Water conservation decision-making by producers on the Ogallala Aquifer

by

Rebekah Carnes

B.A., University of Kansas, 2007
M.S., Kansas State University, 2013

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Sociology, Anthropology, and Social Work
College of Arts and Sciences

KANSAS STATE UNIVERSITY
Manhattan, Kansas

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Abstract

This study investigates the roles of values, beliefs, and norms in water conservation decisions made by producers on the Ogallala Aquifer, in order to better understand the motivating factors that could lead toward environmental sustainability in this region of groundwater depletion. I focus on an over-arching question: how do farmers make decisions regarding water conservation? This question is broken into two specific sub-questions. First, how does culture affect decision-making? How do farmers' beliefs, values, political ideologies, and education influence their concern for the environment, measured by the extent to which they elevate guiding principles such as "respecting the earth, harmony with other species, protecting the environment, preserving nature, unity with nature, and fitting in with nature"? Secondly, how does the climate, and potentially climate change, affect the attitudes that prompt and justify decisions? This research relies on data from the 2019 Ogallala Producer Survey, and Climate data from the USGS in corresponding counties, and examines these questions through a series of regression models.

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Chapter 1 - Introduction

The Ogallala Aquifer is the underground geological, mineral, topographic, and biological foundation of several above-ground ecosystems that have been considered sacred and supported Great Plains people for centuries. Landscapes that supported hunting, fishing, and livelihoods, were formed by the sedimentary rock layers in which the aquifer is embedded, and the water itself, shaped the chemical composition of and the moisture available to the soil at the surface (Assal, Melcher, and Carr 2015). The "largest underground body of freshwater in the United States" is unique among water sources in its formation by glacial melts from the Rocky Mountains that settled through layers of sediment hundreds of feet below the surface, and in its distance from groundwater systems in time and space, earning it the distinction of non-renewable "fossil water" (Opie 2018:1). "Unlike most of the world's water supplies, Ogallala groundwater is largely nonrenewable because its sources were cut off thousands of years ago" when glacial melt slowed and diverted into aboveground river systems like the Pecos and Rio Grande (p.3). Before it was accessed by deep-well pumps, more than 3 billion acre-feet was deposited, and slowly trickled in a southeasterly direction through 150-300-foot-thick gravel beds, 50-300 feet below the surface. It supported aboveground ecosystems through the layers of igneous and metamorphic rock in the Front Range, alluvial and glacial deposits in eastern Colorado, and eolian sediments with discontinuous colluvial material in portions of Kansas, Oklahoma, and Texas. Although layers of sedimentary rock and bedrock stood between the aquifer and the surface water, in places, it played an important role in forming the geology, and in-turn soil development, topography, biology, and ecology of the surface (Assal, Melcher, and Carr 2015). Still the underground reserves remained in relative equilibrium until intensive pumping and irrigation began after World War II. "About one billion acre-feet of Ogallala water were consumed by irrigation farmers between 1960 and 1990, mostly in southwest Kansas, the Oklahoma panhandle, and west Texas" (Opie 2018:3). Now it is a threatened resource upon which much of the agriculture production of middle America depends.

The Aquifer, along with the town of Ogallala, Nebraska are named after the Oglala band of the Lakota First People. Along with two other branches of the Lakota and Sioux (though this is the official name, it is contested by some members as a Eurocentric name), the Oglala resided on the land supported by the Ogallala and Arikaree aquifers until the Fort Laramie Treaty of 1851 began the process of European encroachment on their territory, demand on the land, and subdivision of the Oglala people (Davis, Putnam, and LaBelle 2014). The original treaty severely restricted the land of the Lakota, Cheyenne, Arapaho, and several other indigenous people, to the sacred lands, or *Paha Sapa* (the Black Hills), which included nearly all of present-day South Dakota and Nebraska, as well as parts of Kansas, Wyoming, North Dakota, Montana, and Colorado- giving the Lakota (including the bands: Western Sioux, Teton Dakota, Oglala, Brule, Hunkpapa, Minneconjou, Sans Arc, and Two Kettles) sovereignty or ownership (Churchill 1988). As European settlers demanded more food, resources, and direct routes to gold and silver mines in Virginia City areas of the Montana territory, The Federal government broke the treaty several times. In 1851, they first entered open violation of the treaty by sending in troops to defend the construction of the Bozeman Trail, establishing a series of forts along its route through the northern territory. Under the leadership of Red Cloud, the Lakota joined military forces with the Cheyenne and Arapaho to mount attacks on the invasion between 1866-1867. In 1868, the U.S. had suffered many defeats and sued for peace, establishing a newer version of the treaty that promised the forts would be used to protect Lakota land from encroachment in exchange for peaceful removal of many of the troops. The new treaty severely restricted the sovereign land to the "Great Sioux Reservation" and left the Lakota with only access, not ownership of "unceded Indian territory". This left a major loophole that was exploited after a Priest, Jean de Smet, trespassed on the Black Hills and reported that he had discovered gold. This prompted the commission of Custer's 7th Calvary to deploy into the Black Hills to confirm the report in violation of both treaties. When gold was confirmed in the sacred center of the Lakota territory, the U.S. tried to purchase the territory. The Lakota refused, and the U.S. officially shifted tactics, allowing the Department of War to take over from the Bureau of Indian Affairs. President Grant secretly commanded the army to disregard its directives under the treaty to prevent invasion, and instead treat all Lakota defenders as "hostiles". The "Great Sioux War" ensued. The Lakota withdrew to the Powder River, in southeastern Montana, and reconvened a collective army under the leadership of Crazy Horse. The U.S. launched a three-pronged attack, all of which were sent into defeat in 1876 in the valley of the Little Big Horn. At the point of defeat, the U.S. army sent in Col. McKenzie, under a "total war" directive that gave the army permission to shift tactics from fighting the alliance of indigenous soldiers to genocide- targeting women, children, and elderly people in isolated villages (Brown 1970). In 1877, Sitting Bull and Gall retreated with their followers to Canada, while the rest of the Lakota leaders surrendered. Through a combination of genocide, a massacre at Wounded Knee, the passage of bills that slowly eroded sovereignty over sections of land, a declaration of a "state of emergency" that further justified violence and theft, economic assaults, and the assassination of Sitting Bull, the U.S. displaced the Oglala people several times in the 1870s before establishing the Pine Ridge Reservation in South Dakota in 1878 (Oglala Lakota Nation 2019). Still, the people's sovereignty continued to be weakened by the 1920s and 1930s Indian Citizenship and Indian Reorganization Acts. The Lakota responded by suing the U.S. under the terms of their own laws, but the legal battle was stalled for 19 years in the courts. It was appealed and is ongoing. The American Indian Movement (AIM) also worked to block the continual attempts to transfer the remaining land (only about 10% of the original size) to the U.S. Park Service and to access by private corporate ownership. After the Bradley Bill in the 1980s, the Lakota were able to reclaim some mineral and water rights in their own territories and claim $122.5 million in compensation for lost resources but would not receive compensation for the billions of dollars in resources and land lost (Churchill 1868).

Handed over the mostly European settlers, the land above the Ogallala was transformed through the industrialization of agriculture and the onset of the “treadmill of production” that required intensive irrigation to support a growing global grain-livestock complex (Sanderson and Hughes 2018). Without the intensive level of human intervention brought on through the industrialization of agriculture and large-scale pumping, the “natural” state of this 10,000 square mile geological formation underlying eight states of the American High Plains would remain in relative equilibrium: the natural discharge of water to sustain the tallgrass prairies, shortgrass prairies, shrub steppe and other ecosystems would roughly equal the natural recharge through rainwater, runoff, etc. (Guru and Horne 2001). Imagining the Ogallala in its “natural” state, is of course, problematic, as human intervention shapes most of the earth’s “natural” surface and humans, themselves, are part of the constructing force of “anthropogenic biomes,” including the cropland and rangeland of the Ogallala (Freudenburg, Frickel, and Gramling 1995; Cronon 1995; Ellis and Ramankutty 2008). We are, essentially, a part of the ecology. Ecology shapes us and we shape it in physical, social, and conceptual ways. We are a part of the food chain. Every species holds a niche in controlling and sustaining the population dynamics of other plants and animals, by consuming resources, building habitats, creating waste, etc. and humans are no different. We are physically part of an elaborate socio-ecological system (Carolan 2005). We are also conceptually part of an elaborate socio-ecological system. How water is perceived shapes our social organizations and vice versa (Humphrey and Buttel 1982). For example, the perception that water needs to be managed changes how organizations are structured around it. Different social relations create different shapes, uses, commodification, access, rights, and appreciation for water. At the same time, the physical properties of water structure (and sometimes disrupt) social relations, as is the case where socioeconomic class and race divides resources for flood or hurricane recovery (Linton and Budds 2014). Therefore, the human disruption in equilibrium through activities like pumping from wells, "surface-water diversions for irrigation and hydroelectric power generation, and cultivation and grazing practices" are a part of the current ecology and the social construction of the aquifer itself (Guru and Horne 2001:321).

Post-World War II Irrigation in the Ogallala

Although wide-spread farming, and the introduction of mono-cropping began on the Great Plains as early as the 1880s, intermittent droughts made farming risky. The Dust Bowl of the 1930s illustrates this point. Irrigation in this area began when irrigation technology became cheap and widely available after World War II. Irrigation, first generated by windmills attached to small wells, and now by over 150,000 natural gas-powered pumps that feed center-pivot irrigation systems, transformed a landscape that might have been considered precarious into the breadbasket of the world, and enabled the prosperity of corn, milo, wheat, and alfalfa (Opie 2018). The rapid development of irrigation technology allowed farmers who were previously on less productive land to outproduce corn and sorghum growers in much more productive regions of Iowa and California. The Ogallala region went from irrigating about 3.5 million acres in 1950 to about 16 million acres in the early 2000s. Beginning in the1990s, irrigation has been depleting the aquifer at a rate ten times higher than the rate that it can naturally recharge (Guru and Horne 2001). As of the 1990s, the High Plains represented about 20% of the irrigated land in the U.S. 30% of the groundwater used for irrigation in the U.S. is withdrawn from the Ogallala aquifer (Dugan and Cox 1996). Use of the underground water increased land values and crop production by decreasing the strain of droughts. At the same time, farmers began growing irrigation-dependent crops. The rising cost of equipment and land made farmers dependent on loans that further drove the need for high yields. Compounding this issue, government subsidies that were intended to help farmers meet demand even when market prices were not worth the effort of planting, incentivized the overproduction of surplus crops that require more intensive irrigation (Opie 2018). Each of these structural changes prompted a shift in agricultural norms and prevented any resistance to the new norms. These patterns of production represent a new fragility and dependence on a renewable water-source that surrounding production patterns, which adhere to an older, pre-World War II drought resistance model, do not. Thus, producers are more dependent on the groundwater now that their crops are accustomed to irrigation, and not adapted to drought. Water reserves in the Ogallala are finite, in that they are not able to be renewed at the rate at which they are being depleted by this shift in agricultural norms (Hornbeck and Keskin 2014).

Irrigation and Shifting Cultural Norms

As a part of broader American culture, Agricultural norms among European-American settlers to the Great Plains were likely dominated by what Dunlap (2008) and others term the Dominant Social Paradigm (DSP). Reflected in the Declaration of Independence's conception of "life, liberty, and the pursuit of happiness," this paradigm stressed individualism, private property, progress, and growth, viewing the environment as a resource to be used and controlled in this striving for prosperity. This paradigm may have translated into norms that reflected a belief in the divine right to occupy, own, and subdue the land, making every effort to make it productive (Pirages and Ehrlich 1974). American capitalist ideals intensified after World War II, making the adoption of irrigation technology, and the tapping of the Ogallala for irrigation an obvious or normal choice for producers who now had access to technology that allowed this "progress" and who felt the pressure to produce more for a growing population, growing markets, rising government incentives, and new agricultural industrial norms that emphasized beef and feed production (Gould 2014). This cultural paradigm, combined with the memories of drought from the 1930s, and the fear of risk would have made the decision to adopt irrigation technology and practices obvious, emotional, and rational. Each element of the treadmill of production is governed by norms that embody this unquestioned, or obvious quality (Stern 2018).

However, fear of risk, social, financial, and institutional pressure to produce more are only part of the apparatus that sustains agricultural norms. Norms are also connected to and justified by identity (Dietz 2013). As the environmental movement emerged in the 1960s and 1970s, creating the New Ecological Paradigm (NEP), concerted efforts by industry backlashing against it worked to align the DSP with traditionalism, religion, American, and family values. These industry giants worked to reify agricultural norms, justifying them in terms of a noble drive to "feed the world" (Jacques, Dunlap, and Freeman 2008; Scanlan 2013). Thus, concerns about the depletion of the Ogallala aquifer can be pitted against practices and norms that seem integral to who people are as good farmers, Americans, Christians, etc. In this case, norms are important, not just because they affect decision-making, but because they reveal underlying values and beliefs that may change the outcome of norms. For example, if producers adopt more efficient technology that has the potential to decrease groundwater depletion, it may not be successful in doing that if they adopted it for the purpose of increasing production, not for conservation.

Culture of Agriculture

Despite being embedded in a global agricultural grain economy that incentivizes efficient inputs for ever-increasing outputs, and despite a protestant-ethic and spirit of capitalism ideology that measures success in terms of size and profit, not all farmers in the Midwest are motivated by optimizing their financial returns. In fact, many producers experience a tension in values between this outward measure of success and contrasting senses that community, independence, and quality of life are the ultimate goals. Salamon's (1985) study of corn belt farmers found significant cultural and land tenure pattern differences between recent-immigrant German farmers and more distant-immigrant "Yankees", which suggest that culture can be an intervening factor as farmers make adaptive decisions in similar ecological, environmental, and technological contexts. Although both groups are European-descendent immigrants to America, the Yeoman farming type (emphasizing generational ownership of a diversified farm on owned land, limited by the family's ability to work) remained distinct from the Entrepreneur type (emphasizing business goals and financial returns on expansion to rented land to efficiently utilize equipment, limited by capital), which might reflect the ability of culture to reproduce norms when a community is tightly kit, with a single ethnic origin versus the ability of culture to adapt new norms that form new types of community. Norms within the Yeoman tradition especially could be tied to family structure, such as relying on dairy- a labor intensive, but reliable commodity- in a family of boys, versus diversified crops, in a family of girls. Second and third generations inheriting land within this tradition led to increasing fragmentation within that community. By contrast, the entrepreneurial tradition quickly turned to monocropping commodity crops, and land tenure remained stable. In this example, cultural differences construct the environment differently. Conversely, the environment is known to construct culture.

One of the ways that environment helps to construct culture is through adaptations to environmental problems. The last two decades of drought in the Great Plains, Colorado River Basin, and across California have resulted in litigation, yet the water laws governing access to groundwater take permanent scarcity into consideration by incorporating permanent legal rights with annual precipitation variability (Griggs 2014). On the Ogallala, the "groundwater revolution" of the 1950s that first gave us access to the reserve, has changed the way that western water rights work (p.1265). Unlike surface water arrangements, the groundwater is not affected by annual precipitation variability, so it does not make sense to organize rights and ownership in the same way. Drought on the Ogallala is also different from surface water droughts in that the imbalance is a permanent disruption of the hydrological system. Western water rights built upon groundwater dynamics- ensuring the "imperative necessity" of the climate, hydrology, and topography, private land access, and public land access (p.1268). Building upon manifest destiny ideology, the "law of prior appropriation" made its way into the codes that governed who could access water during the Gold Rush, and European settlement periods, and was codified into state laws by the 1900s (p.1276). The Kansas Water Appropriation Act (KWAA) built on these arrangements but gave the chief engineer some oversight to prevent overdevelopment. After the groundwater revolution, the KWAA was amended in an attempt to regulate depletion in 1957 by only allowing pumping for economic necessity, which created a major loophole that defeated its purpose. In Colorado, the Ogallala was not considered a part of prior landowner's water rights, and instead was governed by well permits, that did not require a maintenance of a certain water level. In Nebraska, a major discrepancy exists between groundwater and surface water regulation so that owners of surface water may be affected by groundwater depletion. In all three states, as wells become depleted, property rights allow pumps to be consolidated. Therefore, problems of legal description, doctrine, and the regulatory uncertainty of property have changed the expectations of owners of western water rights who knew what they owned and what they could expect in the future based on that ownership investment before the groundwater revolution. Now, questions of access and ownership, coupled with disparate strategies to incorporate a newly accessed water source complicate efforts to regulate groundwater depletion.

