Lessons from the 2014 Drought: Water Conservation and California Vineyards

Evaluation of the Community Alliance with Family Farmer's Outreach and Education Water Stewardship Programs for California's Wine Grape-Growing Industry

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Table of Contents

Executive Summary

Purpose and Structure

California and much of the American west is in the midst of one of the worst droughts in decades. Despite the severity of the current situation, droughts like this have happened in the past and could increase in frequency as the effects of climate change progress. In addition, California is one of the most important agricultural states in the nation. Agricultural producers use a large proportion of California's water each year, and in order to have a real change in California's water use, there must be a change in agricultural water use.

There is great potential for improving water efficiency in California agriculture, and there are many options for farmers to increase efficiency including efficient irrigation technologies, improved irrigation scheduling, regulated deficit irrigation, and practices that enhance soil moisture. By utilizing these methods, the agricultural sector has made significant strides to optimize on-farm water use over the past decades—many farmers in California have already adopted these on-farm water stewardship methods—however, as a sector, adoption rate of new water stewardship methods has been slow and opportunity exists to further increase adoption or improve use. While many studies have examined the magnitude of the problem and methods that farmers could use to improve, the *reasons* why some farmers are unable to adopt these practices are relatively under-analyzed. Determining the barriers to implementing efficiency practices and offering assistance programs could be the key to large-scale water efficiency gains in California.

The Community Alliance with Family Farmers (CAFF) is a non-profit group that advocates for small-scale growers and sustainable agriculture in the state of California. CAFF works directly with farmers throughout the spectrum of farm management, including production planning, food safety, marketing, and sales. They operate six regional offices throughout north-central California.

The project team worked with CAFF on this project to survey wine grape growers about their adoption of water stewardship practices after attending a CAFF workshop. The goal was to gather information about water use, educational effectiveness, and barriers to producers' adopting certain water conservation practices.

Methodology

There are a variety of stakeholders and decision makers involved in the scope of project, including federal government agencies, state government agencies, local governments, non-profit organizations, universities, cooperative extensions, private consultants, technology suppliers, consumers, technology and start-up companies, and wine grape growers themselves. While this paper provides only an overview of the most important stakeholders, this problem affects agricultural producers in California, citizens of California and, consumers throughout the United States.

In order to construct an effective survey and communicate successfully with grape growers, the team collected and examined a variety of literature. There are a variety of best management practices (BMPs) for water conservation on vineyards, including soil horizon mapping, soil moisture sensors, salt monitoring, irrigation scheduling, vine water status monitoring, evapotranspiration and weather-based data use, sap flow monitoring, regulated deficit irrigation, and dry farming. This report summarizes these practices, which were essential for our team to understand in this completion of this project.

As part of this project, our team conducted a survey. All of the survey participants took a baseline survey at the conclusion of the CAFF workshop they attended. The survey conducted for this project was designed to gauge which water conservation practices farmers have implemented since their workshop and the barriers to implementing these practices. The survey design stemmed from three main sources: the original survey that CAFF distributes on paper following their workshops, a 2013 American Farmland Trust survey that measured motivations for specialty crop growers to adopt efficient irrigation practices, and the team's personal learning interests. CAFF staff distributed the survey through email, and CAFF staff and the project team conducted follow-up phone calls with grape growers.

Findings and Results

The team's survey was emailed to 151 people who attended a workshop hosted or sponsored by CAFF in 2012, 2013, and 2014. A total of 39 people participated in the follow-up survey. The participants represented five different wine grape growing regions; sizes of vineyards ranging from 1 to 3,000 acres; and 4,314 total acres of wine grapes.

The overall adoption rate of new BMPs is 30.7%. Survey respondents reported a range of on-farm practices that they have yet to adopt and many of them were addressed in a CAFF workshop. These practices include drip irrigation, dry farming, soil moisture monitoring, vine water status monitoring, regulated deficit irrigation, and irrigation scheduling.

The survey also asked growers to rank the top three of nine potential barriers to adopting best management practices. Limited financial resources was the most commonly cited barrier, with lack of information, bureaucracy, and regulatory barriers receiving the second highest amount of votes.

Data on actual changes in water use is very limited. As much as the survey encouraged attendees to provide specific numbers and units of water use in growing seasons since 2012, only nine respondents entered any data in this section. Water use seems to have decreased over the last three growing seasons because of the drought, with a larger decreases over 2013-2014 compared to 2012-2013.

Recommendations

Market Transformation

A common theme throughout our stakeholder interviews, survey results, and follow-up phone calls is a need for market recognition for changes in practices that require additional

resources to implement and maintain. A labeling or certification program would recognize farmers for adopting this practice and could increase the price end users are willing to pay.

In addition to labeling or certification programs, direct education of consumers could also grow the market of people seeking out wines where the grapes are grown through sustainable water management practices. CAFF could explore encouraging more dry farmers to have targeted tastings with other dry farmers where the public receive education about the quality and sustainability benefits of dry farming.

STP Framework

The STP framework (segmentation, targeting, and positioning) is a marketing tool used to ensure products and services are getting to the correct audience. This approach is applicable to CAFF's future outreach and education activities. By segmenting members into homogenous subgroups, targeting content to the appropriate segment and positioning resources efficiently, CAFF can have the greatest impact with limited resources.

Data Collection

In order to assess CAFF's future success, it is imperative to collect data assessing whether sessions had the intended impact. CAFF could consider tracking attendees that attend more than one workshop to obtain longitudinal data. In order to collect this info, it may be useful to formalize a water data collection program in the form of a focus group where CAFF pays for water use monitoring technologies to be implemented on a small number of farms.

Introduction

Drought in California

California and much of the American west is in the midst of one of the worst droughts in decades. Despite the severity of the current situation, droughts like this have happened in the past and could increase in frequency as the effects of climate change progress.[1] Traditionally, California has relied on snowmelt to supply most of its water needs. In the past, snowmelt has been reliable and could last throughout the dry season, so reservoirs have not been built with the capacity to last through the dry season.[2] As the effects of climate change set in, temperatures have increased and precipitation has decreased, leading to a lack of snowmelt water supply and the need for increased water storage.[3] California does have groundwater as well, which traditionally has supplemented snowmelt in drought years. However, groundwater has been essentially unregulated and not monetized until recently, leading to groundwater supplies have been significantly depleted since 2006.[4]

To adapt to increasingly common dry conditions and deal with projected water shortages, homeowners, businesses, industries, and agricultural producers across the state and region need to make unprecedented alterations to their water consumption behavior. In fact, citizens of California were recently asked to voluntarily reduce their water consumption by 20%,[5] and the State Water Resources Control Board adopted a regulation, effective August 1, 2014, that requires urban water suppliers to implement their Water Shortage Compliant Plans, which impose mandatory restrictions on outdoor irrigation of outdoor landscaping and other water uses by urban dwellers.[6] While these measures will have a small effect on water use in California, in reality, it is trivial compared to the water used by the agricultural industry.

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[1] Severe drought? California has been here before. http://articles.latimes.com/2014/feb/23/local/la-me-drought-weakness-20140223. Accessed on November 28, 2014.

[2] California's Drought: Cheap Water, But No Free Lunch. http://voices.nationalgeographic.com/2014/02/14/californias-drought-cheap-water-but-no-free-lunch/. Accessed on November 28, 2014.

[3] California's Drought: Cheap Water, But No Free Lunch. http://voices.nationalgeographic.com/2014/02/14/californias-drought-cheap-water-but-no-free-lunch/. Accessed on November 28, 2014.

[4] California's Drought: Cheap Water, But No Free Lunch. http://voices.nationalgeographic.com/2014/02/14/californias-drought-cheap-water-but-no-free-lunch/. Accessed on November 28, 2014.

[5] Liquid Assets: How business can take action on the California water crisis. http://www.greenbiz.com/blog/2014/02/18/california-drought-highlights-importance-water-stewardship. Accessed on November 28, 2014.

[6] State Water Resources Control Board Adopts Emergency Water Conservation Regulation in Response to Drought: Regulation Requires Agencies to Restrict Outdoor Irrigation and Prohibit Certain Uses of Water. http://www.bbklaw.com/?t=40&an=31473. Accessed on November 28, 2014. *See also* How California Water Agencies Are Responding to Record-Dry Conditions. http://www.acwa.com/content/local-drought-response. Accessed on November 28, 2104.

California Agriculture and Water Use

California is one of the most important agricultural states in the nation, producing over 250 different crops and 75 commodities, 12 of which are only grown in California.[7] Half of America's fruits and vegetables are grown in California, the production of which also supports a large food processing industry.[8] This production would not be possible without massive irrigation systems. In an average year, California agriculture uses 34 million acre-feet of water to irrigate 9.6 million acres.[9] An acre-foot is a measure of volume equal to an acre of land covered by a foot of water. This water use accounts for over 75% of the state's total water use.[10] Recent satellite data has shown that between 2012 and 2013, the state's primary agricultural basins pumped an amount of water equivalent to the rest of the state's total water use.[11] In order to have a real change in California's water use, there must be a change in agricultural water use.

Improving Water Efficiency in California Agriculture

There is great potential for improving water efficiency in California agriculture. According to recent studies, agricultural water use could be reduced by about 20% while maintaining current production levels.[12] There are many options for farmers to increase efficiency (discussed *infra* in more depth), including efficient irrigation technologies, improved irrigation scheduling, regulated deficit irrigation, and practices that enhance soil moisture.[13] By utilizing these methods, the agricultural sector has made significant strides to optimize on-farm water use over the past decades—many farmers in California have already adopted these on-farm water stewardship methods—however, as a sector, adoption rate of new water stewardship methods has been slow and opportunity exists to further increase adoption or improve use. While many studies have been done regarding the magnitude of the problem and methods that farmers could use to improve, the *reasons* why some farmers are unable to adopt these practices are relatively under-analyzed.

