into the future. This report can help identify appropriate starting points for those more nuanced and locally-tailored efforts.

While farmers and ranchers are the definitive experts on their own experiences with drought and heat, it is also essential to consider that including participants' perceptions or statements within this report does not indicate that those perceptions are immutable truths. Instead, this report aims to provide policymakers and experts with accurate insights into farmers' and ranchers' experiences and perceptions in order to increase opportunities for outreach and collaboration. For example, if producers within this assessment express a need for an already available resource, policymakers and relevant experts may use this information to direct efforts toward improved marketing and outreach to stakeholder groups to address this information gap.

Finally, while this report is organized into sections for clarity, it is crucial to recognize that farms and ranches are complex systems, where actions or activities taken in one capacity often impact, and are impacted by, other management decisions or practices. Such interconnections extend beyond the farm as well. While data and grants are discussed separately from policy, for example, policy often dictates the conditions and amounts of funding available for research and programming. Therefore, readers should consider each action or practice as embedded within the broader context of an interconnected web instead of viewing them as discrete variables.

Report Structure

This document begins with current irrigation systems in use by project participants (Chapter Two) and Irrigation Management Strategies (Chapter 3). Non-irrigation, on-farm approaches such as ecosystem management (Chapter 4), soil health management practices (Chapter 5), and commodity-based management practices (Chapter 6) are also addressed.

The report's remaining sections focus on off-farm variables that influence on-farm drought and heat resilience. These elements include data resources currently used to inform on-farm drought and heat-related management choices (Chapter 7), current funding sources for drought and heat-related on-farm projects (Chapter 8), and additional policy and funding obstacles not addressed within other sections of the report (Chapter 9), before concluding with an overview of the findings (Chapter 10).

Each section identifies and describes activities, obstacles, and producer-informed potential solutions relevant to the chapter topic. Summary tables are provided at the end of each section, including actions or activities, obstacles associated with those actions, and potential solutions grounded in participants' suggestions.

In some cases, frequency reports are also included alongside an action or activity. These figures reflect the number of participants engaged in an activity or that expressed a thought or perception and are provided both as a whole number (e.g., n=10) and as a percentage of total participants (n=59) (e.g., 10/59= 17%). It should be noted that provided frequencies reflect the total number of participants that referenced a variable at least once and do *not* reflect each discrete reference. For example, if a participant referenced composting as a soil health measure 14 times throughout their interview, they would still only be counted once towards the frequency total.

Producer quotes (sample data) are also abundant throughout this document. The addition of these quotes serves three distinct purposes. First, it provides clear examples of data types coded for each described theme. Second, it highlights producer voices and positions the project participants as content experts. Lastly, participants in this assessment expressed keen interest in learning about strategies or ideas directly from other producers with firsthand experience managing drought and heat. In part, the provision of sample data addresses this request. Quotes have been attributed to participants by region (central, coastal, eastern, n. Willamette, southern, western), commodity type, and scale of operation (small, moderate, mid-sized, large).

Project Overview

Phase I: Project Design, Project Identification, and Inter-Organizational Collaborations

Phase I of this assessment focused on project design, identifying OSU faculty engaged in drought and heat-related projects, and establishing relationships and collaborations with organizations external to OSU working on drought and heat-related issues.

PROJECT DESIGN. Because this assessment involved exploring the intersections of two highly complex systems (i.e., environmental and agricultural), the project team utilized qualitative methods to complete this assessment. Unlike quantitative methods, which often rely on limited pre-determined choices, qualitative methods allow for more in-depth and rich discussions on multifaceted issues. These methods also position research *subjects* as the experts and enable them to identify and describe what is of significance to *them* about a topic rather than focusing on the researcher's or expert's ideas or hypotheses (Denzin & Lincoln, 1994 as cited in Dooley, 2007; Reeves et al., 2008).

Though the data collection period for this project was relatively short, the project team nevertheless engaged in extensive travel to spend time in the field with participants at industry-related events, workshops, and meetings to present the project and recruit prospective project collaborators. Semi-structured interviews were selected as the primary data collection method as they would allow the team to "explore and provide deeper insights into real-world problems" and to "gain insights into the hows and whys" of drought and heat-related activities (Tenny et al., 2023: n.a.). As the question of how to deal with drought and heat will very likely require creative thinking and perhaps little-known or under-utilized solutions, the emphasis on "how and why" rather than "how much" particularly appealed to the project team as it left more space for new ideas and solutions.

IDENTIFICATION OF OSU EXTENSION AND FACULTY PROJECTS. From July 2022 to October 2022, the project team built upon the work initiated by Dr. Gwin to identify current and ongoing OSU Extension and faculty projects focused on drought and heat mitigation in Oregon agriculture. The team employed multiple methods to gather this essential information, including accessing the OSU's faculty records database (Faculty Success), conducting interviews with faculty members, and administering a survey to 20 participants. This project phase provided the team with a more nuanced understanding of drought and heat impacts in agriculture and the opportunity to assess which faculty and experts had direct stakeholder engagement and could assist in participant recruitment for Phase II of the project.

The team determined through the data collection efforts that at least 38 OSU Extension faculty or faculty working at Oregon Agricultural Experiment Stations were currently involved in drought and heat-related projects. These projects encompassed a wide range of foci, including the development of online watershed modeling tools, trials and workshops on dry farming and no-till practices, evaluation of drought and heat-resistant crop varieties, applied water use and yield research, irrigation timing and application trials, and studies on the use of regenerative practices and rotational grazing to increase drought resilience. Out of the 20 faculty who participated in the survey, 11 reported direct engagement with farmers or ranchers on drought and heat-related projects. Subsequent interviews were conducted with these faculty members to gather information on farmer practices and needs, which would inform the development of the team's assessment questions.

INTER-ORGANIZATIONAL COLLABORATIONS. During this phase, the team collaborated with non-OSU organizations and individuals to assist in the producer outreach process. By the completion of Phase II, the team had established connections and partnerships with 24 organizations actively involved in drought or heat-related projects within Oregon's agriculture sector, including Oregon Climate and Agriculture Network (OrCAN), Energy Trust of Oregon, Friends of Family Farmers (FoFF), Oregon Community Food Systems Network (OCFSN), the Oregon Raspberry and Blackberry Commission, Sustainable Northwest, Pacific Hydro-Geology Inc, University of Oregon School of Law, Union County Wheat and Seed Growers Association, as well as various food hubs and Soil and Water Conservation Districts. These collaborations provided the team with further information on ongoing drought and heat mitigation projects and issues and access to the farmer/rancher networks associated with these groups.

After collecting background data from extension faculty and ag-based organizations across the state, the team completed Phase I by designing participant recruitment and interview materials. In addition to inquiring about on-farm mitigation strategies and resource needs, the team also included inquiries about participants' location, operation size, operational acres, products, whether they had water rights, current irrigation practices, and types of irrigation systems employed. These additional explorations were necessary to gain crucial contextual information that would allow the team to better understand variabilities in managing drought and heat based on individual producers' circumstances.

Phase II: Participant Recruitment and Data Collection[1]

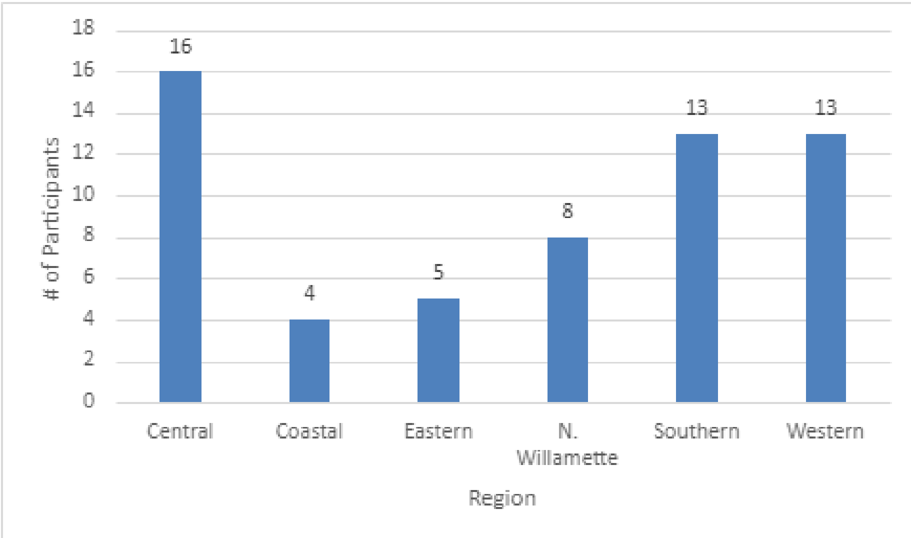
Phase II of the project included designing recruitment materials and development of the semi-structured interview questions posed to participants in the assessment. The recruitment process commenced in October 2022 and continued until April 2023. Interviews were conducted in person, via Zoom, or over the phone based on the preference and location of the producers. The interviews were scheduled for approximately thirty minutes to an hour. With the participant's consent, the interviews were recorded to facilitate the transcription and analysis of the interview data in Phase III. The team also conducted three non-interview farm visits throughout the recruitment period. Two visits were conducted in southern Oregon, while one was in the Willamette Valley.

SAMPLE OVERVIEW. Fifty-nine (n=59) farmers and ranchers were recruited and interviewed for this assessment (Figure 1). Recruitment was primarily achieved through distributing recruitment materials via organizational listservs, outreach by OSU faculty, snowball sampling, and industry events.

REGIONAL DISTRIBUTION. Despite collaborations with locally-based organizations and Extension faculty, recruitment of participants in coastal and eastern Oregon was limited. The reason for low participation from these regions remains unclear; however, collaborators from these areas suggested that the lack of participants may be partly attributable to current Extension faculty vacancies along the coast and the lack of proximity of eastern producers to OSU and the state capital. Additionally, it was suggested that perceived ideological differences between producers and government organizations or representatives may have played a role in the smaller turnout from eastern Oregon in particular.

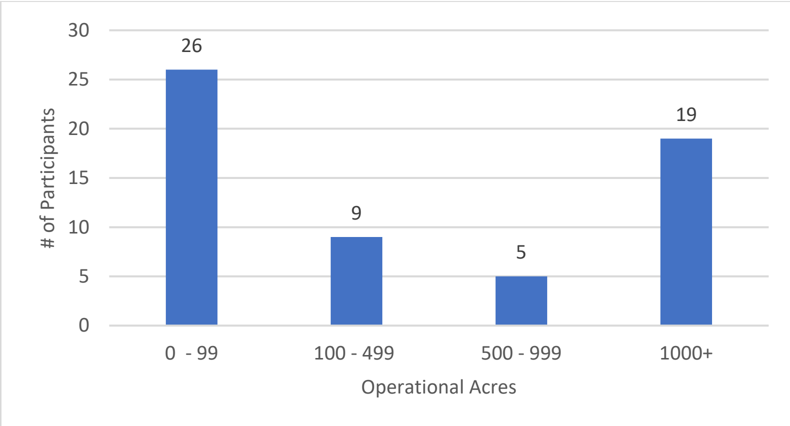
[1] Prior to generating recruitment materials or recruiting participants, the project team received a Non-Research Oversight Determination from the OSU Institutional Review Board (IRB) indicating that this project is considered an assessment specific to Oregon and is therefore not generalizable (non-research) and does not require a full review.

Figure 1: Participant Distribution by Region



OPERATION SIZE DISTRIBUTION. While interfacing with prospective participants for this assessment, it was shared with the project team that producers often felt that operation size was often ignored in assessments despite being a critical factor in how farmers and ranchers make decisions and choose to operate. For this reason, the team has opted to include a breakdown of assessment participation by size both here and alongside sample data throughout the report. It should be noted that conventional approaches utilize gross cash farm income (GCFI) to categorize and group farms by size (USDA ERS, 2022). The team felt, however, that collecting this data would potentially overreach what participants were comfortable sharing and was extraneous to the central goals of the assessment. Instead, this report utilizes acreage to classify farm or ranch size: small= 0-99 acres, moderate = 100-499 acres, mid-sized=500-999 acres, and large=1000+ acres. These ranges are based on the average Oregon farm size (425 acres) and may not be relevant or applicable in other contexts (Oregon State Board of Agriculture, 2021). Most participants in this assessment fell within the small farm category, followed by large-scale, moderate, and mid-sized operations.

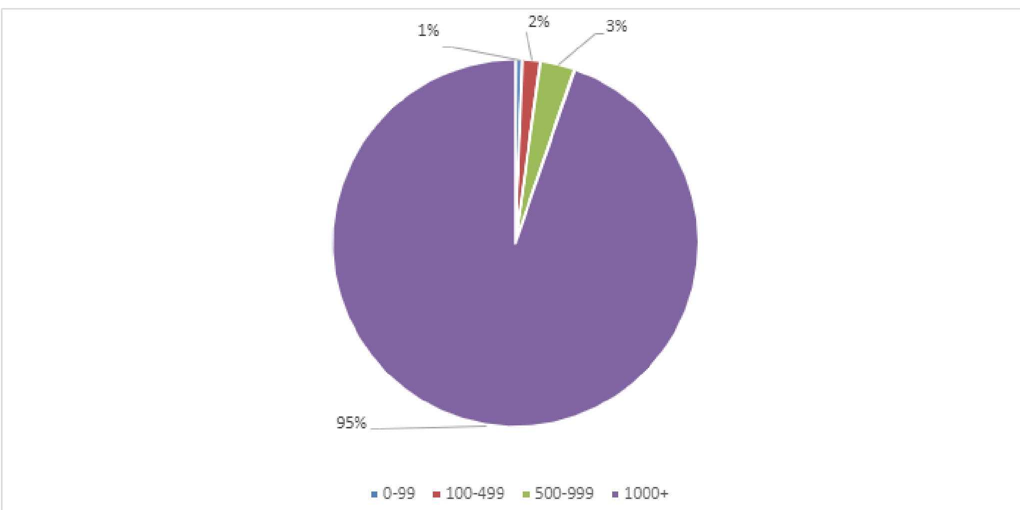
Figure 2: Participant Distribution by Operation Size



^ n=59

Though the second largest category behind small-scale producers, the 19 producers with farms larger than 1000 acres accounted for 95% of the total combined acreage of all project participants (Figure 3). This consideration illustrates that while frequency analyses can be helpful, they may misrepresent what is occurring or needed on the most significant proportion of land under cultivation. Thus, frequencies should be seen as an analytical starting point rather than an endpoint.

Figure 3: Proportion of Total Acreage Accounted for by Operation Size Category



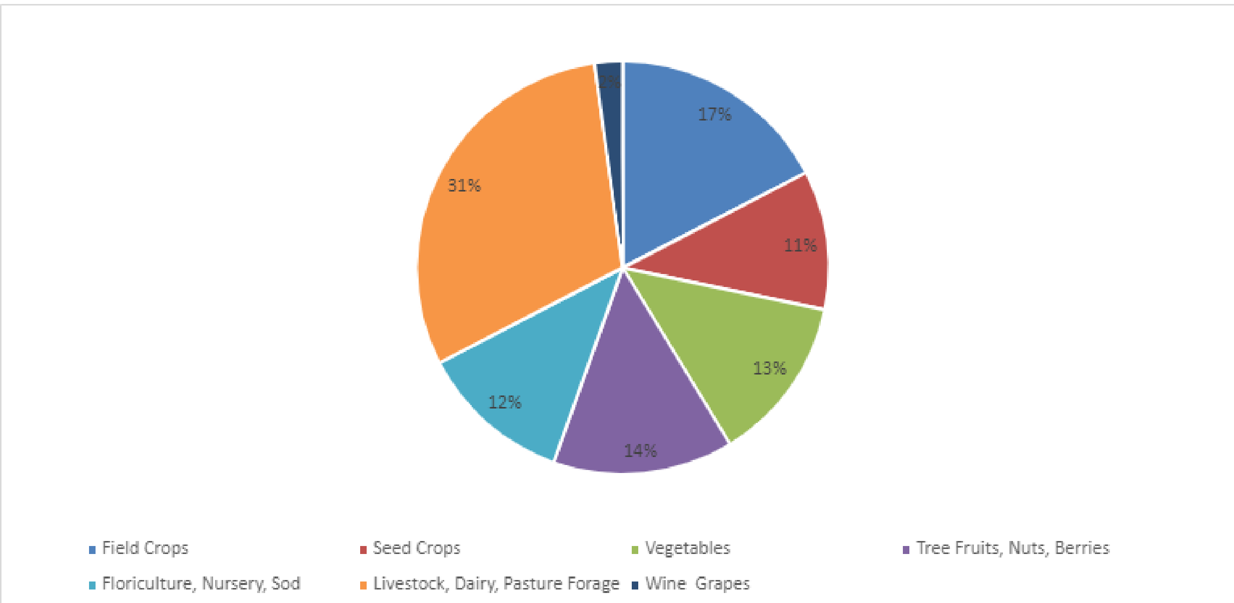
Large-scale producers emphasized this point during meetings and workshops and indicated that they felt research or assessment projects often omit this consideration for total acreage from their analysis, which can result in misleading outcomes. While the results of this project are not divided by sub-categories such as region, scale, or commodity due to the limited sample size, sample data has been associated with operation size to acknowledge this concern. It is also suggested that future assessments should actively operationalize farm and ranch size within their analyses.

COMMODITY DISTRIBUTION. Project participants were engaged in the production of various commodities, including (Oregon Department of Agriculture et al., 2022):

- Field crops (e.g., hay-alfalfa, hay-all other, oats, peppermint, spearmint, sugar beets, wheat)
- Seed crops (e.g., annual ryegrass, fescue, bluegrass, clover, native seed, carrot)
- Tree fruit, nuts, and berries
- Floriculture, nursery, sod
- Vegetables
- Pasture forage
- Livestock and dairy
- Wine grapes

Most operations were diversified, with producers farming or ranching two or more commodity types.

Figure 4: Participation by Commodity Type



Phase III: Data Analysis

TRANSCRIPTIONS. Interviews with the participants were completed in early April of 2023, and two temporary workers were hired to help expedite the transcription process. The transcription software, ExpressScribe, was employed to ensure accurate and efficient transcription of the interviews.

DATA ANALYSIS. Transcriptions were analyzed using the qualitative software program NVivo. The interview transcriptions were systematically coded for data related to the main research questions, which focused on on-farm practices, obstacles faced by farmers and ranchers, and resources or support needed. Content analysis was based on the identification of common or recurring themes.

While the frequency of mentions of a theme did assist the project team in understanding the relative importance of different issues within the dataset, it should be stated again that the frequency of mentions is an analytical starting rather than an endpoint, as lower-frequency thematic responses may entail creative or novel ways of thinking that can open new doors or identify new solutions to these complex and multi-faceted issues.