Norms and Groundwater Depletion

Irrigation norms that emerged around 1950 with the prevalence of groundwater-based irrigation mark a stark shift in water-level changes in the aquifer from "predevelopment" to 2015. Irrigation norms did not just change once post development. They continue to change as irrigation technology improves, and as the agri-industrial system demands ever increasing production of surplus. Because of the self-perpetuating nature of norms, however, neither condition is required to maintain irrigation norms. As a result, the water level in the aquifer experienced 15.8 feet (on average, weighted by area) of decline between the 1940s and 2015 and a 0.6 feet decline just from 2013 to 2015. From pre-development to 2015, the aquifer lost 283.2 million acre-feet. 10.7 million acre-feet were lost just in the last two years. The total amount still stored in 2015 was only 2.91 billion acre-feet (McGuire 2017). The norms regarding irrigation are related to the rate of depletion, as they intensify together.

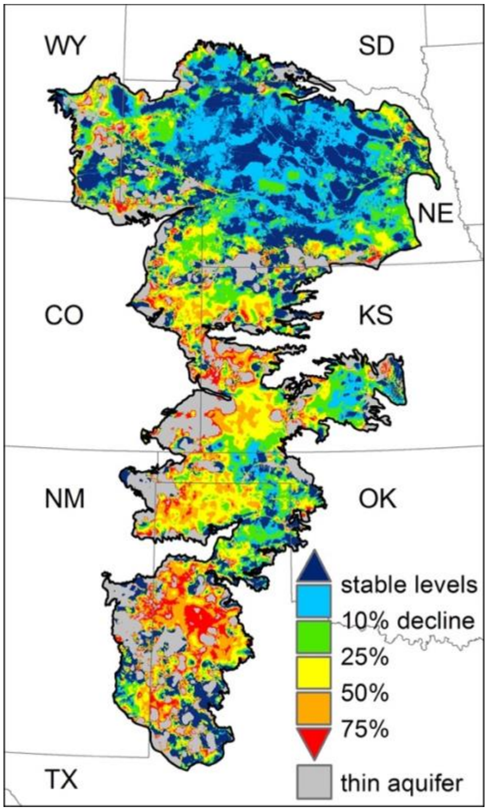

Figure 1. 2013 Water Levels in the Ogallala Aquifer (Cameron and Basso 2013)

Irrigation, as an agricultural norm, emerged out of overall intensification and productivity norms. Agricultural norms are integrally related to consumer, production, and market norms. The intensification of wheat, corn, and other grain crops for use in processed foods and animal feeds justified the manipulation of environments like the Great Plains that were not easy to cultivate. Early plains settlers were skilled, persistent, and driven by a cultural desire to produce more for the sustenance of a growing agricultural complex. Now these norms of innovation and persistence are embedded in an agricultural economic system that demands increasing production, and therefore increases the pressure to keep declining land in production. This production norm drove a new reality in which 10-15 square miles of land is thought to (at least indirectly) feed five thousand people. This was an enormous departure from the earlier hunters' relationships with the land where 10-15 square miles of land could support only one family.

Complicating this need for intensification is an agricultural system disconnected from food. While most soybeans in the world are consumed as food, Americans consume them indirectly through animal feed, sweets, packaged foods, thickeners, meet substitutes, paint, paper, textiles, and plastics (Opie 2018). All of this contributes to norms that intensify irrigation from the aquifer.

At the same time that the reserves in the aquifer are shrinking, agricultural runoff in the form of chemical and livestock waste contaminate the dwindling reservoirs (Opie 2018). This new reality makes the water considered suitable only for irrigation in the short-term, which uses 95% of the groundwater extracted from the Ogallala currently (Gowda et al. 2018). Increasing salination makes it already unsuitable, by EPA standards, for treatment for drinking, which affects non-farming and farming members of communities alike. The water quality will soon make it less suitable for irrigation as well as the concentration rises (Guru and Horne 2001).

The Role of Climate Change

Complicating this outlook, climate change will likely impact the sustainability of the use of the aquifer for irrigation purposes as the region will become warmer and drier. "The adoption of soil conservation methods and irrigation with Ogallala water improved soil health and reduced soil erosion while expanding the region's economy. However, major portions of the Ogallala Aquifer should now be considered a nonrenewable resource" (Gowda et al. 2018:10). Advances in precision irrigation, increases in drought tolerant crops, improved tools for weather-based irrigation scheduling, and other innovations should have led to a levelling off of the depletion of the aquifer and a return to equilibrium. However, the effects of climate change further exacerbate the problems that cause over-pumping as producers respond to droughts and dust storms that rival those experienced in the 1930s, not long after the turn of the century replacement of native grassland by cropland and rangeland (Gowda et al. 2018).

Under three projections of severity in average temperature increases, the Missouri and Arkansas basin are likely to lose their ability to recharge through runoff and lateral flow. The increasing incidence of flood and drought, and extreme cold and heat will also contribute to the rate of recharge (Rosenberg et al. 1999).

Across the Great Plains region, which already experiences extreme climate variability, climate change will result in rising temperatures which will add stress to limited water and energy supplies. Variability is one of the hallmarks of climate change. In this region, it will likely cause the landscape to become increasingly fragmented, changing the range and habitat of plants and animals. Increased CO2 levels may increase plant efficiency, but leave them nutrient-poor, affecting the nutrition and health of the animals that consume them (Gowda et al. 2018). While humans work toward innovation that will allow crops to survive out of their range, other species which depend on each other in a web of interconnectivity may be absent, further changing the soil quality or removing the predatory controls of pests. In this sense, aquifer depletion will be closely connected to a variety of other changes to entire ecosystems.

In the southern region of the aquifer dryer days and higher temperatures will increase surface evaporation and increase cooling demands with a diminished ability to transmit electricity in extreme temperatures (Ojima and Lackett 2002). “Changing extremes in precipitation are projected across all seasons, including higher likelihoods of both increasing heavy rain and snow events and more intense droughts” (Shafer et al. 2014:446). The northern region of the aquifer is likely to see increased erosion, decreased water quality, and devastating flood events as heavy winter and spring precipitation increase runoff and flooding of the major rivers and urban areas. Despite these concentrated precipitation events, in general, the increasing frequency of drought and per capital water shortages may turn marginal lands into deserts. These changing biomes are likely to affect the ecological landscapes of the entire region.

Climate change will alter crop growth cycles, lengthening growing season, but increasing the chances of freezing winter crops that leave dormancy earlier. "Rainfall events [mostly in winter] already have become more intense, increasing erosion and nutrient runoff, and projections are that the frequency and severity of these heavy rainfall events will increase" (Shafer et al. 2014:447). At the same time, summer increases in temperature will increase evapotranspiration, increasing the perceived need to irrigate.

Wildfire risks, rural to urban migration, and aging rural populations leave some populations more vulnerable than others as water resources get redirected toward urban areas and areas of concentrated wealth. "Populations such as the elderly, low-income, and non-native English speakers face heightened climate vulnerability. Public health resources, basic infrastructure, adequate housing, and effective communication systems are often lacking in communities that are geographically, politically, and economically isolated" (Shafer et al. 2014:451). The 70 tribal communities that are federally recognized in the Great Plains "are now constrained by physical and political boundaries" (p.451). As a result, First People experience compounded effects of climate change as the resources supported by the aquifer, and the surface water systems affected by it are depleted. Climate change decreases the natural resources on which they have always relied physically, in addition to ecosystems that hold cultural and ceremonial significance (Therrell and Trotter 2011). Already, they cope with diminished access to resources because of the broken treaty agreements that severely restricted their land, so further competition for resources affects them first and most intensely.

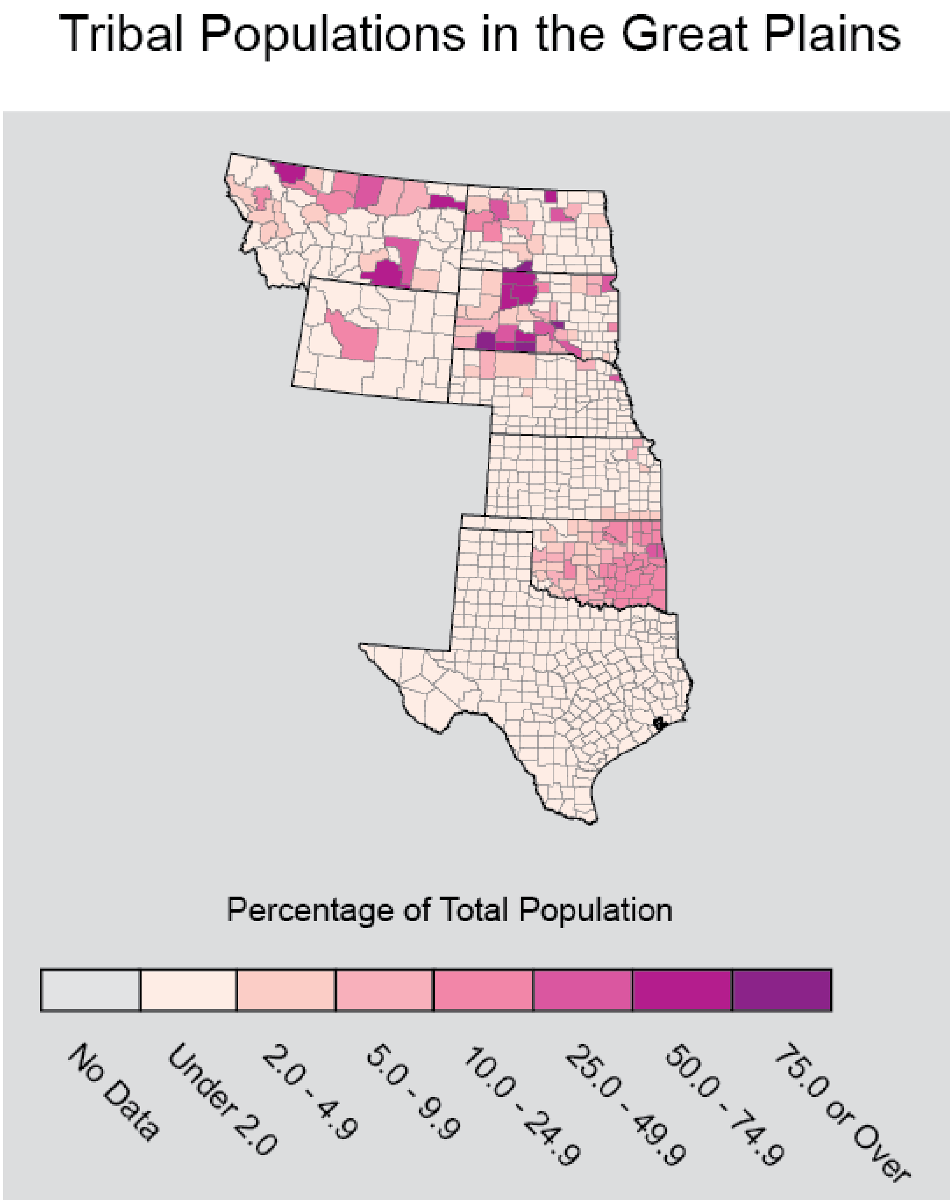

Figure 2. Osage, Sioux, Blackfeet, Crow, Lakota, Cherokee, Chickasaw, Choctaw, and many other tribes are concentrated near reservation lands and have less access to the aquifer (Source: reproduced from Atlas of the Great Plains by Stephen J. Lavin, Clark J. Archer, and Fred M. Shelley by permission of the University of Nebraska. Copyright 2011 by the Board of Regents of the University of Nebraska)

Policy Concerns on the Ogallala

Therefore, understanding how best to conserve is an important question for the future of this region, the people who depend on its production, and the ecosystems that surround and interact with the Ogallala. However, an understanding of the environmental needs must be translated into action in order to affect change. Commonly held resources tend to become overused if unregulated (Peterson, Marsh, and Williams 2003). Therefore, how individuals and lawmakers approach decision-making with regard to regulation or technological change is key to the effectiveness of any initiative. On the Ogallala in particular, survey data from 1966 and again in 1988 suggested that producers perceive drought in relation to the droughts they have experienced and responded to within their memory, and may be less concerned with depletion overall, or the trajectory towards a greater incidence of drought (Taylor, Stewart, and Downton 1988).

These questions matter at the state and federal level. “Debates in the 1970s focused on conserving the Ogallala for national and international food security. During the 2002 farm bill debate, the focus shifted to the regional impacts of federal policies through their effects on water use” (Peterson, Marsh, and Williams 2003:16). Congress instigated two assessments of the Ogallala in the 1970s, both aimed to resolve food security issues, but conducted alongside a series of U.S. Geological Survey studies on the hydroecology of the region: “the Regional Aquifer-System Analysis, which examined the hydrogeology of all the major aquifers in the U.S” and a cooperative assessment between private consultants and government agencies at the local, state, and federal level “to analyze the potential economic and social impacts of aquifer depletion and management options” (Guru and Horne 2001:323). Each of these actors held different interests in the outcome of the studies. While the state and local concerns centered on “the potential negative economic and demographic impacts of partial or total depletion of the aquifer,” the “increased pumping costs, due to both the increasing depth of water and the energy price shocks of the mid and late-1970s, as well as the potential social disruption due to the abandonment of irrigated farming in the region” elevated the social, food security, and agri-industrial concerns to national significance (p.323).

Now, the groundwater management districts (GMDs) are taking steps toward conservation, but conservation goals depend on the cooperation of the people who manage irrigation. In short, farmers are the key decision-makers; they ultimately make decisions to irrigate or not, to adopt more efficient technologies or not, etc. While the adoption of sustainable technologies is also an important piece of the conservation puzzle, it does not come without complications. “Improved irrigation systems may not reduce water use, particularly if irrigation runoff is recaptured and reused. In some cases, the rapid adoption of new irrigation systems has enabled High Plains irrigators to grow more water-intensive crops or to irrigate more land” (Huffaker and Whittlesey 1995:17). Pfeiffer and Lin (2014) found that even when state-led, subsidized programs led to behavioral change, so that farmers used a more efficient irrigation strategy, “the shift to more efficient irrigation technology increased groundwater extraction, in part due to shifting crop patterns” (p.189). It is possible that structural solutions in the form of changes to federal crop insurance categories could shift to encourage less irrigation; or wholesale precision agriculture technologies could enable decreased groundwater pumping (Basso, Kendall, and Hyndman 2013). However, since efficiency does not always translate into environmental restoration, it is important to understand how people value efficiency in relation to long-term resource use for their families, and in relation to their underlying beliefs and guiding principles related to family, environment, property, etc.

Water Conservation Decision-Making

Knowing that conservation of the Ogallala depends on the decision-making of producers, it is important to understand how decisions relate to environmentalism, efficiency, economics and other drivers and outcomes.

People are not rational decision-makers. We filter our cognition through mental shortcuts like availability and immediacy. We see patterns that do not exist. We prefer anecdotal stories over scientific evidence. We anchor what we learn to what we already know rather than elevating the more important information. We display biases towards norms that fit us into society more seamlessly, and we archive our memories according to these biases (Stern 2018). The non-rational brain plays such an important role in our decision-making, that it cannot be considered the opposite of the rational brain. Reason and emotion, at least, present contiguously with each other in what feels rational to us (Massey 2001). Considering this reality, our non-rational decision-making is worth considering, not as a barrier to overcome, but a part of being human and social that shapes us and our interactions with the environment.

There is great variety in the extent to which we can control how we decide to act as "bounded rationalists." Marx acknowledged that "men make their own history, but they do not make it just as they please; they do not make it under self-selected circumstances, but under circumstances existing already, given and transmitted from the past" (Marx 1852:329). Producers, therefore, can make their own decisions, rationally, but they can only do so within the structures of industrialized agriculture, the demands of the treadmill of production, and the new ecology created on the Great Plains by irrigation and global beef production. Furthermore, their rationality is constructed by culture- the identities formed of values and beliefs that make up attitudes that drive normative action.

