

AGRICULTURAL CONSERVATION DECISION-MAKING UNDER ENVIRONMENTAL
RISK AND UNCERTAINTY ON THE CALIFORNIA CENTRAL COAST

A Project

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TITLE: Agricultural conservation decision-making under environmental risk and uncertainty on the California Central Coast

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ABSTRACT

Agricultural conservation decision-making under environmental risk and uncertainty on
the California Central Coast

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Global climate change is a process that is, in part, caused by agricultural practices, and will adversely affect agricultural operations, especially vineyards. The objective of this project is to determine how viticulturalists in Paso Robles, California view global climate change and how they use conservation practices that combat climate change and prepare for the associated negative effects. Interviews were conducted with vineyard advisors and managers to determine what general risks associated with wine grape production exist for their operations, and whether wine advisors and producers perceive global climate change to be one of those risks. The interview responses were then coded and after twenty interviews were conducted, the coded responses were compiled to determine trends and patterns. Qualitative analysis revealed that while nearly all wine advisors and producers perceived global climate change to be a risk to their operations, long-term planning and adoption of practices was limited due to the year-to-year nature of vineyard operations, meaning that most vineyards may not be prepared for negative impacts in the future.

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CHAPTER 1: INTRODUCTION

Global climate change poses threats to grape production. With increases in average temperatures, grapes mature at different rates, experiencing differences that effect production yield and quality of wine (Orduna 2010). In 2019 in California, wine grapes were the third most valuable agricultural commodity behind dairy and almonds, with the wine crush totaling \$3.2 billion (CDFA 2020). Although yields are projected to decrease by only about 10% by the year 2100 (Pathak, et al. 2018), impact on grape quality will be more severe. As projected heat waves increase in length and temperature and growing season shifts, the ripening potential changes beyond a threshold for most of the currently grown varieties (Jones, et al. 2005). This is particularly important because grapes reach maturity quicker as a result, and with an increased amount of days with higher temperatures, more sugars are produced and acidity of wine grapes increases, causing differences in grape and wine flavor (Orduna, 2010).

With these changes occurring over the next few decades, awareness of and adaptations to these changes must be adopted to maintain the industry. Agriculturalists in other industries and geographic regions may not necessarily believe in global climate change, for example wheat farmers in Indiana and Nebraska (Church, et al. 2018). When asked about whether or not they agree that climate change has been scientifically proven, only 36% of farmer responses in North Carolina, and about 25% of farmer responses in Texas, Mississippi, and Wisconsin affirmed that belief (Rejesus, 2013). Additionally, a belief in the severity of effects on their own farms drove farmers in the Corn Belt, the midwestern states such as Wisconsin, Minnesota, Iowa, etc., to respond that they would change practices in response to the projected effects (Roesch-McNally, et al. 2016).

It is expected that vineyard advisors and producers are more likely to believe that climate change is a major risk to their operations (Nicholas and Durham, 2012). In a study of Canadian wine growers, 97% recognized the effect human activities have on climate change, 92% recognized that climate change will effect their operations, and 76% believed there were some negative effects related to climate change (Poirier, et al. 2018). Because of the effect heat and water shortages have on grape vines, vineyard managers and advisors are also more aware of the specific climate change related effects, and perceive them to be a greater threat than other industries (Belliveau, et al. 2006). Winegrowers in France, Germany, and Italy indicated that climate change has not only impacted wine quality, but has also increased threats associated with climate change (Battaglini et al. 2008). However, although these viticulturalists are aware the effects climate change will have on their operations, managers and advisors respond with reactive practices or short-term anticipatory practices, illustrating that short-term maintenance of the vineyard was of higher priority than long-term practices used to prevent or prepare for climate change effects (Nicholas and Durham, 2012). It is important to note that vineyards in California form social networks, and that these social networks if utilized correctly can drive regional adoption of practices that will combat climate change and its effects (Levy and Lubell, 2017).