Chapter 2: On-Farm Irrigation Systems

Overview

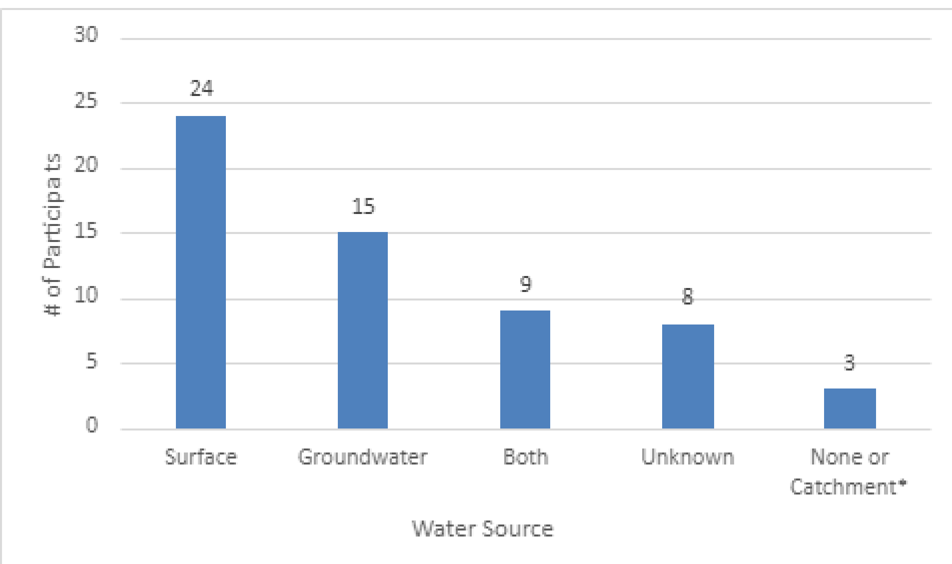
Agricultural practitioners carefully consider irrigation system types to be implemented within their operations to manage drought and heat. The project team therefore initiated interviews by inquiring about participants' irrigation system types, the difficulties or obstacles associated with those systems, and the potential resources and support that could help alleviate some of these challenges.

Irrigation Systems: Water Sources, System Types, Water Storage, and Associated Irrigation System Components

Irrigation Water Sources

Amongst participants in this assessment, surface water rights were the most commonly held, followed by groundwater, a combination of surface and ground, and finally, no water rights/not irrigating (dryland grazing or dry farming) or use of catchment systems only. Eight participants chose not to disclose their water sources (Figure 5).

Figure 5: Irrigation Sources by Participant



*Catchment entails the capture of surface water off of structures.

Irrigation System Types

The selection of irrigation systems for farming and ranching operations is influenced by various factors, including local climate and weather patterns, soil type, labor requirements, cost, commodity type, operating pressures, and topography (Bayabil et al., 2020). Consequently, many participants noted utilizing multiple system types to accommodate variations within their operations.

For this report, participants' irrigation systems were categorized into three groups: Low Potential Application Efficiency (LPAE), Medium Potential Application Efficiency (MPAE), and High Potential Application Efficiency (HPAE), based on the lowest achievable efficiency rates for each system (Table 1). HPAE systems have been categorized as those with a potential efficiency of 85% or higher, followed by MPAE systems with a potential efficiency of 75% or greater. LPAE systems are characterized by having a minimum potential application efficiency rate of less than 75%.

> **"In terms of mitigation that we do at our end, we've replaced every sprinkler nozzle on all four wheel lines, so they're doing the minimum amount of water coming out of the wheel lines. We're certainly not getting more than we need on the water."**
>
> —Central, Hay, Small

It is important to note that potential application efficiency indicates that the actual system efficiency can vary significantly depending on how well it is managed. For example, while Low Energy Precision Application (LEPA) and Low Elevation Spray Application (LESA) systems are generally seen as being significantly more efficient than hand-lines or wheel-lines, as Table 1 highlights, optimally maintained hand-line and wheel-line systems have the potential to outperform higher efficiency systems if those higher efficiency systems are not properly maintained and managed. Furthermore, specific nuances within each system may also influence potential efficiency. For example, center-pivot systems may operate with or without an end gun, impacting the overall potential application efficiency (Water Resources Program, 2023).

Table 1: Irrigation Systems Currently in Use by Project Participants

High Potential Application Efficiency (HPAE)			
Irrigation System	**Potential Application Efficiency Range (%)**	**# Of Participants**	**% Of Total Participants**
Micro spray or Micro sprinklers	85-90	6	10%
Drip	85-95	24	41%
Medium Potential Application Efficiency (MPAE)			
Irrigation System	**Potential Application Efficiency Range (%)**	**# Of Participants**	**% Of Total Participants**
LEPA, LESA	80-90	4	7%
*Manual**	75-85	3	5%
*Center-Pivot or Linear****	75-85	11	19%
Low Potential Application Efficiency (LPAE)			
Irrigation System	**Potential Application Efficiency Range (%)**	**# Of Participants**	**% Of Total Participants**
Solid Set	70-85	1	2%
*K-Lines***	70-85	4	7%
Unspecified Overhead Sprinkler	65-85	13	22%
Hands Lines or Wheel Lines	65-85	19	32%
Guns or Travelers	65-75	4	7%
Flood	45-80	5	8%

Note: Potential application efficiency ranges originally listed in Irmak et al. (2011) unless otherwise noted below.

^N=59

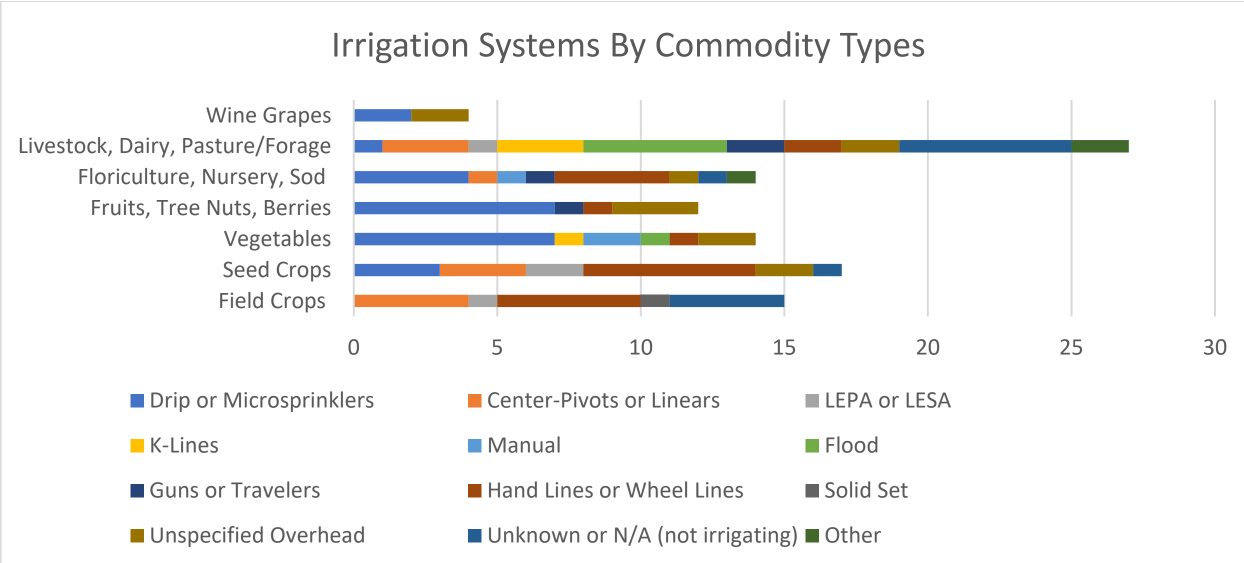
* Source: De Leon Gonzalez, 2021

**Source: K-Line Irrigation Co., personal communication, May 2023

***Systems have the same PAE range

The predominant irrigation system participants employed was drip, followed by hand lines/wheel lines, unspecified overhead, and center-pivot/linears. Four of the 19 participants utilizing wheel and hand lines were upgrading to adopt more efficient systems, including drip irrigation, LEPA/LESA, or center-pivot/linear systems.

Figure 6: Irrigation Systems by Commodity Type



HIGH POTENTIAL APPLICATION EFFICIENCY SYSTEMS (HPAE). Amongst the HPAE systems, drip irrigation was the most frequently used system type, especially in fruit, tree nuts, berries, and vegetable production. Various factors, including cost-effectiveness, labor requirements, low water availability, and disease prevention measures drove the decision to adopt drip systems.

> **"A big part of our strategy too is doing a lot of drip irrigation which…in addition to water conservation, it's good for weed abatement, and also for diseases in the crops. It's just better for averting disease."**
>
> —Southern, Seed, Small

HPAE: Obstacles and Needs. While drip irrigation systems are efficient concerning water usage, they were also reported to be relatively challenging to maintain compared to more durable (i.e., metal) systems. The susceptibility of drip systems to punctures from rodents, roots, and wildlife, as well as issues like clogged emitters and natural degradation of the plastic over time, were identified as difficulties that could increase both the costs and labor requirements. Furthermore, the lack of sustainable disposal methods for the plastic components of drip systems added to some growers' discomfort in using drip. Farmers in remote southern and eastern Oregon regions also shared their concerns regarding the availability of drip system components in local stores. They highlighted that parts were not always readily available, and if ordered online, they could take several weeks to arrive. This delay in access posed additional logistical challenges for farmers, leading to delays in the maintenance or repair of their systems.

Participants were also clear that drip was incompatible with certain commodities, such as pasture forage production, sod or turf, grass seed, and some cover crops.

LOW AND MEDIUM POTENTIAL APPLICATION EFFICIENCY SYSTEMS (LPAE AND MPAE). Field crops, pasture forage, turf/sod, and seed producers were more likely to utilize MPAE and LPAE systems as their primary irrigation methods, excluding manual watering. However, it should be noted that many fruit and vegetable producers employed a combination of overhead sprinklers and drip irrigation, with the overhead sprinklers primarily used for heat and frost protection purposes.

LPAE and MPAE: Obstacles and Needs. Producers who still utilize LPAE irrigation systems but produce commodities compatible with MPAE systems, such as center pivot/linear, LEPA, or LESA systems, frequently cited the equipment cost as the primary barrier to upgrading their systems. Despite producers' awareness and utilization of grants and cost-shares such as the Environmental Quality Incentives Programs (EQIP) through NRCS, five producers noted that they could still not secure the necessary funds to upgrade their systems. Producers also shared that MPAE application systems like center pivots/linears, LEPA, or LESA were not feasible for their operation due to landscape irregularities, such as non-rectangular fields or steep slopes.

NOVEL IRRIGATION SYSTEMS (10%>). Two producers described utilizing novel tools to enhance the efficiency and efficacy of their irrigation systems. The first producer installed specialized equipment within a vineyard's irrigation system pump housing. This equipment utilizes vibrational frequencies to change the structure of the water molecules before they are applied to the plants. The claimed benefit of this system is that in altering the composition of the water molecules, the system enhances the root absorption of water and nutrients, thereby increasing the overall health of the plants.

> **"The drip system water goes through a metal pipe in your pump housing, the outflow of your pump housing, it literally changes the frequency of the water, the vibration of the water molecules that will create more root absorption of nutrients and helps with the biomass, the ecology of the soil and then also increases photosynthesis. It's a new technology, but it does make it so your plants don't need as much water. They're more efficient."**
>
> —Central, Wine Grapes, Small

A nursery owner in North Willamette implemented the second novel irrigation system. This system is closed-looped and operates similarly to an "ebb and flow" system, where the water is distributed to the plant's roots in a tray and then the water is captured and reused. Despite the high upfront cost, this producer believed the investment was worthwhile in terms of labor efficiency and water-saving benefits over time.

> **"This is a contained system with a tank each; each one has a big tank, and the water is in the one range. It's all rubber floors; the other range is concrete, so you're recapturing everything the plants aren't using. It's expensive upfront, but over time the labor savings pay for it over and over and over."**
>
> —N. Willamette, Nursery, Moderate

Water Storage

Twenty-four (40%) producers reported on-farm water storage, such as ponds, reservoirs, and storage tanks, as integral parts of their irrigation systems. According to these participants, storing water collected during the rainy season is crucial for meeting irrigation demands during peak drought and heat periods. Producers fill their storage systems by collecting water from tiled fields, precipitation, and surface water sources when appropriately permitted. Depending on their soil type, producers also reported using bentonite or commercial pond liners to prevent seepage and water loss.

> **"It's [to] store water up high and use gravity; that's the key. If you can't build ponds because of your soil, create swales you know to catch runoff water because we get...I tell people we are a winter rainforest and a summer desert, so you have to figure out how to balance it out."**
>
> —Southern, Seed, Small

Water Storage: Obstacles and Needs. Policy and finances create barriers for producers seeking to initiate or increase on-farm water storage. Highlighted policy issues included restrictions on withdrawing water from surface water sources during the non-irrigation seasons, requirements for permits to store water for future use, and roadblocks related to wetland protection rules and regulations.

> **"That's the single, easiest, cheapest solution to managing drought is to use the water we have in the winter months to store it so that we have it in the summer months. Yeah, I think if you want to do an inexpensive and extremely effective fix to drought? Then make Department of State Land (DSL) operate with a little bit of common sense."**
>
> —Western, Nursery/Fruit/Seed, Large

Financial constraints were also identified as a significant obstacle. Producers expressed difficulties securing the sometimes-substantial capital required to access the machinery to build reservoirs or ponds or to hire external services to complete the work. Those who already had reservoirs or ponds mentioned the lack of grants or cost-sharing options for lining and sealing their water storage facilities. Additionally, the cost of tanks, and other non-pond or reservoir storage equipment and the limited availability of grants for such purchases were identified as barriers to enhancing on-farm water security.

> **"If there were direct…. how to help farmers, like help them buy tanks, would go a really, really long way, along with like a technical info sheet or free online course on water quality when you get those tanks. That would go a really long way all on its own, I think to help farmers mitigate."**
>
> —Coastal, Livestock, Small

Associated Irrigation System Components and Challenges

ENERGY (N=17, 28%). Energy expenses associated with irrigation were identified as a significant obstacle to on-farm resilience, particularly during drought. This claim is supported by a study from the California Public Utilities Commission (CPUC) which found that energy use in drought seasons increases by 30% compared to non-drought years, as increased pumping is required to reach dropping water tables (Kotin, 2015). Producers have implemented various strategies to address this pressure, including installing variable frequency drives, some with support from the Energy Trust of Oregon.

Energy: Obstacles and Needs. Despite the installation of variable frequency drives being a well-known and often utilized energy-efficiency approach, some producers expressed that they could not wait for support funds as time is of the essence in increasing efficiency and getting water on the fields, particularly during drought and heat events.

> **Interviewer: "With the variable frequency drive, was that with Energy Trust or out of pocket?"**
>
> **Participant: "We don't have time on these things; we realized we're going into another drought here….we realized we needed to do something with that well because it hadn't been done for 20 years, and we can't afford for it to go down. It's either jump and go, or we sit there, and we take a big risk if we're waiting for Energy Trust money."**
>
> – Southern, Pasture Forage, Large

AUTOMATION AND MONITORING (N=9, 15%). Some participants saw the automation and remote monitoring of irrigation systems as a potential way to reduce energy usage, save water, and reduce labor costs. Producers mentioned, for example, the possibility of automation or monitoring equipment enabling them to remotely monitor pressure, application rates, and system health to quickly identify problems without needing physical field inspections.

Automation and Monitoring: Obstacles and Needs: Cost considerations were the primary limitation shared concerning the adoption of automation and monitoring technologies. Some producers also said they would not feel comfortable relying entirely on automated systems because system failures could result in severe financial consequences or water loss.

Irrigation Systems Summary

Assessment participants demonstrated awareness of the different types of irrigation systems available, with many having already invested in adopting HPAE systems if compatible with their operations. For those still using lower-efficiency systems, the cost of equipment and limited options for overhead watering were identified as constraining factors. Producers suggested increasing funding opportunities to assist farmers in upgrading their system equipment, including automation and monitoring tools, subsidizing energy costs, and expanding their water storage capacity to improve irrigation system efficiencies. Technical support might include expanding the availability of service providers to assist producers in accessing grants and technologies for energy and water savings and providing farm-specific information on system efficiencies, set-up, and maintenance.

Table 2: Irrigation Systems, Obstacles, and Potential Solutions Summary

Practice or Activity	Obstacles	Potential Solutions
Upgrade to HPAE or MPAE systems	• The cost of systems is too high despite the availability of cost-share programs. • Some higher-efficiency systems are incompatible with certain commodities or topographies.	• Adjust cost-sharing parameters to account for increasing inflation and input costs. • Provide incentives to producers who require overhead irrigation to upgrade to more efficient components within those systems (e.g., non-impact sprinkler heads).
Managing Energy Costs	• High electricity, diesel, and gas costs, particularly under drought conditions, despite the use of VFDs and energy-related incentive programs.	• Maintain financial support programs (e.g., Energy Trust) but expand them to improve turnaround time and services provided. • Collaborate with power companies to provide moderated rates for irrigators. • Provide or expand programs for renewable energy equipment or machinery such as solar panels, solar-powered pumps, or electric farm equipment.
Automation and Monitoring	• Programs are too expensive or unavailable.	• Provide cost-shares to assist producers in automating their irrigation systems.
Water Storage	• Policies and costs hinder the ability of producers to install ponds and reservoirs. • Storage tanks are expensive, and most grants do not cover storage equipment.	• Re-evaluate rules and regulations around access to water in non-irrigation seasons. • Subsidize or invest in cost-share programs that support producers in building water-storage facilities or purchasing storage equipment.

Chapter 3: On-Farm Irrigation Management and Off-Farm Irrigation Infrastructure

Overview

In addition to selecting appropriate irrigation systems, farmers and ranchers must carefully contemplate suitable irrigation practices when utilizing irrigation-based approaches to manage drought and heat. Management strategies noted by participants included reallocating water to higher-value crops, transferring water rights or altering planting locations, excavating new wells or digging deeper wells, and increasing water applications.

Off-farm infrastructure improvements were also brought into the discussion on irrigation management strategies, particularly by producers in drier regions of the state (i.e., eastern, southern, and central Oregon). These producers suggested that no on-farm infrastructure upgrades would adequately manage drought and heat pressures if certain off-farm infrastructure upgrades were not also pursued.

On-Farm Irrigation Management and Off-Farm Infrastructure

On-Farm Irrigation Management

ALLOCATION DECISION-MAKING (N= 13, 22%). As drought conditions have intensified and water availability has declined, participants shared that they have had to make allocation decisions to stretch their water as far as possible. For some, this has meant reducing water application on all operational acreage. In contrast, for others, it means prioritizing water only to the most profitable fields. Alternatively, some producers have explored options such as transferring water rights or relocating their operations to locations with better access to water or sun protection.