When our identities are less threatened, our decision-making can be explained by theories of motivation, cognition and reasoning, but in long-standing emotional conflicts our actions can be better explained by theories of morals, intuitions, culture, and identity (Stern 2018:26). In many ways, producers' decisions may straddle this ambiguous divide of rationality. On the one hand, they are making business decisions where they have time to deliberate and intentionally attempt to be more "rational." On the other hand, environmental decisions are wrapped up in culture and conflated with certain religious and political identities in America.

For this reason, it is important to understand how decision-making works, and to what extent we act as bounded rationalists in our decisions to engage in conservation. If we can understand these processes, it will help us understand how to be effective in collective efforts toward social, and hopefully environmental change.

Decision-Making and Culture

The answers to these questions about water conservation decisions reflect deeper driving forces behind decision-making that may be rooted in identity and culture. Dunlap (2008) and Pirages and Ehrlich (1974) argue that American culture is dominated by a social paradigm centered around a commitment to individualism and laissez-faire government. Individualism includes belief in the American dream that considers individual merit and hard work the building blocks of a fair society. Laissez-faire government enables individuals to succeed without meddling in their ability to better their own circumstances. Both views make social structures taboo or invisible. They assume a fair and equal starting point for individual, and therefore social progress. "America's DSP [Dominant Social Paradigm] emphasized beliefs in progress, material abundance and the goodness of growth; faith in the efficacy of science and technology; and a view of nature as something to be subdued" (Dunlap 2008:5). However, this paradigm is changing and affected by many other cultural factors.

New Ecological Paradigm (NEP)

A New Ecological Paradigm, popularized by Muir, Carson, Marshall, and others in the 1960s directly opposed the DSP by emphasizing "the inseparability of human and nonhuman natures" (Pellow and Brehm 2013:229). American culture began to shift towards a narrative that recognized the role of power and social inequality in shaping the natural world, of which humans are a part. The NEP highlighted "the fragility of the biosphere and the extraordinary harm that human society has visited upon it through material extraction and industrial pollution," and formed the basis of an environmental movement (p.230). As a part of the movement deep ecology and social ecology saw humans as just one of many species in ecosystems and attempted to decentralize them (Gould 2014). Ecofeminism built on the idea of decentralizing humans (and what had become patriarchal power relations with the earth) under the basic premise "that the ideology which authorizes oppressions such as those based on race, class, gender, sexuality, physical abilities, and species is the same ideology which sanctions the oppression of nature" (Gaard 1993:240). However, the incorporation of this perspective posed threats to American capitalism. The NEP, was therefore, socially constructed, not as an opposing viewpoint, or a new perspective, but as a threat to a uniquely American way of life, something that encompassed tradition, faith, family, individualism, conservatism, and other key identities.

Dominant Social Paradigm (DSP)

The subsequent decades, following the emergence of the NEP produced a calculated political and corporate backlash aimed at discrediting science and appealing to an underlying cultural ideal of traditional values and conservatism through a narrative of doubt (Oreskes and

Conway 2010). Antienvironment attitudes (a resurgence of the DSP) were conflated with conservative values and institutionalized through deregulation in the Bush era. Antienvironment attitudes became powerful enough as a cultural identity to marginalize conversations about conservation, biodiversity, and climate change and vilify them as political issues (Jacques et al. 2008; Pope and Rauber 2004; Shulman 2006). By aligning environmentalism with a fringe identity, making it appear opposite to traditional values, conservativism, and the American dream, the DSP gained a powerful way to prevent people from changing their minds- to push the bounds of bounded rationality with regard to the environment. Now, when people consider environmental concerns, they may see the NEP as a threat to who they are at their core, and will therefore, react in defensive, self-preserving ways that reify their identities, rather than in calculated ways that consider facts and consequences alone (Stern 2018). Despite the historical ebb and flow of DSP and NEP beliefs, the ways they have come to express our values, and the backlash to new environmental realities by corporate interests, these belief paradigms both now influence American attitudes, sometimes in partisan ways.

Specific to this study, understanding how people make decisions about water conservation on the Ogallala may hinge on how DSP and NEP beliefs manifest in people's identities. They may decide to organize or not to organize, to irrigate or not to irrigate based on who they feel they are in relation to these cultural paradigms, even as they consider profits, family, future generations, responsibility, community, etc.

Values, Norms, and Environmental Decision-Making

This cultural backdrop constructs personal norms or "an individual's internal standards about what is right and wrong in a given situation" (Stern 2018:31). Under a given set of conditions, these norms can be activated for action, even when an action seemingly opposes an individual’s best interest (Schwartz 1997). In environmental decision-making, norm activation is usually predicated on a driving set of underlying values, which influence general environmental beliefs. Three values: self-interest, altruism toward humans, and altruism toward the biosphere have been reliably measured as influencers of environmental decision-making, often filtered through the lens of identity, beliefs, and norms (Dietz 2013).

Although relying on environmental values to develop an identity and make decisions out of that identity is a privilege reserved for those who have their most basic needs met, among those individuals, it can be a great predictor of decisions to support environmental conservation. Values as a component of identity can help explain phenomena such as support for climate policies (Dietz, Dan, and Shwom 2009), perceptions of environmental risk (Slimak and Dietz 2006), and support for wildland protections (Vaske and Donnelly 1999). It stands to reason that attitudes about water conservation on the Ogallala aquifer may also be driven, in large part, by values, whether those values are examined in deliberation processes, whether they shaped identity and worldview in covert ways, or whether they are drawn on to justify decisions long after the decisions have been made. Therefore, it is important to understand the historical and cultural contexts that constructed human relationships to water and the environment on the Ogallala. These historical and structural changes shaped the values, beliefs, and attitudes that lead to decisions and practices that become norms over time.

Chapter 2 - Literature Review

The following literature review outlines the human construction of nature and water within it, and proceeds to consider the ways that our understanding of our environment have been shaped by industrial and economic change, the post- World War II grain livestock complex and the treadmill of production that these changes produced. Within this context, it reviews the literature on how this changing environmental reality may have constructed values, beliefs, and norms that drive water conservation decision-making.

Human Construction of Nature

Much of the Ogallala aquifer comprises what Ellis and Ramankutty (2008) refer to as cropland and rangeland. These categories are two of eighteen identified socially constructed "anthropogenic biomes," based on human activity, population, land use, land cover, interaction, institutions and cultures. "More than 80% of the region's land area is used for agriculture, primarily cropland, pastures, and rangeland. Other land uses include forests, urban and rural development, transportation, conservation, and industry" (Shafer et al. 2014:446). The land atop the Ogallala Aquifer is also used for energy sources from coal, oil, natural gas, wind, and biofuel. These land uses, and the characteristics of the biomes, are likely to change as human-induced climate change increases the demand for water and energy and the competition over resources for different ecological needs. Prior to World War II and the widespread mono-crop agriculture on the Great Plains, the prairie grasses existed in relative equilibrium. Tribes of First People who hunted and subsisted in this biome prior to westward expansion and the land rushes of European settlers in the late 1800s would have recognized the grasses that grazers preferred, and recognized the changes due to fire, climatic fluctuations, human, and animal interference.

Similarly, early European settlers prior to the 1900s would have recognized the grasses that indicated richer soils for various crops. Winter wheat and dryland grain sorghum replaced mixed prairie of little bluestem and sideoats grama, and corn replaced tallgrass prairie of big bluestem and sloughgrass. “However, the exchange was far from equal” as cereal crops do not fix nitrogen or work as “increasers” in the same way that native grasses do (Opie 2018:41). The first waves of settlers gave up on the plains which they deemed to be desert-like conditions following grasshopper infestations over summer and harsh winters from 1859-187, which made it less productive for corn than Illinois or Iowa. Those that remained “reluctantly shifted from corn, the symbol of American prosperity to wheat [Turkey red and hard red German-Russian Mennonite varieties of winter wheat]” (p.57). These remaining settlers learned dryland farming techniques, Congress enacted the Timber Culture Act of 1873, the Desert Land Act of 1877, and they pushed forward to plough and grow more under the belief that the “climate anomaly” of 1878-1887 was a reward for cultivation and irrigation (p.59). A belief in an “underflow” sustaining the plains prompted an 1891 USGS investigation into the presence of large underground water supplies, and 23 pumps began operation near Garden City in 1908 (p.74). Windmill-powered irrigation grew throughout the early 1900s, but mostly as “crop insurance to be used during abnormally dry years” (p.132). However, the devastation of the soil erosion and loss of productivity from the dust bowl[1] started to change how farmers thought about irrigation, so that by the “late 1930s, when new technology, lower cost equipment, and trouble free pumps had trickled onto the great

[1] The Dust Bowl was a severe drought between 1933-1936 in the western Great Plains that caused top-soil depletion and contributed to the economic downturn associated with the Great Depression (Opie 2018:98-99).

plains, high capacity pumping systems began to be seen as a necessity for productivity- 'rain when you want it''' (p.133). Thus, the anthropogenic biome was changing.

Labelling biomes with their human activities in mind acknowledges that the human elements of the creation of biomes is important, along with the climate and geological forces that shape land and climates. "More than 75% of Earth's ice-free land showed evidence of alteration as a result of human residence and land use, with less than a quarter remaining as wildlands, supporting just 11% of terrestrial net primary production" (Opie 2018:439). This suggests that human activity is a key piece of understanding environments almost everywhere.

Humans shape the environment through their physical alterations of it, and through their perceptions of it (Freudenburg et al. 1995). "Far from being the one place on earth that stands apart from humanity, [wilderness] is quite profoundly a human creation-indeed, the creation of very particular human cultures at very particular moments in human history" (Cronon 1995:7). In fact, cultural constructions around the idea of wilderness transformed from useless wasteland in biblical times to divine perfection in Thoreau and Muir's times. This transformation, according to Cronon, occurred in two areas. First, in the sublime: "the concept of wilderness had to become loaded with some of the deepest core values of the culture that created and idealized it: it had to become sacred," associated with the saints and imbued with religious symbolism (p.10).

Secondly, in the myth of the epic national frontier: "wilderness came to embody the national frontier myth, standing for the wild freedom of America's past and seeming to represent highly attractive natural alternative to the ugly artificiality of modern civilization" (Cronon 1995:14). This cultural construction set up a perception of wilderness dualism in which farmers and indigenous people were the enemy, and hunter-gatherers were the ideal. "If the core problem of wilderness is that it distances us too much from the very things it teaches us to value, then the question we must ask is what it can tell us about *home*, the place where we actually live" (p.23).

In many ways, the "paradox of farming" on the Great Plains reflects this dualism. "The transformation of the High Plains grassland into a [monocropping of annuals from fence line to fence line] bonanza of high-yield, chemically dependent, mechanized cropland" for the purposes of commodity markets works in opposition to "nature's pull toward a polyculture of perennials" (Opie 2018:46). Still, this dualism is a myth. While our grain-intensive, agricultural system, based on monoculture for commodity markets seems to work against nature by disrupting equilibrium in the later system and stability in the ecology, actors like the Kansas Rural Center and The Land Institute work towards building a sustainable food system through agricultural diversity that mimics the ecological role of native grassland (Opie 2018).

Despite the fact that humans are not simplistically for or against nature, but they are a part of an ever-changing ecology, the cultural narrative about the human profane spoiling the natural supports the myth. It is possible that producers on the Ogallala experience this dualistic construction, in which they identify with the heroic American frontier, being men (mainly) of the land, yet they also represent a modernized irrigated agricultural industrial complex that epitomizes human encroachment into the wilderness. Since the Great Plains' identity as the "breadbasket of the world" hinges on center-pivot irrigation and pumping from the Ogallala, irrigation now defines the biome, the place, the feedlot production economy, and the people that constructed it (Opie 2018:176).

Human Construction of Water

Linton and Budds (2014) argue that understanding the human impact on water is not just about the relationship to a resource, but the actual nature of how water is understood- as a resource, life force, setting, defining feature, etc.- and how it shapes the structure of society. “This implies a shift from regarding water as the object of social processes, to a nature that is both shaped by, and shapes, social relations, structures and subjectivities” (p.170). Using a hydrosocial model that is based on the hydrologic model, Linton and Budds (2014) observe this co-construction in a variety of contexts. For example, the idea that water needs to be managed changes how organizations are structured around it. Different social relations create different types of water. The physical properties of water structure (and sometimes disrupt) social relations, as is the case where socioeconomic class and race divides, privatizes, or stratifies access to resources for flood or hurricane recovery. The hydrosocial model considers the co-constitution of water and power, including within it other dialectical relationships, all within “a broader framework for attending to the ontology and epistemology of water within hydrosocial relations, and for undertaking critical political ecologies of water” (p.179).

Similarly, those that document a pendulum swing between the intensification of agricultural production and subsequent attempts to mitigate or reverse the environmental degradation caused by the intensification also notice a dialectic relationship between water cycle, environmental changes, and human responses. Hydrologic management is influenced by “the underlying socio-economic and institutional structures, which are themselves shaped by societal values – and these values are fluid and ever-changing, thus requiring constant re-visiting of predictive model assumptions” (Kandasamy et al. 2014:1039). In an understanding of ecology that includes human relations, values play a key role. Whether people value humans first and foremost (humanistic altruism), the environment, themselves, traditionalism, or change will inform their worldview- what they believe is true about the world- what water *is* (Sanderson and Curtis 2017; Stern, Dietz, and Guagnano 1998).

Water is Life

From a female Lakota perspective, Jewett and Garavan (2018) describe a dual-level construction of water. It is as a communal life force that flows in and out of people, connecting present, past, and future community members to each other and to the earth. It is also a relative, where the relationship requires mutual care and respect. In ceremonial “Nibi Walks”, women carry water from its source, praying and making offerings for the protection of the water, as they walk along its course, affirming their symbolic roles as the protectors of water and parallel life-givers.

Healing and sacrifice are essential, in their view, to restoring what has been lost by colonial “rape culture.” A worldview that considers water life also considers threats to water as threats to the body and the soul. Much like Mies and Shiva’s (1993) connection of environmental rape to gender-based violence, Jewett and Garavan (2018) explain that “Rape culture is the colonisation. Our bodies, our lands, our culture. When you do things without permission” (p.46). Criminalizing indigenous people’s rituals and forcing them into “prison camps” stripped the land and water of its protectors just as it stripped women of their dignity, at the same time, it legitimized a colonial masculinity founded on pillaging for profit. In this sense, the ceremonial aspect of activism around the Standing Rock pipeline protests was a symbolic affirmation that water is life. Indigenous Environmental Network Activists fight the construction of oil and natural gas pipelines in Nebraska, Texas, South Dakota, Alaska, and across Canada partly because they threaten the health of reservations like Standing Rock that are vulnerable to leakages, but more importantly because they threaten water systems in general, and these water systems are considered central to spiritual and physical being. As Dallas Goldtooth, a “Keep It in the Ground” Campaign organizer, said:

> Our commitment has always been to protect the sacred; from the source at the Tar Sands to the ports on the coasts, we stand by this commitment and continue to fight to keep fossil fuels in the ground. Today, with our allies we mobilize the people to stop this dangerous and unnecessary project. As we continue this fight against KXL and Transcanada we will assert our rights as Indigenous Peoples and we encourage and call on Tribes and Indigenous Peoples across the nation to rise up to protect our way of life, our futures and to defend Mother Earth. (Indigenous Environmental Network 2017)

Similarly, tactics in the resistance to water desecration were ceremonial. They include sweatlodges, consultations, and sundances.

> 'Change was beginning, more sundances were occurring.' Part of that identity was the confidence to reach out and take on the responsibility of living as a relative to all Being including water. To speak again for water. To not be ashamed or fearful to take on this role again. (Jewett and Garavan 2018:53)

Water as a Symbol of Heritage, Resource, or Amenity

Solis (2005) found that water could be re-constructed through resource conflict so that rural communities considered it a natural symbol of heritage- something that was rightfully theirs, associated with the landscape, forming the context of family traditions, pastimes, and livelihoods for generations, but was being destroyed by agricultural corporations that only exploit it for profit. In Edwards county in the early 2000s, the controversy around an inter-basin water transfer for irrigation from the Arkansas River struck an emotional chord because it reminded residents of historical losses from the 1940s, where land owners lost the rights to streams adjacent to their properties, and from more recent economic decline to urban migration, loss of opportunity, loss of population, and loss of agency. The loss of water triggered emotional responses like fear and identity loss, as it resonated with the current reality of declining and aging rural communities.