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[7] California Department of Water Resources: Agricultural Water Use. http://www.water.ca.gov/wateruseefficiency/agricultural/. Accessed on November 28, 2014.
[8] California's Drought: Cheap Water, But No Free Lunch. http://voices.nationalgeographic.com/2014/02/14/californias-drought-cheap-water-but-no-free-lunch/. Accessed on November 28, 2014.
[9] California Department of Water Resources: Agricultural Water Use. http://www.water.ca.gov/wateruseefficiency/agricultural/. Accessed on November 28, 2014.
[10] California's Drought: Cheap Water, But No Free Lunch. http://voices.nationalgeographic.com/2014/02/14/californias-drought-cheap-water-but-no-free-lunch/. Accessed on November 28, 2014.
[11] California's Drought: Cheap Water, But No Free Lunch. http://voices.nationalgeographic.com/2014/02/14/californias-drought-cheap-water-but-no-free-lunch/. Accessed on November 28, 2014.
[12] Pacific Institute and Natural Resources Defense Council. Issue Brief: Agricultural Water Conservation and Efficiency Potential in California. Available at: http://www.nrdc.org/water/files/ca-water-supply-solutions-ag-efficiency-IB.pdf.
[13] Pacific Institute and Natural Resources Defense Council. Issue Brief: Agricultural Water Conservation and Efficiency Potential in California. Available at: http://www.nrdc.org/water/files/ca-water-supply-solutions-ag-efficiency-IB.pdf.

Determining the barriers to implementing efficiency practices and offering assistance programs could be the key to large-scale water efficiency gains in California.
Many farmer assistance programs already exist (see discussion *infra*); however, these voluntary programs do not reach many farmers for a variety of reasons. In California, there is a divide in California between large- and small-scale farms. Large-scale farms act as agribusinesses, carefully calculating benefits and costs of any sustainability related action and often bringing in private consultants to advise them on best practices, which sometimes leads to the adoption of voluntary water efficiency practices, as reducing water use can reduce costs, conserve energy, and allow for more flexibility in water management and use. Small-scale farms are often family-run and are much more widely dispersed. There is less clarity around the use of water efficiency practices by these farms and what would compel them to begin using water more efficiently. This project focuses on small agricultural producers, specifically, wine grape producers, asking what efficiency measures work for them and how can they be incentivized to reduce water use.

The Community Alliance with Family Farmers

The Community Alliance with Family Farmers (CAFF) is a non-profit group that advocates for small-scale growers and sustainable agriculture in the state of California. CAFF is California's longest standing sustainable agriculture advocate with a thirty-year history of farmers and urban activists working together to foster agriculture with a consciousness for land-use, local economies, and social justice. They operate six regional offices throughout north-central California.[14]

CAFF offers a variety of programs targeted to the public, schools, hospitals, state and federal policy makers, and farmers themselves. CAFF works directly with farmers throughout the spectrum of farm management, including production planning, food safety, marketing, and sales. The Biological Agriculture program promotes on-farm biodiversity strategies such as building hedgerows, integrated pest management, and water efficiency.[15]

In response to the unprecedented drought, CAFF has increased its offerings related to water efficiency. Through their webpage on drought-related programs, CAFF posts links to dozens of resources such as the State Water Efficiency and Enhancement Program, California Certified Organic Farmers, University of California Drought Expert Contact List, and others.[16] The Sustainable Winegrape Production program includes options for sustainable certification through the California Sustainable Winegrowing Alliance, Lodi Rules, Napa Valley Vintners, and the Vineyard Team.[17]

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[14] Community Alliance with Family Farmers. 2013 Annual Report. Available at: http://caff.org/wp-content/uploads/2010/07/CAFF-2013-Annual-Report1.pdf
[15] Community Alliance with Family Farmers. Biological Agriculture. http://caff.org/programs/bio-ag/. Accessed on November 28, 2014.
[16] Community Alliance with Family Farmers. Drought Resources. http://caff.org/programs/drought/. Accessed on November 28, 2014.
[17] Community Alliance with Family Farmers. Sustainable Winegrape Production. http://caff.org/programs/bio-ag/winegrape/. Accessed on November 28, 2014.

As drought conditions continue in the foreseeable future, there is an even greater need to provide family-scale farmers with resources to enhance water management and promote agriculture that cares for the land, sustains local economies, and promotes social justice. Small farmers face a different set of barriers compared to large farmers who have access to capital for technology and human resources to solve water scarcity problems. It is in CAFF's best interest to continue to leverage nonprofit organization partnerships, government agencies, and its previous success to provide the most value to its target audience.

Methodology

Summary of Stakeholders

Federal Government

United States Department of Agriculture – Natural Resources and Conservation Service

The federal government agency most relevant to water conservation in California is the U.S. Department of Agriculture (USDA) Natural Resources and Conservation Service (NRCS), which provides financial and technical assistance along with various tools and resources. Their aim is to help, "America's farmers, ranchers and forest landowners conserve the nation's soil, water, air and other natural resources."[18] Their financial assistance programs include the Agricultural Management Assistance (AMA), the Conservation Stewardship Program (CSP) and the Environmental Quality Incentives Program (EQIP).[19] In the past, NRCS also had an Agricultural Water Enhancement Program focused on driving adoption of water enhancement activities.[20] The most significant of these programs is EQIP, which covers up to 50% of the purchase price of materials and services needed to implement a conservation practice with a maximum payment of $450,000.[21] This program is part of the Farm Bill and the newest version of the bill channels up to $3.2 billion in funding to EQIP annually, up from a maximum of $1.4 billion in the previous farm bill.[22]

Water conservation is one of their main focuses of EQIP in California. There is a specific provision in the program that allows farmers with limited resources, as well as beginning and socially disadvantaged farmers, to get a larger portion of their investment covered by the program. One of the key parts of the program is the creation of a conservation plan. The NRCS requires producers to create a conservation plan as part of their participation in EQIP, which helps producers comprehensively consider a plan for conservation and sustainability.[23] In response to the California drought, NRCS expanded its drought

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[18] USDA – Natural Resources and Conservation Service. http://www.nrcs.usda.gov/. Accessed on November 6, 2014.
[19] USDA – Natural Resources and Conversation Service. Programs. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/. Accessed on November 28, 2014.
[20] USDA – Natural Resources and Conservation Service – Financial Assistance. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/. Accessed on November 6, 2014.
[21] USDA – Natural Resources and Conservation Service – EQIP. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/eqip/?cid=stelprdb1242633. Accessed on November 6, 2014.
[22] "2014 Farm Bill Drill Down: The Bill by the Numbers." http://sustainableagriculture.net/blog/2014-farm-bill-by-numbers/. Accessed on November 6, 2014.
[23] USDA – Natural Resources and Conservation Service. Environmental Quality Incentives Program. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/. Accessed on November 28, 2014.

assistance program and provided technical resources to help farmers and ranchers adapt to the drought.

Federal Bureau of Reclamation

The Federal Bureau of Reclamation is involved in water issues in California through several large infrastructure projects, mainly the Federal Central Valley Project, built starting in the 1930s through the 1970s. The Bureau of Reclamation, through the Central Valley Project, is responsible for water storage and regulation of over 13,000,000 acre-feet of water in California's central valley. [24]

State Government

California Department of Food and Agriculture

The California Department of Food and Agriculture (CDFA) is an agency responsible for promoting and protecting California's agricultural industry. In 2014, they announced for the first time a new program titled the State Water Efficiency and Enhancement Program (SWEEP). $10 million in funding for water conservation measures that could be tied to energy efficiency came from AB32: The California Global Warming Solutions Act of 2006.[25] Each grant is limited to $150,000 and is evaluated based in several criteria: water savings, greenhouse gas savings, location in a drought designation area, use of soil moisture sensors, use of electronic weather station connected to irrigation controller, use of evapotranspiration-based irrigation scheduling and flow meters, use of micro-irrigation or drip systems, use of low pressure irrigation systems, and use of variable frequency drives. The agency was concerned that the complicated and technical nature of the application process, which requires farmers to estimate water and greenhouse gas reductions, may prohibit small farmers from applying.[26] CDFA is interested in learning more about how it can target resources for small farmers.[27]

California State Water Control Board

The California State Water Control Board is part of California's Environmental Protection Agency and, along with the nine Regional Water Quality Control Boards, protects water quality and allocates surface rights.[28] The nine regional boards, created in 1967, develop rules and regulations relevant to California's different water basins. The individuals on the water boards are appointed by the governor and approved by the state senate.[29]

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[24] U.S. Department of the Interior, Bureau of Reclamation, Central Valley Project. http://www.usbr.gov/projects/Project.jsp?proj_Name=Central+Valley+Project. Accessed on November 8, 2014.

[25] Interview. Carolyn Cook, California Department of Food and Agriculture. May 1, 2014.

[26] Interview. Carolyn Cook, California Department of Food and Agriculture. May 1, 2014.

[27] Interview. Carolyn Cook, California Department of Food and Agriculture. May 1, 2014.

[28] California State Water Resources Control Board. About the Water Board. http://www.swrcb.ca.gov/about_us/. Accessed on November 28, 2014.

[29] California Water Boards Fact Sheet. http://www.waterboards.ca.gov/publications_forms/publications/factsheets/docs/boardoverview.pdf. Accessed on November 6, 2014.