Allocation Decision-Making: Obstacles and Needs. Almost a quarter of farmers and ranchers in this assessment expressed the need for improved predictive water modeling to facilitate preemptive allocation decision-making, as water availability and delivery uncertainty hinder planning and preparation for the upcoming season. Participants highlighted two fundamental data needs associated with predictive data: expected water quantity and when water will be delivered. Difficulties in assessing groundwater levels and the occurrence of extreme heat events were also identified as challenges related to predictive data.

> **"I can't go out and buy fertilizer because I don't know if I need zero or ten thousand tons this year. I can't do it! It hamstrings me. It's killing me."**
>
> — Southern, Field Crops, Large

INCREASING WATER APPLICATION (N=15, 25%). Despite reductions in water availability, fruit, and vegetable growers still frequently rely on increased overhead watering to mitigate the impacts of extreme heat events on their crops. Wine grape and fruit producers also commonly use overhead irrigation to protect crops during frost events.

Increased irrigation during heat events and increasing water application in a concentrated manner (i.e., watering longer but more infrequently) were also noted as strategies to keep ground temperatures cool and increase crop resilience by encouraging the roots to grow deeper into the ground where more moisture is available, respectively.

> **"The whole notion of water deeply and infrequently rather than frequently and not very much to create this, you know, these deep tap roots that can really access water and therefore be bringing up aquifers instead of us continuously pumping and depleting."**
>
> – Western, Vegetables/Fruits, Small

Increasing Water Application: Obstacles and Needs. Unsurprisingly, many participants pointed out that increasing water applications to contend with drought and heat pressures was impractical as there is often no water available. This obstacle was true even in the “off-season” if summer conditions were especially dry. According to wine grape producers in central Oregon, for example, if evening temperatures start approaching freezing following a drought season but before winter precipitation arrives, they risk having insufficient water to apply to the grapes, leading to frost damage.

Producers also expressed the need for resources, research, and information on evapotranspiration rates, specific crop and cover crop water requirements, and interpreting plant stress data to make informed irrigation decisions and reduce plant stress.

> **"I've yet to… let's say…. management-wise, [to] completely understand evapotranspiration and how to start gathering….data collecting. What that looks like, and how much more water I need to apply to the vineyard to stay at least even with it if possible."**
>
> – Central, Wine Grapes, Small

One producer also specifically requested user-friendly resources to understand dendrometer data (caliper data used in tree trunks) and how to use this data to inform irrigation and cooling practices (Ruehr et al., 2016).

DROPPING WELLS DEEPER OR DIGGING NEW WELLS (N=8, 14%). To increase access and availability of water, participants with groundwater rights pursued digging new wells and lowering existing wells to access receding water tables. Dropping pumping systems was also common practice in conjunction with deepening existing wells.

Dropping Wells Deeper or Digging New Wells: Obstacles and Needs. The most common difficulty associated with drought and heat resilience and the use of wells were rules and regulations restricting whether, where, and how wells for irrigation could be implemented. These difficulties were grouped into two categories: rules regarding the use of domestic wells for irrigating commercial crops (n=3) and regulations related to digging wells for irrigation purposes (n =10).

Small-scale producers seeking to engage in suburban or urban farming expressed issues with domestic well rules that dictate domestic wells are not permitted to be used for irrigating crops intended to be sold commercially. Permission to use domestic wells for irrigation would enable them to farm in areas where water-righted land is unaffordable without breaking the law.

> **"You can't buy farmland off what you make as a farm laborer, so I've also held other jobs to make some money and was able to purchase a half-acre with a house in the city as a primary residence. I am still looking for farmland that I can afford. I grow primarily vegetables, also flowers, beans, and small fruits, I have a small orchard, and I sell out to local farmer's markets. It's currently my only job, and I am actively looking for more open land and expect to run into more problems of it being illegal."**
>
> – Western, Flowers/Vegetables/Fruits, Small

While allowing the use of domestic wells for irrigation may not intuitively seem like a drought and heat mitigation strategy, some participants indicated that lowering barriers for smaller-scale farmers could serve as a long-term drought and heat mitigation solution. One farmer, for example, believed that smaller-scale producers were often better stewards of natural resources, including water, and that encouraging small-scale farming could be seen as a drought and heat mitigation strategy.

> **"I also believe that if there were more small-scale farmers around that there would be more resources, there would be more connection, there would be more shared thoughts."**
>
> – Western, Vegetables, Moderate

Moratoriums and restrictions on digging new, non-domestic irrigation wells were also identified as obstacles to on-farm drought and heat resilience. Both large and small producers emphasized the criticality of accessing groundwater for survival in years when their water supply was curtailed or shut off completely.

PURCHASING OR SELLING WATER, TRANSFERRING WATER RIGHTS, AND WATER RIGHTS-RELATED ISSUES (10%>). A small percentage of participants also shared that they buy or sell water or transfer water rights to other parts of their operation to enhance on-farm resilience.

> **"We're just going to plant them [non-productive acres] to a perennial cover crop, and we'll either transfer the water and get a beneficial use out of that somewhere else, where we don't have to come back and water that every two out of five years. We're kind of in a fortunate position where we have a big enough land base and some ground that doesn't have water right that we can transfer to that."**
>
> – Central, Seed, Large

Water Rights and Related Issue: Obstacles and Needs. There was significant variability among participants regarding the specific issues they encountered with water access policies. Some producers expressed frustration with the inability to fully utilize water rights from what they perceived as abundant sources, such as the Columbia River. Others highlighted challenges related to the requirement to use water rights in order to retain them even in drought or dry conditions, lengthy administrative processes to transfer water rights to other portions of their property, and policy or administrative barriers to sharing water and water rights among farmers.

> **"Week on, week off! I could take one week on and two weeks off at the end of the irrigation season if I could share that water right with whoever has it downstream from me. I mean, that would be a great solution."**
>
> – Southern, Vegetable, Moderate

Off-Farm Irrigation Infrastructure Improvements

Thirteen (22%) participants in this assessment expressed a need for off-farm irrigation infrastructure improvements. These participants represented various regions, including central (n=5), coastal (n=1), eastern (n=2), and southern (n=5) Oregon.

Coastal, central, and southern farmers and ranchers were predominantly concerned with whether irrigation canals should be piped, with varying opinions amongst contributors. Supporters of piping the canals argued that it would conserve water by preventing leakage back into the ground or evaporation before reaching its intended destination. Additionally, they emphasized that pressurized water delivery to farms would enhance overall irrigation efficiency. Opponents of canal piping expressed concerns that piping would hinder the percolation of water back into the watershed, potentially affecting wildlife habitats and groundwater levels. They also raised concerns about the potential negative impact on the region's aesthetics, reducing locals' quality of life and property values.

Participants in central Oregon furthermore suggested a need for changing diversion points of surface water sources to enable increased water access and automating off-farm infrastructure to facilitate remote sensing and monitoring of water levels, gates, and valves. In line with this, one farmer recommended integrating off-farm infrastructure systems with communication systems that could send timely notifications to producers, providing them with information on expected timelines for water delivery to their operations. This automation would enhance operational efficiency and enable proactive water management.

Producers in eastern Oregon primarily spoke to their dissatisfaction with the perceived lack of interest shown by the state and other government entities in collaborating on large-scale, off-farm water storage and water quality maintenance projects.

> **"The frustrating thing about this is for the last six years, Union County, we got some grant money to do a place-based water resource planning, and there was this committee that was formed, and it had everybody on it. The tribes are in on it; all the federal agencies are on it; the local people are on it; there are members from the community that are just interested in fishing or boating or things like that. So basically, we're looking at this question, what do we do? So, we've identified some areas that we can maybe put some reservoirs, and EVERYBODY is on board. Except. Our. State."**
>
> – Eastern, Seed, Large

Irrigation Management and Off-Farm Infrastructure Summary

Irrigation management activities are crucial in producers' strategies for mitigating drought and heat impacts. These management strategies encompass adjustments in water allocations across operations and efforts to access increasingly scarce groundwater. Producers offered suggestions to enhance irrigation management strategies, including facilitating water sharing among producers, streamlining water rights transfers, and easing regulations surrounding the drilling and usage of wells in regions where groundwater levels are adequate.

Addressing off-farm infrastructure concerns such as large-scale water storage projects, piping of irrigation channels, and the automation of irrigation infrastructure were also suggested as pathways to more effective water resource management. By addressing these areas of interest and supporting collaborative efforts, the state can play a vital role in ensuring the resilience and efficiency of off-farm irrigation infrastructure across the state.

Table 3: Irrigation Management and Off-Farm Infrastructure Activities, Obstacles, and Potential Solutions Summary

Practice or Activity	Obstacles	Potential Solutions
Moving locations, transferring water rights, or sharing water rights	• Transferring water rights to other locations or sharing rights can be a lengthy and challenging process due to administrative backlogs or complex rules and regulations.	• Expand services to facilitate quicker and easier water rights transfers or water sharing.
Increasing water application to reduce heat impacts on crops (e.g., crop cooling)	• Producers in particularly dry or hot regions may not have water to spare for cooling. • When temperatures reach extreme highs, water application ceases to be effective. • Better research and data are needed to help producers understand evapotranspiration rates, plant, stress, and how that data translates to water application and decision-making.	• Increase research and funding on alternatives to overhead watering for cooling (e.g., shade structures). • Increase research and distribution of accessible materials on adjusting irrigation management in heat events by crop type, soil type, etc.
Dropping Wells Deeper or Digging New Wells	• It is challenging to determine groundwater quantity and availability per region. • Digging or dropping wells is often expensive. • Policy hurdles prevent producers from digging new wells or using domestic wells for irrigation.	• Invest in better modeling of groundwater resources. • Improve data communication to producers on groundwater availability if groundwater levels are low. • Relax well drilling regulations if data suggests groundwater levels are adequate. • Provide financial assistance for well digging or maintenance if water levels are adequate.
Purchasing or Selling Water	• Particularly vulnerable producers do not have extra water to sell. • Reduced bottom lines because of limited production may mean a lack of funds to purchase water (when and if it's even available).	• Maintain or expand programs that allow producers to access financial incentives for selling water.
Increased piping, reservoir development, and riverbed restoration	• There is a lack of cohesion amongst irrigators regarding whether large-scale infrastructure projects are worth the potential loss of habitat and impact on property values.	• Support ongoing mediated conversations between stakeholders (including government entities) to encourage compromises on creative, off-farm infrastructure improvements to increase water availability and delivery for irrigators.

Chapter 4: Ecosystem Management and Fire Mitigation

Overview

Approximately one-third of participants in this project were either engaged in or seeking assistance with ecosystem management strategies to address drought and heat challenges. These approaches entailed considering farm and ranch resilience within the broader ecological landscape in which they operate and included forest management, silvopasture, and riparian development and restoration.

In discussions on ecosystem health, some participants also described the relationship between forest health, drought, heat pressures, and wildfires. Strategies to mitigate fire pressures have thus also been Included within this chapter, despite not initially being a central focus of this assessment.

Ecosystem Management

FORESTRY, SILVOPASTURE, AND RIPARIAN FOREST BUFFERS (N=15, 25%). Among the various approaches categorized under ecosystem management, forestry and silvopasture were the most frequently mentioned as effective means for enhancing on-farm resilience. Silvopasture, which involves growing perennial grasses or grass-legume mixes in forest stands for livestock to forage, also provides shade for livestock and the ground, windbreaks to reduce desiccation, reductions in erosion, and improvements to soil health (Angima, 2009). Participants also recognized the benefits of general forestry improvement both on- and off-farm, as forests act as a natural "sponge" on the landscape, capturing water from the atmosphere and transferring that moisture to the ground.

> **"We're going to put in rows of trees actually and do a silvopasture program. And that's one of the things that we're using to adapt to heat and drought is sort of tailoring the type of infrastructure, the type of plantings we do to the conditions…the specific conditions on the site but also considering the wider conditions we're dealing with."**
>
> – Western, Vegetables/Seed, Small

Riparian areas, including river banks, streambanks, creek beds, wetland areas, and terrestrial (land-based) ecosystems were considered by participants to be critical habitats for flora and fauna. Encouraging the diversity of these non-cultivated species was seen as a method for fostering more "complete" or "intact" ecosystems that could withstand more severe environmental pressures. Protecting riparian spaces was also seen as a method to improve local water quality, as these zones act as a contaminant and sediment filter for water before it rejoins off-farm waterways (Wentzel & Hull, 2021).

> **“In this time, like our ranch in Beatty, we have not grazed the riparian area during the time of year that’s harmful to it, which would have been helpful for us, right? We’re in crisis. But we value it so much that we’re trying to adapt in other ways so we don’t have to hurt the land.”**
>
> – Southern, Livestock, Large

Forestry, Silvopasture, and Riparian Buffers: Obstacles and Needs. The challenges highlighted by participants in implementing forestry, silvopasture, and riparian restoration strategies were a lack of information on best practices for site preparation and installation, appropriate locally-specific species, and species that can withstand future increasing temperatures and decreasing water availability.

LANDSCAPE MANAGEMENT (N=8, 15%). Participants also described using the landscape’s topography to slow natural water flow across their farms and ranches. These practices included digging “bulges” (short-term reservoirs), swales, and other on-contour earthworks projects. By slowing the water flow across their property, producers provided more time for water to infiltrate the soil, thereby increasing soil moisture content and recharging the water table (Cahill et al., 2018).

> **“I want the water, but it would be more drought-proofing of the landscape if it [water] were slowly sinking definitely as opposed to like a plastic lined pond, and that’s…. because that’s not really, that’s protecting your crop not drought-proofing your area.”**
>
> —Western, Vegetables/Fruit, Small

Landscape Management: Obstacles and Needs. Though some small-scale projects may be achieved using manual labor and tools, earthworks projects generally require expensive or specialized equipment that may be financially inaccessible for many producers.

OVERALL ECOSYSTEM BIODIVERSITY ENHANCEMENT (N=7, 12%). Several producers promoted ecosystem biodiversity beyond tree plantings as a drought and heat mitigation strategy. For these participants, encouraging biodiversity also involved attracting pollinators, beneficial insects, diverse plants (including weeds), and animals such as beavers, which are vital for slowing and infiltrating water back into the water table. These strategies were once again described as important for creating a more "whole" ecosystem that could better endure environmental stressors.

Ecosystem Biodiversity: Obstacles and Needs. Producers provided limited or indirect insights into the obstacles they face in improving overall ecosystem biodiversity. This lack of feedback may partly result from the magnitude of ecosystem-based approaches and the wide variety of pathways available to enhance ecosystem resilience through overall increases in on-farm biodiversity.

Fire Mitigation

FIRE MITIGATION AND MANAGEMENT (10%>). Although not directly asked about fire pressures, some farmers and ranchers considered fire danger as pressing of a threat as drought and heat and, in some cases, had to decide between retaining water for irrigation or keeping water available for fire management. For example, one producer noted that they felt it was crucial to use some of their allocations to apply water to marginal areas at the edge of their fields to keep them green and act as a buffer in the event of a fire. Fire mitigation strategies also included forest management through clearing debris and increasing the planting of trees to improve forest health and reduce the risk of destructive blazes.

Ecosystem Management and Fire Mitigation Summary

Managing the ecosystems within which farms and ranches operate was viewed by some producers as a "big picture" pathway toward increasing on-farm drought and heat resilience. Due to the relatively short timeline of this project, a more in-depth analysis of these broader and more complex themes was not possible; however, more extensive and in-depth research on each theme included in this section should be considered moving forward.

Table 4: Ecosystem and Fire Management Activities, Obstacles, and Potential Solutions Summary

Practice or Activity	Obstacles	Potential Solutions
Establish and protect forests, on-farm trees, and riparian areas.	• More information is needed on site- and function-specific species.	• Increase research and outreach on place-based silvopasture, forestry management, and riparian-specific species selections. • Increase investment in forestry management and forest health improvement initiatives.
Use of the landscape to slow and sink water.	• Earthworks projects require extensive time and labor.	• Subsidize or support programs that assist producers in landscape-based water management projects.
Enhance ecosystem biodiversity by planting diverse species and providing wildlife habitat around the property.	• No specific feedback was provided.	• Support further research on farmer insights and needs concerning increasing overall on-farm biodiversity.
Create defensible spaces to prevent fire damage.	• Water is needed to keep areas green and moist enough to act as buffers.	• Increase research or outreach on non-water-based fire mitigation strategies.

Chapter 5: Soil Management

Overview

"If your soil is full of carbon and is in total health, then you can retain that moisture and cut one or two watering's out. So, I think first you have to start on-farm. It has to be a change in practice, and then from there, you move on to the infrastructure."

—Southern, Seed, Large

Whether small or large, in the Valley or east of the Cascades, farmers and ranchers across Oregon are working to improve their soil quality. Even participants who did not feel that their framework for drought and heat resilience started with soil management still engaged in practices such as soil moisture sensing, soil testing, or various strategies for building up biomass and improving soil quality as drought and heat mitigation strategies.

On-Farm Soil Management Practices and Obstacles

MULCHING AND COMPOSTING (N=30, 51%). Mulching and composting were the most frequently cited practices for improving soil quality mentioned by participants in this assessment. Mulching involves using organic materials and inorganic inputs such as plastic sheeting to retain soil moisture, reduce weed pressure, and minimize the need for herbicides or manual weed removal. Leaving plant stubble after harvest was also noted as a technique to help keep the soil covered and stabilized to prevent erosion during wet weather.

> **"Our normal farming practices are such that we don't have an awful lot of open ground or anything like that, so leave the stubble on the ground, and with flooding in the winter time, we are able to stabilize the soils fairly well."**
>
> — Southern, Field Crops, Large

Compost amendments included manure, leaves, and any other organic debris that could be found on or near the property. Many participants also engaged in "chop and dropping," which involves leaving cuttings or prunings in the field rather than removing or burning them. Producers engaged in composting stated that by increasing the organic matter in the soil they were improving the soil's porosity, allowing plant roots to penetrate deeper and reach water at lower depths in the soil profile. Increasing organic matter was also seen as an effective way to increase the soil's water holding capacity, increasing the soil's resilience to drought and heat events.

> **“[Composting for] water retention and for weed abatement. I think it's also part of getting organic matter back into the soil. We don't remove any of the wood like the tractor was mowing down there. We grind up the pruning’s, and the only thing that leaves the field are ripe berries that we can sell.”**
>
> —N. Willamette, Fruit, Moderate

Composting was felt to improve soil nutrient content and the ability of plants to uptake nutrients, making plants healthier and more capable of withstanding drought and heat while reducing the need for fertilizer applications.