Considering this reaction, it could be argued that producers on the Ogallala might also construct the aquifer as a symbolic piece of their heritage, particularly if they descend from generations of producers, and that they might also feel a sense of injustice surrounding the declining resource and outside pressure for them to conserve amidst the other hardships of declining rural economies and livelihoods. This construction of water as heritage- something meant to be shared and protected collectively and not privately defended- might conceptually mirror First People's perceptions of water.

However, the over-exploitation of water as a resource for capitalist gain fits differently into the equation. The prospect of privatizing water conflicts with this construction of water as heritage, and with the American ideal of natural resources' purpose for human prosperity. Privatized water promises to unlevel the playing field- benefiting large-scale operators over family farmers, playing into the American ideal of elevating capitalism and private property, at the same time that privatization and consolidation hurt competition, and small-scale family farms, another hallmark of American values. "Privatization creates enormous pressures to abandon the long history of water's nonmarket function based on a water ethic…In the American West, water costs have been set extremely low to support the farmer in perpetuity a low cost, high-consumption consumer" (Opie 2018:272). Yet, whether privatization might be a solution for sustainability remains to be demonstrated.

Thus, the way people relate to water may reflect their identities. Producers, in particular, may identify as "good farmers" which encompasses the values of doing what is best for their farm and their family. Depending on how producers construct water as a resource, amenity, or symbol of heritage, they may make decisions about it differently out of that worldview. Identity theory suggests that certain identities take prominence over others in our internal rankings, but we will stay committed to those identities even if we need to reconstruct the natural world to make it fit (Stern 2018:65). Therefore, if producers identify as “good farmers”, the values that shape that identity and their worldview (what they believe water actually *is* in relation to them) are important pieces in how they make sense of their roles and responsibilities as producers and what the attitudes about their water conservation decisions will be.

Groundwater in Context

The terrestrial water cycle, comprised of groundwater, soil moisture, surface water, snow, and ice, is increasingly shifting due to human activity: most notably glacial melt, due to global warming, and groundwater depletion in underground aquifers. Groundwater is the most difficult element of the water cycle to observe, but it is also important because it provides domestic water needs for half of the world’s population, and 38% of irrigation water (Rodell et al. 2018; Siebert et al. 2010). Vorosmarty et al. (2010) estimate that 5 billion people depend on threatened water sources, making water security a key challenge of the 21st century, as these sources become increasingly depleted by climate change, population growth and human activity. From 2002-2016, satellite data from the Gravity Recovery and Climate Experiment (GRACE) reveals that climate change and human activities have shifted water cycle trends, mostly at the poles, but also in North America, Central and Southern Asia, the Middle East, and concentrated sections of Australia and Argentina and Brazil.

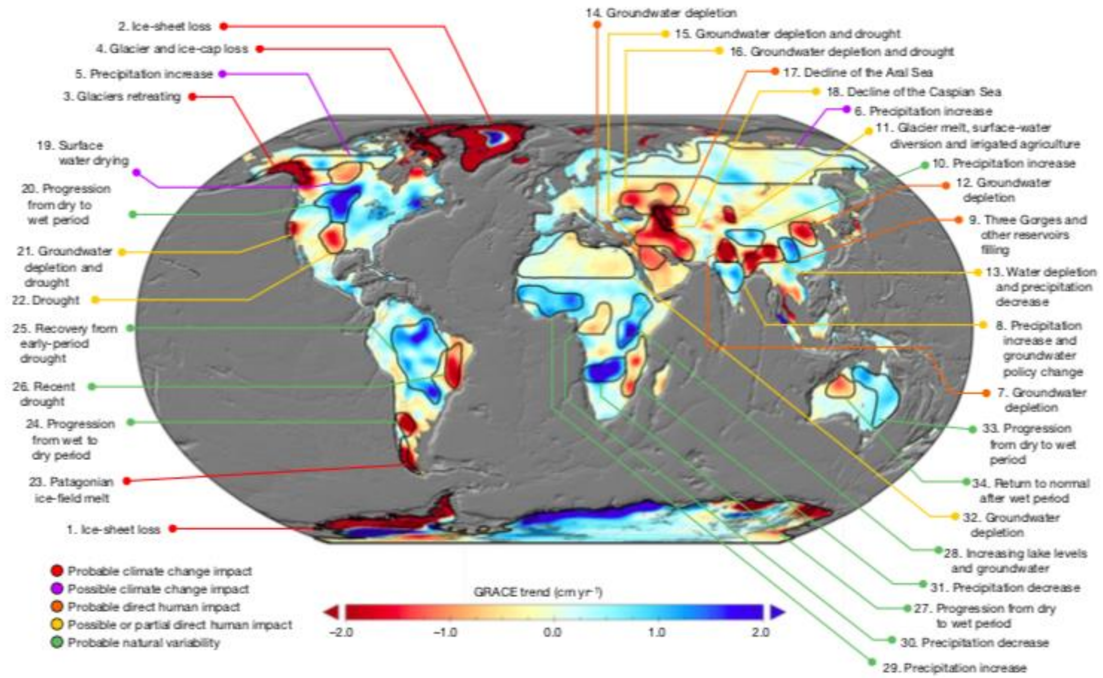

Fig. 1 | Annotated map of TWS trends. Trends in TWS (in centimetres per year) obtained on the basis of GRACE observations from April 2002 to March 2016. The cause of the trend in each outlined study region is briefly explained and colour-coded by category. The trend map was smoothed with a 150-km-radius Gaussian filter for the purpose of visualization; however, all calculations were performed at the native 3° resolution of the data product.

Figure 3: Water Cycle Changes in the GRACE period (Rodell et al. 2018)

The Northern Great Plains, where the Ogallala is located, has experienced contradictory drought and flooding trends, due to groundwater depletion and climate change.

> The wetting trend in the northern Great Plains (region 20)… arises from a combination of deep drought during 2001–2003, which depressed water levels greatly at the start of the GRACE period, followed by nine of the next eleven years having greater-than-average precipitation, including flooding in 2010–2011. The trend is likely to diminish over time, although a 7% increase in precipitation is predicted by 2100. (Rodell et al. 2018:655)

The combination of climate change, aquifer depletion, and population growth has been successfully managed in places like Israel but requires large-scale state-led change that recognizes these increases in extremes and incentivizes a decrease in production (Fietelson 2013).

How Does the Environment Affect Attitudes and Behaviors?

An environmental sociology perspective suggests that just as important as human's role in shaping the environment is the environment's role in shaping humans. Therefore, the environment shapes the context that binds producers as decision-makers and defines the values and beliefs that form their attitudes. We are deeply connected to the places and ecosystems we inhabit, and this sense of place can change our identity and cause us to act in ways that relate to the natural world (Gurney et al. 2017). For farmers of the Great Plains, their identity and behavior might be driven by the actual climate, soil chemistry, and resources that surround them. These identities are informed by core values and beliefs about who we are and what the natural word is. They, in turn, create the attitudes that allow us to take actions over and over that become norms. If the climate, itself, stimulates unique ways of relating to it and unique behaviors, this can translate into broad cultural differences between different biomes, as people adjust their values and beliefs to justify their normative behaviors. This is particularly important where norms and the attitudes that drive them are codified into legal structures.

The environmental shaping of culture manifests in reactions to shortages as much as to abundance, where shortages (in water, coal, or any other resource) might prompt "efficiency policies", which prompt a rise in affluence, or a heightened participation in a global economy, and create a paradoxical depletion of the already depleted resource (Alcott 2005). This phenomenon, known as Jevon's paradox, also affects producers on the Ogallala, who are affected by subsidy incentives to use more efficient irrigation technology, but must actually, increase overall irrigation through the more efficient methods to experience any income increase. Policy incentives tend to individualize a collective problem. Examples include the Water Right Transition Assistance Program (WTAP) that pays producers to give up irrigation rights and the

Conservation Reserve Enhancement Program (CREP) that pays irrigators to return some irrigated fields to grassland. However, most common incentives subsidize more efficient irrigation technology (Sanderson and Hughes 2018). This strategy reflects a popular ecological modernization theory that "the only way out of the ecological crisis is by going further into the process of modernization" (Mol 1995:42). However, this flawed assumption fuels a "treadmill of production" that makes the system inherently unsustainable. To complete in a global capitalist system that supplies grain for ethanol and feed, and for global markets, farmers must find ways to produce commodities with higher market values and invest in capital-intensive technologies (like irrigation systems) that can produce higher yields more efficiently (using less water for more), but the overproduction incentivized by this system causes prices to go down, so that they need to produce more for incomes to remain stable, and to cover the fixed costs of the irrigation technology (Schnaiberg 1980; Cochrane 2003). At the basis of this treadmill are finite resources that must be extracted at higher and higher rates to keep the system from crashing, meanwhile the state incentivizes the production of these commodities for the global market (Sanderson and Hughes 2018). This observation suggests that the socially constructed environment, in the form of treadmill of production systems and conditions, affect our attitudes and behaviors just like the physical environment affects our attitudes and behaviors.

Environmental influence on humans manifests in social and physical ways, to the point that the physical and cultural effects are nearly inseparable. One example of this phenomenon is the sexual dimorphism in populations that descended from users of the plow, which advantaged particular men with disproportionate upper body strength, and disadvantaged women, leading to an evolutionary shift in the sexual dimorphism of stature. The invention of the plow changed the culture of agriculture in these communities toward a greater sexual division of labor and greater gender inequality that does not appear in agricultural societies where the crops were not suited to plowing (Boserup 1970; Sanderson, Heckert, and Dubrow 2005). These differences may have altered the course of evolutionary history so that higher male testosterone levels were selected for over time, increasing entire populations' risk of cancer and altering the ratios of male to female mortality rates (Fielding 2015).

The environment's ability to shape the type of agriculture in a place also shapes the social structure, organizations, and culture that stem from particular types of agriculture. Talhem et al. (2014), for example, suggest a rice theory that builds upon a subsistence style theory, arguing that the environments conducive to rice farming in southeastern Asia produced a type of agriculture that requires more collective work, while wheat farming in northern Asia required a much more individualistic and stratified work hierarchy. Within this division of labor difference, paddy rice might require even more interdependence, while mixed farming with herding might not. This environmental condition, therefore, can help to explain fundamental differences in cultures that highlight communal values, interdependence, and holistic thinking (Talhem et al. 2014).

Post-World War II Grain-Livestock Complex

The grain-livestock complex that emerged after World War II, its neoliberal foundation, and its integration of a global agricultural market form the political-economic environment that also constructs producers' values, beliefs, constraints, perceptions of the environment, and the physical organization of agriculture. This system embeds producers on the Ogallala into a global re-organization of agriculture according to neoliberal policies, which facilitated the export-driven agricultural economies of entire countries that overspecialize in certain exports, creating poverty and hunger by displacing local capacities to grow a variety of food (Bonanno et al. 1994:53).

Agricultural innovation, in the form of biotechnology (GMOs) can increase production, theoretically helping to feed the hungry, but the empirical evidence shows that is not the likely result. “While production and productivity are indeed increasing significantly, their benefits are not necessarily accruing to small farmers or the hungry” (Otero 2008:2). Instead, most producers are not producing food to be consumed locally, but inputs into other sectors of the global economy- beef, ethanol, etc.

Strategies for food production have also changed dramatically, especially since World War II, as food markets are increasingly interconnected, and as the world embraces neoliberalism and deregulation. Changes in food production strategies again reinforce particular values that get defined as “traditional” and certain beliefs that align with the DSP.

This new global reality is organized around commodity crops, which have a variety of social and environmental impacts. Corn is a prime example of these impacts. Despite the fact that American supermarkets appear to embody biodiversity, most of our processed foods- chicken, eggs, beef, soft drinks, coffee whitener, oil, frozen yoghurt, and processed snacks all rely on a few varieties of corn that yield the most calories from mostly sunlight and water, unlike their diverse predecessors that relied on nutrients from the soil. The rise of corn epitomizes American capitalism. “Hybrid corn now offered its breeders…the biological equivalent of a patent” (Pollan 2006:31). As corn became more profitable, it was produced faster and planted closer together. Iowa farmers switched all their crops to corn. When the price of corn inevitably dropped, subsidies encouraged them to plant more to make up for the loss. By the 1950s the flood of cheap corn made raising livestock more profitable on feedlots than farms. “By the 1980s, the diversified family farm in Iowa was history, and corn was king” (p.39). Corn, like other grains, operates now less as a food, and more as a commodity to uphold a system that emphasizes processed foods and grain-fed meat.

This shift between 1950 and 1980 produced a livestock revolution within which all producers are embedded, regardless of whether they produce corn or cattle. Roberts (2009) sees the commodification of grains (wheat, corn, and soybeans) as having culminated in a technological shift that facilitated the livestock revolution, from the first human evolutionary shift in *Homo erectus* towards metabolizing meat-produced amino acids to the agricultural revolution, the rise of cities, and eventually a grain surplus that could be used to feed livestock which could be sustained through antibiotic enhancement.

Between 1961 and 2001, the amount of grain dedicated to livestock feed more than doubled (from 273 to 685 million metric tons). "The cereal supply dedicated to feed in developed countries in 2001 was almost 460 million tons: that is well over 50% of the amount of grain consumed for food in developing countries, where 78% of the world's population is concentrated" (Otero 2008:12). Thus, livestock consumption in the industrial world redirects environmental resources from the places that need it most.

Meat consumption began to separate rich and poor, emphasizing rising global inequalities. In the colonial systems of the1900s, the world's poor were weak, mostly grain fed. World War I and II corresponded with the emergence of an international food system, built on improved preservation and shipping technology and facilitated by an ideology of free trade, that "began to connect the starving demand centers in Europe with distant suppliers in Australia, Argentina, and the United States- countries that possessed surplus land and small populations, but were just then undergoing industrial transformations of their food production" (Roberts 2009:17). Superabundance, followed by the leveling-off of yields created a crisis that spurred innovation, such as the use of synthetic nitrogen produced in offshore petroleum factories. At the end of World War II, the global food system was linked in a network of commodity buyers and processors. This revolutionized wealth in America as food got cheaper. Global trade built food security for middle class Americans, but created vast plantations of export crops, building food insecurity into the developing world. At this point, the global market experienced price-led consolidation, where the most powerful buyers and processors could set standards and tariffs while enjoying the exclusive benefits of privatized agricultural technology.

In this sense, producers on the Ogallala are both autonomous decision-makers and constrained by the global market of commodity crops, over which they have little control in terms of prices and ownership. This political-economic environment helps to set the conditions within which they construct their values and beliefs about the environment, as well as their perceptions of efficacy.

Environmental Beliefs

Beliefs differ from values in the sense that they define who we think we are, what the environment is to us, and what the shape of the relations within our worlds take. Values certainly inform those beliefs, but unlike beliefs, they form the basis for which aspects of life take precedence over others in our moral orders. A humanistic altruistic value, for example, may drive a belief that humans are meant to rule over the natural world. The co-constructions of the natural world with human society makes our beliefs about the earth and our place within it particularly important. Our beliefs shape what we feel are our roles and responsibilities towards the earth, and whether we consider ourselves as rulers, stewards, admirers, dependents, or members of ecosystems.

Social Institutions Shape Environmental Beliefs

A great deal of research explains the relationships between beliefs and environmental decision-making with regard to climate change. It is possible that many of these ideological connections will also apply to beliefs about water conservation, particularly if people see the Ogallala aquifer as a part of larger ecological systems.

Inequality can be a powerful constructor of beliefs, as positionality plays a role in which underlying beliefs become elevated into ideologies. In the case of climate change, denial of science represents a belief that can be used to justify ideologies opposed to environmental justice. Norgaard (2006) noticed that among the elite in Norway, holding status and a stake in the capitalist system that relied on oil production allowed an organized denial of climate issues.

> Ongoing changes in social organization create a situation in which, for privileged people, environmental and social justice problems are increasingly distant in time or space or both. Social inequality helps to perpetuate environmental degradation making it easier to displace visible outcomes and costs across borders of time and space, out of the way of those citizens who are most politically able to respond. (P. 367)

Doubt was also wielded as a political tool used by capitalists and lawmakers that controlled the narratives heard by the American people with regard to climate change. Decision theory suggests that "uncertainty favors the status quo" (Oreskes and Conway 2010:267). As a strategy for instilling climate change denial, doubt worked to build on society's antiquated and skewed positivist view of science, where people assumed that if science could not provide certainty (a status that is purposefully not a part of the scientific method), then it was somehow flawed and worthy of doubt. In this case, an institutional strategy to shape beliefs actually worked toward creating a political ideology that could align with American identities as capitalists.