California Department of Water Resources

The California Department of Water Resources is "responsible for the management of water usage including the delivery of water to two-thirds of California's population through the state water project."[30] Other resources related to water conservation in California include remote sensing data that farmers can use to monitor weather and precipitation. The California Irrigation Management Information Station (CIMIS) is a program in which the Office of Water Use Efficiency within the California Department of Water Resources manages 120 weather stations and makes the data available free of charge online.[31] The Department of Water Resources also manages the California Water Project – a series of reservoirs, storage facilities and 701 miles of canals and pipelines that provides water for both municipal and agricultural uses throughout the state.[32]

Local Governments

In California, some local governments develop water conservation programs for their own jurisdictions. They primarily target residences and commercial business owners. In agricultural regions of California, local governments may help connect local farmers to drought-related state and national resources.

Non-Profit and Non-Governmental Organizations

There are many non-profit organizations and non-governmental organization across California working to address the drought and water conservation. Three specific organizations working directly on these issues include the Pacific Institute, the Community Alliance with Family Farmers (also discussed *supra*) and the California Sustainable Winegrowing Alliance.

The Pacific Institute is a non-governmental organization headquartered in Oakland, CA. The group develops reports that address water policy and conservation in California. Founded in 1987, their main focus is research and policy analysis related to development and environmental protection around freshwater issues.[33] The Institute currently owns www.californiadrought.org where they post predictions and weekly updates related to the drought.[34]

In the Institute's data analysis efforts, the group recognizes the difficulty of pinpointing the exact reasons for increases or decreases in water consumption and teasing apart the drivers behind any water use savings. The Institute usually relies on data from country agricultural commissioners. The water use data the Institute presents in its reports are extrapolated from irrigated acreage by crop type and any assumptions on efficiency are developed in-house. The Pacific Institute would like state or federal government agencies

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[30] State Water Resources Control Board. http://www.swrcb.ca.gov/about_us/. Accessed on November 6, 2014.
[31] California Department of Water Resources. California Irrigation Management Information System. http://www.cimis.water.ca.gov. Accessed on November 28, 2014.
[32] California State Water Project at a Glance. California Department of Water Resources. April 2011. Available at: http://www.water.ca.gov/recreation/brochures/pdf/swp_glance.pdf.
[33] Pacific Institute. www.pacinst.org. Accessed on November 28, 2014.
[34] Interview, Heather Cooley and Kristina Donnelly, Pacific Institute. May 13, 2014.

to provide more accurate data on how much water the agricultural sector uses. There are estimates that the agriculture sector accounts for anywhere from 40-80% of the total water use in California.[35]

The Community Alliance with Family Farmers (CAFF) aims to connect with small-scale farmers throughout California by developing various outreach and communication programs. Two of their key initiatives involve their Sustainable Winegrape Program and the California Agricultural Water Stewardship Initiative that "aims to raise awareness about approaches to agricultural water management that support the viability of agriculture, conserve water, and protect ecological integrity in California."[36] This online resource was developed by a coalition of agricultural organizations and is currently managed by CAFF. Content is guided by an Editorial Board and the site supported financial by several government agencies and private foundations.[37]

There are also numerous agricultural industry groups that educate and advocate for their members. For the winegrape industry, these groups include both statewide and regional groups. The California Sustainable Winegrowing Alliance (CSWA) focuses on educating members about sustainable practices through self-assessments and peer-to-peer education.[38] Regional groups include the Napa Valley Grape Growers, Lodi Rules, Vineyard Team and many others.[39]

Universities

Universities throughout California host institutes and employ researchers that provide valuable resources to farmers. California State University, Fresno alone has three different groups on campus looking at water issues: the California Water Institute, the International Center for Water Tech and the Center for Irrigation Technology. Specifically, the Center for Irrigation Technology researches existing and emerging technologies and then develops best practices.[40] They also partner with one of California's largest utility PG&E to administer a water pump energy efficiency program.[41] Other universities that focus on water and agriculture are University of California Davis and California Polytechnic State University, San Luis Obispo.

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[35] Interview, Heather Cooley and Kristina Donnelly, Pacific Institute May 13, 2014.
[36] California Agricultural Water Stewardship Initiative. http://agwaterstewards.org/index.php/About-Us. Accessed on November 28, 2014.
[37] California Agricultural Water Stewardship Initiative. http://agwaterstewards.org/index.php/About-Us. Accessed on November 28, 2014.
[38] California Sustainable Winegrowing Alliance. http://www.sustainablewinegrowing.org. Accessed on November 28, 2014.
[39] Kendall Lambert. CAFF. Email Correspondence. November 5, 2014.
[40] Fresno State University. Center for Irrigation Technology. http://www.fresnostate.edu/jcast/cit/. Accessed on November 28, 2014.
[41] CAWSI. http://www.agwaterstewards.org/. Accessed on November 6, 2014.

UC Cooperative Extension

The University of California's Division of Agriculture and Natural Resources is a statewide network of agricultural experts who provide training and technical assistance to farmers. They focus on bringing practical, science-based solutions to farmers.[42]

Private Consultants

Throughout the state, there are firms and individuals that offer services to growers that influence on-farm water use decisions. A few of these organizations specific to the winegrape industry include Advanced Viticulture, Wyatt Supply, and Vineyard Soil Technologies.[43]

Agricultural Community

California is an agricultural powerhouse, providing over 15% of the country's crops and $42.6 billion annually in revenues.[44] The state produces plant and animal commodities on 80,500 farms and ranches and over 43 million acres of land.[45] The focus of this white paper is California's wine grape growers although nearly all farmers in the state are dealing with water conservation to some extent.

Wine grape Growers

Wine grape growers are a diverse group of producers, with over a half million acres spanning the entire state. One perception of wine grape growers is that they are a wealthier population who work with a luxury crop and may be willing to invest in new technology, another perception is that they are ordinary farmers with a love for the work and the same struggles to get by. Traditionally, all wine grape growing in California was conducted as dry farming, without irrigation, but many vineyards became irrigated production systems in the 1970s and '80s.[46] Currently, the majority of vineyards in California are irrigated, while only a handful of vineyards are dry farmed. The wine grape industry as a whole is focused on sustainable water use and has been early adopters of efficient irrigation technologies. But still water management techniques and water use between vineyards varies greatly, due to location, climate, and adoption of practices.[47] Some wine grape growers focus on quality and others, often growing grapes for low-priced wines, focus on quantity.[48] There is no typical wine grape grower in California, which makes reaching out to this population even more difficult.

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[42] UC Division of Agriculture and Natural Resources. We are UC ANR. http://ucanr.edu/About_ANR/What_is_ANR/. Accessed on November 8, 2014.
[43] Kendall Lambert. CAFF. Email Correspondence. November 5, 2014.
[44] California Agricultural Production Statistics. California Department of Food and Agriculture. http://www.cdfa.ca.gov/Statistics/. Accessed on November 8, 2014.
[45] California Agricultural Land Loss & Conservation: The Basic Facts. American Farmland Trust. Nov. 23, 2009. Available at: http://www.farmland.org/documents/AFT-CA-Agricultural-Land-Loss-Basic-Facts_11-23-09.pdf
[46] Personal observations. Napa Valley. July 19, 2014.
[47] Personal observations. Napa Valley. July 19, 2014.
[48] Interview, Heather Cooley and Kristina Donnelly, Pacific Institute, May 13, 2014.

Other Farmers

There are tens of thousands of farmers in California, each with unique water management situations. One specific group of agricultural producers focused on sustainability is almond growers. In California, almond growers have a long history of adopting efficient and sustainable practices with their water-intensive crop. The Almond Board reported that the California Almond Sustainability Program (CASP) indicates that 70% of almond orchards (about 560,000 acres) use micro-irrigation systems.[49] Their survey also found that 83% of growers schedule irrigation based on tree need and soil/weather conditions and 62% of growers use soil maps to understand the soil characteristics in their orchards in order to best design an irrigation system to enhance water infiltration and distribution.[50]

Technology Suppliers

Local Irrigation Supply Stores

Throughout California, small-scale farmers visit local retailers to purchase equipment for small-scale projects or to hire contractors for larger projects. Harmony Farm Supply in Sebastopol is an example of a local irrigation supply store. When our team visited the store, sales representatives mentioned that there had been a lot of interest this year around drip irrigation systems. They knew about the specific farming and water management practices of specific vineyards and farmers nearby. These types of stores act as a hub where people come together to discuss what's happening on their farms and get additional information about new and proven technologies. One employee explained that people often look to new irrigation systems to cut the electricity cost from pumping once they have already addressed any low-hanging fruit related to water conservation. Many farmers feel like they have already taken a lot of steps reduce their water consumption.[51]

Tech & Start-Up Companies

There are countless technology companies that provide both hardware and software to assist farmers with on-farm water management. Imagine H2O is a San Francisco nonprofit focused on helping water technology companies get their ideas of the ground.[52] There are also technology-related water research centers that support start-up companies in Fresno, San Diego, Fort Collins, Boston, and Milwaukee.[53] Often it is large industrial farmers that have both the financial resources and incentives to test new water-savings technologies.[54] These technology companies have a harder time convincing small farmers to adopt state-of-the-art practices. This could change if irrigation costs increase dramatically. New York Times contributor Todd Woody mentions prices could, "double or triple as growers are forced to buy water on the spot market." If water prices increase, the incentives to invest in

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[49] Danielle Veenstra, The Almond Board. Email correspondence. May 2, 2014.
[50] Danielle Veenstra, The Almond Board. Email correspondence. May 2, 2014.
[51] Interview, Tom, Harmony Farm Supply, May 14, 2014.
[52] Imagine H2O. http://www.imagineh2o.org. Accessed on November 28, 2014.
[53] "Drought-Ravaged California Turns to Tech for Help." March 21, 2014. http://www.cnn.com/2014/03/21/tech/innovation/drought-water-tech/. Accessed on November 28, 2014.
[54] Interview, Sarge Green, Fresno State, May 5, 2014.

new water-saving technology shift.[55] Some of the media interviews from March 2014, a time of heavy media attention on the drought, mentioned farmers potentially changing their views: One family strawberry farmer mentioned, "We have not used any new methods, any new technologies. We're a small farm…but now, I think we have to consider it."[56]

Consumers

When it comes to the drought and its impact on consumers, food prices are the main concern. For wine, there is the possibility that as consumers become more aware and impacted directly by more severe and frequent drought they may shift their preferences to wines that are produced more sustainability, potentially even seeking out dry-farmed vineyards. This is the belief of one app developer who is creating an app that will list all of the dry farms in Napa.[57] Wine makers are also considering including information about dry farming and other water conservation practices on labels to communicate their practices to consumers.