Mulching and Composting: Obstacles and Needs. Producers' primary barrier concerning composting and mulching was accessing affordable and appropriate equipment, such as chippers or biochar reactors. One producer, for example, had expressed interest in creating biochar from orchard cuttings to amend his soil but shared that the permit for the necessary equipment would cost thousands of dollars. Similarly, other producers working with products like orchard tree fruit stated that accessing chippers for full or even partial orchard recycling was cost-restrictive, and equipment for rent was not readily available.

> **“Right now, it’s [biochar production] very expensive to do and [redacted], and those guys had a bio-char burner in Hood River, and it was going to cost them 20 thousand dollars to permit this little burner that hardly did anything. And it’s kind of like, but you can pay five bucks to get a permit to go burn all of this stuff that you want? Yet you have to pay 20 thousand dollars to permit this biochar [reactor] which is much less polluting and fixes lots of carbon?”**
>
> — Central, Fruit, Moderate

Accessing compost materials such as leaf litter or wood chips was challenging for farmers in remote regions in eastern and southern Oregon due to the lack of proximity to material collection services. However, even in more densely populated areas like western Oregon, farmers expressed the need to be resourceful and “savvy” to secure free or inexpensive composting materials.

> **“I feel like there’s also some other micro-enterprises that could help make things more sustainable. So, if there was somebody like me that was serving, you know, several dozen farmers out here who need mulch and compost and stuff to help with that mitigation, heat mitigation, like that could be really helpful as well.”'**
>
> —Eastern, Vegetables, Small

Two farmers from central and southern Oregon shared that despite attempts at increasing soil health through composting practices, the conditions of their region were such that it was mostly futile. For one, the cool temperatures of their soil throughout most of the year posed a seemingly insurmountable barrier as it prevented the breakdown of organic materials; for the other, soil quality was the main hurdle.

> **"All of that fertilizer application from natural fertilizer over the years has not done a thing to amend the soil. And it's because the soil, it really isn't soil; it's not organic soil. It's like I laughingly say it's like ground glass. If you put enough fertilizer and water into it, it will grow things, but can you change the retention of the soil? Not in this country, you can't."**
>
> —Central, Pasture Forage/Cattle, Small

NO-TILL AND REDUCED TILL (N=23, 39%). Reducing or eliminating tillage was the second most frequently mentioned practice that producers used to improve soil health to contend with drought and heat. Unlike conventional tillage, which involves extensive soil disturbance, no-till management uses specialized equipment for planting seeds with little disruption to the soil structure (USDA (b), n.d.). In leaving the soil intact, producers felt that no-till and reduced tillage kept moisture in the ground while enriching the soil by retaining crop residues and biomass. No-till practices also reduce inputs and labor costs, which were significant concerns for many in this assessment.

> **"I would tell you, I guess one thing that we've done more of in the last ten years is inter-seeding fields instead of where before, a lot of times we would work up the whole field and replant in the spring or fall. Now instead of working that up and losing the moisture and the cost of doing it, we'll drill more grass into a field as it starts thinning down. That's all helping, especially during the summer. If you worked ground, you're going to lose some moisture."**
>
> — Coastal, Dairy, Moderate

No-Till and Reduced-Till: Obstacles and Needs. The primary obstacle reported by producers seeking to implement a no-till system was the lack of access to appropriate equipment. Specifically, farmers expressed difficulties acquiring no-till drills due to high costs or lack of rental programs. It should be noted that both small and large-scale producers addressed the cost of no-till equipment as a barrier to these practices.

> **"We don't have a large enough no-till drill to use on all of our land, and a new no-till drill is just out of our means right now. But the tools that allow us to implement regenerative ag practices of a scale, at least monetarily, we can't afford that right now."**
>
> — Southern, Livestock, Large

One producer also suggested that despite the positive impact of no-till practices on soil quality, their no-till acreage seemed to require *more* water. Although they were fortunate enough to have enough water to meet this increased demand, an uptick in water requirements would not be sustainable for many producers already contending with water curtailments. Another producer also raised concerns about potential pest increases associated with no- or low-till systems. Producers emphasized the need for further research and understanding to maximize the benefits of these systems while mitigating any negative consequences.

> **"I have fields that I don't cultivate for four years solid, and then we go into a strip-till for two years, or a limited till cover crop and then a strip-till plant, and now we're barely working the soil. We need to study what other problems THAT is going to bring. What problems am I going to have with rodents? With moles and voles in particular."**
>
> — N. Willamette, Nursery, Large

SOIL MOISTURE MONITORING (N=20, 34%). Over a third of producers engaged in soil management practices highlighted the importance of monitoring soil moisture content to avoid under and over-watering crops.

> **"Yeah, probably the most beneficial for us has been irrigation water management because prior to doing that soil moisture monitoring, we kind of scheduled our irrigation based on the evapotranspiration model. We'd kind of look at the published crop water use for our area through AgriMet, and sort of just use the checkbook method of modeling the crop water use and irrigating according to that. But we found that with the soil moisture sensors, we're using much less water and overwatering less."**
>
> —Eastern, Field Crops, Large

Multiple methods varying in cost and complexity were employed for testing soil moisture, with some producers manually pulling soil cores while others had remote systems that could be monitored in real-time via a smartphone or computer.

REGION, COMMODITY, SCALE	SAMPLE DATA
SOUTHERN, FIELD CROPS, LARGE	"I measured it different than other people. I had a large-sized wood drill bit that was probably 1.5" around is what it was. I would go to different places in the field, this bit was like three feet long, and I could just augur down into the ground just like a post-hole digger, only real small, and I could tell where the moisture was at."
CENTRAL, TREE FRUIT, LARGE	"We utilize remote monitoring systems to...you know, I look at every six inches, from zero to six inches, all the way down to the 36 inches, I monitor that in real-time, what my water levels are."

Soil Moisture Monitoring: Obstacles and Needs. The main obstacles related to soil moisture monitoring were the cost of soil moisture sensing equipment and the variability of soil, temperature, and topography across farms, necessitating sensors in multiple locations. Producers already using soil moisture sensors also noted that it's not always clear what actions should be taken based on the collected moisture data. Furthermore, automation of systems introduces the risk of system errors that could be costly, emphasizing the importance of continuing manual checks for soil moisture content.

> **"It gets to be unrealistic in a way; you have your water probe out there checking it, but anyway, it's a farm field; they're not all flat or all the same across each corner. So, you're gonna have a dry spot and a wet spot, high and low spots, so are you gonna put 1800 probes out there? Which one is it gonna turn on?"**
>
> —N. Willamette, Fruit, Moderate

COVER CROPPING (N=19, 34%). Integrating cover cropping practices was the third most common practice described by participants pursuing drought and heat mitigation through soil health management and practices. Cover cropping was suggested to help reduce evaporation by keeping the ground covered, enhance soil water infiltration, and prevent erosion. Diverse cover crop mixes were also valued for increasing biomass when terminated, fixing nitrogen, suppressing weeds, and reducing the need for fertilizers and herbicides (Clark, 2007). Livestock farmers furthermore suggested that diverse cover crop mixes provide healthy forage for their animals, benefiting both soil and animal health.

> **"I've planted buckwheat this year in a field not to harvest it, just to put it back in the field and then plant permanent forage into that afterward just to then ramp up the soil organic matter and microbial growth."**
>
> —Western, Dairy/Pasture Forage, Moderate

Cover Cropping: Obstacles and Needs. Several key challenges were identified regarding cover cropping practices. These challenges included the need to manage them in such a way as to avoid competition with cash crops, difficulties finding equipment for non-chemical termination, uncertainty about suitable species based on unique conditions, and lack of sufficient water for establishment.

REGION, COMMODITY, SCALE	SAMPLE DATA
N. WILLAMETTE, NURSERY, LARGE	"You know why am I applying four inches of water to grow a cover crop and two inches of water to grow a tree crop? It's a little annoying, and so we switched to non-irrigated cover crops, but now my soil is so dry I'm putting on four inches of water to facilitate cultivation."
SOUTHERN, VEGETABLES/FIELD CROPS, SMALL	"Ideally, I would have done a cover crop like daikon radish that broke up the compaction, but I didn't have water to water the cover crop."

ROTATIONAL GRAZING (N=10, 17%). Participants who implemented rotational grazing for their livestock recognized this system as a practical approach to improving soil and overall ecosystem health. In rotational grazing systems, only a specific section of pasture is grazed at a given time, allowing the other areas of the operation to regrow. Animals are moved to another section once the forage has been grazed down to a certain height rather than based on a predetermined period (Ates & Filley, 2019). Producers emphasized that this system allows animals to naturally fertilize the soil while minimizing issues such as compaction and over-grazing.

> **"Last year, after implementing for two years this sort of holistic planned grazing on that hay ground, we almost doubled our yield of hay with less water than we have ever had. So again, this touches not just on the heat buffering capacity of healthy biologically alive soils but your water holding capacity increases significantly."**
>
> —Central, Pasture Forage/Vegetables/Livestock, Moderate

Rotational Grazing: Obstacles and Needs. As in many other soil-based management cases, equipment to execute rotational grazing was seen as a critical barrier. Fencing, in particular, was described as too expensive to implement rotational grazing effectively. Because animals need to be moved, more shade structures and water troughs for each location were also identified as potential barriers.

> **"There are a lot of great programs out there for people who want to do high tunnels and all that kind of thing…. there's really not much out there for people producing meat if they don't feed their animal's grain. I mean, the infrastructure for rotational grazing in terms of nets and whatnot."**
>
> — Southern, Livestock, Small

One producer also suggested additional information and outreach efforts to educate ranchers on proper grazing management to prevent over-grazing. This participant emphasized that overgrazing could lead to soil degradation and erosion, highlighting the importance of knowing when to remove animals from the land as a mitigation strategy.

On-Farm Soil Management Summary

In this assessment, it was evident that producers widely recognized the importance of appropriate soil management practices in enhancing their resilience to drought and heat. However, the main barriers faced by participants were accessing the appropriate equipment needed to increase or protect their soil health, accessing and understanding resources to interpret soil moisture content data, and resources to help determine appropriate actions based on that information. Despite an overall positive association with managing soil health to contend with drought and heat, some producers expressed concerns about the suitability of certain soil health practices, such as no- or low-till and cover cropping, to their particular circumstances.

Table 5: On-Farm Soil Management Activities, Obstacles, and Potential Solutions Summary

Practice or Activity	Obstacles	Potential Solutions
Mulching and Composting	• Lack of access to off-farm organic materials • Lack of affordable and appropriate equipment for on-farm resources • Incompatible soil types	• Provide seed money or support for locally-based organizations that can streamline urban waste resources such as leaf debris and wood chips to farmers and ranchers. • Explore options to support affordable and appropriate equipment rental programs or subsidize equipment purchases. • Seek partnerships and funding opportunities to reduce equipment costs. • Increase research and outreach on improving soil quality in high-desert conditions. • Advocate for streamlined permit processes and reduced permit fees. • Encourage the development of local material collection services in areas with limited access to compost materials.
Reduce or no-till	• Lack of access to appropriate equipment • Reduce or no-till is not always appropriate (some cases requiring *more* water)	• Establish and support financial assistance programs like those in Yamhill and Clackamas Counties to help farmers afford to buy or rent no-till equipment. • Foster collaborations between equipment manufacturers and farmers to develop affordable options. • Increase on-farm research to determine appropriate and inappropriate no-till and reduced tillage conditions.
Soil Moisture Monitoring	• Cost of monitoring equipment and variability of farm conditions • Difficulty interpreting data and linking it to actionable items	• Explore funding opportunities for subsidized soil moisture monitoring equipment. • Develop affordable and user-friendly soil moisture sensing technologies. • Increase research, outreach, training, and resources on interpreting soil moisture data (in simple terms) and

		actionable items associated with the data for making informed irrigation decisions. • Improve resources to input and process data and receive summary reports.
Cover Cropping	• Management • Lack of water to establish a cover crop • Uncertainty about selecting appropriate species • Competition with cash crops • Lack of access to equipment for non-chemical termination	• Develop best management practices and guidelines for effective cover crop management • Programming that permits the renting or subsidizing of equipment, such as roller crimpers, to terminate crops. • Support research and Extension efforts to identify suitable cover crop species for different regions and climates (e.g., selection based on context-specific parameters such as cash-crop type, location, and soil type). • Explore innovative and cost-effective methods for the non-chemical termination of cover crops. • Increase research and outreach on drought-resistant cover crop species. • Promote water conservation practices and efficient irrigation strategies to establish cover crops.
Rotational Grazing	• Expensive equipment (e.g., fencing and infrastructure)	• Subsidize or provide rental programs for fencing. • Provide financial assistance or subsidies for shade structures and water sources for rotational grazing operations. • Develop comprehensive educational materials and outreach programs on proper grazing management practices. • Increase offerings of training and workshops to ranchers on rotational grazing and preventing over-grazing.

Chapter 6: Commodity Management Activities and Obstacles

Overview

In addition to soil and irrigation-based strategies, producers have also implemented adaptations and adjustments within their commodity (i.e., crop or livestock) management practices to mitigate the impacts of drought and heat. These activities include exploring different crop varieties, transitioning to new commodities, adapting planting and harvest management and timing, and changing grazing patterns.

On-Farm Commodity Management Activities and Obstacles

CULTIVAR/VARIETY SELECTIONS OR TRANSITIONING TO NEW COMMODITIES (N=31, 53%). Many producers have proactively sought or implemented new species to enhance on-farm resilience in the face of water curtailments and rising temperatures. The selection process for these choices focuses on three primary desirable outcomes: 1) drought or heat tolerance, 2) contribution to overall diversification of the cropping system, and 3) desirable planting or harvest timing.

Farmers believed that diversification of their overall production mitigates risk by having varieties that perform better under varying conditions, thereby lessening potential losses from extreme or variable weather events.

> **"I selected five varieties to spread it out over the season, and there are definitely differences in heat resilience. Legacy [blueberries], for instance, is a southern-northern cross, so it has southern genetics, making it much hardier to heat. But at the same time, it doesn't go completely dormant, so in some aspects, it might have more vulnerability to frost."**
>
> — N. Willamette, Fruit, Moderate

Cultivar and variety selections by producers were also guided by ripening or harvest time, as selecting varieties with particular lifecycles can help farmers avoid the hottest times of the year when sun damage, heat stress, and water curtailments are most likely.

REGION, COMMODITY, SCALE	SAMPLE DATA
CENTRAL, FRUIT, MODERATE	"We're certainly not planting varieties that are going to be late in the season because it's just more likely that you're going to get heat issues later in the season."
CENTRAL, PASTURE FOR AGE, LARGE	"Just this year and last year both, we have grown more grain crops so that they finish irrigation around, let's just say, the first of July, you know? Plus or minus. Where a hay crop or a row crop needs water, you know, from the 15th of April clear through the 15th of August, until harvest, or September for that matter."

One producer in eastern Oregon shared that he had also been experimenting with planting crops with varying water requirements throughout the season. This approach allowed him to allocate water to crops at different times of the year rather than forcing him to irrigate everything simultaneously and stress his water supply.

> **"One thing I can think of is our irrigation systems don't have the capacity to basically stay on top of every field all the time. So, in our scheduling, we sort of have to prioritize and water fields in sequence by priority. But the diversification has helped spread out the demand from each crop so that some crops are taking the water early, some mid-season, some later, to where we don't need to water every field all the time."**
>
> — Eastern, Field Crops, Large

While diversification mostly involved selecting different cultivars or varieties, some producers have begun integrating or transitioning to entirely new commodities. For example, some southern and central Oregon vegetable farmers indicated they were shifting away from vegetable production to field crops and pasture forage due to limited water availability and increasingly early and intense high temperatures.

> **"I'm also really changing which crops I'm growing, and so I'm trying to grow crops where I'm not just fighting an uphill battle all the time and ones also that are...some of them can be candidates for dry farming which...dry farming isn't technically super do-able here just because we don't get enough precipitation, but I still think there's a lot of techniques to be borrowed from that idea. So, I'm going to be growing actually more field crops [instead of vegetables]."**
>
> –Central, Vegetables, Small

Species Selections or Transitioning to Commodities: Obstacles and Needs. Producers expressed a need for increased research into locally-specific drought and heat-tolerant varieties that could also withstand colder winter temperatures in the eastern and southern parts of the state. While research articles and resources were considered valuable to producers, many participants emphasized the importance of financed on-farm trials. This approach aligns with other needs assessments conducted by the project team, highlighting that farmers and ranchers are more likely to adopt practices or methods when they can see the results in person and in real-time (Nelsen et al., 2022). Financed trials also foster engagement and empower producers to be active participants in finding solutions to drought and heat-related problems within their operations. As one participant in this project noted, “Agriculturalists, by and large, do not want more money; they want to farm.” Financed on-farm trials encourage collaborations and further necessary research while allowing agriculturalists to continue their work.

> **"I would not be in favor of more assistance financially. I don’t…. I think it just limps the problem along, you know? Okay, we’ll get them through this year, and we’ll see what happens next year. Well, how many years can you do that in a row? And then how many years are farmers going to want to do that, you know? I don’t think that’s a very productive way of that money…. I think spending it on being more efficient or, you know, if we can do more studies on replacement style crop stuff, THAT’S financially viable."**
>
> – Southern, Pasture Forage, Large

It is important to acknowledge that while species selection based on on-farm trials was seen as an accessible and suitable option for many producers, transitioning to entirely new crops was felt by many to be unrealistic, particularly by those in perennial crop production. The costs of tearing out the original system, investing in new infrastructure and equipment, and waiting a few years for the latest commodities to establish and provide a return on investment were too high for most.

REGION, COMMODITY, SCALE	SAMPLE DATA
CENTRAL, PASTURE FOR AGE, SMALL	Interviewer: “Maybe you’d be open to transitioning, but the cost and the risk are very high. Does that sound right?” Participant: “That’s exactly right if you think about it. For instance, I could grow some wheat here, but to buy a combine for 70 acres, and a combine will cost me 200k? That doesn’t make sense. I could never amortize that out over the period of farming and make it logical.”
CENTRAL, PASTURE FOR AGE /VEGETABLES/LIVESTOCK, MODERATE	“Our financial system, normal farm credit systems, where you need to pay back your operating line in full each year, or you’re paying on the principal and the interest every year, those models don’t allow for the safety that transition needs.”

SHADING AND OTHER NON-IRRIGATION COOLING STRATEGIES (N=16, 19%). While water-based strategies were common for cooling crops and livestock, producers also employed alternative strategies that did not rely on water availability to cope with increasing heat pressures. The most common approach described is the introduction of structures or materials to provide shade to crops and animals. These tools included shade cloth, opaque plastics, shading structures such as greenhouses and high-tunnels, row covers, trees, and companion planting. Other strategies included using fans for livestock, refrigerating cool-weather crop starts, and applying chemistries and inputs such as anti-desiccants and particle films to protect susceptible fruit from sunburn and heat damage.