Long term adaptive practices that viticulturalists utilize include cover crops that cause a cooling effect through the development of canopy microclimates (Nazralla, 2007) as well as decreased erosion and runoff, and increased water retention (Agam, et al. 2019), reduction in water use through drip irrigation (Keller, 2010) and strategic timing, like deficit irrigation in which water is withheld from vines in order to reduce growth and

nutritional or water needs (Keller, 2005), and the reduction, or even abandonment, of tillage which reduces the use of fossil fuels and decreases soil compaction, allowing for greater infiltration of water (Hobbs, et al. 2008). Short term adaptive practices include picking grapes early before heat can destroy the crop and adjusting the chemistry of those fruits in the winery, the spraying of kaolin clay compounds to act as a shield against the sun, manipulating growth of the vines so that leaf growth may shield grapes from the sun, and using evaporative cooling by spraying water on vines that the sun will evaporate, reducing the temperature of the plants (Nicholas and Durham, 2012).

The Paso Robles AVA represents one of the largest viticultural regions in California at 615,000 total acres (Wine Institute, 2019) and generated a total of \$636 million in total wine income (Matthews and Medellin-Azuara, 2016). The Paso Robles AVA is an area of about 614,000 acres in Northern San Luis Obispo County, with approximately 40,000 growing acres as of 2015 (Matthews and Medellin-Azuara 2016). There were over 200 wineries in the Paso Robles AVA in 2016, with 95% owned by families and small businesses according to the same report. According to the 2018 San Luis Obispo County Agricultural Commissioner's Office annual report, grape varieties include Cabernet Sauvignon (84,741 tons), Merlot (16,496 tons), Chardonnay (15,313 tons), Syrah (10,874 tons), Sauvignon Blanc (7,408), Zinfandel (6,822 tons), Pinot Noir (6,728), and other red and white varieties totaling 22,336 tons and 6,284 tons respectively for a gross value of \$276,002,000, third in 2018 behind Napa County and Sonoma County respectively (Izquierdo, 2018) (Linegar, 2018). The Paso Robles AVA was chosen for this project because of the immense value vineyards and wineries provide to San Luis Obispo County

and the State of California, and due to its proximity to California Polytechnic State University, San Luis Obispo.

One major issue facing the Paso Robles AVA and the wine industry in general is the oversupply market (MacMillan, 2020). The demand for wines are decreasing in the United States, and at the same time more vineyards and wineries are being established which leads to an accumulation of unused grapes and lost profit (MacMillan, 2020). This oversupply is a factor in the continued consolidation of wine distributors in the United States; in 1995 the US was home to about 1800 wineries and 3000 distributors, but as of 2017 those numbers have shifted dramatically to 9200 wineries and 1200 distributors (Adams, 2017). With a bigger economic burden as a result of market oversupply, smaller vineyards and wineries might be looking to sell to larger ones, continuing the trend of consolidation.

The overall research goal of this project is to determine whether viticulturalists in the Paso Robles AVA believe global climate change to be a serious risk for their operations, and what, if any, adaptations they have or will adopt in order to mitigate the negative effects. Additionally this project aimed to fill a knowledge gap that exists regarding thoughts and motivations of vineyard advisors and producers. Cal-Adapt, a free climatic projection service available online that has projections regarding a wide range of topics discussed later in the methodology, was used to illustrate the effects these vineyards may face in order to solicit deeper responses about practice adoption. Cal-Adapt was chosen because it is free and easily accessible, and was developed by the State of California with reliable data compiled by multiple California universities and state agencies. The project goal was achieved by interviewing vineyard advisors and producers in the Paso Robles

AVA. These interviews will provide a deeper understanding of the thoughts and motivations of the entire region and beyond, allowing local and state agencies to better communicate and work with these vineyards to combat global climate change and prepare for its negative effects. Another goal of this study was to help prepare a survey that will be based upon a representative sample, although that survey has not been completed during the scope of this project. Additionally, this study can be applied to other industries, allowing for California and the United States in general to prepare the entire agricultural sector for global climate change.