[55] "Water-Cleaning Technology Could Help Farmers." February 17, 2014. Available at: http://www.nytimes.com/2014/02/17/technology/water-cleaning-technology-could-help-farmers.html?_r=0. Accessed on November 28, 2014.
[56] "New Tech Helps Some Farmers Save Water, But Bigger Concerns Still Loom." March 19, 2014. Available at: http://blog.sfgate.com/inthepeninsula/2014/03/19/farming-water-tech/. Accessed on November 28, 2014.
[57] Personal observations. Napa Valley. July 19, 2014.

Literature Review

In order to learn about water efficiency practices for California vineyards, the team collected and examined a variety of literature. There are a multitude of best management practices (BMPs) for water conservation on vineyards, including soil horizon mapping, soil moisture sensors, salt monitoring, irrigation scheduling, vine water status monitoring, evapotranspiration and weather-based data use, sap flow monitoring, regulated deficit irrigation, and dry farming. This literature review summarizes these practices, which were essential for our team to understand in this completion of this project.

Mapping of Vineyard Soil Horizons

Mapping the soil horizons in a vineyard allows the grape grower to understand the different soil types and the water and nutrient needs of each soil type.[58] A soil horizon map gives the grape grower the knowledge to accurately install soil moisture sensors and the most appropriate irrigation practices.[59]

Soil Moisture Sensors

Soil moisture sensors allow growers to detect the soil moisture content, which is the moisture in the soil that the plants can use.[60] There are a variety of ways to measure soil moisture, including soil sampling, tensiometers, electrical resistance blocks, neutron moisture meters or neutron probes, and dielectric soil moisture sensors.[61] Neutron meters and dielectric sensors offer the most precise measurements of soil moisture.[62]

Monitor Salts

Monitoring soil salts, or electrical conductivity, is usually done to gauge soil nutrients; however, it can be useful for soil water detection, as wet areas where water accumulates

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[58] Loca: The Wines of Lodi California. Using Soil Moisture Sensors for Vineyard Irrigation Management: A Practical Guide for Installing and Interpreting Information from Soil Moisture Monitoring Technologies in Vineyards, Part I. http://www.lodigrowers.com/using-soil-moisture-sensors-for-vineyard-irrigation-management-a-practical-guide-for-installing-and-interpreting-information-from-soil-moisture-monitoring-technologies-in-vineyards-part-i/. Accessed on November 28, 2014.

[59] Loca: The Wines of Lodi California. Using Soil Moisture Sensors for Vineyard Irrigation Management: A Practical Guide for Installing and Interpreting Information from Soil Moisture Monitoring Technologies in Vineyards, Part I. http://www.lodigrowers.com/using-soil-moisture-sensors-for-vineyard-irrigation-management-a-practical-guide-for-installing-and-interpreting-information-from-soil-moisture-monitoring-technologies-in-vineyards-part-i/. Accessed on November 28, 2014.

[60] Prichard, T. et. al. University of California Cooperative Extension. Deficit Irrigation of Quality Winegrapes Using Micro-Irrigation Techniques. Available at: http://www.lodiwine.com/Final_Handbook.pdf.

[61] Prichard, T. et. al. University of California Cooperative Extension. Deficit Irrigation of Quality Winegrapes Using Micro-Irrigation Techniques. Available at: http://www.lodiwine.com/Final_Handbook.pdf.

[62] Prichard, T. et. al. University of California Cooperative Extension. Deficit Irrigation of Quality Winegrapes Using Micro-Irrigation Techniques. Available at: http://www.lodiwine.com/Final_Handbook.pdf.

tend to have higher electrical conductivity than surrounding areas that are well-drained.[63] In addition, soils with higher salinity may require different water management practices, so monitoring salinity can be important.[64]

Irrigation Scheduling

An irrigation scheduling program lays out when to irrigate and how much water to apply to achieve a farmer's specific objectives, which usually include predictable vine growth, high yield, and great fruit quality.[65] Because wine grapes thrive when provided with less water than necessary, irrigation scheduling is used to cause water deficit at certain optimal times.[66]

Vine Water Status Monitoring

Vine water status monitoring is a way for growers to measure water stress.[67] Vine water status is measured using a pressure chamber, also called a pressure bomb, in which a leaf in a plastic bag is placed in a pressure vessel, which is sealed from the atmosphere. The amount of pressure required to exude the sap is the leaf water potential.[68] Well-watered plants show significant fluctuations throughout the day, while moderately stressed plants show fewer fluctuations.[69] Factors that determine the status of the vine water include the availability of soil water and evaporative demand.[70]

Evapotranspiration or Weather-Based Data

Grape growers can use evapotranspiration (ETo) values to approximate the water use of the grapes.[71] ETo values are calculated using measurements of climatic variables, including

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[63] United States Department of Agriculture, Natural Resource Conservation Service. Soil Electrical Conductivity. Available at: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053280.pdf.
[64] Vineyard Team. May 2014 Virtual Tailgate Meeting. Available at: http://www.vineyardteam.org/virtual-tailgates/soil-water/.
[65] Prichard, T. et. al. University of California Cooperative Extension. Deficit Irrigation of Quality Winegrapes Using Micro-Irrigation Techniques. Available at: http://www.lodiwine.com/Final_Handbook.pdf.
[66] Prichard, T. et. al. University of California Cooperative Extension. Deficit Irrigation of Quality Winegrapes Using Micro-Irrigation Techniques. Available at: http://www.lodiwine.com/Final_Handbook.pdf.
[67] Vineyard Team. May 2014 Virtual Tailgate Meeting. Available at: http://www.vineyardteam.org/virtual-tailgates/soil-water/.
[68] http://ucmanagedrought.ucdavis.edu/PDF/WINEGRAPE%20DROUGHT%20LONG-1.pdf
[69] Vineyard Team. May 2014 Virtual Tailgate Meeting. Available at: http://www.vineyardteam.org/virtual-tailgates/soil-water/.
[70] Vineyard Team. May 2014 Virtual Tailgate Meeting. Available at: http://www.vineyardteam.org/virtual-tailgates/soil-water/.
[71] University of California, Davis. Irrigation Management of Winegrapes with a Limited Water Supply. Available at: http://ucmanagedrought.ucdavis.edu/PDF/WINEGRAPE%20DROUGHT%20LONG-1.pdf.

solar radiation, humidity, temperature, and wind speed.[72] Standard ETo values are calculated by the California Irrigation Management Information System (CIMIS), which calculates the values based on its data collected from 100 weather stations throughout California.[73]

Sap Flow Sensors

Sap flow sensors measure the amount of water in the grape vines by measuring temperature before and after heat is applied.[74] These sensors can be left on the vine, sending data back to the grape grower.[75]

Regulated Deficit Irrigation (RDI)

Regulated deficit irrigation (RDI) is a term that refers to the practice of regulating or restricting the application of irrigation water limiting the vine water use to below that of a fully watered vine. RDI requires accurate soil or plant stress sensing, ability to estimate crop demand, and ability to irrigate frequently. There are many other factors to consider when implementing RDI. For example, young vines may need full irrigation before they are fully established; cover crops may take up additional water; extreme climate and drought years may impact a grower's ability to use RDI; and high soil salinity may prove to be a stressful environment. Overall, RDI can greatly reduce water use, up to 50%.[76]

Dry Farming

Dry farming is a method of grape growing that works with natural conditions to produce a crop that can thrive without irrigation.[77] Dry farming entails training the vines to extract as much natural soil moisture as possible with careful tillage practices and appropriate vine spacing.[78] Although there is a lack of data on exact water savings from dry farming, the

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[72] University of California, Davis. Irrigation Management of Winegrapes with a Limited Water Supply. Available at: http://ucmanagedrought.ucdavis.edu/PDF/WINEGRAPE%20DROUGHT%20LONG-1.pdf.
[73] University of California, Davis. Irrigation Management of Winegrapes with a Limited Water Supply. Available at: http://ucmanagedrought.ucdavis.edu/PDF/WINEGRAPE%20DROUGHT%20LONG-1.pdf.
[74] O'Brien, J. The Vine Nerds. http://www.wired.com/2012/10/mf-fruition-sciences-winemakers/all/. Accessed on November 28, 2014.
[75] O'Brien, J. The Vine Nerds. http://www.wired.com/2012/10/mf-fruition-sciences-winemakers/all/. Accessed on November 28, 2014.
[76] Vineyard Team. May 2014 Virtual Tailgate Meeting. Available at: http://www.vineyardteam.org/virtual-tailgates/soil-water/.
[77] California Agricultural Water Stewardship Initiative. Dry Farming. http://www.agwaterstewards.org/index.php/practices/dry_farming. Accessed on November 28, 2014.
[78] California Agricultural Water Stewardship Initiative. Dry Farming. http://www.agwaterstewards.org/index.php/practices/dry_farming. Accessed on November 28, 2014.

practice usually eliminates all irrigation needs; Frog's Leap in Rutherford, CA estimates that it saves 16,000 gallons/acre compared to lightly irrigated vineyards.[79]

Conclusions

In general, water deficits are widely acknowledged to improve grape quality.[80] Early in the season, rain is common, so demand for irrigation is low; pre-veraison (ripening) deficits control vegetative growth, but allow photosynthesis to continue; and moderate post-veraison deficits are necessary to maintain desired fruit characteristics.[81] In general, using less water when growing grapes limits excessive vegetative growth, increases berry quality, and is a necessary practice in times of drought.[82] When a grape grower plans to reduce water use, it is important to gather data on current water use, carefully plan and implement solutions based on the data gathered, and monitor grape condition after implementing water conservation measures.[83]

Survey Design and Implementation

As part of this project, our team conducted a post hoc survey. All of the survey participants took a baseline survey at the conclusion of the CAFF workshop they attended. The survey conducted for this project was designed to gauge what water conservation practices farmers have implemented since and the barriers to implementing these practices.