Shading and Other Non-Irrigation Cooling Strategies: Obstacles and Needs. Producers' primary difficulty with shading to protect commodities from sun damage is the expense of shade cloth and related equipment. Some participants also expressed uncertainty about the efficacy of shading and whether it was worth the steep cost, considering the dearth of compelling data. One large-scale producer in western Oregon attempted to manage this uncertainty by applying for a cost-share grant to install shade structures and conduct in-field research on the effects of shading on their blackberry plants. According to this participant, their application was denied because the trial was too large.

> **"We're trying to shade significant acreage of blackberries and research how that affects the physiology and conditions of the plant. We were going to look also at things like differences in pest pressure between shaded and unshaded. Pretty much left no stone unturned. Like I said, we were actually going to pay for more than half of the costs, so it's not like we were asking them to fund our entire shading structure. We were like, "Hey, we would just like some support to help put this thing up; we'll pay for the majority of it," and we had quite a few in-kind hours, which means a lot of my time was going to be free."**
>
> –N. Willamette, Fruit, Large

Despite the immense cost of installing the shade structures without assistance and the uncertainty about the efficacy of this approach, this operation went on to pay for their shading infrastructure out-of-pocket, as they felt that without the structures their farm might not survive the following summer. In sharing this story, this participant hoped to highlight that many large-scale producers often cannot afford to conduct and wait for the results of small-scale trials, which makes many funding programs and resources unhelpful or infeasible for bigger farms or ranches.

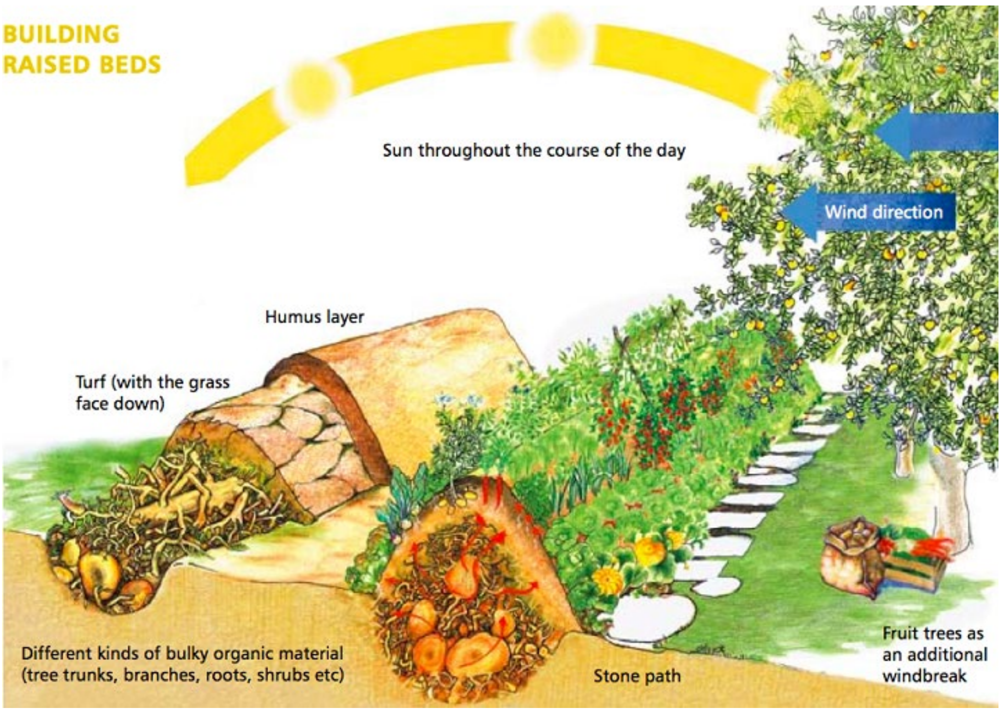
Lastly, chemistries and applications for heat protection were also noted as a strategy for heat protection with mixed results, as producers were unsure about their efficacy. It was also shared that many wholesalers would not accept products with protectant films on them as they were too difficult to remove.

ADAPTING CULTIVATION STRATEGIES (N=11, 19%). Predominantly smaller-scale vegetable producers described experimenting with different cultivation strategies, such as dry farming, as a drought and heat mitigation strategy. According to The Dry Farming Institute (2023), the aim of dry farming Is to irrigate "once or not at all" and is appropriate in regions with at least 20 inches of rain annually. It involves selecting sites with deep soil and good water holding characteristics, lower planting density, surface protection, weed control, cover cropping, and the selection of drought-resistant varieties.

> **"The year after that, in 2016, we heard about Amy Garrett and the work she was doing with dry farming, so we totally jumped in and learned as much as we can and grew some of the varieties. We were real pleased with the results, in particular, one variety of potatoes, Red Pontiac, that produced almost as much without irrigation as it did with and then the different kinds of tomatoes."**
>
> —N. Willamette, Vegetables, Small

Another strategy used by smaller-scale farmers is the use of Hügelkultur beds. To build Hügelkultur beds, farmers and gardeners cover woody materials and other organic matter with dirt before leaving the mounds to rest and decompose (Sweetser, 2022). Once decomposition has begun, planting can be done on the sides and tops of the piles. Despite potentially increasing exposure to desiccating wind and sun, proponents of this method suggest that the woody materials at the center of the bed act as sponges, retaining water for extended periods and reducing the need for irrigation (Rozie, 2022).

Figure 7: Hügelkultur Cultivation System



Note: Original figure taken from Rozie (2022).

Other cultivation management strategies included building in-ground beds instead of raised beds to prevent exposure to drying winds and companion planting cool-weather, shade-loving crops with taller, heat-loving crops.

Adapting Cultivation Strategies: Obstacles and Needs. Most producers adopting novel or unconventional cultivation strategies within this project were small to moderate-sized. One producer provided a potential reason for the discrepancies in experimentation with cultivation strategies and operation size by noting that many of these strategies involve close observation of changes and results, which may not be feasible for farmers and ranchers with larger acreage. Additionally, many of these systems rely on receiving a certain amount of precipitation, which is lacking in drier parts of the state.

> **"We get between 10 and 15 inches of precipitation a year, and so a lot of the 'plant while you're in the rainy season and then let it get watered in and then don't water it again'.... that's just not... I just don't have enough precipitation to pull that off."**
>
> – Southern, Vegetables, Small

ADJUSTING PLANTING OR HARVEST TIMING (N= 10, 17%). For those farmers not transitioning to new varieties or species of crops, adapting or modifying the timing of planting and harvesting is of the utmost importance. Producers have been using season-extending equipment such as hoop houses or high tunnels to start crops earlier, aiming to avoid the late summer heat and water pressures. They also practiced early or late facilitation of germination to capture spring and fall precipitation while minimizing crop exposure to extreme temperatures.

> **"We had windy conditions and triple-digit temperatures, and it was just impossible to keep the top of the soil surface wet enough to germinate the crop. So since then, we've come out with that crop and shifted to planting as early as possible. It's pretty susceptible to frost, but we weigh the risk of, you know, frost damage versus getting into a higher heat situation later."**
>
> —Eastern, Field Crops, Large

Adjusting Planting or Harvesting Time: Obstacles and Needs. One limitation mentioned by producers in changing planting or harvest time is the increased risk of frost damage if germination is started too early or harvest is pursued too late in the season. Producers noted that season-extension equipment and infrastructure like hoop houses and wind tunnels could assist in keeping crops protected; however, the cost of these structures could be significant. It is worth noting that several producers already implementing these practices had received grants through organizations such as the NRCS to implement season-extension projects.

REDUCING OR LIMITING OPERATION SIZE (N=10, 17%). Participants in this assessment have also taken steps to reduce or limit the size of their operations to manage drought and heat. For some farmers, this has meant removing acreage from production and enrolling it into drought relief programs where they receive compensation for not cultivating. For ranchers, limiting production has meant maintaining their herd sizes or selling off animals, primarily due to a limited feed supply created by drought conditions.

> **"We've taken part of our property out of production just because you can't put 2k worth of seed in the ground and then not be able to water it. That's just not logical, and so that's something.... what we're doing now is slowly but surely taking things out of production."**
>
> – Central, Pasture Forage/Livestock, Small

Reducing or Limiting Operation Size: Obstacle sand Needs. The obvious challenge with reducing acreage or herd size for farmers and ranchers is that less production often means diminished income. Participants expressed concern that as drought pressures increase, agriculture in Oregon is becoming increasingly a “get big or get out” environment and that they were at risk of being out-competed by corporate farms and losing their communities' entirety.

> *“If it comes to the end, if I sell the land, or my bank sells the land, someone is going to sell the land, and someone is going to buy it. What we’re going to end up with if they keep screwing around is we’re going to end up with the corporate farms, we’re going to end up [redacted] and [redacted] or somebody in here that is so big, that they come in with the attitude that, 'hey we’re going to farm every acre once every three or four or five years'; that’s their business model, they’ll make it work. And they’re not going to be here supporting our schools, our churches, our businesses, and our communities. They’re going to have an office in Denver, or Pasco, or Idaho Falls, and they’re going to have a manager here.”*
>
> *– Southern, Field Crops, Large*

WEATHER STATIONS (N=6, 10%). Approximately 10% of participants indicated that they were using weather stations on their operations to track evapotranspiration, wind speeds, atmospheric pressure, and overall weather trends over time.

> **“I was kind of skeptical, even until the end, until I got my final data was kind of like, ‘well, I don’t know about these weather stations.’ Why do I need a weather station? I can just go outside [laughs]. But my human brain can’t like…I can’t figure out what was going on in May or like how it was different between the first of June and the first of July or whatever, and so I do feel like the weather stations could be a really great investment for people if they had that help with seeing the trends."**
>
> -- Eastern, Vegetables, Small

Weather Stations: Obstacles and Difficulties. Even though weather stations are reasonably affordable, some participants hesitated to invest in them as their farms or ranches varied dramatically in climate, slope, and aspect from location to location. This variability necessitated purchasing multiple stations to account for micro-climatic conditions, increasing associated costs. Difficulties interpreting the data due to time constraints or lack of background knowledge on appropriate interpretation methods were also shared as potential obstacles to using weather stations to assist with irrigation and heat management and planning.

LEAVING OR STOPPING FARMING (N=6, 10%). The most concerning action being considered by producers to manage drought and heat is completely stopping farming. Though only one participant had retired early “because of the water situation,” others described friends and neighbors folding under and children deciding not to pursue farming partly because of the increasing pressures of drought and heat.

> **"When my dad passed, I took a step back, and a good friend of the family said, 'Look, what do you want to do? Do you want to farm, or do you want to live on a beach the rest of your life?' And all of those things were in play. I look back at how hard my father, grandfather, and uncle worked to build this, and myself too. I don't want to sound like I'm tooting my horn, but I've worked hard, and I've expanded and…[sighs]. I'm not going to say I want my kids to do this, but I'd like to have the choice."**
>
> —Southern, Field Crops, Large

OTHER STRATEGIES (10%>). Additional strategies for managing drought and heat pressures noted by producers included cutting overall costs of their operations (e.g., freezing hiring or equipment purchases), relying more on off-farm income, or relocating their operations to areas more suitable for their specific commodities.

On-Farm Commodity Management Summary

Non-irrigation strategies for managing drought and heat ranged from crop-level choices, such as choosing new cultivars or varieties, to significant lifestyle changes, including leaving farming altogether. Though variable in their approaches and ideas about best practices with non-irrigation techniques, most participants in this assessment recognized the need for integrated systems to deal with drought and heat pressures and were engaged in at least one or more non-irrigation mitigation practice.

Table 6: On-Farm Commodity Management Activities, Obstacles, and Potential Solutions Summary

Practice or Activity	Obstacles	Potential Solutions
New cultivars or varieties selection	• Uncertainty about variety or cultivar options based on locally-specific variables such as climate, soil type, topography, water availability, etc.	• Increase research on locally-specific drought and heat-tolerant varieties • Financed on-farm trials to illustrate real-time efficacy to producers.
Transition to new crops	• High costs and risks, particularly for established operations with perennial crop systems.	• Support or establish financing resources for producers transitioning to more resilient systems. A participant provided this sample model.
Shading and other non-irrigation cooling strategies	• High costs of shade cloth and equipment. • Uncertainty about the efficacy of shading in extreme temperatures. • Mixed results and difficulty in removing protectant films.	• Subsidize the purchase of shading equipment. • Increase research and outreach on the efficacy of shading on crop quality and other considerations for those looking to use physical barriers to protect their commodities.

		• Further research on chemistries and inputs that assist with heat damage prevention and are amenable to wholesalers.
Adapting cultivation strategies	• Requires close attention to each stage of the process. • Some systems still require quantities of water that are not available to all producers.	• Increase research or data on the scalability of alternative cultivation strategies for more extensive operations. • Increase research on alternative cultivation strategies for arid climates.
Adjusting planting and harvest timing	• Increased risk of frost damage. • High cost of season-extension equipment.	• Increase the availability of cost-share programs and financial assistance to provide season-extension equipment and infrastructure.
Reducing or limiting production size	• Decreased income as a result of reduced production. • It is difficult to know if reducing production is warranted based on a lack of predictive water and temperature data.	• Improve research and other efforts related to predictive data on water availability and delivery. • Continue and expand programs that support producers who need to take land out of production or sell animals.
Weather Stations	• Difficulty in interpreting data • Time constraints and variability of data	• Improve training and education on weather station data interpretation OR • Fund the development of simplified data analysis tools or access to experts who can assist with data interpretation.
Leaving or Stopping Farming	• Loss of culture and community • Loss of family farms across the state	• Integrated approaches that consider as many of the potential strategies noted within this report as possible.
Other Strategies	• Cutting overall costs around the operation. • Increased reliance on off-farm income • Relocation to more favorable areas • Barriers to generating on-farm income due to EFU rules and regulations.	• Support the diversification of income sources and new business development supports (e.g., agritourism). • Potentially relax rules to allow producers to generate secondary income from agritourism. It should be noted that this recommendation may be contentious as some see it as opening the door to non-farmers taking over farmland.

Chapter 7: Drought and Heat Data Resources

Overview

Most farmers and ranchers actively seek and utilize research and data to inform their drought and heat mitigation decision-making strategies. This section will describe the sources of information used by producers and present suggestions from stakeholders on how to support the flow and adoption of new ideas and methods related to drought and heat resilience.

Data Sources

OSU AND OSU EXTENSION SERVICES (N=17, 29%). Amongst the various formal sources of information on drought and heat utilized by producers, OSU and OSU Extension Services emerged as the most commonly used organizational resource. Data and information were predominantly disseminated through research publications, informational events, field trials, and consulting sessions. Participants in our assessment reported benefiting from research and events conducted by OSU faculty covering topics such as evapotranspiration and irrigation scheduling, pest management, marketing for small farmers, pasture management, irrigation delivery systems, dry farming techniques, and drought-resistant crop varieties across several commodities.

Producers particularly valued on-farm trials and consultations, describing them as collaborative partnerships with the university to explore innovative approaches for progress. Trials spanned a wide range of topics, including assessing the presence of pollinators in orchards, implementing silvopasture methods, adopting fire prevention techniques, dry farming, use of tensiometers, cover cropping, and variety trials.

> **"There's going to be a feed forage variety trial held here soon, and we're going to ask our researchers to consider varieties for silvopasture specifically because we want to use those areas in addition to maintaining husbandry quality."**
>
> —Coastal, Livestock, Moderate

OSU and OSU Extension Services: Obstacles and Needs. Despite the widespread use of information from OSU and OSU Extension Services, producers also shared frustrations, difficulties, and unaddressed needs that this institution could meet in the future. For example, some participants expressed the need for updated climate data as they perceived OSU's information as outdated or not applicable to their specific microclimate, location, or size. As previously noted, predictive modeling of precipitation, water availability, and climate trends were also identified as critical needs.

REGION, COMMODITY, SCALE	SAMPLE DATA
N. WILLAMETTE, VEGETABLES, SMALL	"The vast majority of data that OSU has is older than that [the last five years], and you know, the people doing research in the 1980s, 1990s, and 2000s…there's a lot of that stuff that's kind of the basic growing guides and stuff like that, they don't really have what you do if it's 115 in June for your salad production or something like that."
CENTRAL, VEGETABLES, SMALL	"The questions I have, I guess, as far as trying, in my climate, trying to retain moisture in the soil.... all these things that I'm trying, I don't easily find information and research on those things. It's either meant for Willamette Valley, or it's meant for large-scale. Those categories are pretty prominent, obviously, which makes sense, but it would be nice to have more research around that stuff."

Participants felt that as technologies such as weather stations, soil moisture sensors, and tensiometers become increasingly prevalent, there was also a need for assistance in understanding and translating the data collected from these tools into actionable items. For example, a previous intitiave by the Dry Farming Collective was applauded by participants in this project who had participated as they felt that the training on the tools, financial incentives, and data interpretation *combined* were what had made the project a success.

> **"If you use it [weather station] and you submit your data for, you know, maybe OSU or whoever, DEQ, whoever is interested in it, if you submit your data, you get these quarterly email or reports that give you some suggestions on what to look at and what's interesting about your place or whatever. I feel like those email prompts were really helpful to be like, 'Oh yeah, think about that thing that's out behind the compost pile that you can't even see [laughs].''**
>
> —Eastern, Vegetables/Livestock, Small

Participants also raised questions regarding the technical aspects of irrigation systems, particularly related to installation and maintenance. For example, there was interest in upgrading to more efficient overhead or pivot systems but also uncertainty about the specific types of pivots and sprinklers to invest in and the required pipe size. Other participants expressed the need for guidance on irrigation system maintenance, calibration, optimal pressures, and overall system health assessment.

> **"I think there is a total absence in extension on how to calibrate an irrigation system, how to test an irrigation system, how to service an irrigation system, how to be monitoring your static levels, how to look at your well and pump health."**
>
> —N. Willamette, Nursery and Specialty Crops, Large

As stated in previous sections, continuing research on appropriate crop varieties and crops resilient to drought and heat pressures emerged as another information need. Producers expressed a strong interest in receiving information on drought and heat-resistant varieties and general mitigation strategies through financially-supported on-farm trials. Supported on-farm trials are particularly effective in delivering information to producers as farming and ranching are not just a way of life, they are livelihoods, and as such, management decisions must be viewed through an economic lens. Farmers and ranchers, therefore, prefer to see firsthand proof of the efficacy of an approach (as opposed to listening to a lecture or reading a paper) before adopting potentially risky changes (Norton & Alwang, 2020; Sutherland & Burton, 2011).