CHAPTER 2: METHODOLOGY

The personnel involved in this project included Dr. Nicholas Babin and two graduate students, Diego Rivera and Jazlyn Guerrero. The project was initiated by gathering a database of contacts affiliated with local viticulture in the Paso Robles AVA. A list of three vineyard managers and three vineyard advisors was compiled in consultation with a local grape grower organization and were the initial subjects of the project sample, with further subjects recruited through the snowball, or chain-referral, method of sampling (Schutt, 2015). This means that at the end of each subjects interview, they were asked for a contact they believed would be a good subject for an interview, usually a neighboring vineyard's advisor or producer, or a local vineyard that the previous subject is familiar with. This sampling was chosen instead of a more randomized sample because compiling a short list of contacts was already difficult, and rather than prolonging the study by attempting to identify a statistically significant amount of potential interviewees who may not agree to speak with the project members, this method allowed for easier contact accumulation. This sampling method also made the chances higher that the interview subjects would be willing to speak due to the network that was developed, utilizing social capital gained from interviewing someone in their own personal network. The drawbacks of the sampling method, however, is that by tapping into a group of people who know each other and may be very similar to each other, there is bias. This bias is addressed through the idea of saturation, or interviewing until no new responses arise during the interviews (Prokopy, 2011).

This resulted in twenty total interviews, nine were advisors and eleven were producers. As mentioned earlier, there are approximately 200 wineries in the Paso Robles

AVA, which means 10% of the wineries were represented in this project. Advisors included cooperative extension advisors, irrigation and pest control consultants, university researchers, and grower organization representatives. Producers were either owner-operators, estate employees or management company employees. Interviews were conducted at the subjects' places of work after reaching out through email to set an interview date and time, and to obtain an address to be used for personalized temperature and rainfall projections using the free online projection service developed by the State of California, Cal-Adapt, although the managers and advisors were not made aware that these projections were to be created. All interviews were conducted between May and November of 2019. Before interviewing subjects, the interviewer asked if the subject consented to be being recorded, to which each subject agreed.

The interviews assessed what risks vineyard managers and advisors perceived to be the greatest threat to their vineyard operations in the short-term (1-2 years) and long-term (3-10 years) future. Then the perceived risk of global climate change to their operation was discussed, preventing bias by initially asking about risks in general and not mentioning climate change in this line of questioning, then starting a new line of questioning directly addressing climate change once the conversation about general risks was completed (Church, et al. 2018). After questioning about general and climate change risks, the created projections were displayed to the interviewee and a summary of the projections was given by the interviewer.

The personalized projections were created for each vineyard at a 6 km by 6 km resolution and included two emissions scenarios, RCP 4.5 which presumes emissions peak in 2040 then decline and RCP 8.5 which presumes emissions rise strongly through 2050

and plateau around 2100 (CAL-ADAPT, 2020). The projections included historic hottest day of the year, historic precipitation amount and frequency, historic annual maximum and minimum average temperatures, historic heat wave length and frequency, and historic amount of days over 100 degrees Fahrenheit. These same parameters were also projected for the time periods of 2020-2040 and 2040-2070 to illustrate approximately one century's worth of change. After displaying and summarizing these projections, interviewees were asked for their general thoughts about them, how they might adjust their practices according to the projections, and how the projection tools might be improved for future use.