The survey design stemmed from three main sources. The bulk of the survey design came from the original survey that CAFF distributes on paper following their workshops. Another source of survey design was the 2013 American Farmland Trust survey that measured motivations for specialty crop growers to adopt efficient irrigation practices.[84] This survey was the basis for questions regarding resources growers used when adopting new practices, gaps in resources, and other barriers to adopting new practices.

Our team also used personal learning interests in drafting the survey. Through the literature review, informational interviews with stakeholder, and conversations with CAFF, the team encountered the challenges in collecting specific data pertaining to water use,

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[79] California Agricultural Water Stewardship Initiative. Dry Farming. http://www.agwaterstewards.org/index.php/practices/dry_farming. Accessed on November 28, 2014.

[80] University of California, Davis. Irrigation Management of Winegrapes with a Limited Water Supply. Available at: http://ucmanagedrought.ucdavis.edu/PDF/WINEGRAPE%20DROUGHT%20LONG-1.pdf.

[81] Vineyard Team. May 2014 Virtual Tailgate Meeting. Available at: http://www.vineyardteam.org/virtual-tailgates/soil-water/.

[82] Vineyard Team. May 2014 Virtual Tailgate Meeting. Available at: http://www.vineyardteam.org/virtual-tailgates/soil-water/.

[83] Vineyard Team. May 2014 Virtual Tailgate Meeting. Available at: http://www.vineyardteam.org/virtual-tailgates/soil-water/.

[84] Shaffer, S. and E. Thompson. American Farmland Trust. Encouraging California Specialty Crop Growers to Adopt Environmentally Beneficial Management Practices for Efficient Irrigation and Nutrient Management. Available at: http://www.farmland.org/documents/SpecialityCropGrowersBMPs.pdf.

technology adoption, and effect of drought on crop yields. These topics are sensitive to discuss with farmers and collecting detailed data is difficult for researchers and policymakers. Many of the questions were left open as optional questions to give farmers flexibility in how much they wanted to share.

An email announcement preceded the survey to give CAFF workshop attendees prior notice in hopes to increase the response rate. The email announcement and the final survey went through many iterations between the team and CAFF staff before they were sent from a CAFF email address. After four reminder emails to participants who had not completed the online survey, the team conducted phone interviews with participants who indicated they would like to further explain their responses and with those who did not complete the online survey, to gather more information and increase the response rate.

Discussion of Findings

Stakeholder Interviews

Initial Farm Tour and Interviews

One specific wine grape grower and winery owner in Sebastopol, CA dry farms both merlot and pinot noir varietals. They also utilize organic and biodynamic practices – for example they use organic sulfur as an anti-fungal. This producer does not feel as much scarcity in terms of water for the vegetable garden and restaurant that is located on their property because they are in the bottomland and have a well-functioning well. They believe the most powerful source of information is from their neighbors and often spread new practices through this channel.[85]

Another dry farmer explained the concept of "canyons" of granite that can lie under separate properties. This allows one farmer to pump groundwater with our affecting his/her neighbor's supply. He believed that dry farming does not have to have 3-5 years of low initial yield because of solutions related to grafting rooted stock to non-rooted stock.

Organic Winegrowing Conference and Dry Farming Workshop

On July 29, 2014, one of our team members attended the Organic Winegrowing Conference in Rutherford, California.[86] While the conference, put on by the Napa Valley Grapegrowers and CAFF, was not focused solely on water use and conservation, it was a large component of the day. In the morning, the wine grape growers listened to a keynote presentation from Sustainable Agriculture Education (SAGE), a talk on the policy issues in organic farming from the Organic Farming Research Foundation, and a lecture by Dr. Julie Jedlicka, of the University of California Berkeley, on the benefits of increased animal diversity in vineyards.

While the growers seemed interested in these talks, the audience became visibly more engaged during the fourth talk of the morning: a panel of grape growers titled "What We Do and Why We Do It." During this panel, two grape growers and a vineyard consultant discussed a variety of issues, including water use and conservation. Iva Jermaz, a grape grower who practices dry farming, stated that grapes are adaptable and can handle the dry conditions. Mike Benzinger, a grape grower who uses irrigation but is transitioning to dry farming, used 39% less water the first year of his transition and 60% less water the second year. Benzinger also stated that using soil monitors gave him the confidence to hold back water and that in response to the drought he has implemented a complex cover crop program, applied winter compost, and pruned vines more thoroughly. Finally, Garrett Buckland, a vineyard consultant, emphasized the cultural pressures on grape growers to reduce water consumption and stated that lack of water is not always the problem but that the timing of rain is especially important.

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[85] Interview, Barbara Sattler, Russian River Vineyards, May 14, 2014.
[86] Napa Valley Grapegrowers. Organic Winegrowing Conference. https://www.napagrowers.org/events/nvg-events-2014/organic-winegrowing-conference/event-overview/. Accessed on November 28, 2014.

During the afternoon, our team member attended a dry-farming workshop, one of two breakout sessions at the conference. At the dry-farming workshop, all of the participants took a shuttle to White Barn and Rossi Ranch dry-farmed vineyards operated by Frog's Leap Winery. For the first half, grape growers gave tours of the dry farmed vineyard, and answered questions about various aspects of practicing dry farming. During the second part of the workshop, four grape growers assembled for a dry-farming panel, in which each panelist described their growing practices and took questions from the audience. Stu Smith, a long-time dry farmer, spoke to a number of water conservation issues. He attested that dry farming yields better berries that are more intense in favor. Smith stated that eventually, dry farming, while initially riskier, is actually easier, as the vines come to a symbiotic relationship with the soil. Smith also spoke about the social responsibility of grape growers to use less water, as it is an industry that grows a crop that can actually afford to use less water, and that dry farming can help tell a story about sustainable water use. Tod Mostero, a relative newcomer to dry farming told a slightly different story, acknowledging the risk and difficulty of dry farming. Mostero also talked about dry farming as a continuum of practices, not simply turning off the water.

Overall, this conference showed that listening to and engaging with other grape growers yielded the most interest from grape growers. It also demonstrated the wide array of practices available to farmers and the wide array of perspectives among growers. Our team gained a lot of perspective by attending this workshop, and it certainly informed our survey and overall project going forward.

Dry Farming Experts Panel

CAFF and its partner organizations, Center for Urban Education about Sustainable Agriculture (CUESA) and the Commonwealth Club of California hosted a panel of dry farming experts in San Francisco, CA on Monday November 3, 2014. Over 100 members of the community attended this educational event.

Panelists

- Frank Leeds, Winegrower, Frog's Leap, Rutherford
- Guillaume Eicholz, Vineyard Manager, Dominus Estate, Yountville
- Will Bucklin, Winemaker, Bucklin Old Hill Ranch, Glen Ellen
- Tegan Passalacqua, Winemaker and Vineyard Manager, Turley Wine Cellars, Amador, Paso Robles and St. Helena
- Peter Ganoff, Master Sommelier, Panel Moderator

The panelists represented a long history of dry farming in northern California, stretching back to the growers who planted the original vines and establishing dry farming in the region. The panelists were not all exclusively dry farmers and some were also organic dry farmers. Through their experience, these farmers described how dry farming is possible in 80% of the north coast of California because of the appropriate climate for dry farming, additional resiliency of dry-farmed vines to withstand heat waves, longevity of the vines, and sense of pride and tradition.

The panelists agreed that dry farming not only creates environmental benefits and reduces costs, but it also produces a higher quality wine that can be sold at a premium. The grape growers emphasized the need for consumers to understand that wine should not be a homogenous commodity product and that wine should vary depending on the season's weather. Consumers are also not usually aware of dry farming, as there are no labeling standards to recognize this practice. The panelists were in favor of more regulation of wine bottle labels by the Food and Drug Administration, which would allow growers to promote wines that are good for the environment and human health.

These experts also had practical advice for farmers who are thinking about planting new vines or converting current vineyards to dry farming. Accurate spacing for dry-farmed plots is more crucial than irrigated planting. Dry farming is also highly dependent on soil conditions; organic farming is recommended for non-virgin soil. Some rootstock varieties are not as tolerant to dry farming, yet most rootstocks, if not all, can be trained to grow deep roots. If a grower is irrigating, then regulated deficit irrigation is one way of growing root depth while increasing grape quality. Dry farming avoids the need to need for drainage ponds and other significant start-up costs, such as installing an irrigation system. One farmer offered the following irrigation schedule for newly planted vines: five gallons per day for two months the first year, the same amount for only one month the second year, and no more irrigation after the second year.