> **"As I say, at the end of the day, I've never done efficiency out of altruism [laughs]. I did it for very individualized, greedy purposes, you know? I mean, I didn't do it so I could feel good and tell people, 'Oh yeah, I use way less water than you do' I did it because that's how I could make it work, you know what I mean?"**
>
> — Central, Fruit, Small

Involving producers in financed on-farm trials was also highlighted as crucial, as producers feel that pathways forward are often designed by those without farming experience or those who don't understand the nuances that make an approach feasible or infeasible. Conducting financially supported on-farm trials *with* farmers and ranchers enables researchers and agriculturalists to collaborate and develop innovative solutions that account for both the scientific aspects behind approaches and the on-the-ground realities that must be considered. Producers were furthermore more likely to feel valued, respected, and willing to contribute their time and energy to improving and advancing agricultural research when trials were financially supported.

REGION, COMMODITY, SCALE	SAMPLE DATA
CENTRAL, FIELD CROPS/LIVESTOCK/VEGETABLES, MODERATE	"We have so much that we could do together, and I just feel like there's a loss of opportunity happening through the lack of engagement. And a lot of times, they'll be like, 'Oh, we're going to do this research project,' right? How to grow potatoes sustainably. How to build soil health and organic matter. What cover crops to use? And it's like YO ask us. We've been doing these trials and research ourselves unsupported for the last seven years. We could tell you everything that we've learned through our own self-funded trials. So again, I just wish that there was some financial support and general respect for the work we are doing here."
SOUTHERN, VEGETABLES, SMALL	"If I had just given them [trial participants] those sensors and been like "GO" and like had no accountability...and you know they got paid for their time to participate in this program and take measurements and stuff, and if that wouldn't have been there, I know for me that those sensors would have just sat there and I never would have used them."

Lastly, financed on-farm trials would also address the perceived lack of context-specific information related to drought and heat. As discussed in both previous and subsequent sections of this report, farms and ranches sit at the intersection of unique climates, topographies, sizes, water access, and socio-political contexts. Providing research and information specific to each farm, even within a single region, can therefore be extremely difficult for only one or two faculty to manage, and as the above farmers from central and southern Oregon note, OSU faculty are often overstretched and unable to make themselves available to producers as much as needed.

REGION, COMMODITY, SCALE	SAMPLE DATA
CENTRAL, FRUIT, LARGE	"I would say that my comment to that is that the [Oregon State] University Extension Service and I'll just be blunt, has been gutted over the last twenty years. I've seen it.... there's far less staff and far less support, and yet the agricultural industry has increased, let's say, in its tons generated in the state, dollars generated in the state; however, you want to think about that. You essentially have a skeleton crew of researchers or professors.... Extension has essentially become a skeleton crew; that's what I'm trying to say. And that is sad. What it means is, is that in an organization such as mine, we have the ability to do our own research, but the average farm does not have that ability."
SOUTHERN, VEGETABLES, SMALL	"I would say the same thing about OSU. We have a small-farm rep that's like pulled in a billion directions and is never available to help me. So, technical assistance would be nice."

On-farm trials may help alleviate this issue by recruiting farmers to serve as part of the research team and take on some of the research burdens. This challenge may also be addressed by creating or expanding teams of experts in soil health, commodities, water quality, sociocultural issues, etc., that can work together in more localized and specific contexts.

Lastly, it was shared by some participants within this assessment and others (Nelsen et al., 2022) that OSU Extension resources frequently seemed geared towards newer farmers and were at times lacking in the complexity and nuance required by larger-scale or more experienced farmers or ranchers. Though this feedback was only provided by a handful of participants, past works have revealed that more advanced courses or workshops, particularly concerning soil health and management, would be desirable for many more experienced Oregon agriculturalists (Nelsen et al., 2022).

> **"We've got the SOU extension center just right down the road....and there are a ton of classes, and there's a lot going on but…. with farmers that are sole farmers that have been farming for, you know, multiple generations, getting people that are not hobby farmer….. it seems like it's more for beginning farmers."**
>
> —Southern, Vegetables, Moderate

FARMER-TO-FARMER INFORMATION SHARING (N= 16, 27%). The sharing of information amongst farmers emerged as the second most common resource participants utilized to access drought and heat-related information. Participants felt they could put more trust in other individuals actively trying to make a living farming or ranching than companies seeking to make a profit or organizations with ulterior motives (e.g., conservation).

> **"Well, I'm not going to push an amendment or a product on my neighbor or my friend because my friends… you know all these people, you see them out and about, you talk with them at meetings, there's a social aspect to farming and the community, and as a salesman, I'm not going to sell my friend a product I've never tried, right?"**
>
> – Central, Fruit, Small

There was additionally an element of producers feeling that information from other farmers and ranchers was potentially more reliable than data or suggestions coming from organizations or institutions that interface with agricultural industries but don't necessarily engage in farming or ranching directly.

REGION, COMMODITY, SCALE	SAMPLE DATA
N. WILLAMETTE, NURSERY, LARGE	"The only reason I am pushing forward with it [strip tilling] is because... you know, I went to this conference with 400 people who went through this, and every single one said, "But yeah, in years four, five, and six, we're making way more money." And so it's having that ability to hear from somebody who does this for a living versus somebody whose.....reading books or doing small-scale research plots in their backyard."
CENTRAL, WINE GRAPES, SMALL	"I think the information [on soil health] is there, but it needs… farmers are kind of… they get stuck in their ways, and it's not necessarily…they need to hear it from another farmer than say a study from something you know?"

Farmer-to-Farmer Information Sharing: Obstacles and Needs. Notwithstanding high interest in farmer information networks, some producers felt communication and community networking amongst agriculturalists had disintegrated, particularly in recent years. Within this cohort, many expressed willingness and excitement about sharing their experiences and discussing their successes and failures with other producers in their industries and areas.

REGION, COMMODITY, SCALE	SAMPLE DATA
SOUTHERN, VEGETABLE, MODERATE	"We used to have the grange, you know, where they'd go socialize, and they'd talk politics, and they could do their thing at the grange and or... SOU would have... you know, what do they call them? The research centers would communicate more with the farmers. We're diverse down here, and the whole country is so tight; we can't do that anymore, we don't do that anymore."
EASTERN, LIVESTOCK, SMALL	"Ways to build a better community connection would be great, so yes, gatherings to get together like-minded people are always beneficial, and I would like to see more of them."

Other Data and Information Resources (10%>). Federal agencies and their resources, such as the Bureau of Reclamation's AgriMet weather network, were mentioned by a small percentage of producers as an important information source. Co-sponsored by the United States Department of Agriculture NRCS (USDA-NRCS), Cooperative Extension System, USDA Agricultural Resources, and other public and private organizations, the AgriMet network collects data from over 70 agricultural weather stations located throughout the Pacific Northwest (Bureau of Reclamation, 2016: N.A.). This data is then translated into usable Information, such as weather data or crop water use overviews, which farmers and ranchers can use to plan or schedule their irrigation management, planting, and harvest plans. Other non-federal information sources cited included agricultural non-profits, university Extension programs from outside of Oregon, and private industry representatives and organizations.

Data and Information Resources Summary

Participants In this assessment described using various resources to collect data relevant to drought and heat mitigation and decision-making. While OSU was the most commonly utilized formal avenue for information, farmer-to-farmer networks played a crucial role in disseminating information and, in many cases, were preferred to more formal options or institutions.

Table 7: Data and Information Activities, Obstacles, and Potential Solutions Summary

Practice or Activity	Obstacles	Potential Solutions
Use of OSU or OSU Extension Services resources	• Data is outdated or lacking, or not locally-specific. • Lack of engagement with OSU faculty and staff. • Need for assistance with translating data into actionable items • Gaps in knowledge on operating and maintaining irrigation systems.	• Continue and increase on-farm, financially supported trials of drought and heat-resistant varieties, crops, and mitigation practices. • Expand funding to increase the hiring of faculty that can work as teams on locally-specific, commodity-specific research teams. • Develop advanced courses and workshops for experienced farmers. • Assist in translating data from weather stations and sensors. • Provide updated and accessible information on installing, operating, and maintaining various irrigation systems and train more providers to visit with producers and help them better understand their systems.
Farmer-to-farm information networks	• Perceived declines by producers in communication, community networking, and social engagement.	• Encourage and support programming that utilizes in-person community-building approaches and techniques. • Promote sharing of experiences and discussions among farmers. • Expand training for both organizations and individuals in fostering the development of social networks and community-based planning and strategizing.
Other Data and Information Resources	• None noted	• Enhance access to information from federal resources like the Bureau of Reclamation's AgriMet weather network (facilitate communication for decision-making processes). • Facilitate and integrate information exchange with private industry representatives and other organizations.

Chapter 8: Funding Sources

Overview

The utilization of funding and financial support from government and non-government organizations (NGOs) has played a significant role in supporting farmers and ranchers in managing drought and heat pressures. While project participants often described the origin of funding and distribution pathways as murky, organizations such as the Natural Resources Conservation Service (NRCS) and local Soil and Water Conservation Districts (SWCD) were familiar to the vast majority of producers and had been collaborated with on numerous drought and heat-related projects. This section will highlight these projects and collaborations and present feedback from farmers and ranchers on optimizing grant and funding programs.

Given the interconnectedness among funding organizations and programs, obstacles and expressed needs will be addressed in a single section within this chapter. Proposed solutions will also be addressed in further depth as this was a robust topic of discussion that requires a more extensive description than summary bullet points alone can offer.

Funding Organizations and Programs

FEDERAL ORGANIZATIONS (N=21, 36%). The most frequently utilized organizations that had provided participants with funds to complete drought and heat-related projects were federal entities. Within the federal category, the programs offered by the Natural Resources Conservation Service (NRCS) were the most familiar to producers and in particular, the Environmental Quality Incentives Program (EQIP), followed by the Conservation Stewardship Program (CSP) and Agricultural Conservation Easement Program (ACEP). The various projects, upgrades, and equipment facilitated by NRCS included drip installation, cover cropping, small-scale water storage, tensiometers, irrigation system conversions (e.g., from high to low pressure or away from flood irrigation), soil sensors, ongoing implementation of solar pumps, and the development of comprehensive farm conservation plans.

REGION, COMMODITY, SCALE	SAMPLE DATA
EASTERN, FIELD CROPS, LARGE	“The contracts we've had with NRCS have allowed us to try out some practices that we probably wouldn't have otherwise, and kind of takes some of the risk out of doing that.”
EASTERN, SEED, LARGE	“Those programs [NRCS] are very well utilized, there have been a lot of good programs, and myself, and my neighbors take advantage of those programs. I mean, they’re full every year. Every year they max out, and you know, several times, I’ve had to go in and apply the following year because they’ve had too many applicants.”

STATE ORGANIZATIONS (N= 13, 22%). Soil and Water Conservation Districts (SWCD) emerged as the most prevalent state-based funds and programs employed by farmers and ranchers. Across Oregon, SWCDs collaborate with resource users, government entities, non-profits, and NGOs to support stakeholders and facilitate resource conservation. Producers described SWCDs as pathways through which state and government funds were distributed, collaborative partners, and at times, mediators between higher levels of government and local stakeholders.

Other state-based organizations named by participants included the Oregon Water Resources Department (OWRD), Oregon Department of Fish and Wildlife (ODFW), Oregon Watershed Enhancement Board (OWEB), Oregon Department of Agriculture (ODA), and commodity commissions. However, these organizations were less common of a resource than the SWCDs. Though not verifiable with the current data, the infrequent mention of these organizations may be attributed to the role of SWCDs as intermediaries between government organizations and stakeholders, which could make the origin of funding and programs more convoluted or less likely to be cited.

NON-PROFITS AND OTHER ORGANIZATIONS (N=8, 14%). Non-state or federal entities had also provided financial support to producers engaged in drought and heat-related projects. These groups include the Oregon Community Food Systems Network (OCFSN), Energy Trust, Klamath Project Drought Response Agency (KDRPA), American Farmland Trust, National Young Farmers Coalition, and Sustainable Northwest.

Funding Organizations and Programs: Obstacles, Needs, and Proposed Solutions

TIMING AND TIMELINESS (N= 16, 27%). The most frequently cited difficulty faced by participants regarding financial support and benefits was the timing and timeliness of fund allocation. Participants expressed frustration with the lengthy grant application and distribution processes.

REGION, COMMODITY, SCALE	SAMPLE DATA
CENTRAL, PASTURE FOR AGE/LIVESTOCK, MODERATE	"There are lots of inefficiencies within those organizations, and the farmers are like, 'You know what? It's September, and I really could have used that in March'".
CENTRAL, FIELD CROPS/ PASTURE FORAGE, LARGE	"The grant system is kind of crummy. There is totally someone that's available, and I've communicated with them and all of that, but it's a really, really slow process, and the funding is pretty limited."

Despite feedback that programs and organizations were often slow in processing applications and distributing funds, many participants also postulated that funding organizations often face understaffing and are simply unable to process and distribute funds promptly. A possible solution proposed to contend with poor timing or lack of timeliness of funding was to introduce retroactive compensation for producers who make out-of-pocket investments in upgrades and who can demonstrate that those upgrades have resulted in increased water-use efficiency.

Given that time is often farmers' and ranchers' most valuable resource, increased support in navigating the complex landscape of organizational acronyms and required documentation for funding programs was also described as a highly desirable service that could be improved upon. This expansion of services would involve hiring more readily available staff who could assist with a broader range of tasks, particularly identifying relevant funding sources and proactively helping producers populate and submit applications.

> **"Over at the Trout Unlimited, Kelly....at Sustainable Northwest, they'll help you through the paperwork, and you know, here's what you need to do. But you need that kind of help. Most folks are not government or whatever you call it, and I think that you probably within the government agencies themselves, you probably need a lot of people dedicated to coming out sitting down, or coming to town and sit down with them and fill the damn stuff out in one sitting you know, not ten different back and forth, you know what I mean."**
>
> – Southern, Pasture Forage, Mid-Size

REWARDING GOOD PRACTICES (N= 13, 22%). Despite the heavy utilization of financial support programs for heat and drought mitigation projects, there was also a recurring sentiment that many funding sources and programs were primarily aimed at supporting those who had not yet adopted efficient practices rather than offering incentives (i.e., funding) to those who are already implementing water-wise irrigation management.

REGION, COMMODITY, SCALE	SAMPLE DATA
CENTRAL, FRUIT, LARGE	"We have very poor systems, regulatory-wise, for rewarding people that are trying to do a good job. In fact, oftentimes, when the question is asked, what can the state do to help water users? The most help and focus goes on people that are doing the...for lack of a better term, the crappiest job, and I have some farmer words you can put in there if you want... but they get all the attention and all the effort."
SOUTHERN, PASTURE FORAGE/LIVESTOCK, LARGE	"I really think where we've touched on a couple of times, just reiterating that people have been doing it right, and people have been doing it wrong. Reward people who are doing it right instead of trying to pay the people who've been doing it wrong to quit doing it wrong."

To address this concern, participants proposed providing financial benefits for demonstrating highly efficient irrigation practices rather than only providing funds to help farmers and ranchers underperforming in water-use efficiency.

REGION, COMMODITY, SCALE	SAMPLE DATA
SOUTHERN, SEED, SMALL	"If monitoring is incentivized, and they do, they reward you financially, or even if they take a thousand dollars off of taxes that I owe, great! Not having to spend the money is also saving it."
WESTERN, VEGETABLES/SPECIALTY CROPS, SMALL	"I wish there was a way to reward farmers that maybe use less water. I don't know how that's determined exactly. But maybe some creative policy solutions for rewarding smart irrigation use."

Other suggestions for rewarding efficient water users included restructuring water allocations based on efficient water use and sustainable practices (rather than seniority) and expediting project review processes for permittees in good standing who have demonstrated implementation of sustainable practices.

> **"That's when you should [have] better privilege at water rights. So, you are being efficient; you are dripping. Yeah, they should get water rights, not the knucklehead that's got the big bird out there hosing down everything if you want to be technically fair about some of that."**
>
> – Western, Nursery/Sod, Mid-Size

INADEQUATE COST SHARING (N=10, 17%). While participants often expressed gratitude and appreciation for the financial support provided by the organizations mentioned above, the combination of increasingly limited water allocations paired with rising input costs has rendered some programs inaccessible to some producers, even with generous cost-share offerings.

> **"Largely, it's [upgrading irrigation infrastructure] a financial issue. As everything has gone here the last couple of years, I've had some projects, EQIP projects approved and funding, but the cost of the equipment has gone up so much, they have literally more than doubled. The cost-share did not increase whatsoever, and so it just was not feasible. And it's terrible. On the one hand, I don't have enough water, but on the other hand, you know, I'm trying to put one linear right now to replace six wheel lines."**
>
> –Southern, Field Crops, Large

ELIGIBILITY BARRIERS AND OTHER OBSTACLES (N=7, 12%). Participants also voiced concerns regarding the feasibility of specific grant criteria that applicants must meet. These criteria included strategies for managing and terminating cover crops (e.g., no chemical terminations, no grazing), trial scales (i.e., funding for larger-scale trials is more limited), and operation size requirements (i.e., too much small-scale or large-scale specific funding).

> **"I understand that these things are complicated, but like NRCS, they head a cover cropping incentive program that opened up two seasons ago, and we applied for it and didn't get it, and I was just like 'God, so annoying.' But a part of their stipulations was that it couldn't be grazed. So again, if you're asking people to do this cover cropping incentive things and then you're restricting like how they're going to terminate that crop, and ultimately if it's going to benefit the farmer to come in and graze that, why would you stop that if that's what the farmer or the rancher needs?"**
>
> – Central, Pasture Forage/Livestock, Moderate

Funding Organizations and Programs Summary

Fundamental difficulties associated with current financial support for farmers and ranchers primarily revolved around the lengthy application process and a lack of financing and rewards for those already implementing efficient water practices. Potential solutions that could enhance relationships between organizations and producers include expanding services to expedite application and distribution processes and introducing programs that provide retroactive compensation to producers demonstrating efficient water management practices.

Table 8: Funding Resources, Obstacles, and Potential Solutions Summary

Practice or Activity	Obstacles	Potential Solutions
Federal Organizations	• Lack of clarity and transparency concerning funding sources and distribution pathways.	• Improve transparency and communication regarding funding sources and distribution pathways.
State Organizations	• Limited mention of state-based organizations other than Soil and Water Conservation Districts (SWCDs)	• Promote awareness and accessibility of state-based organizations and programs.
Non-profits and Others	• Limited financial support from non-state or federal entities	• Increase funding and support from non-profit organizations
Use of grants and loan programs: Timing and timeliness	• Lengthy grant application and distribution processes	• Introduce retroactive compensation for out-of-pocket investments. • Expand services through the hiring of more employees who are *accessible, available, and trained* to help with identifying grants and loans and completing application processes.
Use of grants and loan programs: Rewarding Good Practices	• Funding primarily supports those who have not yet adopted efficient practices.	• Provide financial incentives through payments or tax breaks for adopting and demonstrating highly efficient water use practices and reward producers who implement sustainable practices. • Update water rights and allocations to be based on efficient water use practices. • Expedite application review processes for producers in good standing (cross-list with Timing and Timeliness).
Use of grants and loan programs: Inadequate cost-sharing	• Limited access to programs due to rising input costs.	• Review and update cost-sharing parameters to account for inflation and accessibility for all producers.