After completing each interview, the audio recording was sent to a transcription service and each interview lasted between one and two hours. Each interview was anonymized by removing the name of the interviewee, and replacing it with a random number. Before analyzing the transcripts, a code book was developed. One interview was selected to be coded individually by each member of the project independently of each other, with a list of themes developed by the group of researchers to serve as a preliminary code book. This interview was then uploaded into the interview coding software NVIVO Version 12 (QSR International, 2019). After coding the interview, of which there was 80% agreement between each interviewer, the interviewers consulted with each other to further refine and develop the code book. After a second round of coding and an improvement to 95% coding agreement, the code book was accepted because it surpassed a 90% coding agreement which is considered "acceptable to all" (Mouter and Vonk, 2012) and was used to code the other nineteen interviews. See Table 1 for the coding framework that was developed for this project. One student researcher coded all eleven producer interviews,

while another student researcher coded all nine advisor interviews to maintain consistency throughout each set of interviews.

Table 1. Coding framework

| Risks (short and long-term) | Climate Change Risks | Downscaled Projections | Climate Change Risk Management |
|--|---|---|--|
| Labor Water Market Regulations Disease or pests Input costs Climate or weather | Water availability Extreme heat Growing degree change Erosion Grape Quality Pests Phenology Yields Frosts | Overall response Risks/adaptations Improvements | Current practices to reduce risk Potential practices to reduce risk <ol style="list-style-type: none"> 1. Short term farming and winemaking adaptations 2. Long-term diversification and vineyard design adaptations |

With all interviews coded and responses divided into specific categories based on the coding framework, basic statistical analysis was performed. A summary of basic demographic data was developed, and the percentage of each group that responded with specific short-term, long-term, and climate change associated risks was calculated. The percentage of each group that responded with practices that have been adopted or will be adopted in the future was also calculated. Because the list of potential practices included a large amount of practices mentioned by only one interviewee, the calculation included the most widespread practices, while examples of novel practices were given without calculation. Quotes were chosen from interviews and included with the data because they best expressed how managers and advisors thought about specific risks or practice.

CHAPTER 3: RESULTS

Demographics

Of the 20 subjects interviewed, nine were advisors to wineries (GA) and eleven were producers (GP). Of the nine advisors, the average age was about 44 (two did not provide their age) and 66% of the advisors held either a Master of Science degree or a doctoral degree (one did not provide their highest level of education). Of the eleven producers, the average age was 51 (two producers did not provide their ages) and seven of the producers held either a Bachelor of Arts or Science (two producers did not provide their highest level of education). To maintain anonymity for advisors and producers, they were not asked for their names or gender. Quotes below are labeled with which advisor or producer said that quote, GM stands for grape manager, and GA stands for grape advisor. The number following the abbreviation indicates a random number assigned to the manager or advisor.

Unprompted Risk Perception

Climate and weather volatility (specifically any changes in temperature or rainfall) as a short-term risk were mentioned by 27% of managers and 44% of advisors (see Table 4). The most pressing general short-term risk to wineries according to managers interviewed was labor, mentioned by 64% of the managers interviewed. This included how many laborers are available for hire and how much it would cost to hire laborers.

“But we’re seeing labor increases of 10% every year. Anywhere from a third to half of your vineyard cost outlays are in labor-related categories. So in terms of

your farming costs, labor plays that very out or a very heavy weight on what's happening and with mandated, not just wages, but ag is changing labor hour requirements.” GM6

Following closely were market oversupply, or a saturation of Paso Robles grown varietals driving prices down, and diseases and/or pests. Water supply was the most prominent short-term issue facing wineries by 78% of advisors.

“...but with dry farm grapes, if it's not raining, we've got to turn the water on. So now we're using something that wasn't being used in the past. We're depleting a resource. And so, basically, the water table in Paso dropped about 70 feet...”

GA4

Water supply includes access to groundwater and how neighbors and wineries in the same watershed will share the limited resource. As with managers, market oversupply was a close second.