The panelists acknowledged the financial risks of being a new dry farmer in a time of drought. It takes, on average, 40 tons of grapes for a grower to break even. This may be difficult for the family-scale farmers that CAFF supports. Another source of risk for wine grape growers is, as one panelist called it, "irrigated vineyard disease," a controversial correlation between irrigated vineyards and greater presence of pests due to increased root structures near the soil surface—these pests can spread to dry farmed vineyards.

The panel concluded with that dry farming is the right thing for wine grape growers and winemakers to increase the future value of the American wine and to continue to conserve tens of millions of gallons of water every year.

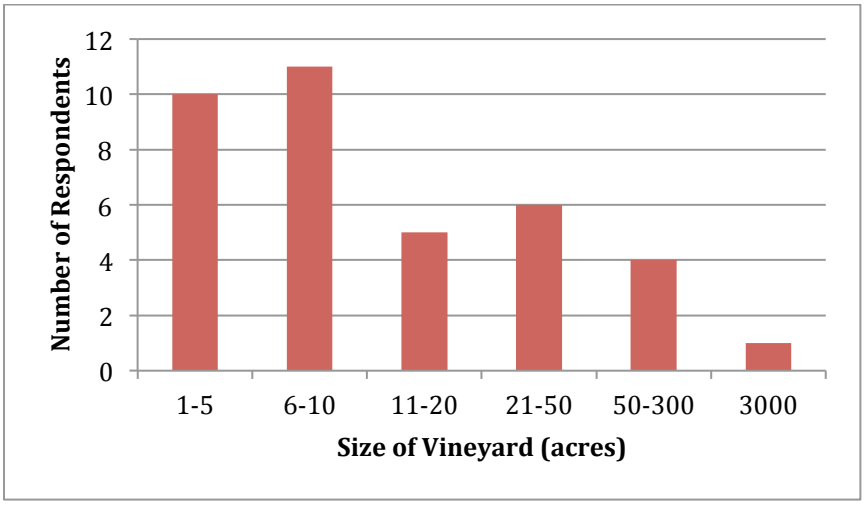
Results

Introduction

In October and November 2014, CAFF and the team conducted an email and phone survey. The survey was emailed to 151 people who attended a workshop either hosted or sponsored by CAFF in 2012, 2013, and 2014.

A total of 39 people participated in the follow-up survey. They represented five different wine grape growing regions: Sierra foothills, Sonoma County, Contra Costa County, and the Central Coast. The size of their vineyard ranges from 1 to 3,000 acres (Figure 1). The respondents represented 4,314 total acres of wine grapes.

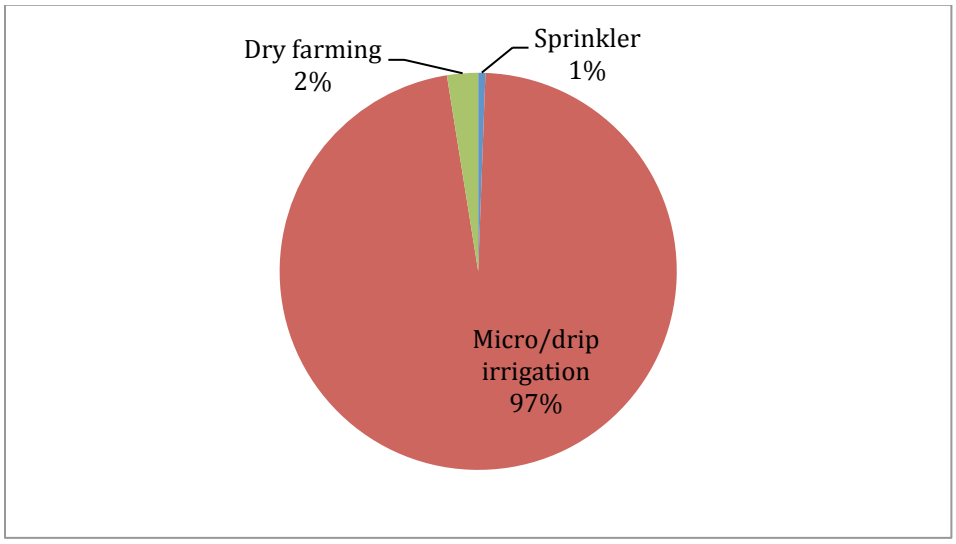
Figure 1: Distribution of Vineyard Size



Existing Irrigation Practices

Figure 2 indicates the irrigation practices present on the farms of the survey respondents. One respondent commented that he planted seven acres of new vineyard that will be dry farmed once the roots are ready after initial years of sprinkler irrigation. Another respondent commented that the weather in 2014 compelled him to irrigate for part of the growing season on some of his vineyards using sprinkler, drip, and hand irrigation. He had also dry farmed in the past on his vineyard.

Figure 2: Types of Irrigation Practices by Acreage



Adoption of Best Management Practices

At each of CAFF's workshops, experts and farmers cover 3-6 different best management practice and then distribute a survey at the end of the workshop asking about the attendees' current and future intended practices. The survey completed this fall followed up on these results to see whether farmers modified their practices since attending. The survey results are broken down by the specific practices covered in each practice in Table 1 and then the overall adoption rates for each practice in

Table 2. The four workshops included in these tables are:

1. Soil Moisture Tailgate (Broken Earth Winery, Paso Robles, Date: 3.12.2014)
2. Drip Smart, Improve Irrigation Efficiency (Bernier Farms, Healdsburg, Date: 4.16.2014)
3. Vineyard Water Management II: Irrigation Strategies and Sap Flow Sensors (Ridge Vineyards, Cupertino, Date: 4.18.2013)
4. Inches to Hours (Old School House, Plymouth, Date: 4.29.2014)

Table 1: Adoption of Best Management Practices by Workshop

Best Management Practice (N=39)	Already Used and Expanded	Already Used and Maintained	Adopted After	Still plan to adopt	Unsure about adopting	Do not plan to adopt
1.1 Mapping of vineyard soil horizons	0	1	0	0	1	0
1.2 Install soil moisture sensors for the first time	0	1	0	0	0	1
1.3 Re-install soil moisture sensors	0	1	0	0	0	1
1.4 Install soil moisture sensors at multiple depths	0	1	0	0	0	1
1.5 Monitor salts with soil moisture sensors	0	0	0	0	0	2
2.1 Soil moisture monitoring	0	1	0	0	0	1
2.2 Soil moisture sensor for each crop type or row	0	0	0	0	1	1
2.3 Re-install soil moisture sensors	0	0	0	0	1	0
3.1 Irrigation scheduling	0	1	0	0	1	0
3.2 Vine water status monitoring	0	0	0	0	1	1
3.3 Soil moisture monitoring	0	1	1	1	0	1
3.4 ET or weather-based data	0	1	1	1	1	1
3.5 Sap flow sensors	0	0	0	1	1	2
4.1 Irrigation scheduling	0	6	1	0	0	1
4.2 Vine water status monitoring	0	3	1	0	1	3
4.3 Soil moisture monitoring	0	4	1	0	0	3
4.4 ET or weather based data	0	4	0	0	1	3
4.5 Sap flow sensors	0	0	0	0	1	7
4.6 Regulated deficit irrigation	0	4	0	2	1	1
All Practices	0	29	5	5	11	30
% Distribution	0%	36%	6%	6%	14%	38%

Table 2: Overall Adoption of Best Management Practices by Type

Type of BMP (number of times topic covered in any workshop)	Already Used and Expanded	Already Used and Maintained	Adopted After	Still plan to adopt	Unsure about adopting	Do not plan to adopt
Evapotranspiration or Weather-based Monitoring (2)	0	5	0	0	2	3
Irrigation Scheduling (2)	0	7	1	0	0	2
Regulated Deficit Irrigation (1)	0	4	0	2	1	1
Sap Flow Sensing (2)	0	0	0	0	2	8
Soil Moisture Monitoring (10)	0	10	3	3	4	12
Vine Water Status Monitoring (2)	0	3	1	0	2	4
Grand Total	0	29	5	5	11	30

Dry Farming Workshops

For the dry farming workshops, similar data was collected about the adoption of dry farming practices. Table 3 shows the results from these respondents. Zero out of eleven respondents converted irrigated acres to dry farming in 2014. One respondent planted five additional acres of dry farmed vineyards. A dry farmer commented that he had to irrigate for the first five years when he first started and has not irrigated for 12-14 years after because of good soil and deep roots.

Farmers cited that they adopted the following techniques after attending a dry farming workshop: cover cropping, soil management, hedging, and irrigation redesign. Because of the drought, one farmer noted that he had to change to deep-water irrigation once per week and avoided irrigating between noon to 6PM because of peak energy costs.