Inequalities may call into question the agency that individual producers have to make water conservation decisions as they try to compete in a system that is increasingly stacked against them. Wright and Middendorf (2008) track a change in consciousness from the post-World War II era, where food became cheap, convenient, and plentiful, and the public's changing gendered division of labor required great confidence in agribusiness to the turning point in public awareness of the environmental degradation produced by the food system brought about by Rachel Carson's *Silent Spring*, and the more recent realization that agricultural policy has created a "production treadmill" making cheap abundant food. On this "treadmill" farmers must go into debt to keep up with more efficient technology, increasingly expensive inputs, and increased demand for grain by the global livestock industry; while the regulations and incentives disadvantage small farms. This leads to increased consolidation, as farmers are dispelled from their land, "with crippling effects for rural economies" (p.4). At the same time concern with health and safety in the west has produced enormous inequalities, where affluent grocery shoppers pay high prices for a "diet of affluence"- products grown out of season and shipped long distances, beef, and highly processed goods (p.66). Participation in the institutions associated with agribusiness plays a role in shaping political ideologies and conflating them with beliefs and values.

This role of institutions suggests that we often act according to the norms that will help us fit in with the groups in which we belong. Norms signify membership in our groups and are so commonly accepted and unchallenged that they are just easier to follow than to question in terms of whether the practices work in accordance with our identities or beliefs, or whether they makes economic sense. Agricultural norms that fit in with the treadmill of production may not be the most water-efficient or the best for restoring biodiversity to the soil, but they are still upheld by attitudes instilled by the institutions that create the demands of the treadmill.

Environment and Sense of Place Shape Environmental Concern

Rural people develop particular environmental concerns based on their identities which are attached to a sense of place. In northeast Oregon, for example, conservation means different things for producers in semi-urban areas and for people in forest fire-threatened areas. A sense of geographic and metaphorical sense of place defines environmentally constructed social dynamics like environmental concern, and yet, these are constantly changing as rural people become semi-urban, and the demographic indicators like education, political orientation, gender, and religion blur rural/urban categorical boundaries. For example, Republicans in northeast Oregon were less likely to believe in human induced climate change, to favor wind and solar energy over oil drilling, and to support wolf conservation, as their sense of place translated into a belief that local needs should trump national interests in managing public lands (Hamilton et al. 2013). Because of the environmental conditions of the place, and the differing constraints of people more and less connected to it in terms of livelihood, issues like wind power, wolf population, and public land management aligned with beliefs about global climate change, while issues like threats to local forests aligned more with educational background and partisan divisions. In areas where the population is growing, and people are less tied to natural resources for their employment, people held more freedom to favor environmental policies that might restrict development. In this sense, rural environmental concern is tempered by what Inglehart and Baker (2000) refer to as postmaterialism, it is constructed by the place, and it depends on the degree to which rural people are producers or involved in livelihoods directly dependent on natural resources.

Temporal Focus Norms Reveal Beliefs and Ideologies

Norms can shape not just what we think or do, but how we think - such as whether we tend to focus on the short or long term. Baldwin and Lammers (2016) argue the major difference between liberals and conservatives' views about climate change are more indicative of their psychological temporal focus (a part of their worldview), than their value systems, beliefs, or rational calculations. "Psychological processes, such as temporal comparison, underlie the prevalent ideological gap in addressing climate change" (p.14953). Conservatives make evaluations based on a comparison between the present relative to the past, which is tied to the conservative ideology that prefers tradition or the status quo. Therefore, conservatives tend to favor environmental conservation practices more, when they consider the practices as a return to a better ecological reality of the past. This may indicate that water conservation practices among political conservatives on the Ogallala might depend on whether they see conservation as a way of preserving heritage or tradition or whether they see it as a mitigating response to a future threat. Nevertheless, temporal focus may represent a piece of the worldview that still draws on underlying values of altruism or self-interest as a standard of comparison between the past and present, or future to be asking for whom is it better: me, others, or the ecosystem? When attitudes are held in tension with one another, which ones win out? Temporal focus may help explain how people elevate certain values over others in developing their attitudes. Hypothesizing that values and beliefs result in norms, we can guess that conservative identities, which reflect traditional values may hold a shorter temporal focus and see groundwater depletion as less problematic for the future of their families or communities.

Identity Theories: Beliefs are Intensified by Education

The idea that norms are bolstered by something deeper and that rational decision-making cannot easily supersede is consistent with the finding that beliefs are not generally shaped by education but intensified by it (Drummond and Fischhoff 2017). This is consistent with research on confirmation biases, and with identity-based theories, such as self-affirmation, which would assert that new knowledge is best integrated into cognition when it bolsters who individuals think they are and what they already know and believe that fits into that narrative. People tend to reject, reframe, or manipulate any perceived inconsistencies to fit the narratives about themselves and what they stand for (Stern 2018).

> Beliefs on controversial issues typically display a funnel pattern, such that the gap between beliefs among political conservatives and liberals widens as education increases. For example, political conservatives are more likely to reject the scientific consensus on climate change if they have more education. (Drummond and Fischhoff 2017:27)

This tendency to double-down on beliefs may reflect a reality in which beliefs are a core part of our identities. When challenging beliefs equates to challenging our own legitimacy and view of the ourselves in the world, it is easier to justify them through new knowledge. Interestingly, “beliefs on climate change were associated with political but not religious identity” (p.4). While religious and political identity are often conflated, and one used to justify another, the fact that political identity is more powerful here might indicate the power of the denial narratives in American politics over underlying values established by religion. American evangelicals who believe God created the earth for his glory, for example, could use that to justify an ideology that sees humans as a responsible part of a complex ecosystem, or coupled with a political ideology, could see their role as individual producers and consumer as divinely authorized. This suggests, that while identity is key, there are other factors that play a role in decision-making.

Within identity theories, identity-protective reasoning might be employed if producers feel that their gender, work ethic, family traditions, religious, or political identity is somehow threatened by a new practice. This reasoning removes the focus from the merits of an argument and places it onto "how they perceive themselves and how new information calls those self-definitions into question" (Stern 2018:71).

Culture Theories: Culture defines norms, values, and worldviews

Beliefs, the ideologies they justify, and the underlying values they reflect all derive from processes of culture-making. Martin Luther's assertion that the bible was the only source of theological truth led to a cultural change toward literacy. Lutz (2017) argues that a similar, belief and value system driver for cultural change is needed to promote education and health as underlying prerequisites for a social change that can address climate change. "A similar priority focus on empowerment of all segments of all populations through education and health (*sola schola et sanitate*) is needed today for sustainable development" (p.6904). This assertion is based on the view that people are not rational decision-makers, so understanding how elements of education and culture- emotions, narrative, values, beliefs- play into their decision-making process is key.

Swidler (1986) argues that every belief or ideology, based on emotion and reason, makes a "tool kit" for people to use to motivate actions at will, making us "active, sometimes skilled users of culture." Our habits are not all individually motivated because they have been practiced as "strategies of action" (p.277). She argues that ideology governs our actions in stable ways during "settled periods," and more conflicting ways during "unsettled periods" where competing ideologies struggle to become mainstream or they will be discarded. She observes that "culture appears to shape action only in that the cultural repertoire limits the available range of strategies of action" and these vary over time and space, particularly at times of being settled and unsettled (p.284). People may be aware of their own ability to change their behaviors or to change culture, only within these somewhat stable ideologies. One might expect that producers on the Ogallala draw from this tool kit of action, related to the practices that have always worked for them, or the narratives that they hear and repeat. However, one might also find that this era of depleting reservoirs and increasing restrictions represents an "unsettled period" where the tool kit is being reshaped into new repertoires of action- culture is changing.

One of the values that American culture seems to return to in this tool kit is that of individualism. Being an individual oversees how Americans tend to approach decisions, considering the community secondly. This can affect perceptions of interrelated concepts like ecology. In his discussion of community, Bellah (1988) argues that the particular type of individualism constructed in America emphasizes involvement in community on the basis of individual choice, and this is exemplified in the tendency to retreat into "lifestyle enclaves" (p.250). This allows us to pursue "callings" at work, and to incorporate new alternative religious beliefs by drawing out "strands from traditional moralities and reweaving them into a fabric that ties into American culture as a whole yet differs in the pattern from any one of its traditions" (p.357). This explains the rise of religious fundamentalism and the reframing of "anti-intellectualism" as an individual and religious value. This might mean that many of the producers on the Ogallala might approach conservation decisions from an individualistic standpoint and might fit other beliefs or values into the narrative that can support their decision.

Simpson and Willer (2015) suggest that most decisions to act are reflections of pro-social behavior driven by rules (socially defined norms with sanctions that keep them in place), reputations (status within group membership), and relations (institutions and social networks that help define norms and elevate certain reputations). "Person-level factors alone are generally unable to sustain cooperation at the high levels observed in many human groups" (p.56). In experimental settings where people are removed from social networks, they "initially show much variation in contributions, with more altruistic individuals giving at high levels and more egoistic people contributing little or nothing at all" (p.56). However, altruistic individuals tend to participate less and less in response to the more egoistic nonparticipation. Therefore, the driving social forces of rules, reputations, and relations, are necessary parts of prosocial behavior, regardless of personal values. "Precisely because they direct less altruistic individuals to behave the way more altruistic people do, these mechanisms benefit groups while obscuring our view of one another's true motivations" (p.58). When ideologies like individualism and ecology conflict, people may fall back into less altruistic behaviors because they follow the norms of the group.

Being a good farmer or land manager is a collective identity that becomes most salient in decision-making in times of change in the contextual circumstances (Fielding, Terry, and Masser 2011). Since producers on the Ogallala are facing uncertainty and change in their climate and circumstance, it stands to reason that their senses of collective identity are already coming to the forefront of their conservation decisions. However, the identity of "good farmer" is complex, as discovered by Naylor et. al (2016), who found that livestock handlers respond to disease outbreaks from the standpoint of a variety of conflicting personal and collective identities. It can be personal, public facing, neighborly, or skill-specific, suggesting that identities are constructed as unique places within social systems.

The powerful “feed the world” narrative builds upon American individualism and the collective identity of the “good farmer” in order to justify the treadmill of production by aligning it with neoliberal technological development, even as it conceals food insecurity and a lack of food sovereignty (Scanlan 2013). Nelson and Stock (2016) argue that farmer identities- intertwined with geography, family, health, ecology, social capital, community, and autonomy- exist in a constant state of tension with the neoliberal contexts within which they operate. As farmers work to maintain growth on a treadmill of production for a global grain economy that demands more efficient inputs and higher yields, the system works towards threatening their existence or pushing them out of vertically integrated supply chains. Rather than categorizing farmers into those whose entrepreneurial values keep them on the treadmill, and those whose peasant values allow them to resist, a study of Kansas farmers suggests that many use peasant strategies to resist neoliberal structures and work toward sustainable agroecology as an adaptation regardless of their worldview (Van der Ploeg 2008). As they employ strategies of decentralization, diversification, and equitability, they work against “structures and institutions of industrial agriculture including banks, land grant universities and extension agencies, farmer groups, marketing agencies, agri-businesses and community organizations that maintain a narrow and entrenched view that only commodity agriculture is farming” (Nelson and Stock 2016:5). This “productivist” myth is further entrenched by narratives about “feeding the world” that are actually disconnected from the commodity market reality they maintain (Rosin 2013). Repeasantization, by contrast, stresses livelihoods, social relations, and autonomy in the face of increasing dependency from capitalist neoliberalism in agriculture.

Emotions Shape Values and Beliefs

In agreement with much of the literature on decision-making, Barbalet (1998) critiques the assumption that people are rational actors, suggesting that emotion is key to explaining the relationship between culture and social structure, as it is intricately related to reasoning, either as a support to reason, or continuous with it, but not as its opposite. Fear, for example, can be both debilitating or defensive as it allows society to respond to danger (or perceived danger associated with change or loss of class status). A fear of unemployment, for example, can be widespread and form new public ideologies about the threats to economic well-being and social life- creating "emotional climates" that distinguish groups. In this case, fear of encroachment from outsiders or the future loss of livelihoods as water stores become depleted may drive political ideologies that cause people to elevate their own interests or be protective of their rights and land. Similarly, fear can drive denial and doubt, which can drive inaction. While people are not likely to justify their actions based on the emotion, the political ideology that grew out of the emotion can become inextricably linked to identity.

Massey (2001) suggests that the connection between culture and action is based on emotions. He argues that our motives cannot be rational calculations of our interests, or conscious applications of ideological tools, as Swidler suggests, because rationality came after emotion (in evolution and in brain function) in the construction of structures and mythic cultures. Therefore, emotion, as a cultural construct, has a more central role to play in motivation than calculated adherence to rules. "Information reaches the amygdala about a quarter of a second before it reaches the prefrontal cortex. Thus, the emotional brain perceives danger and acts before the rational brain knows what is happening" (Massey 2001:18). He argues that culture-norms and values- stem from interactions between social structure and the emotional brain, and this interaction is exemplified by irrational beliefs like fear and prejudice.

Similarly, Schultz et al. (2004) argue that biospheric values (care for the environment) are connected to the way that people see themselves as a part of nature. “Values are related to an individual’s exhibited feelings of interconnection between the self and nature, a link between values and identity” (Dietz, Fitzgerald, and Shwom 2005:363). Environmental issues evoke strong feelings that are also tied to religious identity or spiritual experience.

Environmental Values

Clearly, the relationships between culture, emotions, values, identities, political ideologies, worldviews, beliefs, and decisions are complex, but interrelated. Underlying many of these elements through which we see the world are a set of core values, or guiding principles that allow us to prioritize moral decisions. While theories of morals, intuition, culture, and identity can help explain where and how these values emerge, the values themselves are most useful to us in in determining how environmental decisions are made. Values are the focus here, partly because, unlike intuition and emotion, they are measurable in a quantitative way, and partly because they form an important, well-documented causal link to beliefs and then norms for action. Values are measurable by a variety of different metrics that pit guiding principles against each other and ask people to prioritize one over the other in each set. According to Rokeach (1968), values are the “enduring beliefs that a specific mode of conduct is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence” (p.160). As binaries, they can be documented by the Schwartz Value Survey and measured on a scale of values including “power, achievement, hedonism, stimulation, self-direction, universalism, benevolence, tradition, conformity, and security” which reveal tendencies toward either self-enhancement or self-transcendence and either openness to change or conservation/traditionalism (Dietz et al. 2005:347). Stern, Dietz, and Guagnano (1998) modified this value set to adapt conformity and security as measures of tradition and "to capture the biospheric-humanistic distinction. In addition, some researchers have examined the influence of traditional values and openness to change on environmentalism" (Dietz et al. 2005:349). Thompson and Barton (1994) proposed a different measure of values.

> One set of items measure what they term ecocentrism, which is similar to biospheric altruism. However, they posit as a polar opposite anthropocentrism, which is composed of items that tap a sense that the value of nature is dependent on human use and combines self-interest and humanistic altruism. (Dietz et al. 2005:350)

The Schwartz value items can be measured by regression using models like Stern, Dietz, and Kalof (1993):

> M (The Motivation to Act) = Vego (self-interest) AC (Awareness of consequences for self) + Vsoc (humanistic altruism) AC (Awareness of consequences for others) + Vbio (biospheric altruism) AC (Awareness of consequences for the environment).

Inglehart (1995) also used Schwartz and Rokeach's scales but argued that "environmentalism is a product of postmaterialist values" where values can change as the result of privilege, technological, and industrial change (Dietz et al. 2005:354). Values relating to the environment might be considered a luxury, very high on Maslow's hierarchy of needs.

Dietz et al. (2005) problematize the diversity of scales and approaches to measuring values.

> Schwartz and his collaborators continue to develop their refinement of the Rokeach approach. But they have not focused on altruism, which is central to the theoretical arguments linking values to environmentalism, so their work has to be

> supplemented if its potential for the study of environmentalism is to be realized. (P. 354)

Each of these scales can shed light on how underlying values relate to each other and how they might be used to make environmental decisions.