Table 2. Short-term (1-2 years) unprompted risk perception.

| <i>Risk</i> | <i>Manager (N=11)</i> | <i>Advisor (N=9)</i> |
|----------------------------|------------------------------|-----------------------------|
| Labor | 7 (64%) | 4 (44%) |
| Market oversupply | 6 (55%) | 6 (67%) |
| Diseases/pests | 6 (55%) | 3 (33%) |
| Water supply | 5 (45%) | 7 (78%) |
| Regulations | 4 (36%) | 4 (44%) |
| Climate/weather volatility | 3 (27%) | 4 (44%) |

When asked about long-term risks, again only 27% of managers mentioned climate and weather volatility. However, climate volatility was perceived by advisors to be the most pressing long-term risk, mentioned by 56% of advisors, with water supply coming in a close second.

“...when I first started, nobody would give climate change much credence. Now I find even amongst the farmers here locally, they're saying wow, things are getting really hot. We've had a number of very hot-- severe hot spells during our summers, that didn't seem to happen in the past.” GA7

The most pressing long-term issue to managers was water supply with regulations following closely behind. Regulations encapsulates how wineries are to use their limited water supply with respect to state and local laws, including local Resource Conservation Districts and local Regional Water Quality Control Boards.

“The regulatory climate is scary. And water is a big problem. I mean, those two are tied together... So many of the different areas we farm in are in the throes of water. Water battle is maybe not right, but figuring out how to manage water as a resource.” GM11

Table 3. Long-term (3-10 years) unprompted risk perception.

| <i>Risk</i> | <i>Manager (N=11)</i> | <i>Advisor (N=9)</i> |
|----------------------------|-----------------------|----------------------|
| Labor | 3 (27%) | 3 (33%) |
| Market oversupply | 1 (9%) | 3 (33%) |
| Diseases/pests | 4 (36%) | 1 (11%) |
| Water supply | 6 (55%) | 4 (44%) |
| Regulations | 5 (45%) | 3 (33%) |
| Climate/weather volatility | 3 (27%) | 5 (56%) |

Specific Climate Risk

There was universal acknowledgement by vineyard managers and advisors that the climate is changing and that it would have impacts on wine grape growing. An overwhelming majority of managers and advisors identified extreme heat events and water availability as the most significant risks associated with climate change. Extreme heat events encompass not just an increase in average temperatures, but an increase in the amount of heat waves during a year and the length of those heat waves as well. Water availability encompasses the fact that as plants become stressed due to extreme heat events, watering is used as a defense against heat damage. Managers and advisors were also aware that with climate change, rain events become more concentrated. While average rainfall is expected to remain constant, climatologists anticipate larger storms that occur less often, causing farmers to rely more on groundwater to irrigate in the dry

spells between storms. Advisors also perceived pests to be a significant risk associated with climate change.

Table 4. Climate change risks.

| <i>Risk</i> | <i>Manager (N=11)</i> | <i>Advisor (N=9)</i> |
|---------------------|-----------------------|----------------------|
| Extreme heat events | 9 (82%) | 8 (89%) |
| Water availability | 8 (73%) | 8 (89%) |
| Seasonal shifts | 4 (36%) | 5 (56%) |
| Frosts | 4 (36%) | 2 (22%) |
| Pests | 0 (0%) | 7 (78%) |

Adopted Practices

When asked about practices adopted to mitigate negative effects that may arise from future climate change, there were three categories that saw nearly universal agreement on adoption. Every manager, and 78% of advisors mentioned that cover crops were not only being used in the operation they work for, but that nearly every operation they have encountered or are aware of has also adopted usage of cover crops.

“We’ve got cover crop. We’ve got growth on every place it will grow, it all dies in the summer but it all comes back in the winter.” GM4

Reduced or no tillage as a practice was mentioned by 82% of managers and 89% of advisors. The standard practice is to till between every growing season, requiring the use of large farming vehicles that increase cost, emissions, and compact soil. Reduced or no tillage means that vineyard managers and advisors either till sparingly where needed, for

example to kill and incorporate cover crops into the soil prior to growing season and after rain has ceased, or do not till at all.