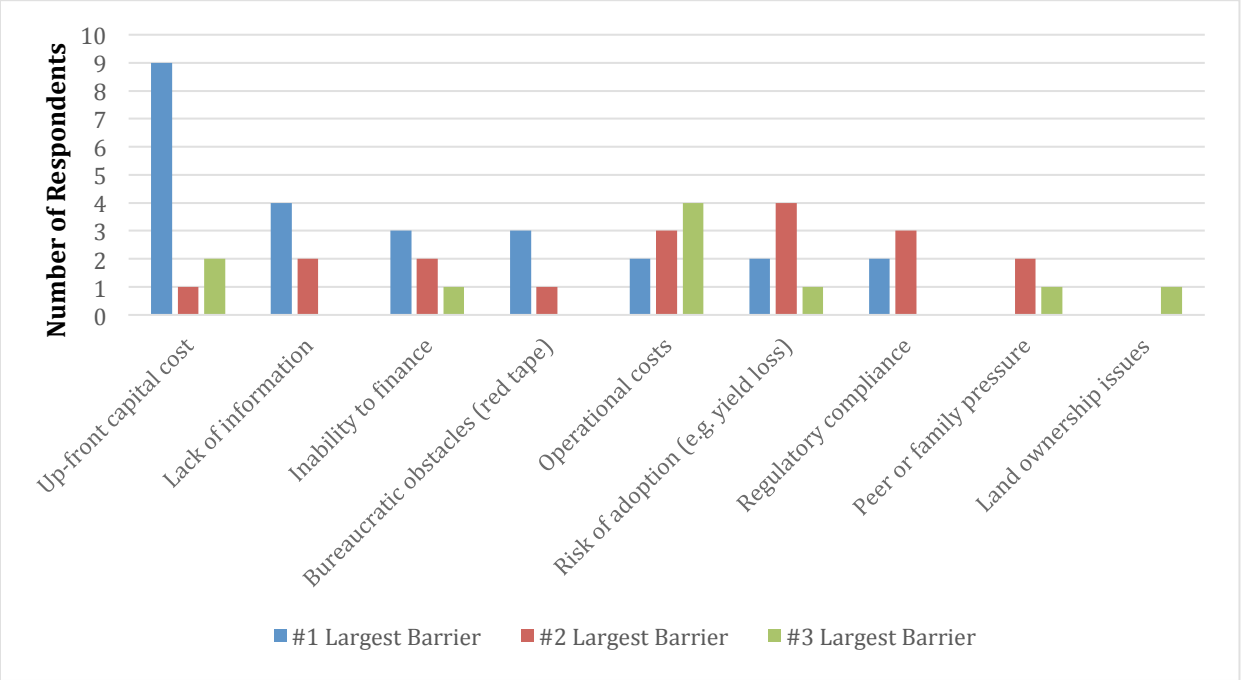
Table 3: Dry Farming Workshops Best Management Practices Adoption Rates

(N=11)	Already dry farmed	Adopted after the workshop	Still plan to adopt	Unsure about adopting	Do not plan to adopt
Since attending a Dry Farming Workshop in 2013 or 2014, have you adopted dry farming-related practices?	3	0	1	3	4

Barriers to Implementation

The survey asked growers to rank the top three of nine potential barriers to adopting best management practices. Limited financial resources was the most commonly cited barrier, with lack of information, bureaucracy, and regulatory barriers receiving the second highest amount of votes (Figure 3).

Figure 3: Largest Barriers to Adopting Best Management Practices



Outreach & Education Needs

Survey respondents reported a range of on-farm practices that they have yet to adopt and many of them were addressed in a CAFF workshop. These practices include drip irrigation, dry farming, soil moisture monitoring, vine water status monitoring, regulated deficit irrigation, and irrigation scheduling. Practices that respondents want to adopt that are not related to the irrigation workshops include composting, culverts, cover cropping, and sulfur use.

In addition to CAFF resources, survey respondents who made a change in practices used Natural Resource Conservation Service advisors and other consultants.

The survey revealed a few topics that growers would like to see in future workshops, including storm water storage, gray water use, fertigation, difference in rootstock varieties, water quality assessment, and irrigation system evaluation and maintenance. Soil moisture sensors and irrigation scheduling, common topics in current workshops, were also mentioned as topics farmers would like to continue to see in the future.

One grower noted that the distance he and his spouse need to travel to a CAFF workshop takes a considerable time away from his work. He suggested that online classes would be

useful. General comments applauded the educational value of the CAFF workshops. Many farmers enjoy the hands-on learning of additional tools, perspectives, and interpersonal networks that can help conserve water. However, many growers also mentioned that information and tools are not the limiting factor—the weather is the ultimate determinant of their success.

Respondents had some suggestions for CAFF to improve the usefulness for their workshops (Table 4). Some also indicated that they need more local workshops in Santa Clara County and time to implement the practices shown in the workshops. They also see a need for more lobbying and sales-related content.

Table 4: Steps CAFF Can Take to Address Barriers and Improve Workshop Effectiveness

Survey Question: What can CAFF do to address these barriers and improve overall usefulness?	
More in-field or technology demonstrations	10
Hold additional workshops	7
Provide more connections with farm advisors/consultants	5
Provide connections to financial services	5
Provide additional handouts or take-home information	2

Water Use Data

Data on actual changes in water use is very limited. As much as the survey encouraged attendees to provide specific numbers and units of water use in growing seasons since 2012, only nine respondents entered any data in this section. Water use seems to have decreased over the last three growing seasons because of the drought, with a larger decreases over 2013-2014 compared to 2012-2013. In this section of the survey, five respondents also included the acreage on which they implemented a new BMP (Table 5).

Table 5: Newly Adopted Practices and Number of Acres

Soil moisture monitoring	6
Soil moisture sensor for each crop type or row	8
Irrigation scheduling	6
Shredding and soil covering to reduce evaporation	3.5
Moving soil moisture sensor to new location	2.5

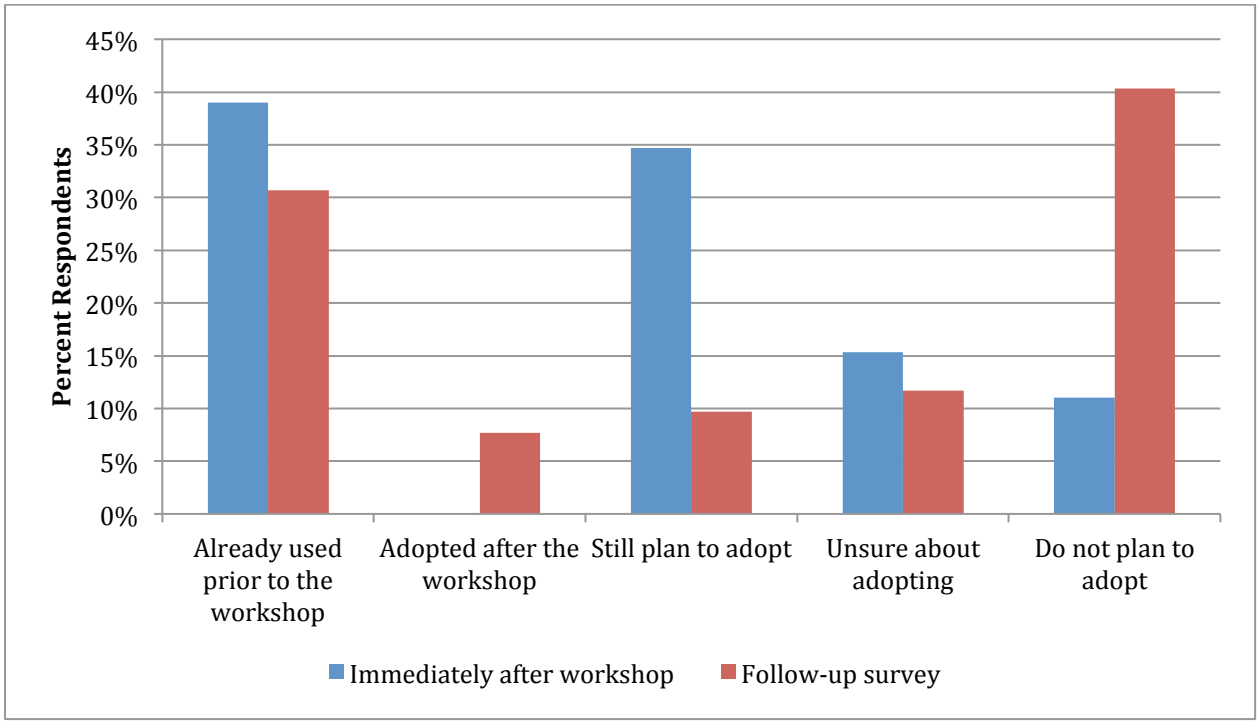
Overall Adoption Rate

By calculating adoption rate by combining new BMP adoptees from the irrigation workshops (N=5), dry farming workshops (N=4), and other workshops (N=3), the overall adoption rate is 30.7%. Four respondents marked that they "still plan to adopt" new practices, which equals 10%. The changes in attitudes towards adoption from immediately after a workshop and this team's follow-up survey are shown in Table 6 and Figure 4.

Table 6: Change in Perspectives Towards Adopting Best Management Practices

		Already used prior to	Adopted after	Still plan to adopt	Unsure about adopting	Do not plan to adopt
Soil Moisture Tailgate (Paso Robles, 3.12.2014)	Immediately after workshop	43%	--	34%	14%	9%
	Follow-up survey	40%	0%	0%	10%	50%
Vineyard Water Management II: Irrigation Strategies and Sap Flow Sensors (Cupertino, 4.18.2013)	Immediately after workshop	39%	---	28%	15%	18%
	Follow-up survey	8%	17%	25%	17%	33%
Inches to Hours (Plymouth, 4.29.2014)	Immediately after workshop	35%	--	42%	17%	6%
	Follow-up survey	44%	6%	4%	8%	38%

Figure 4: Change in Perspectives Towards Adopting Best Management Practices



Phone Call Follow-Up Interviews

After filling out the online survey, several farmers indicated for the team to follow up directly to speak with them in more detail. This section includes summaries of these conversations.

El Dorado County Wine Grape Grower

This wine grape growing family owns a 7.5-acre vineyard on a slope. They utilize soil moisture monitoring techniques on various parts of the slope using a tool called the Bosmere. Overall, they watered less this year because of the warm weather, leading to an early harvest. Previous harvests were around November 1st. In general, they utilize 1200 gallons over the course of twelve hours and water six days per week for each 2.5-acre block.