Values and Loss in Relation to Climate Change

Despite the fact that climate change, and environmental issues, in general, are highly politicized and highly polarizing, they also highlight some of the universal underlying values and the loss that people fear when they develop certain beliefs and norms. Barnett et al. (2016) argue that loss is essentially being "dispossessed" of anything that we value, including health, safety, sense of belonging, autonomy, dignity, landscapes, home, culture, sense of place, meaningful belongings, and occupational identities. Industrialization, imperialism, colonization, consolidation of industry, and rural to urban migration all began a process of dispossessing that climate change threatens to intensify. As people consider losses they have experienced or the threat of future losses, they make decisions based on "situated values" tied to their environment.

Political and Religious Values and Climate Change Attitudes

Arbuckle (2016) found that both religious ideology and politics influence attitudes about climate change, but the relationship between ideologies are far from simple. Political ideology and partisan affiliation hold the strongest influence over climate beliefs and supersede evidence of changing conditions on people's perceptions. McCright and Dunlap (2011) argue that political orientation is such a powerful indicator of attitudes because people use their values to filter information that is ambiguous to them. The more that climate change becomes politicized, the more people rely on elite political leaders to interpret new information.

Despite the fact that religious beliefs do not determine political orientation, the two relate to each other in interesting ways. McCright and Dunlap (2011) found, for example, that religious affiliation held more affect over concern about human-induced climate change among political liberals than among political conservatives. Ideologies can help explain why such a chasm exists between popular American opinion on climate change, where only 45% believe it is a serious problem, and the scientific consensus which asserts that human activities are affecting the earth's ability to sustain life (Pew Research Center 2015b; International Panel on Climate Change 2007). Blaming the Judeo-Christian affiliation for the discrepancy ignores the fact that Christians vary across denominations, and various intersections of identity. Liberal Catholics and Evangelicals, for example, are less likely to be concerned about climate change than liberals who are non-affiliated, while Catholic and Evangelical moderates and conservatives are similarly unconcerned about climate change as conservatives who are not affiliated. Unlike these religious traditions, Jewish people showed less effect of ideology on their climate change concern. White, upper class evangelicals, and black protestants tend to be less concerned about climate change even though their political ideologies tend to differ otherwise. The broad category, "Christian" contains values that vary across race and socioeconomic boundaries and is an American religious ideology that can prompt climate change concern, especially among those who consider their role in relationship to the environment as one of "stewardship". However, it can also prompt elevating other values over the environment, a "mastery of nature ethic", or attitudes that stress our rights to prosper, or align individualism with Christianity, or that allow apathy by stressing trust, especially when filtered through political orientation (Arbuckle 2016:4). However, in general, people aligning with certain conservative Christian traditions do tend to care less about climate change than non-religious people (Clements, McCright, and Xiao 2014; Arbuckle and Konisky 2015).

Other socioeconomic intersections, like level of education and gender, also moderate climate change beliefs through these ideologies, where greater than 12 years of education, and being female tended to predict higher levels of climate concern. Church attendance, age, income, region, and rural residence influence concern negatively (Arbuckle 2016).

Moral Reasoning and Climate Change Adaptation: Vulnerability and System-based Frames

One of the reasons that value systems emerge in environmental attitudes differently among religious and political groups is that “different forms of moral framing resonate to a greater or less extent with differing political rationalities” (Adger, Butler, and Walker-Springett 2017:372). A vulnerability-based moral frame emphasizes solidarity, ability, need, entitlement, fairness, and protection from harm, while a system-based moral frame emphasizes respect for authority, stability, system preservation, duty, responsibility, sanctity, purity, and naturalness. While the vulnerability frame has been used by liberals in narratives about climate change adaptation, especially with regard to the protections of vulnerable populations, resettlement, etc. the system-based frame can also motivate environmental adaptations. Whether the public sees adaptation options as feasible, salient, and legitimate depends on the moral frame through which they understand the adaptation. Adger et al. (2012) found that when people recognize that the negative effects of climate change disproportionately affect vulnerable populations, a paradigm of justice emerges. The public can affect policy change to reallocate the responsibilities of public and private stakeholders who can address the risks. Policies, in turn, can have the effect of slowly changing norms as people perceive a change happening (Nyborg et al. 2016). Do climate change attitudes relate to attitudes regarding water conservation on the Ogallala? The fossil fuel industry and a handful of large corporations hold a disproportionate amount of power with regard to making decisions to adapt to climate change, so their attitudes matter more than the general public's, but collective attitudes regarding who should be held accountable and why, and the solutions that society supports matter. Producers on the Ogallala hold more power than others to stem depletion, so in that sense, their attitudes carry more weight. However, unlike the fossil fuel industry, producers are constrained by a much larger agricultural system that feeds into a global grain economy. They are on a treadmill- the conditions of which are larger than them, even as their norms, and global food and energy demand (manufactured or not) is complicit in keeping the treadmill moving. In this sense, policy changes that incentivize stepping off of the treadmill could result in the norm change required to start changing beliefs and even values.

Chan et al. (2016) argue that environmental moral reasoning emerges in relationship values, present in many major religious beliefs and philosophical traditions, make people value the environment in a more complicated way than what can be measured as instrumental (for the sake of humans) or intrinsic (for the sake of itself). People hold a sense of what is right and wrong, based on the relationships that produce meaning, whether to other people, social groups, or the natural world.

Values that align with environmental justice do not always translate into attitudes or action. This discrepancy may partially be due to what Pearson et al. (2018) describe as the environmental belief paradox, in which Asians, blacks and Latinos tend to hold higher environmental justice values than whites, but they do not perceive themselves as environmentalists and think their communities care less than they do. A similar finding showed that low income Americans tend to hold higher environmental justice values than they realize, even as they are systemically excluded from environmental and conservation efforts. This discrepancy between what people think their community believes and what they actually believe exemplifies the ways that norms (individual, prescriptive, behavioral, or perceived) link altruistic values to environmental action (Dietz and Whitley 2018).

Moral framing of environmental values is particularly important in light of Manfredo et al.'s (2016) assertion that since values are slowly adaptive- embedded in culture, ecology, and institutions- so that they remain somewhat stable over time, they are not likely to change quickly, even as climate change demands more of a shift towards elevating environmental values. Instead, they argue that conservation efforts must focus on multi-level analysis of contrasting cultural values and political organization (particularly including small-scale societies living close to critical biodiversity), so that they can align conservation efforts with pre-existing value structures.

By contrast, Ives and Fischer (2017) argue that while interventions at shallow leverage points, consistent with Manfredo et al.'s (2016) suggestion of working within value systems, may be part of the solutions, they are limited. Instead, "If one believes that the current global system of human-environment relationships is not only superficially but also deeply unsustainable, deep leverage points must be considered. This includes changes to values, culture, and prevailing models of social order" (Ives and Fischer 2017:1484). Still, Manfredo et al. (2017) argue that intentional value changes are unrealistic. Taking an evolutionary perspective on values assumes that they change only as new behaviors become the norms, in response to belief systems that adaptively respond to conditions.

Environmental Attitudes as Outcomes of Values, Beliefs, and Norms

Farm management decisions are complex, and meta-analysis of barriers and motivations for conservation practices reveal "very few consistent determinants of conservation" (Ranjan et al. 2019:21). Cultural elements such as social norms and perceptions of government are both motivators for and barriers to conservation. Producers are influenced by their own characteristics, their farm's characteristics, environmental awareness, trust in information sources, management habits, perceptions of conservation effectiveness, perceptions of risk, land tenure, economic factors, social norms, and perceptions of government (Ranjan et al. 2019). Attitudes that help solidify values and norms into decision-making principles can provide insight on the lens through which producers formulate their trust in information sources, which might be politically motivated or economic factors, which might be values-based. Decisions that may seem purely economical, for example, require thresholds that are subjective, and influenced by attitudes. Deciding that a conservation practice is too expensive or impractical requires that thresholds for expense and practicality have been set by attitudes.

Values, Beliefs, and Norms (VBN) in Decision-making

The VBN theory for environmental decision-making helps to explain the assumptions from which the theory of planned behavior begins. The theory of planned behavior begins with a foundation of norms and attitudes that make up decision-making. It argues that "no matter how people arrive at their behavioural, normative and control beliefs, their attitudes towards the behaviour, their subjective norms and their perceptions of behavioural control follow automatically and consistently from their beliefs" (Ajzen 2011:1116). While some environmental sociologists argue that this theory tried to make explicit what are actually implicitly stimulated behaviors, born out of emotion, social networks, identity, and other irrational and unexamined core values, it can also be understood as a different part of the same decision-making process (Greenwald and Banaji 1995). VBN theory explains the part of decision-making upon which this, more conscious part depends, beginning with values, the underlying principles that Ajzen considers "beliefs". It is most interested in how people first arrive at these non-rational, and less tied to circumstance precursors to decision-making. VBN also makes sense of the feedback loops between norms and beliefs that allow certain beliefs to rise in salience over others. VBN theory suggests that self-interest, humanistic altruism, and biospheric altruism are the most salient of values because they "are the most fundamental determinants of environmental concern" (Dietz et al. 2005:356). They tend to be stable in the face of industrial and technological change, or personal changes like education. They also wield the greatest influence over worldviews and specific beliefs related to the environment. These three values motivate decision-making directly and indirectly. These "values influence our worldview about the environment [NEP] (general beliefs), which in turn influences our beliefs about the consequences of environmental change on things we value [AC], which in turn influence our perceptions of our ability to reduce threats to things we value [AR]. This in turn influences our norms about taking action" (p.356). The norms about taking action may begin with an attitude, such as a sense of obligation, and lead to more overt behaviors.

The Values-Beliefs-Norms theory builds on Norm activation theory to add precursors of values and beliefs to the awareness of consequences, acceptance of responsibility, activation of personal norm, and behavioral intentions or action chain reaction.

Values: Stern (2000) defines values as the most stable parts of moral identity. They are the guiding principles that allow us to prioritize moral decisions. Stern uses *biospheric* (altruism toward the environment), *altruistic* (care for humanity), and *egoistic* (care for oneself). Dietz et al. (2005) and others add *traditional* values (respect for the elderly, authority and tradition), and *openness to change* to these 3 core values.

Environmental Beliefs: Beliefs use the abstract principles provided by underlying values to form a paradigm- a general conception of how the world works. Taken together, these beliefs form entire narratives and worldviews. Scholars have identified the Dominant Social Paradigm (DSP) and the New Ecological Paradigm (NEP) as two such general belief systems about the environment and human's role within it (Pirages and Ehrlich 1974; Dunlap 2008; Pellow and Brehm 2013).

Norms: Norms may encompass the last three steps in the diagram below. They are the commonly accepted ways of thinking and doing things that no longer need to be analyzed because they have become habit or generally accepted. They are often stimulated by values and beliefs, but not necessarily consciously so. When awareness of the consequences exists, it is often to justify a norm or to form a new one. In this case, attitudes like "I feel personally responsible for groundwater depletion" reveal something of the third and fourth step in norm formation, while attitudes like "groundwater depletion is a problem for my family" reveal more about personal norms and behavioral intentions.

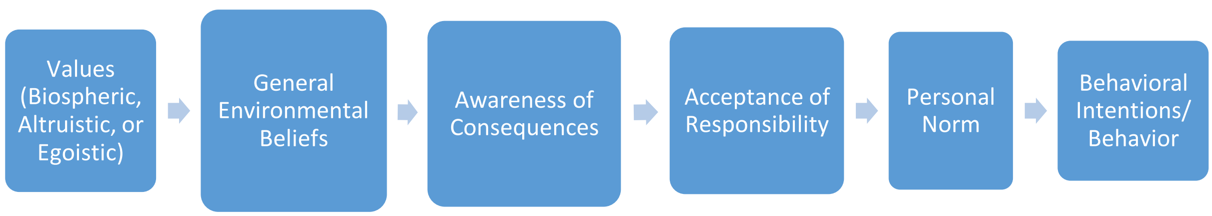

Figure 4. The Value-Belief-Norm Theory of Pro-Environmental Behavior (Stern 2000)

Sanderson et al. (2018) developed a model that integrates the motivating factors of values, political ideology, knowledge, and worldview, determining that values underlie consensus and tensions between farmers and nonfarmers and within these demographic groups. The VBN model could help explain the pathways between types of values and beliefs, which was more direct in non-farmers, and filtered through ecological worldviews, political ideologies, and local environmental knowledge in farmers.

This framework brings together three theories of environmental behavior and can be applied to show how the connection between culture and decision-making works to link values to farmer's decisions on how to use environmental resources. Beliefs in anthropogenic climate change have been found to be positively correlated with environmental values and with the perceptions of potential climate-change related risks to the groundwater supply. Environmental values also predict the norms people abide by to reduce their carbon emissions (Sanderson and Curtis 2016). "environmental values are the basis of a chain of cultural factors linking climate change beliefs to climate change risk perceptions to mitigative norms, and ultimately, to adaptive water conservation strategies" (p.290). This framework makes sense of the factors that influence decision-making in a causal flow and has been successfully applied to explain environmental choices.

VBN Theory: Environmentalism, Land Use, and Identity

Using this framework in an Australian study of irrigators and dryland operators, Sanderson and Curtis (2017) found that while both balance environmental values with financial concerns, "irrigators tend to hold a stronger business orientation toward their properties and that dryland operators tend to hold stronger environmental concerns" (p.1453). Business focus may relate to a sense of place and belonging that stems from irrigators more often, living on the farm and working more intimately with the day-today operations than their dryland counterparts. While irrigators tend to be concerned about the environment, it is for different reasons than dryland operators. Stronger environmental concerns may relate more to a relationship the land that includes more other non-production uses among dryland operators. Since rural landowners are complex and hold multiple, overlapping identities as producers, consumers, stakeholders, etc. often using the land for recreational, aesthetic, or conservation purposes in addition to production, it is necessary to control for occupational identity in looking at attitudes and values in decision-making. Non-farmers holding rural land, make decisions differently based on their nonfarming identities. A VBN (Values, Beliefs, and Norms) framework helps to make sense of the way these values link with norms and beliefs in chains of decision-making. “Three broad value orientations underlie a chain of social-psychological decision-making linking values to general and specific beliefs, norms, and ultimately behaviors: biospheric values (concerns about the biosphere), humanistic-altruistic values (concern for others), and egoistic values (concern for self)” (p.1458).

Research Focus

Clearly, the human social systems that construct identity, intuition, values, beliefs, and norms are interrelated with water systems. It is less clear exactly how these constructs interact. Pande and Sivapalan (2017) suggest that socio-hydrology needs “to consider the two-way feedbacks between human and water systems in order to explain puzzles, paradoxes, and unintended consequences that arise in the context of water management, and to suggest ways to avoid or overcome these challenges” (p.1). The over-irrigation of cotton from the depleted water reserves of the Ural sea might be a foreshadowing of the type of human-water interactions taking place on the Ogallala. This moment, therefore, provides an opportunity to heed the authors’ suggestion that two-way feedbacks should be explored on more global levels, using methodologies that model the feedback links between aspects like population, awareness, irrigation, etc. It would be beneficial to better understand the ways producers contribute to the feedback (how their educations, political ideologies, and core values affect their water usage, organizing, or perception) or how the water shapes them.

What prompts water conservation decisions?

Focusing on decision-making as an outcome of these five core values and two environmental belief paradigms can add to this existing literature, helping to reveal the shape of the relationship between people and water conservation. This study can explore the causal links between who producers are and their agricultural practices and attitudes. Although we know a great deal about how beliefs and ideological identities are culturally constructed by emotional and rational means, and how they reflect underlying values, we know less about exactly how each of these comes into play with regard to environmental decision-making. It is possible that decision-making regarding water conservation looks quite different and is shaped by different forces than decision-making regarding climate change, although they may be related since both may be connected to our identities as a part of nature. We also know less about how each of these forces come together to shape values related to environmental justice and whether they translate into action. Studying these processes in producers, who have one of the voices most formative for policy and conservation norms, may provide insight on how environmental action can be taken globally.

A disconnection between values and action is possible. People can be constrained from acting by their circumstances, or they can contain conflicting values within themselves. Dietz, Fitzgerald, and Shwom (2005) evaluated the claim that environmentalism and altruism are linked, finding that "environmentalism emerges when basic material needs are met and that individuals and societies that are *postmaterialist* in their values are more likely to exhibit pro-environmental behaviors" (p.337). Using the Schwartz value measures, they also found contradictions. Environmental concern can be linked with the motivation of conservation, which encompasses the values of tradition, conformity, and security, but it can also be linked with the opposing motivations of self-transcendence and openness to change, which encompass the values of universalism and self-direction. They conclude that "values are a reasonable way of conceptualizing how we make decisions about the environment," that values and an environmental belief paradigm (NEP) are linked at the individual level, but that how values shape decision-making (through identity, norms, or beliefs, for example) is unclear (p.370).