Use of grants and loan programs: Eligibility barriers	• Barriers to qualification and elimination of necessary practices	• Review and potentially revise program participation requirements based on farmer input regarding the feasibility of qualifying activities and the potential incurred risks in adopting program or grant stipulations. • Review and revise eligibility criteria and requirements to accommodate necessary practices and provide larger-scale trial opportunities.

Chapter 9: Additional Policy Obstacles and Proposed Pathways Forward

Overview

This chapter will provide an overview of additional policy-related challenges and solutions to drought and heat mitigation that have not been addressed elsewhere in this report. This section will also summarize participants' general suggestions regarding improving relationships between governing bodies and irrigators.

Additional Policy Obstacles

Conflicting Uses

WILDLIFE (N= 16, 27%). Some central and southern Oregon participants felt in-stream requirements to protect certain species were partially responsible for ongoing and increasing water insecurity in their areas. In central Oregon, the species in question was the spotted frog. In contrast, the coho salmon, shortnose and Lost River suckers, and bull trout were the focus of discussions on water-related policies influencing irrigators in southern Oregon. Though most feedback on conflicting uses with wildlife originated from these regions, coastal and eastern producers also provided input that water access in their areas was influenced by competition with wildlife for water resources.

REGION, COMMODITY, SCALE	SAMPLE DATA
COASTAL, DAIRY, MODERATE	"I'm not sure when it happened, but fish and wildlife [ODFW] came in and bought all the water rights to a certain level in the rivers on the coast….you can get it [water] for the wintertime, you can get more water rights, but spring, and summer, and fall it hits that threshold where there's no more excess water because they have to have enough for the fish."
EASTERN, FIELD CROPS, LARGE	"I've been participating in our basin's Water Resource Planning Group, which is trying to investigate storage options for the whole basin for multiple uses and user groups. But it's very expensive and very difficult to find suitable storage locations in our basin, especially because of the listed fish species that we have here."

Producers recognized that while wildlife water needs were not the main reason for decreased water allotment, the in-stream needs were felt to be exacerbating the critical water situation that many irrigators are currently finding themselves in.

> **"Our biggest issue is that we are in a 100-year drought, and what's exacerbating that is the spotted frog issue. The spotted frog did not frickin' create the issue we're in today; it's three years of fricking drought."**
>
> –Central, Seed, Large

Despite the increasing water scarcity pressures created by conflicting uses with wildlife, participants also by-and-large expressed an intense desire to protect vulnerable species and frustration that their willingness and efforts to support and collaborate on wildlife conservation projects were often under-reported or ignored. This omission was felt to contribute to public perceptions that farmers and ranchers were enemies of the environment and unwilling to collaborate and conserve vulnerable species.

> **"They went so far as to hire a helicopter and design a dredge that the helicopter could pull to try to get water moving in Tule Lake Sump 1B because we had a botulism outbreak that made it a kill pool for waterfowl. WE ALL DID THIS. The farmers paid for it 100%. We barely even had cooperation from fish and wildlife, certainly had no support, and we got NOTHING. We get no recognition for it whatsoever. You know, we don't want recognition per se, but let's be fair about what's going on and quit demonizing the very folks that are trying to provide the solution."**
>
> – Southern, Field Crops, Large

However, even among those actively supporting wildlife and ecosystem protection, there was a prevalent belief that many conservation policies are based on questionable science or are heavily politicized. Additionally, they felt that influential special interest groups are not interested in compromising but instead aim to prohibit producers from utilizing water resources entirely. These perceptions foster hostility and a lack of interest amongst producers in collaborating on initiatives to conserve and allocate water for wildlife and conservation projects.

REGION, COMMODITY, SCALE	SAMPLE DATA
SOUTHERN, SEED, LARGE	"I make most of my money off of conservation, you know. There's a difference between environmentalism and conservation. Environmentalists do not want you using that resource. Conservationists say we have to use that resource, but we have to do it responsibly and, at the same time, renew it. And all farmers are conservationists, not so much environmentalists."
EASTERN, SEED, LARGE	"The government would come in and say, okay, well, we need to learn how to be givers, and that's where I actually [long pause], I posted up and actually withdrew from the program. I've given. I've given so much, and to have a government agency tell me that I need to learn how to be a giver? That's how you make me stop."

Lastly, stakeholders felt that it is unfair and unreasonable to place the majority of the burden of a species' survival on farmers and ranchers when they perceive that much of the habitat and ecosystems of those species have been destroyed by urban expansion.

> **"We should be doing everything we can to save species that are on the brink of extinction, but it is an asymmetrical burden that the rural populations carry on behalf of all of humankind, and I have yet to see that really addressed in any sort of way by any of the conservation groups or by the state or by the federal government. So, I just want to highlight that."**
>
> – Central, Pasture Forage/Livestock, Moderate

URBAN AND RECREATION (N=14, 24%). Some project participants expressed exasperation and concern over water being allocated for urban and recreational purposes while farmers struggled to apply enough water to produce a crop. Urban water users, in particular, were seen as significant competitors and included both private companies and residential developments.

REGION, COMMODITY, SCALE	SAMPLE DATA
WESTERN, NURSERY/TURF AND SOD, MID-SIZE	"I was trying to lease some ground and work on a water right. Well, I literally got told by water resources that that area, they're not doing any more water, and they're going to preserve it for residential [use], way in the future sometime, and it's like, this is stupid. We need sensible water policy."
CENTRAL, FRUIT, LARGE	"I don't remember the number, so bear with me on that, but Google is slurping a bazillion amount of gallons out of this well to run their....cool their servers and their data center here, and they just sailed right through that process. No questions asked. Whereas if I wanted to have an ag well doing the same thing, it would probably not happen. Probably wouldn't be able to do an agricultural well."

OTHER IRRIGATORS (N=9, 15%). As mentioned in previous sections, participants in this assessment also felt that other irrigators were vital contributors to increasing drought pressures. Participants who spoke on this topic felt that all irrigators need to be up-to-speed on best practices to conserve water and suggested that water rights should (or could) be revoked in cases of blatant inefficient water use.

OTHER (10%>). It is essential to highlight that the issue of water allocation within southern Oregon, specifically in the Klamath region, has been a highly contentious matter for the past decade and has been the subject of entire books and extensive research programs. Due to this project's scope (i.e., statewide), this report can provide only a snapshot of the insights farmers from this area provided. Nevertheless, the project team felt it was essential to acknowledge and address some of the insights unique to this region of the state with the hopes that some new or novel insights might be gleaned.

Participants from the Klamath region spoke of difficulties collaborating with local tribes and the federal Endangered Species Act (ESA) as significant contributors to water scarcity and limited irrigation capacity. It should be noted, however, that while participants believed that policy changes and compromise with neighboring tribes could lead to increased allocations for irrigators, they also knew that drought was a crucial factor in their lack of water, regardless of local tribes' willingness to compromise or the restrictions imposed by federal policies.

REGION, COMMODITY, SCALE	SAMPLE DATA
SOUTHERN, FIELD CROPS, LARGE	"The project irrigators were in a good position at that time ten years ago; now, we are, as I say, at the bottom of the pecking order. We can't revive that because, first of all, we violated our trust with the tribes, and now there's no water to be given and no water to be redistributed."
SOUTHERN, PASTURE FOR AGE, MID-SIZE	"My final opinion after spending thousands and thousands of dollars on it is that we're not going to beat the Tribes, and we're not going to get any water now that the drought is as bad as it is. There's no water for the Tribes to give out anyway."

Producers offered two potential solutions to increase community trust and possibly water allocations. The first suggestion was to conduct additional non-partisan, unbiased assessments of in-stream need for vulnerable species. The second and more critical suggestion was to improve communication and data sharing on whether and to what extent initiatives to increase in-stream flows support the recovery and survival of vulnerable species. Participants in this region emphatically stated that a significant source of conflict around water allocation was the perceived lack of provision of clear, concise, and compelling evidence to irrigators that the curtailment of water for irrigation that was critically endangering their ability to continue farming and ranching was helping save suckerfish and salmon populations.

> **"That's what I'm getting at with fish and wildlife; they have snubbed their nose at us the last two years, not getting us data. That's disrespectful, in my opinion. That shows that you have no care. I want to know if what we're doing is helping because I'm out here farming half my property."**
>
> – Southern, Seed, Large

Producers also expressed concerns that if better-quality studies were not done soon, not only would farming and ranching in the Klamath disappear, but also the fish populations that the current policies are designed to protect.

> **"I assure you that none of us, *none of us,* want the extinction of a species on our conscience. We're not doing that. The science proves that… we have 30 years of science now that prove that more water does not equal more fish! But we ignore the science. It's ignored…. we have all this data now, and it was for years, 'Well, we don't have enough data; we've got to keep trying.' Well, we're 30 years now; is that enough? Clearly, it's not, so is 40 years enough? Because if it's 50, at the rate we're going, there aren't going to be any sucker fish left, yet we continue to have these artificially high lake levels and artificially high river flows of *hot, nasty, rotten water* that are killing fish in the river."**
>
> – Southern, Seed, Large

Inclusivity and Applicability

Farmer Integration into Policy Development (N=13, 22%). Stakeholders also recommended improving future drought and heat-related policies by increasing the integration of farmer perspectives and expertise into the policy generation process. The underlying rationale for farmer integration into policy development was that policymakers often lack familiarity with the realities of farming, leading to a disconnect between the feasibility and efficacy of policies and their alignment with the goals and practicalities of farming operations.

REGION, COMMODITY, SCALE	SAMPLE DATA
CENTRAL, FRUIT, LARGE	"As I reflect on this question, a few things come to mind. One is that many of the people on the regulatory side of water management in my.... this is just my point of view, have never had a hand in agriculture. And they're making policy about agricultural water use without understanding the agricultural part of that. And often times that hand is heavy-handed with water use."
CENTRAL, PASTURE FORAGE/LIVESTOCK, MODERATE	"More often than not, it seems like whether the University or agency…there tends to be a bit of disconnect of where the decisions are made in the office versus out in the field, real-time problem-solving, how do we get things done."

When considering how to increase farmer and rancher participation in creating drought and heat-related policy, many participants expressed appreciation for this type of project and articulated respect for politicians and researchers who take the time to engage with them directly. Assessments, hosted and mediated meetings, listening sessions, and even informal conversations were all noted as appropriate pathways for improving stakeholders' involvement in policy development.

It should be cautioned, however, that despite appreciating the opportunity to voice their opinions and ideas within this project, some stakeholders were skeptical about the actual integration of their input into any meaningful policy changes or practices. All organizations and individuals working with producers should consider this cautionary note, as repeated requests for participation in ventures that do not result in positive outcomes can dramatically erode trust and the potential for meaningful collaborations over time.

Context-Specific Policies (N=8, 14%). Several interviews highlighted the importance of basing Oregon agriculture's drought and heat mitigation policies on context-specific data. As every region, commodity, operation size, and even soil type presents unique attributes and challenges, it was emphasized that policies cannot and should not be considered within a "one-size-fits-all" framework.

REGION, COMMODITY, SCALE	SAMPLE DATA
COASTAL, LIVESTOCK, MODERATE	"Oregon's antiquated… or I shouldn't say antiquated, but Oregon's rules on water rights are not area-specific; that's my biggest issue with it."
COASTAL, LIVESTOCK, SMALL	"The thing about those bills is a need for legislatures to understand that what works for us here on the coast is not going to work in Eastern Oregon and maybe not even in the Cascade counties."
WESTERN, SEED, LARGE	"If you study it, you'll hear Gabe Brown, Ray Archuleta, Jay Brandt, Klein Schmidt, some of those.... some of them....know it all. But they don't. What works in North Dakota doesn't work on the coast in Oregon. What works in North Dakota don't work in Hermiston."

While project participants did not suggest straightforward solutions for creating context-specific policies, broader recommendations included considering both environmental (i.e., climate, water access, and availability) and social and political contexts when considering policy-oriented solutions.

Other Policy-Related Options

MARKET-RELATED POLICIES OR SUPPORT (N= 7, 12%). As profit margins tighten, farmers articulated a desire for assistance accessing new markets, potentially involving shipping to other states or exploring opportunities internationally. Participants expressed a need for the state to play a role in developing these markets and expanding the horizons of Oregon agriculture.

One suggested intervention in the market involved establishing a certification program that recognizes and economically rewards producers implementing water-wise practices. This approach aligns with the "carrot versus stick" approach desired by producers, can provide actual economic returns, and could potentially improve the general public's perceptions of farmers and ranchers, thereby improving the political climate within which agriculturalists are operating (see below).

EDUCATION OF THE GENERAL PUBLIC (N=6, 10%). Some participants saw a current imbalance in political power within Oregon politics as responsible for policies that make contending with drought and heat more difficult for farmers. These producers felt that an increased effort by the state to educate the public on the severity of the drought and its impacts on Oregon agriculturalists could help foster a more favorable socio-political environment for creating policies that support irrigator needs.

CLIMATE POLICY (10%>). A small percentage of participants in this assessment emphasized the need for more comprehensive climate change solutions to address drought and heat rather than solely focusing on on-farm practices. Some of these stakeholders suggested approaches such as subsidizing electric farm equipment, adapting carbon policies to reward farmers for carbon sequestration, and issuing limitations on emissions. Although essential, these recommendations are currently being addressed in other contexts and political arenas and supersede the scope of this particular project. Nevertheless, it is important to note that some participants believe that discussions of drought and heat resilience must be grounded in the broader context of climate change moving forward.

Other (N=1, 2%). Lastly, one interviewee suggested evaluating approaches from other industries involved in natural resource management, and in particular the oil and gas sector. A past oil and gas industry employee, this participant suggested that policy makers might look into the oil and gas industries' approach to unitization and assess the potential for applying this practice to groundwater resources. Although only offered by one participant, a cursory search revealed that this suggestion had been explored within the academic literature and may warrant further consideration (Golovina & Shchelkonogova, 2023; Jarvis, 2011).

Proposed Pathways Forward

IMPROVED COMMUNICATION (N=25, 42%)

On Data and Information Behind Decision-Making. Participants suggested better or more exhaustive sharing of decision-making processes, and the data behind them would improve relationships and collaborations between farmers, ranchers, and government groups. In addition to the biological data requested by producers in the Klamath area, the most commonly requested data types were associated with water modeling and aquifer levels, particularly concerning irrigation well rules and regulations. Stakeholders expressed that they felt rule makers often lacked a comprehensive understanding of the science behind irrigation and hydrologic data, leading to illogical or ineffective policies and regulations.

REGION, COMMODITY, SCALE	SAMPLE DATA
SOUTHERN, PASTURE FOR AGE/ LIVESTOCK, LARGE	"The other key that is desperately needed is all parties have to have trusted water modeling resources. So, one of the issues we have right now is, I think that when people don't have trusted water modeling to understand what's happening in the system, then you know, farmers or tribes rely on, you know, just that litigation or if not litigation then protest."
CENTRAL, FRUIT, LARGE	"I have participated in, I will just say, regulatory-type discussions, and I'm keeping it general because I don't want to throw anyone under the bus, where the person from the regulatory agency is supposed to be an expert let's say, on water use and wells, and it becomes obvious very, very, quickly that this person doesn't know anything about pumping systems or efficiencies or power use or any of that kind of thing, they just know the rules really well."

Government agencies and other regulatory bodies should prioritize effective communication of data and decision-making processes in a manner that is understandable and relatable to the public. Failing to do so can erode trust, as agricultural stakeholders may feel that they are not being respected enough to have information adequately explained to them or that policies are being arbitrarily established to favor specific groups over others.

As noted earlier in this report, stakeholders have also suggested that a potential solution to addressing inadequate communication between government agencies and agricultural stakeholders is to increase staff and faculty working in producer-facing roles and provide them with enhanced communication, mediation, and facilitation training.

On Water Availability and Delivery. As water becomes increasingly scarce and weather patterns change, not only how much water should be expected by irrigators has come into question, but also *when* to expect water to be available. Stakeholders illuminated that this obstacle might be less impactful if communication between irrigation districts and irrigators was improved, particularly concerning when to expect shut-offs and water delivery.

> **"More importantly, I think the communication is horrible. There's a place where things could be improved because when I see the ditch drop down, I have no way of knowing if and when that's going to happen. I just start to see my water drop. And of course, when you're not out there 24/7, you don't see it until you go out there eight or ten hours later, or in the morning, and you realize the water is totally collapsed, and no one's told you that."**
>
> -- Central, Seed, Small

Suggestions for improving communication regarding water availability and delivery for irrigators included automating off-farm irrigation systems and integrating these systems with information delivery services such as texts, phone calls, or up-to-date websites. Automating both off-farm and on-farm systems would enable irrigators to access real-time information about water availability quickly and easily. A more rudimentary suggestion involved the creation of shared Google documents allowing producers on the same line to input when they received water, enabling others further down the line to estimate their expected delivery times. This strategy was also suggested to increase transparency and accountability between irrigators.

> **"Even just have like a Google calendar and inspire people to use like a shared Google calendar of people that are on the same line, you know? So suddenly, they're accountable to other people."**
>
> – Southern, Livestock, Small

Mediation and Collaboration (N= 15, 25%). Numerous participants within this project noted that the same individuals often attend all the meetings, listening sessions, workgroups, and assessments related to drought and heat mitigation and resilience. It was also shared that many stakeholders experience anxiety and fear when collaborating with government agencies and formal institutions, as it often feels like these groups exist to enforce the law rather than offer support or solutions.

> **Interviewer: "It feels very punitive like they're [Water Resources Department] always kind of trying to catch you out a little bit?"**
>
> **Participant: "That's exactly right, and it's really terrifying for a farmer because what do we need most? Water. And the idea that you could, you know, screw your rights up and end up not having water is really threatening."**
>
> – N. Willamette, Nursery, Moderate

Despite these observations, many participants still felt meaningful solutions to drought and heat pressures could be achieved with mediation between user groups and attempts to increase stakeholder participation beyond those already working with the government to find collaborative solutions.[2]

Additional Policy Obstacles and Proposed Solutions Summary

In addition to tangible activities such as upgrading equipment and improving soil health, participants in this project also felt that trust, collaboration, community, and communication were necessary for increasing farmer and rancher resilience to drought and heat pressures. Stakeholders in this project expressed a willingness to continue working across institutions to find solutions to managing drought and heat; this relationship, however, hinges on transparency and communicating to farmers and ranchers that they are a priority, not an afterthought, and that their work is acknowledged and valued.