They have found that the weather sensing is not useful because the nearest weather station is too far from their vineyard. They are considering implementing regulated deficit irrigation next year to decrease irrigation requirements and improve crop maintenance.

The barriers they face include upfront financing and a shortage of labor to install new management tools. It is challenging for them to market their product to winery buyers with predictability. Without long-term buying contracts, small growers are not able to invest in efficiency technology because there is instability in terms of demand and buyers are not guaranteed, creating risk in investing.

Smoke from the "King Wildfire" destroyed all 32 tons of this grower's vineyard production this year, worth $65,000. They have sought relief from state and federal agencies with no avail. He felt that, "Alliances get you through all of this, along with patience and hard work."

Amador County Wine Grape Grower

This grower/consultant manages 180 acres, using drip irrigation on 156 of those acres and dry farming on 24 acres. In terms of the effect of policies, this grower comments that they are in a small rural area that depends solely on groundwater so water policies is not as contested as other places such as Napa. Consumer demand for low prices has been a major barrier to investments in irrigation technology. This grower expects new state policies to come into effect next year and they are waiting to see what impacts there will be from the regulatory arena before making any further changes in water practices.

Sonoma County Winery & Vineyard

This vineyard already utilized dry farming practices before attending a CAFF workshop. Since the workshop, they redesigned some locations, which improved the efficiency and reduced the need for water. They are using new canopy procedures, compost, cover cropping, and hedging. The barriers they face include upfront capital cost, operational cost, inability to finance, regulatory compliance, and bureaucratic obstacles. In the future, they would like to have access to more in-field or technology demonstrations, financial services, additional handouts or take-home information, and additional workshops.

Paso Robles Wine Grape Grower

This farmer valued the timeliness of the drought compost workshops. He is building a cover crop to retain any rain they do receive in the future. This farmer finds that the farm bureau committees support small farmers. There is the perception that wine grape growers make a lot of money, but this farmer said he is lucky if he makes what he spends. He feels a commitment to farming and tries to use creativity by planting small fruit trees on vineyards and selling that fruit in addition to his grapes. He utilizes all of the land, and this year plans to build a garden on one of the vineyards. Resources such as irrigation assessments and NRCS resources are great, but many farmers don't know about them.

Sonoma County Rare Crop Farmer

This farmer produces rare grapes and other crops on his family farm in Sonoma Country. There is low demand – he currently sells to a few restaurants and at farmers markets but this is not enough. This caused him to find another part-time job.

There is a well that irrigates the garden and there is a spring and lake on the ranch. Their well has never dropped and it holds at least 200 gallons. This allows them to pump endlessly but they do not think it is worth it to water the pastures. The well is connected to 10,000 gallon storage tank and they have a pumping schedule that is dependent on the electricity rates. Currently, they only irrigate one acre and have had some rain recently. He utilizes a soaker hose for irrigating his crops but it is so old that it no longer works properly.

There has been a lot of strain this year due to the drought – Northern California is bad but the rest of California is even worse. Last winter there was 16 inches of rain while the normal amount is 45 inches and south of San Francisco there are places that only received 4 inches.

His crops include flint corn, 17 kinds of potatoes, Andean crops such as quinoa and amaranth, and tubers. These Andean crops survive in temperatures of 40-80 degrees. The rare tuber crops tuberize in late October. When the crops are tuberizing, he has to irrigate because wants the tubers to get big. One particular crop is called Yacon. It is used for supplements and is a sweetener suitable for people with diabetes. The tuber has amazing probiotics and is part of the sunflower family. He sells Yacon at farmers markets from November until March as well as to one local wholesaler last year.

Recommendations

Market Transformation

A common thread throughout our stakeholder interviews, survey results, and follow-up phone calls is a need for market recognition for changes in practices that require additional resources to implement and maintain. Many farmers have adopted these practices for land stewardship reasons but would like for a market transformation to create demand pull for these practices from either the grape purchasers or wine buyers.

Specifically with dry farming, this management practice has significant sustainability benefits but also includes quite a bit of risk. A labeling or certification program would recognize farmers for adopting this practice and could increase the price end users are willing to pay.

In addition to labeling or certification programs, direct education of consumers could also grow the market of people seeking out wines where the grapes are grown through sustainable water management practices. CAFF could explore encouraging more dry farmers to have targeted tastings with other dry farmers where attendees are educated about the quality and sustainability benefits. Such a campaign to start getting dry farming more widely recognized would likely cause more farmers to seek out this cultivation method.

STP Framework

The STP framework (segmentation, targeting, and positioning) is a marketing tool used to make sure products and services are getting to the correct audience. This approach is applicable to CAFF's future outreach and education activities. By segmenting members into homogenous subgroups, targeting content to the appropriate segment and positioning resources efficiently, CAFF can have the greatest impact with limited resources.

Segmentation

Many of the farmers that attended CAFF workshops were already utilizing many of the best management practices covered in the workshops. To maximize the impact CAFF can have on their constituents, it would be helpful to segment members into subgroups, where the members in each subgroup are homogenous enough where their needs would be similar. The segments could be around a variety of factors, including level of experience, size of farm, number of workshops attended, or specific barriers to implementing new practices.

Targeting

Once segments are defined, resources can be developed and targeted towards each of these subgroups. For example, if one group consists of new farmers, they might benefit from a broader overview of many different practices since they have not been exposed previously. More experienced farmers may require education sessions that cover more advanced topics. One idea would be to gauge the experience or adoption status of the people in the audience prior to the session via survey or at the beginning of the workshop in order to adjust content to better suite the audience. A quick pre-workshop survey could have just

one question with a list of ten practices that asks people to check which practices they want to learn about.

Finally, past workshop attendees would like to see more lobbying and sales related content. In terms of best management practices, farmers would be interested in learning more about storm water storage, gray water use, fertigation, difference in rootstalk varieties, water quality assessment, and irrigation system evaluation and maintenance.

Positioning

Once new content and workshops are developed, it will be important to position them with the goal of marketing the best events to the corresponding subgroups. This can be accomplished through descriptive workshop agendas, specific segmented email lists and relying on partnerships to get the word out.

Another possible method for enhancing the positioning of CAFF outreach and education activities is to consider what could be provided online. One grower noted that the distance he and his spouse needs to travel to a CAFF workshop takes a considerable time away from his work. He suggested that online classes would be useful. If possible, CAFF may be able to have a boarder reach if they are able to post content and audio recordings from workshops online.

Framing and Buyer Involvement

Framing the workshops more as opportunities to learn about strategies to enhance wine grape quality can be a useful way to draw more family famers into the CAFF network. In addition to efficient, sustainable water use, farmers would be intrigued to see buyers' interest in best management practices. It can be valuable to bring buyers, representatives from winemakers, into CAFF's on-field workshops to discover first-hand how water efficiency correlates to better wine grapes, ask questions, and interact with small groups of growers.

Data Collection

In order to assess CAFF's future success, it is imperative to collect data assessing whether sessions had the intended impact. CAFF could consider tracking attendees that attend more than one workshop to gather longitudinal data. In order to collect this information, it may be useful to partner with a university or other research institution to formalize a water data collection program in the form of a focus group.

When collecting data in the future, it would be useful to divide questions into "must-haves" and "would-like-to-have". The "must-have" questions could become part of the default list of questions that goes in every in person or online survey in order to get a more significant amount of data. This project was a first attempt at tracking changes in attitude towards BMPs for CAFF and shows opportunities in fine tuning and strengthening the survey methodology. The increase in farmers indicating that they do not plan to adopt a new BMP can allude to the extreme stress of the 2014 drought and need for additional resources.

Conclusion

Climate Change as Multi-Scalar, Multi-Dimensional, Wicked Problem

Although this project directly deals with a problem on relatively narrow scale—water conservation in the wine grape growing industry in California—it necessarily implicates much broader issues, including water shortages throughout the American West, locality of agricultural production in relation to water supplies and product markets, and ultimately, climate change. Not only is climate change likely at the root of the severe droughts California has been experiencing, causing water shortages and tough choices between water uses, but climate change also has the potential to cause even more severe impacts to both the wine industry and American agriculture.

Many people think of more direct impacts of climate change, such as coastal flooding, city heat waves, and species displacement; however, changes in agricultural production will also be an important impact of climate change. The early impacts being seen in the wine grape industry today—such as drought, extreme heat, and wildfire damage—could be the canary in the coal mine for greater agricultural impacts.[87] Because wine grape growing is sensitive to climate and concentrated in Mediterranean climates, it could provide a good test case for impacts that will eventually be felt in all agricultural sectors, such as increased irrigation demand and subsequent water shortages.[88] Attempting to move these sectors to different climates will also be challenging, as wine grape growing and most agricultural sectors have grown very specialized and difficult to adapt.[89] Learning how to adapt to climate change without necessarily uprooting established industries will be a very important piece to climate change adaptation, and this paper contributes to improving the adaptability of the wine industry.

[87] Hannah, L. et. al.. Climate Change, Wine, and Conservation. Proceedings of the National Academy of Sciences of the United States of America. April 23, 2013. Available at: http://www.pnas.org/content/110/17/6907.full.

[88] Hannah, L. et. al.. Climate Change, Wine, and Conservation. Proceedings of the National Academy of Sciences of the United States of America. April 23, 2013. Available at: http://www.pnas.org/content/110/17/6907.full.

[89] Hannah, L. et. al.. Climate Change, Wine, and Conservation. Proceedings of the National Academy of Sciences of the United States of America. April 23, 2013. Available at: http://www.pnas.org/content/110/17/6907.full.