Norms may be beginning to change. Opie (2018) argues:

> farmers are now learning to measure yields, and successful farming, not by the acre of market rice but by the cost of an acre-foot of groundwater. Using new groundwater conservation methods, if a plains farmer could survive on less than a one-foot decline, he would see it as a major accomplishment. (P. 258)

If High Plains farmers are aware of the "history of profligacy and wastefulness of bountiful groundwater" and are seeing the results in the depletion of their own wells, and considering the future, then they may be making decisions very differently than they have in the past (Opie 2018:258). How do they allow these norms to change while clinging to the same underlying values of individualism and dominance over nature? It is possible these values are also changing, or they are being re-evaluated in relation to other values like family and security that have been used to justify pro-environmental and anti-environmental norms.

Why focus on Values, Beliefs, and Norms instead of Identities?

Identities as "good farmers" play a role in decision-making alongside values and beliefs, but the three are not completely separate entities. Morton, McGuire, and Cast (2016) found that the biophysical situation helps to formulate farmer identity as good farmers make incremental changes to their practices to adapt to environmental changes. However, whether they identify as productivists (emphasizing short-term high yields and profits) or conservationists (emphasizing land resiliency), requires that values like efficiency or long-term management be activated (p.19).

Political ideology, as an identity, can also affect the extent to which people see environmental issues as moral issues. Political liberals are more likely to view environmental issues through a moral framework (Feinberg and Willer 2013). On the one hand, this may make their decision-making fit with a Values-Beliefs-Norms model better than political liberals who see the issue as less connected to their underlying values. However, many political conservatives are also religious. It can be argued that re-framing the environment in terms of moral imperatives can make political conservatives think about it differently if they also ascribe to a religious identity.

> Most of the world's religions emphasize humanity's role as stewards of the earth charged with keeping pure and sacred God's creation. Thus, reframing moral rhetoric around the environment to fit with this religious tenet might be persuasive to many religious individuals, a possibility that could be explored in future research. (P. 61)

Thus, there is much that is not known about how these identities form, how they activate underlying values, and in exactly what ways these values relate to decision-making outcomes such as attitudes toward water conservation. Therefore, focusing on values and beliefs as motivators of water conservation decision-making as the focus of this study allows an analysis of the components of identity. If "good farmer" or "good Christian" or other identities motivate attitudes, it is important to know what values and beliefs construct producers' images of what these identities mean to them. Furthermore, while we know that norm-based decisions may be justified in terms of identities, (i.e. "this is what a good farmer does" or "this is how a good farmer thinks"), the underlying values and beliefs that go unexamined may represent a less-than-conscious activation of what "seems" right.

Chapter 3 - Methods

Two overarching questions guide this inquiry: (1) How do producers make decisions regarding water conservation? and (2) how does the environment affect culture? The first question seeks insight into which of the 5 core values and beliefs in the NEP (New Ecological Paradigm) affect water conservation attitudes. Based on Stern et al.'s (1999) VBN (values, beliefs, norms) framework, and the literature that supports this model, the hypothesis is that differences in these normative attitudes relate to differing underlying values and beliefs. Prompted by the literature that suggests that the environment changes elements of culture (including values, beliefs, and norms), the second question seeks to understand whether key environmental indicators like precipitation, temperature, and soil saturation affect people's normative attitudes about water conservation (Boserup 1970; Sanderson, Heckert, and Dubrow 2005; Fielding 2015). Since colder, wetter climates demand less immediate groundwater conservation, it is hypothesized that these climates may present values that do not prioritize openness to change, beliefs in the Dominant Social Paradigm (DSP), and attitudes that reflect norms that are less concerned with groundwater conservation. The answer to the question about how the environment affects culture is a precursor to understanding how culture adapts to climate change.

Since these questions ask how producers make decisions and how the environment affects culture, they were best answered with a quantitative study that can model the relationships between climatic data by county, each of the measured values, two environmental belief systems, and several key attitudinal outcomes that represent norms. These questions set a foundation for further qualitative questions about why the relationships that are found exist and why they take the shape that they do. In the meantime, a series of OLS regressions are able to take a birds-eye view at the patterns of environmental and cultural elements that go into water conservation decision-making attitudes, looking at producers across a wide geographical area that represents the Ogallala aquifer, and to analyze differences in their decision-making by normative practices like irrigating or dryland operating.

Attitudinal responses on the Ogallala Producer Survey were analyzed based on a VBN framework that links ideas about the relationships between beliefs, values, and actions "through a causal chain of five variables: values (especially altruistic values), NEP [New Ecological Paradigm], AC beliefs [about the adverse consequences of ecological change], and personal norms for pro-environmental action" (Stern et al. 1999:85). This chain "moves from relatively stable, central elements of personality and belief structure to more focused beliefs about human-environment relations, the threats they pose to valued objects, and the responsibility for action, finally activating a sense of moral obligation that creates a predisposition to act" (p.85). This framework links several bodies of research on the formation of public opinion with attitude-behavior relationships, and the psychological-social of social movement support through the norm-activation process. It also offers a classification for different types of social movement support: "committed movement activism, non-activist citizenship behaviors, private-sphere behavior, and policy support. As with environmentalism, different social-psychological variables may be associated with each type of support" (p.91). For non-activists, for example, "individuals' susceptibility to mobilization will depend in part on their basic value priorities and their willingness to believe in the claimed threats" (p.92).

The VBN framework provides a human component to a framework that Sanderson et al. (2017) used to model human decision-making in sociohydrology in the Great Plains. Their model "has the capacity to allow feedbacks from natural systems dynamics, and to more rigorously understand the human decision-making components of future integrated models" (p.2). This conceptual model suggests that beliefs (including ecological worldview and political ideology, among 13 other indicators of belief in the NEP – see Appendix A) affect perceptions of vulnerability, which, in turn, affect local policy support for establishing wildlife and water conservation areas and plans and funding best management practices on agricultural land. In this decision-making process, human values, local environmental knowledge, and demographics, affect the formation of each stage, while policy specific economic factors such as financial obligations affected only the final stage of policy support. The strongest and most consistent effect on decision-making models is financial obligation, or economic value, yet "support for conservation policies is usually grounded in environmental values" through an indirect effect (p.15).

The Ogallala Aquifer Producer Survey from ogallalawater.org helps to answer these questions through exogenous variables (representing values) in section 29 and 33 that ask producers about the guiding principles in their lives (see Appendix A). These are analyzed through a series of logistic regressions that can help to model the relationships between values and beliefs, beliefs and particular attitudinal norms. In this case, section 30 asks producers about their environmental beliefs, which can be analyzed as an outcome of their values, but also a driver of their norms and attitudes toward water conservation (decision-making).

Finally, both sets of variables are analyzed in relation to the outcome of their attitudes toward water conservation in section 21 and 22. Other variables such as family values in section 25, religious beliefs and political orientation in section 29, and adherence to tradition in section 19 are included.

Data

To answer these questions, I relied on the Ogallala Producer Survey and the USGS climate data for 2017 in each of the represented counties. The data is sourced from responses to a survey of farmers who produce in the region supported by the Ogallala Aquifer. Surveys were collected from a sample of 8,000 producers on an area of 227 counties in Colorado, Kansas, Nebraska, New Mexico, Oklahoma, and Texas, which approximate the area above the aquifer. Producers were defined as anyone controlling any number of planted acres or livestock.

1226 individuals completed the survey: a response rate of 15.90%. 118 of these were women. The average producer is male, with a political orientation that lands slightly on the conservative side of moderate (median=6, mean=5.30). He was about 65 years old at the time of the survey (mean birth year= 1954), holds a 2- year associates degree, earns a little more than half of his annual income from farming (mean= 57.36%), and his household income falls between $75,000 and 100,000 (median). 601 do not irrigate at all. 577 irrigate, bringing up the average to 302.1 total irrigated acres (mean). The mean irrigated from groundwater was 272.8 acres, and the mean irrigated from surface water was 29.82 acres.

In comparing irrigators to dryland operators, a dummy variable for irrigator was created for anyone who answered more than 0 for number of irrigated acres in the last year. Those who answered 0 for number of irrigated acres but reported a certain dollar amount above 0 for income from irrigated farming were not considered in either category.

Demographics	**Obs**	**Mean**
Farm size (acres)	1160	41.52
Birth year	1149	1954
Gender (% male)	1173	0.9
Education	1173	3.85
1= Less than 9th grade		
2= 9-12th grade		

3= high school		
4= associates		
5= bachelor's		
6= graduate/prof.		
Politics	1148	5.3
1= Very liberal		
7= Very Conservative		
Income	1057	4.27
1= <25,000		
2= 25,001-50,000		
3= 50,001-75,000		
4= 75,001-100,000		
5= 100,001-125,000		
6= 125,001-150,000		
7= 150,001-175,000		
8= 175,001-200,000		
9= >200,000		
% Income from farming	1101	57.36
Number of generations farming this land in the family	812	4.27
Likelihood of a successor for your farm	1135	2.85

The survey questions are designed to understand how these producers elevate biospheric values (concern for the environment), humanistic-altruistic values (concern for others), and egoistic values (concern for self). It asks about their environmental worldview, elements of identity (such as religious and political ideologies), and other narratives about the environment that make up their beliefs (NEP). It also asks about the practices and attitudes with regard to water conservation that make up the norms which spur decision-making.

Research Question 1

How do people make decisions regarding water conservation? How does culture affect decision-making? How do values and beliefs in the New Ecological Paradigm affect producer's attitudes regarding groundwater conservation?

Variables

This study can address these questions about the connections between core values and decision-making by evaluating several key guiding principles that producers on the Ogallala adhere to and asking about the pathway through beliefs and norms that leads them to particular environmental attitudes.

Dependent Variables

This set of regressions looks at 6 attitudes as outcomes of these values and beliefs. Each of the attitudes measures a norm related to how producers might make decisions. The idea that "groundwater should be used because it does not good in the ground" is expected to relate to people's other views on conservation, and whether they think of water as finite and depletion affecting the next generation. "Groundwater levels are a problem for my community" and "groundwater levels are a problem for my family" are expected to measure similar attitudinal outcomes of family and traditional values as they are filtered through a belief in the New Ecological Paradigm (NEP). Differences in these attitudes might represent the degree to which people perceive ecological issues as structural or individual, and how broadly they define family values. The community variable is log-transformed to correct skewness. "I feel personally responsible for groundwater depletion in my area" and "I should reduce my groundwater usage" are both attitudes that underlie conservation action that reflect traditional values of individualism and personal responsibility. Although this is a measure of pro-environmental attitudes and behaviors, in this case, irrigators, on average, displayed these attitudes more prominently. This suggests that dryland operators, though motivated by this thinking, might think that the question does not apply to them, and therefore score lower on these attitudes. The “reduce” variable is also log-transformed to correct skewness. Finally, “I already limit my groundwater usage as much as possible” measures an attitude that may prevent environmental action because people feel constrained in their choices, or it may represent an elevating of self-interest over other values.

Table 1: Descriptive statistics of normative attitudes

Attitudes	Obs	Mean
1= Strongly disagree; 5= Strongly agree		
Groundwater should be used	1068	2.60
Groundwater levels are a problem for my family	1078	3.06
Groundwater levels are a problem for my community	1082	3.23
I feel personally responsible for groundwater depletion	1074	2.17
I should reduce	1056	2.69
I already limit my use as much as possible	1068	3.93

“I already limit my groundwater usage as much as possible was the strongest held attitude, followed by “groundwater levels are a problem for my family” and “community”.

Norms were also measured by the attitudes of personal responsibility regarding depletion and an obligation to reduce: “I feel personally responsible for groundwater depletion in my area” and “I should reduce or minimize my groundwater use”. VBN Theory argues that environmental decision-making rests upon values, beliefs, and norms related to the environment. Among producers on the Ogallala Aquifer, these values and beliefs indicative of the NEP or DSP may partially construct norms related to groundwater use. To measure these norms, respondents rated how strongly they agreed (on a scale of 1-5) with a variety of attitudes related to irrigation and conservation. “I feel personally responsible for groundwater depletion in my area” indicates the level of personal responsibility ingrained in attitudes and behaviors and the level of efficacy people feel in connection to the consequences for their practices, while “I should reduce or minimize my groundwater use” indicates the level of acceptance of an attitude of conservation as embedded into personal norms of right and wrong. In general, producers did not feel personally responsible for groundwater depletion (mean= 2.17), with most respondents answering that they “strongly disagree” with feeling personally responsible (mode= 1) and were neutral on whether they should reduce groundwater use (mean= 2.69).

Table 2: Mean comparison of normative attitudes

Attitudes	**Dryland Operators**		**Irrigators**			
1= Strongly disagree; 5= Strongly agree	*Mean*	*N*	*Mean*	*N*	*t-Test*	*p- Value*
Groundwater should be used (rev)	3.67	506	3.14	540	7.438***	0.000
Groundwater levels are a problem for my family	3.31	511	2.82	545	6.603***	0.000
Groundwater levels are a problem for my community	3.52	514	2.95	545	7.895***	0.000
I feel personally responsible for groundwater depletion	1.97	505	2.34	547	-.573***	0.000
I should reduce	2.53	488	2.83	545	-4.272***	0.000
I already limit my use as much as possible	3.86	496	3.97	550	-1.8583***	0.000

*p < .05; **p < .01; ***p < .001

Significant differences exist between irrigators and dryland operators in every attitude. Personal responsibility attitudes show glaring differences, which suggest that the attitude might connect to irrigation practices and may have something to do with how people place blame with regard to depletion. Since dryland operators see groundwater levels as a problem for their families and communities, it is likely they have already taken steps to reduce or feel they have reached their limit.

Independent Variables

To answer the first set of questions, I include five factor variables for the aggregated responses to 15 questions that, taken together, represent values that fall into five categories: self-interest, humanistic altruism, environmental altruism, traditional values, and openness to change.

Table 3: Descriptive statistics of values

Held Values	Obs	Mean	Factor Load	Alpha
1= Not important; 5= Very important				
Self Interest	1086			0.49
Authority		3.396	0.8374	
Influence		3.2696	0.8454	
Wealth		2.8912	0.6959	
Humanistic altruism	1103			0.49
Equality		4.2066	0.7881	
Peace		4.1652	0.8349	
Social Justice		3.7203	0.8489	
Environmental altruism	1113			0.87
Earth		4.0846	0.8648	
Environment		3.9618	0.9017	
Nature		3.5629	0.9113	
Traditional	1115			0.81
Respect for elders		4.5971	0.8546	
Discipline		4.4122	0.8656	
Family		4.6264	0.8246	
Openness to change	1093			0.81
Variety		4.4764	0.8657	
Curiosity		3.5421	0.8595	
Exciting life		3.3148	0.832	

There are three different ways of asking each question to get at a single value to increase the internal validity of the scales and make sure that participants are ranking their priorities in the categories intended. Each of these categories became a factored variable to represent each held value. The internal validity of these scales is consistent with Sanderson and Curtis' (2017) use of the same scales to measure values, where egoistic, altruistic and biospheric altruism explained most of the variance with alpha scores ranging from .77 - .81. Respondents rated 15 values, or guiding principles in their lives on a scale of 1 (Not important at all) to 5 (Very Important). These fall into 5 categories indicating self-interest, humanistic altruism, environmental altruism, tradition, and openness to change (Stern et. al 1999). On average, family, security, and safety for loved ones was rated as the greatest value (mean= 4.63), followed very closely by honoring parents and elders, showing respect (mean= 4.60). Rated the lowest on average was wealth, material possessions, and money (mean= 2.89).

There is a great deal of overlap between these values, where family security, for example, could be interpreted as a broad concern for loved ones and a broad concern for humanity, which would fit into an altruistic paradigm or it could be interpreted as an elevation of one's own family and insiders to a group, which would fit into a paradigm based more upon loyalty (a traditional value) than altruism. Further complicating this overlap, personal justifications for certain values might be based on others. For example, one can be very open to change for altruistic purposes, but not seek out change for the sake of their own happiness, and therefore not value "variety" or an "exciting life" very highly. Nevertheless, grouped in this way, traditional values emerge as the most dominant, followed by both types of altruism, openness to change, and self-interest.