“Our goal is to implement a no tillage system...But I think you have to every now and then, just to kind of even out the ground and with the rodents and the squirrels, and if you're working ground year after year and all those bumps and things like that. But the goal is to till as little as possible, disturb the soil as little as possible.” GM1

Water management, which involves adopting new forms of irrigation, utilizing instruments that measure water use and flow, as well as reduction of water use, was mentioned by 82% of managers and 67% of advisors.

“4 years ago, we put in a SeFlow monitor and...coupled with a fair amount of pressure bomb, kind of double checking around and about...The net effect of all that is in 4 years, I've slowly weaned my vines...I'm watering them at least one-fourth of what I was watering them 5 years ago, and they're healthier now than they were 5 years ago...” GM10

Table 5. Adopted Practices

| <i>Practice</i> | <i>Manager (N=11)</i> | <i>Advisor (N=9)</i> |
|------------------------|------------------------------|-----------------------------|
| Cover Crops | 11 (100%) | 7 (78%) |
| Reduced/No Tillage | 9 (82%) | 8 (89%) |
| Water Management | 9 (82%) | 6 (67%) |

Novel Practices

While the three practice areas above were the most universally agreed upon, there were interviewees that mentioned novel practices that were tangentially related to the above, but are not widely adopted or were only mentioned by one interviewee. In regards to rising temperatures that will require vineyards to stop laborers from working in dangerous conditions, one manager said:

“Our company has not wanted to pick at night yet. But certainly, if we’re in a climate that it’s just too hot even in the morning to be picking, we’ll just do it at night.” GP9

One advisor discussed spray products that may protect plants from sunburn as temperatures are projected to rise, and heat waves are projected to last longer and occur more often.

“These kaolin clay sprays, one trade name is Surround, that people have tried, that we might see more of those being sprayed as sun protectants.” GA7

CHAPTER 4: DISCUSSION

The overall research goal of this project was to determine whether viticulturalists in the Paso Robles AVA believe global climate change to be a serious risk for their operations, and what, if any, adaptations they have implemented or plan to implement to mitigate the negative effects. While initially less than half of all interview subjects mentioned climate change as a serious short or long-term risk, 90% agreed that climate change is occurring and will have impacts on their operations. These advisors and managers also overwhelmingly agreed that those climate change effects will revolve around extreme heat events and water availability. However, although it was apparent that global climate change is of importance to these viticulturalists, it was not a high priority to managers and advisors to address climate change as quickly as possible. Managers and advisors were more occupied with the year-to-year operations of vineyards. While it is important to know what negative effects they might face in the future, it is hard allocating money and energy to preparing that far in advance when they are unsure of whether or not they will make enough money to survive the next year.

The practices that the advisors and managers did adopt or plan on adopting were mostly reactionary. Whether that is using instruments to measure soil moisture in the present, or as quoted in the results, the advisor who mentioned how their operation had discussed working laborers at night but had not yet adopted the practice, there is a lack of practices that have lasting long-term effects. These results are similar to horticulturalists and rice farmers in a study in Italy, in which these agriculturalists also focused on reactionary practices like following a daily weather forecast or managing water use, rather than long-term planning and infrastructure updates (Nguyen, et al. 2016).

Global Climate Change

Nearly all advisors and managers agreed that climate change is occurring, except for two who did not. However, due to a mixture of skepticism with regards to projections presented to interview subjects, and economic hardship, there was a lack of urgency in addressing climate change or the associated negative effects on vines and grape quality. The practices that are currently implemented by vineyards are implemented to address present issues that vineyards are facing, rather than preparing for future ones. For example, while many managers and advisors mentioned shade cloth as a way to defend against heat, the strategy was only employed by those currently facing heat issues because of the added cost, rather than installing shade cloth in preparation for increases over the next thirty years.