Table 9: Additional Policy Obstacles and Proposed Solutions Summary

Obstacles	Potential Solutions
Conflicting Uses: Wildlife	• Foster improved collaboration and communication between irrigators and wildlife protection groups. • Enhance communication on the science behind conservation policies. • Increase public education regarding farmers' efforts in wildlife conservation.
Conflicting Uses: Urban and Recreation	• Adapt policies to provide preferential allocations to farmers over recreation and non-essential urban uses. • Explore efficient water-use practices in urban areas. • Promote dialogue and collaboration between urban water users and farmers.
Conflicting Uses: Other Irrigators	• Continue encouraging efficient water use practices among irrigators. • Consider revoking water rights for inefficient water users. • Reward good water use practices with priority water allocations.
Poor Communication	• Increase outreach and conversations on water availability, water-related projects, water delivery, and the data and science behind policy decisions.
Mediation and Collaboration	• Increase outreach to involve more producers and groups in water-related policy creation and conservation initiatives.

[2] Though not suggested by producers, the project team did ask participants about their familiarity with the Private Forest Accord. Those who had heard of it and were interested in on-going, mediated conversations, were open to this kind of approach with the caveat that the federal government would likely also need to be at the table. As this proposed solution was introduced by the project team and not project participants, this approach would need to be evaluated further with producers before being implemented.

	• Increase government (including federal) and stakeholder participation in mediated sessions and discussion groups on water sharing and resource management.
Farmer/ Rancher Integration into Policy Development	• Conduct ongoing assessments and engagement initiatives (e.g., needs assessments, meetings, and conversations) that collect and integrate farmer and rancher knowledge, experience, and needs into policy development. • Provide project outcomes and metrics to stakeholders to maintain trust and communication.
Context-Specific Policies	• Facilitate ongoing and increasingly nuanced assessments and policy developments considering the specific qualities and attributes of varying operation sizes, industries, climates, regions, and water resources.
Market-Related Policies or Support	• Assist farmers in accessing new markets and expanding opportunities. For example, support the establishment of certification programs for products created using water-efficient management practices. • Educate the public about farmers' water conservation efforts.
Education of the General Public	• Increase public education and outreach-oriented around the importance of water conservation, the state's drought pressures, and the challenges farmers and ranchers face vis-à-vis drought and heat.
Other: Broader Context Considerations and Thinking Creatively	• Consider more comprehensive climate change solutions alongside on-farm practices. • Subsidize electric farm equipment and adapt carbon policies to reward farmers for capturing carbon. • Explore the unitization of groundwater resources for increased water-sharing efficiency.

Chapter 10: Summary and Conclusion

"No one of these things is going to solve the problem, it's got to be an integrated approach, and that's the only way you ever solve any problem. It has to be an integrated approach. You can't just go, 'Oh well if we change the policy on water use, that's it.' Or 'if everyone just made some slight efficiencies to their irrigation, well, that will fix it.' Or 'If we just grew a different crop.' No. The truth lies in a combination of all of these things."

—Central, Fruit, Small

Overview

Studies have suggested that drought and heat are increasingly hindering the ability of farmers and ranchers to meet their bottom lines, causing financial stress and decreases in overall quality of life (Berman et al., 2021; Luong et al., 2021; OBrien et al., 2014). Participants in this assessment frequently corroborated this assertion, sharing that drought made planning for the future nearly impossible, as it was often unknown how much water could be expected and whether it would be adequate to carry their farm or ranch through to another season.

To cope with these uncertainties and difficulties, farmers and ranchers in this project shared various strategies they had adopted or considered adopting to remain viable in the face of drought and heat. These strategies ranged in scope from the ecosystem to the plant level and considered both irrigation and non-irrigation-specific strategies. Suggestions were also provided on how organizations and government representatives can better support farmers and ranchers in contending with and developing resilience to drought and heat pressures. This report has highlighted these key strategies and solutions to help support policy-makers and institutions in better assisting farmers and ranchers who are contending with drought and heat pressures moving forward.

Summary

On-Farm Irrigation Strategies

Key irrigation-related strategies for producers involved adopting higher potential application efficiency systems such as drip and micro-sprinklers (i.e., HPAE), center-pivots/linears, and LEPA/LESA systems (i.e., MPAE). Producers also reported replacing sprinkler heads with higher-efficiency parts and staying up-to-date on maintenance for lower potential application efficiency systems such as wheel lines/hand lines and other generalized overheads required for germination, cooling, and frost protection in certain commodity types. Stakeholders also frequently relied on water storage facilities such as ponds, reservoirs, and storage tanks to hold water in reserve for the dry seasons.

Despite the water-savings offered by higher-efficiency irrigation systems, fresh market producers, in particular, shared that overhead watering could not be entirely omitted due to the need for overhead cooling and frost protection. It was also suggested that although programs such as the NRCS' EQIP were well-utilized and appreciated, cost remained a key obstacle in updating their irrigation systems to increase efficiency, particularly as decreasing production due to drought and heat pressures has narrowed financial profit margins.

Some producers also suggested that cost was a critical barrier to improving their water storage as they either lacked the equipment or the ability to hire someone to create the necessary infrastructure. Water storage for those in arid regions (i.e., eastern and southern Oregon) was also at times seen as an impractical solution to drought and heat pressure as it was felt that there was simply not enough water to fill those holding facilities even when they were available. In circumstances where there is not enough water despite the availability of water storage and higher efficiency systems, stakeholders suggested reducing policy obstacles to drilling new wells or subsidizing the costs associated with dropping existing wells to access declining water tables. It should be noted that many stakeholders acknowledged that unencumbered well development was an unrealistic and dangerous prospect as groundwater is a finite resource; however, it was felt that, particularly in severe drought conditions, access to wells should be more expedient both in financial and political terms.

On-Farm Non-Irrigation Strategies

Soil management was one of the most common non-irrigation related strategies project participants used to deal with drought and heat pressures. Improving soil health through composting and mulching, adopting reduced or no-till, and cover cropping are all popular practices that producers feel will help in retaining soil moisture content and increase overall water holding capacity. Few obstacles were cited concerning composting and mulching, except for some producers experiencing difficulty accessing appropriate materials or equipment, particularly in remote regions in the southern and eastern parts of the state. No-till alternatively was seen as a challenge or even an impossibility for more participants, as the equipment to practice no-till was described as prohibitively expensive, especially for those who would only be using the equipment on a small portion of land. One participant also shared that their experimentation with no-till resulted in increased water requirements which may be attributable to differences in the efficacy of no-till in different soil types and climatic conditions and which has been addressed in some no-till research (Carroll, 2022; Dorrance et al., 2016). Ranchers in this project who are focused on soil health reported using rotational grazing to increase on-farm resilience. By rotating animals through paddocks or fields within their operations, they could fertilize their property cost-efficiently while reducing compaction and retaining ground cover to prevent erosion and run-off.

Project participants were also practicing soil moisture monitoring and use of weather stations to plan irrigation management. Difficulties with the cost of purchasing a sufficient number of soil probes, interpreting the data and translating it into appropriate actions, and managing system failures were all seen as obstacles or drawbacks to this activity. Producers who used digital probes shared that they often continue to manually check soil moisture levels as there was concern that technological errors could result in plant stress or even death If not caught in time.

Ecosystem approaches for managing drought and heat included strategies such as forestry/silvopasture and riparian improvements or conservation. For these producers, it was felt that by boosting ecosystem health through planting trees and increasing overall biodiversity, they were increasing their farm or ranch's resilience and capacity to withstand drought and heat pressures. Planting trees was seen as a natural and efficient way to provide shade for plants and animals during hot weather and to shade the ground and keep soil temperatures cool. Few obstacles were noted regarding ecosystem strategies except for a need for more information on locally-specific and function-specific (e.g., water filtration) species that are appropriate for varying ecosystem management programs.

Other non-soil or non-irrigation-based strategies included adopting or integrating new crop varieties or species that are more tolerant to drought and heat, or transitioning to entirely new production systems. Though many participants were considering new varieties within their current cropping systems, transitioning to entirely new systems was seen as a significant risk, particularly for farmers engaged in perennial crop production. Participants strongly suggested that multi-year financial support for producers seeking to transition to new crops or integrating drastically different practices to conserve water would benefit Oregon agriculturalists.

Participants in this project were also experimenting with new styles of cultivation and harvesting, including adjusting the timing of planting to avoid the hottest and driest parts of the season, adjusting planting strategies (e.g., transitioning from raised beds to in-ground beds), reducing or limiting their operation size, or even leaving or stopping farming.

Data and Financial Support

Project participants predominantly suggested that needed information to manage drought and heat included improved water modeling and predictive forecasting to assist them in planning for the future. Without data on water availability, producers expressed that they could not plan or purchase what was needed for the upcoming season, making an already difficult occupation even harder. Data was also requested on locally-specific drought and heat-resistant varieties and support and assistance translating information on evapotranspiration, plant stress, and soil moisture content into appropriate actionable items.

Though well-utilized, grant programs were often considered inadequate regarding the amount covered, particularly in cost-share type programs. Programs were also seen as primarily geared towards individuals who were not "up to speed" on irrigation and water efficiency, resulting in producers feeling that it is often poor practices rather than good ones that are rewarded through grant and funding programs. The time it takes to review and approve applications for grants or loans is also a significant obstacle to producers seeking to utilize these programs, as many of their project needs are pressing. They often cannot wait to implement a project without risking major losses or damages.

Suggested solutions to these funding-related issues involved providing retroactive reimbursement programs for producers that can demonstrate increased water efficiency as the result of an out-of-pocket purchase, expansion of training and availability of faculty assisting with funding applications, and better rewards systems for individuals using water-wise practices as opposed to the majority of funding going to producers who are operating inefficiently. Potential reward systems included financial incentives and prioritizing water access based on water-efficient practices instead of seniority.

Additional Policy-Specific Obstacles

Some of the more intangible issues faced by producers were oriented around concepts such as trust and communication. Participants in this project repeatedly expressed that they felt that the government agencies they worked with were there to tell them what they could not do rather than help them find solutions. It was also felt that the data or justifications for why decisions such as water allocations were being made were not communicated effectively to producers. This lack of communication and the adversarial nature of the relationships between stakeholders and the government was seen as a major barrier to future resilience. Producers felt they did not have a seat at the policy-making table and that their interests and needs were almost always secondary to other water users, such as environmental groups and urban municipalities.

Proposed Solutions

Installing shade structures, upgrading irrigation equipment, increasing water storage, and implementing soil health practices to manage drought and heat all require time and money, both of which are becoming increasingly hard for producers to come by *because* of drought and heat. Stakeholders expressed a desire to see the maintenance and increase of funding available for the practices noted in this assessment and a re-evaluation of cost-sharing parameters to consider both the rising cost of Inputs and the decline in yields increasingly experienced by many producers.

To assist farmers and ranchers, funding programs must also be informed by input and information reflecting producers' real-world needs and challenges. For participants in this project, it was felt that many grants and programs have requirements that make sense in an ideal world but are not feasible in their day-to-day lives. Funding should also be accompanied by an expansion of services and service providers who are readily available, trained, and knowledgeable about how the grant and funding systems work and how to help producers navigate those systems.

Other suggestions made by producers included increasing communications on water availability, water delivery, and the justifications for why rules and regulations are being made and enforced. Farmers and ranchers in this assessment shared that they would be more amenable to participating and cooperating in drought and heat-based policies and initiatives, for example, if they felt that their questions were being answered and that they were not being asked to do as they were told without explanation as to why. Communicating the value of initiatives or activities in financial terms was also recommended to facilitate increased collaboration between government agencies and stakeholders. Producers emphasized that while they are not opposed to conservation and wildlife initiatives, they also understand that if they are not financially viable, they cannot survive. In short, asking producers to spend time and energy on initiatives because it is the “right thing to do” is often only a successful strategy when producers do not feel they are on the brink of losing their livelihoods.

"What I’ve been trying to share recently is you have all of these different entities wanting to help like, US Fish and Wildlife Services, Intermountain West Joint Venture, Sustainable Northwest, USDA NRCS, FSA, Trout Unlimited. All of these people they knock on the door and mostly, what they want to do is restoration. And restoration is super important in Klamath, but it’s very, very hard for people to focus on restoration when their cows are burning up, and they’re liquidating their herds."

– Southern, Pasture Forage/Livestock, Large

Finally, while some challenges farmers and ranchers face are universal, many are specific to a region, climate, commodity, soil type, and scale of the operation. Though it may seem daunting to conduct assessments at the intersection of each of these variables, it is necessary for organizations and individuals seeking to help keep Oregon agriculture moving forward. To design policy and programming that solves specific problems, those problems must be understood within their unique contexts. This process will require both time and the collaboration of individuals with a wide range of expertise and continued producer insights and input. Giving producers a continued seat at the table regarding policy and program creation will not only help facilitate trust and the spirit of collaboration, however. It can also help improve policies and programs as farmers and ranchers often have decades of knowledge to share on the feasibility or infeasibility of initiatives or ideas.

Conclusion

The results of this project indicate that mitigating drought and heat impacts in Oregon agriculture is not a task that any individual or group can achieve. Instead, on-farm resilience will only be realized through ongoing collaboration and compromise between stakeholders with varying knowledge and experiences, as multi-faceted problems require multi-faceted solutions. As this report has highlighted, however, collaborations and compromise require trust, communication, and a sense of community before they can be accomplished. Thus, this project team recommends that any actions or changes made due to this report entail the meaningful inclusion of farmer and rancher stakeholders in the decision-making process and opportunities for feedback before implementation. Though challenging, building and maintaining trust and communication pathways between producers, politicians, researchers, and the public will ultimately be the key to enabling Oregon farmers and ranchers to increase their resilience to drought and heat as they face a future in which climate and environmental pressures are both increasingly extreme and uncertain.

References

Bayabil, H. K., Migliaccio, K. W., Dukes, M. D., & Vasquez, L. (2020). Basic Tips for Designing Efficient Irrigation Systems. *EDIS*, *2020*(1). https://doi.org/10.32473/edis-ae539-2020

Berman, J. D., Ramirez, M. R., Bell, J. E., Bilotta, R., Gerr, F., & Fethke, N. B. (2021). The association between drought conditions and increased occupational psychosocial stress among U.S. farmers: An occupational cohort study. *Science of The Total Environment*, *798*, 149245. https://doi.org/10.1016/j.scitotenv.2021.149245

Bureau of Reclamation. (2016). *AgriMet General Information | Bureau of Reclamation*. https://www.usbr.gov/pn/agrimet/general.html

Carroll, M. (2022, July 25). *Why We Can't Practice No-Till Forever*. https://craven.ces.ncsu.edu/2022/07/why-we-cant-practice-no-till-forever/

De Leon Gonzalez, E. (2021). Comparing hand watering, automated, and subsurface irrigation treatments for cost, labor, and water use in community gardens. *Theses and Dissertations*. https://scholarsjunction.msstate.edu/td/5207

Dorrance, A., Lindsey, L., Thomison, P., Michel, A., & Loux, M. (2016). *When is it Time for a No-till Field to be Tilled? | Agronomic Crops Network* [Newsletter]. Agronomic Crops Network: Ohio State University Extension. https://agcrops.osu.edu/newsletter/corn-newsletter/2016-38/when-it-time-no-till-field-be-tilled

Golovina, E., & Shchelkonogova, O. (2023). Possibilities of Using the Unitization Model in the Development of Transboundary Groundwater Deposits. *Water*, *15*(2), 298. https://doi.org/10.3390/w15020298

Irmak, S., Odhiambo, L., Kranz, W. L., & Eisenhauer, D. (2011). Irrigation Efficiency and Uniformity, and Crop Water Use Efficiency. *Biological Systems Engineering: Papers and Publications*. https://digitalcommons.unl.edu/biosysengfacpub/451

Jarvis, W. T. (2011). Unitization: A lesson in collective action from the oil industry for aquifer governance. *Water International*, *36*(5), 619–630. https://doi.org/10.1080/02508060.2011.598656

Kotin, A. (2015, July 17). Energy Use in a Time of Drought. *CalCAN*. https://calclimateag.org/energy-use-in-a-time-of-drought/

Luong, T. T., Handley, T., Austin, E. K., Kiem, A. S., Rich, J. L., & Kelly, B. (2021). New Insights Into the Relationship Between Drought and Mental Health Emerging From the Australian Rural Mental Health Study. *Frontiers in Psychiatry*, *12*. https://www.frontiersin.org/articles/10.3389/fpsyt.2021.719786

Nelsen, B., Jones, G., & Ghajar, S. (2022). *Oregon Pasture Forage Needs Assessment: Phase 1- Executive Summary* [Needs Assessment]. Oregon State University Extension Service.

Norton, G. W., & Alwang, J. (2020). Changes in Agricultural Extension and Implications for Farmer Adoption of New Practices. *Applied Economic Perspectives and Policy*, *42*(1), 8–20. https://doi.org/10.1002/aepp.13008

OBrien, L. V., Berry, H. L., Coleman, C., & Hanigan, I. C. (2014). Drought as a mental health exposure. *Environmental Research*, *131*, 181–187. https://doi.org/10.1016/j.envres.2014.03.014

Oregon Department of Agriculture, National Agricultural Statistics Service, & Northwest Regional Field Office. (2022). *Oregon Agricultural Statistics and Directory*.

Oregon State Board of Agriculture. (2021). *Oregon State Board of Agriculture 2021 Report*. https://www.oregon.gov/oda/shared/documents/publications/administration/boardreport.pdf

Ruehr, N. K., Gast, A., Weber, C., Daub, B., & Arneth, A. (2016). Water availability as dominant control of heat stress responses in two contrasting tree species. *Tree Physiology*, *36*(2), 164–178. https://doi.org/10.1093/treephys/tpv102

Sutherland, L.-A., & Burton, R. J. F. (2011). Good Farmers, Good Neighbours? The Role of Cultural Capital in Social Capital Development in a Scottish Farming Community: Good farmers, good neighbours? *Sociologia Ruralis*, *51*(3), 238–255. https://doi.org/10.1111/j.1467-9523.2011.00536.x

Tenny, S., Brannan, J. M., & Brannan, G. D. (2023). Qualitative Study. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK470395/

USDA ERS. (2022, March 8). *Farm Structure and Contracting*. https://www.ers.usda.gov/topics/farm-economy/farm-structure-and-organization/farm-structure-and-contracting/

Water Resources Program. (2023). *Determining Irrigation Efficiency and Consumptive Use—Program Guidance* (No. 20-11–76). Washington State Department of Ecology. https://apps.ecology.wa.gov/publications/documents/2011076.pdf