A seemingly universal thought for advisors and managers in the next few decades is the change in varietals grown, shifting to hardier varietals from areas like North Africa or Spain to withstand the increasing temperatures and shifting rain patterns. As the central coast faces higher temperatures, amount of days over 95 degrees, and longer heat wave lengths, winery advisors and managers are looking to arid regions around the world (such as Spain and Tunisia) for hardier wines that have grown well in those regions. However, another problem crops up because of this shift. Managers and advisors spoke to the fact that although these grapes will perform better, the grapes they are currently growing (Cabernet Sauvignon, Chardonnay, etc.) already have a firm foothold in the consumer market. With new varieties from different parts of the world, marketing and establishing a foothold becomes increasingly difficult, and failing to do so would mean a failing vineyard.

Economic Hardship

Two of the most mentioned short-term risks by advisors and managers were labor and market oversupply. Labor availability is a constant concern to winery advisors and managers, specifically laborers who are skilled enough to perform work that the advisors and managers perceive to be high quality. However, because of this scarcity of skilled labor, labor expenses then become a big issue. Most wineries use contracted labor, and these crews of contract laborers work multiple properties contributing to the scarcity, but because they are in high demand, and some wineries may be willing to pay more money to maintain continuity of skilled labor, other vineyards might become priced out and lose not just the skilled laborers they prefer, but productivity as well. Vineyard managers and advisors also mentioned that immigration policies regarding legal and illegal Mexican immigrants have caused a decrease in available laborers.

In addition to the uncertainty of labor availability, there is a state of market oversupply that smaller vineyards are currently in. Essentially, so many grapes of the same varieties are being produced that the supply is far outpacing the decreasing demand (McMillan, 2020). Because of this, grapes sit unused in the creation of wine due to decreasing prices which greatly reduces the profit margin for wineries. Lastly, because the wineries located in the Paso Robles AVA are a majority family-owned or small businesses, this oversupply and decreasing availability hits the local wineries much harder than large-scale industrial operations that have money to navigate through these crises, putting a much greater burden on local wineries.

With the combined effect of increased labor costs and decrease in profit margin, there is a much greater economic burden placed on smaller scale wineries and vineyards. This is a major issue because in the United States, there has been a strong trend of winery consolidation where larger operations buy out smaller ones, increasing the amount of acres harvested by a decreasing amount of companies (Adams, 2017). This is increasingly important because larger companies hold more power over the industry as a whole, allowing larger companies to control the prices and reduce competition from smaller wineries and vineyards, effectively starving them until they can take control of their assets (Adams, 2017).

Shortcomings

While the sampling method, the snowball method, was followed until there were no new responses from interviewees, the sample number was small at 20. More interviews may have been conducted, allowing for greater statistical significance, and a larger body of data. Because the interview process required travel to and from vineyards throughout San Luis Obispo County, travel distance and time was a major limiting factor in the amount of interviews conducted in a specific area. If travel was not a limit, this study can be expanded to include more of California's wine growing regions, like Sonoma or Napa Valley to be more representative of the entire state.

CHAPTER 5: CONCLUSION

While viticulturalists are aware of climate change and the effects it may have, long-term planning is generally not being undertaken to mitigate those effects. This comes as a result of systemic issues like economic hardship and the consolidation of the wine industry, but also as a result of an industry that is extremely preoccupied with year-to-year issues that must be addressed. This project will be expanded upon with the development of a survey that will be sent to a representative population to gain a better detailed and more nuanced body of data that will explain viticulturalist perceptions of climate change as well as the practices and even willingness to adopt them to combat climate change. This survey will also determine the prevalence of the experiences discussed in this project on a broader scale. However, wine is not the only major crop that will be affected in California and the rest of the United States.

This project can be adapted to other specific crops in California and the United States, to give a fuller idea of how all agriculturalists think with regards to climate change. In addition to other sectors, other geographical regions can be studied to determine if location influences perceptions and practice adoption. Lastly, this project can be expanded on by collecting more data from the population that was used in this project through the creation of the survey. The interview responses and themes can be used to shape a line of questioning that can be sent to a larger number of people with more ease, allowing a more statistically significant look at perceptions and adoption practice.

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