Table 4: Mean comparisons of values

Held Values	**Dryland Operators**		**Irrigators**			
1= Not important; 5= Very important	*Mean*	*N*	*Mean*	*N*	*t-Test*	*p- Value*
Self Interest						
Authority	3.45	556	3.33	527	1.732	0.084
Influence	3.29	556	3.25	531	0.522	0.602
Wealth	2.91	561	2.88	531	0.467	0.641
Humanistic altruism						
Equality	4.3	570	4.11	535	3.492**	0.001

Peace	4.27	562	4.05	535	3.822***	0.000
Social Justice	3.84	566	3.59	530	3.896***	0.000
Environmental altruism						
Earth	4.18	566	3.98	534	3.626***	0.000
Environment	4.11	566	3.81	537	5.67***	0.000
Nature	3.74	565	3.39	533	5.369***	0.000
Traditional						
Respect for elders	4.61	571	4.59	543	0.599	0.549
Discipline	4.45	567	4.37	538	1.916	0.056
Family	4.65	570	4.61	534	1.059	0.290
Openness to change						
Variety	3.55	554	3.4	527	2.545*	0.011
Curiosity	3.62	554	3.45	528	2.697**	0.007
Exciting life	3.39	561	3.24	531	2.26*	0.024

*p < .05; **p < .01; ***p < .001

When these values were grouped by irrigators and dryland operators, a significant difference was found between the mean values as dryland operators tended to value equality, peace, social justice, the earth, variety, and curiosity (indicators of humanistic altruism, environmental altruism, and openness to change) higher than irrigators.

One factored variable represents aggregate responses to 16 questions that, taken together, represent beliefs in the New Ecological Paradigm (NEP).

Table 5: Descriptive statistics of NEP beliefs

Beliefs in the NEP	Obs	Mean	Factor Load	Alpha
1= Strongly disagree; 5= Strongly agree				
NEP	1057			0.83
Humans will adapt to the environment (rev)	1114	2.53	0.35	
People are abusing the environment	1120	3.28	0.68	
People are meant to rule over nature (rev)	1114	2.95	0.56	
Nature can cope with industry (rev)	1114	3.4	0.71	
Earth is a spaceship with limited resources	1115	3.23	0.59	
We will soon experience an ecological catastrophe	1121	2.91	0.77	
The climate is changing	1124	3.26	0.69	
Human activity is influencing climate change	1122	3.24	0.76	

People have the right to modify the env. (rev)	1117	3.43	0.44
The "ecological crisis" is exaggerated (rev)	1116	2.69	0.71
Plants and animals have a right to live	1122	3.08	0.55
My religious views affect my water use (rev)	1114	3.08	0.08
Individuals protect the environment, not government (rev)	1127	2.22	0.4
Science does more harm than good (rev)	1117	3.25	0.19
We believe too much in science over faith (rev)	1111	2.8	21
We worry too much about the env. and not enough about jobs (rev)	1121	3.19	0.63

16 indicators of beliefs measure to what extent producers agree with the New Ecological Paradigm (NEP) or Dominant Social Paradigm (DSP). Individualism and adaptability emerged as the two beliefs that people felt most strongly in agreement: “Individuals do more to protect the Environment than the Government” (median= 4, mean= 3.78) and “Humans will always adapt to their natural environment” (median= 4, mean= 3.47). Despite this individualism, which is a hallmark of the DSP, respondents tended to disagree with the statement that “people have the right to modify the natural environment to suit their needs” (median= 3, mean= 2.57), reflecting some beliefs consistent with the NEP.

Responses that measure beliefs in the DSP, like “humans will always adapt to their natural environment” and “people are meant to rule over the rest of nature” were reversed before completing the factor analysis so that a high score would reflect a greater belief in the NEP in the single, NEP variable.

Table 6: Mean comparisons of NEP beliefs

NEP (New Ecological Paradigm) Belief	**Dryland Operators**		**Irrigators**			
1= Strongly disagree; 5= Strongly agree	*Mean*	*N*	*Mean*	*N*	*t-Test*	*p- Value*
Humans will always adapt to the env. (rev)	2.64	557	2.42	534	3.993***	0.000
People are abusing the env.	3.51	563	3.04	534	7.385***	0.000
People are meant to rule over the env. (rev)	3.02	557	2.87	534	2.318*	0.021
Nature can cope with modern industry (rev)	3.49	556	3.31	535	3.114**	0.002

Earth is like a spaceship with limited resources	3.49	559	3.04	533	5.906***	0.000
If things continue, we will have an ecological catastrophe	3.17	562	2.65	536	8.025***	0.000
The climate is changing	3.37	562	3.14	536	3.278**	0.001
Humans are influencing the climate	3.38	563	3.1	536	4.297***	0.000
People have the right to modify the env. (rev)	3.53	560	3.33	535	3.625***	0.000
The "eco crisis" is exaggerated (rev)	2.83	559	2.54	534	4.296***	0.000
Plants and animals have right to live	3.58	563	2.88	536	5.779***	0.000
My religion affects views on water (rev)	3.01	560	3.15	532	-2.158*	0.031
Individuals protect the env. not govt. (rev)	2.28	563	2.17	541	2.05*	0.041
Science does more harm than good (rev)	3.21	560	3.3	534	-1.702	0.089
We should believe more in faith, not science (rev)	2.73	557	2.88	530	-2.466*	0.014
We should worry more about jobs than the env. (rev)	3.26	563	3.12	535	2.477*	0.013

*p < .05; **p < .01; ***p < .001

Again, major differences emerged between irrigators and dryland operators in almost every indicator of NEP beliefs. Most notably, dryland operators believe that people are severely abusing the environment and that plants and animals have as much right as people to exist. They hold these beliefs more intensely than their irrigator counterparts.

First, I tested the effects of each of the values on beliefs. Then I tested the effects of each of the values and beliefs on a key set of norms. I controlled for farm size, well capacity, age, gender, education, politics, household, income, percentage of household income from farming, percentage of household income from irrigated farming, total number of irrigated acres, the number of generations that the family had owned the farm, and the degree to which a family member or successor would be able to continue farming into the next generation. Including farm size, well capacity, income, and irrigated acres helps to account for attitudes that are constrained by economic factors. Including successor and generations of farming helps to account for attitudes that are constrained by feelings of obligation to the past and the future.

Models

Each model incorporates the effects of values and beliefs on a single attitude that affect behaviors. These six models are limited in that they are unable to account for the way that values affect beliefs, which in turn, reinforce values, and they are unable to account for the ways that these attitudinal norms may affect behaviors that then must be justified by values and beliefs. For these reasons, the models are dynamic. Each part can shift the other parts over time. Nevertheless, they help to approximate the relative importance of each element on the attitudinal outcomes.

Research Question 2

How does the environment affect culture? Does environmental change affect producer's values, beliefs, and norms regarding water conservation? Does culture change as producers adapt to climate change?

Variables

We know that the environment has the ability to shape humans in social and physical ways (Boserup 1970; Sanderson, Heckert, and Dubrow 2005; Fielding 2015); and that the physical environment intertwines with our sense of place and identity to shape the type of agriculture that we engage in, and the cultural beliefs and norms that emerge from that agricultural context (Talhem et al. 2014; Brown 2016; Brown et al. 2019). Based on this dataset, producers vary in their values and beliefs, showing more similarities to others in their geographical area than to others in their group of irrigators or dryland operators, which confirms this assertion that place and environment matter in the development of values and beliefs.

Table 7a: Demographics by State

Demographics	Overall Mean	KS	CO	NE	NM	OK	TX
Birth Year	1954	1956	1953	1955	1947	1950	1953

Gender	1.10	1.11	1.17	1.08	1.21	1.06	1.10
Education	3.85	3.93	3.84	3.73	4.00	4.02	4.13
Political Orientation	5.30	5.26	5.28	5.20	5.73	5.70	5.57
Adults in House	1.92	1.91	1.98	1.91	1.88	1.90	1.94
Income	4.27	4.00	4.32	4.24	4.21	4.34	4.84
% Income from Farming	57.36	56.34	54.74	61.15	42.75	43.54	53.81
% Income from Irrigated Farming	23.40	12.25	28.92	27.96	7.34	12.13	30.75

Table 7b: Values by State

Values	**Overall Mean**	**KS**	**CO**	**NE**	**NM**	**OK**	**TX**
1= Not important; 5= Very important							
Self- Interest							
Authority	3.40	3.30	3.28	3.39	3.56	3.48	3.67
Influence	3.27	3.18	3.17	3.27	3.41	3.36	3.48
Wealth	2.89	2.84	2.67	2.93	3.00	3.00	2.98
Hum. Altruism							
Equality	4.21	4.20	4.10	4.19	4.47	4.29	4.28
Peace	4.17	4.13	4.01	4.19	4.39	4.16	4.22
Justice	3.72	3.75	3.45	3.71	3.97	3.81	3.81
Env. Altruism							
Earth	4.08	4.02	3.90	4.11	4.21	4.21	4.20
Environment	3.96	3.94	3.81	3.99	4.25	4.10	3.91
Nature	3.56	3.53	3.37	3.60	3.84	3.75	3.53
Traditional							
Elder	4.60	4.58	4.48	4.57	4.82	4.78	4.72
Discipline	4.41	4.40	4.31	4.39	4.70	4.53	4.50
Family	4.63	4.61	4.57	4.61	4.85	4.65	4.71
Openness to Change							
Variety	3.48	3.37	3.41	3.46	3.53	3.66	3.74
Curiosity	3.54	3.46	3.36	3.54	3.66	3.85	3.75
Exciting Life	3.31	3.35	3.23	3.26	3.53	3.44	3.45

Table 7c: NEP beliefs by State

Beliefs	**Overall Mean**	**KS**	**CO**	**NE**	**NM**	**OK**	**TX**
Humans Adapt	3.47	3.45	3.37	3.48	2.97	3.53	3.69
People Abuse	3.28	3.38	3.18	3.22	3.42	3.46	3.33
People Rule	3.05	2.94	3.13	3.00	2.90	3.47	3.33
Nature Can Cope	2.60	2.57	2.63	2.59	2.47	2.58	2.72
Earth Spaceship	3.23	3.23	3.36	3.22	3.28	2.85	3.33
Eco. Catastrophe	2.91	3.00	2.85	2.85	3.13	2.94	2.99

Climate Change	3.26	3.28	3.29	3.22	3.19	3.48	3.28
Hum. Climate Change	3.24	3.21	3.21	3.26	3.28	3.23	3.22
People Right	2.57	2.53	2.68	2.54	2.56	2.54	2.69
Exaggerated Crisis	3.32	3.25	3.50	3.31	3.16	3.46	3.27
Plant/Animal Right	3.08	3.09	2.88	3.16	2.88	2.91	3.01
Religious Water	2.92	2.95	2.85	2.88	3.16	2.98	3.04
Ind. Over Govt.	3.78	3.74	3.80	3.76	3.72	4.02	3.83
Science Harm	2.75	2.68	2.71	2.81	2.75	3.00	2.55
Faith Over Science	3.20	3.23	3.08	3.20	3.13	3.48	3.12
Jobs Over Env.	2.81	2.77	2.87	2.78	2.81	3.02	2.88

Table 7d: Two attitudinal norms by State

Norms	Overall Mean	KS	CO	NE	NM	OK	TX
Pers. Responsibility	2.17	2.18	2.28	2.07	2.00	2.10	2.53
Reduce Groundwater	2.69	2.88	2.66	2.57	2.69	2.62	2.87

Differences in values, beliefs, and a few key norms between different geographical areas suggest that environmental change might affect producer’s values, beliefs, and norms regarding water conservation. Borick and Rabe (2017) cite growing bodies of evidence that “direct experiences with extreme weather events and abnormal seasonal temperature and precipitation levels can affect the likelihood that an individual will perceive global warming to be occurring, and in some cases their policy preferences for addressing the problem” (p.334). This effect is intensified by experiences with high temperatures and flooding, but less by snowfall, unseasonably low temperatures, or drought, which people are less likely to attribute to climate change. At the same time, those who were skeptical about global warming, were less able to estimate climate and weather events in relation to the actual amounts of precipitation or temperatures they experienced. This suggests that while extreme weather events are one way that the environment helps construct our attitudes, the effect is conditioned by pre-conceived beliefs. Since climate change happens faster than cultural change, it is possible that the climate helps to shape culture, but a lag prevents the current climate from aligning with current beliefs in the NEP or norms regarding water conservation.

Independent Variables: Climate

To test the effect of climate on culture, the dataset was merged with climate data from the USGS that measured the storage water availability in acre-feet, average PDSI (a measure of soil saturation), precipitation in millimeters, and temperature in degrees Celsius, of each county in the year of the survey. Factor analysis revealed that most of the variance loaded onto only one factor (Eigenvalue= 1.818, Chi2= 0.000), which was best represented by three variables: (1) precipitation, (2) a cold/wet factored variable that combined PDSI with the reversed temperature so that saturated soil could be associated with less evaporation due to heat; and less so by a (3) third variable that represents the amount of groundwater storage. Storage in acre-feet explained less of the variance than the other two combined climate variables. The scale reliability coefficient was .781.

It is possible that there is a lag between groundwater depletion and a change in climate large enough to affect decision-making. It is also possible that this confirms Morton et al.'s (2016) assertion that "good farmers" pay attention to the weather by paying attention to the weather's effect on the soil.

Control Variables

Each of the demographics and farm specifics were tested to determine which control variables accounted for the most variance and should be included in regression models. Farm size, well capacity, birth year, gender, education, politics, income, percentage of income from farming, percentage of income from irrigated farming, the total number of irrigated acres, the number of generations that the farm has been in the family, and the likelihood of the farm continuing to stay in the family through a successor all make theoretical sense. While these last two control variables explain less of the variation, it makes theoretical sense that those who have family legacies in the past and future that are tied to the productivity of the land might be more concerned about the future effects of climate change or more in-tune with the challenges that climate change poses in recent years in comparison to the past. Finally, the sample was split between irrigators and dryland operators. To prevent skewness, well capacity, percent income from irrigated farming, and number of irrigated acres were only included in the irrigator sample.

Dependent Variables

Several path analyses were tested using R and then Stata to see if multiple relationships with intervening variables might explain the ways that climate affects values, which in turn, affect beliefs, and result in attitudes that people use for decision-making. Beginning with a complex model that included all 16 exogenous variables (3 climate +13 control), 5 values, 1 NEP belief index, 6 attitudes, covariances between the exogenous variables, and direct and indirect relationships between certain steps, the path was then reduced, and variables and relationships excluded to achieve calculatable goodness of fit statistics. A simple path model with only three values (self-interest, environmental altruism, and humanistic altruism), NEP, and one attitude (I should reduce) returned all goodness of fit statistics. However, this model left out key control variables and two of the values. Adding in these other elements allowed me to calculate only SRMR, the best model producing an SRMR of .085. Direct and indirect relationships, covariances, and multi-directional relationships were no longer included in this simplified path, which defeated the purpose of using path analysis to model the relationships. At this point, the model no longer fit the data, and it was determined that a set of regression models would better explain the data because they would allow inclusion of all the variables that were important to the integrity of the study.

Therefore, this set of regressions looks at the effects of climate on each of the 5 values, NEP, and 6 attitudes. Each of the attitudes measures a norm related to how producers might make decisions. The idea that "groundwater should be used because it does no good in the ground" is reversed so that it matches the direction of the other attitudes where a higher score reflects an attitude that upholds greater conservation. "Groundwater levels are a problem for my community" and "groundwater levels are a problem for my family" are expected to measure similar attitudinal outcomes of family and traditional values. "I feel personally responsible for groundwater depletion in my area" and "I should reduce my groundwater usage" are both pro-environmental attitudes that reflect traditional values of individualism and personal responsibility. Irrigators, on average, displayed these attitudes more prominently, which brings up questions about whether the attitude is intensified in irrigators by groundwater shortages or other climatic variables. Dryland operators, though motivated by this thinking, might feel absolved from personal responsibility because they do not pump directly from the aquifer for irrigation (though they, like all consumers, also use the groundwater indirectly). Finally, "I already limit my groundwater usage as much as possible" measures an attitude that may prevent environmental action because people feel constrained in their choices by economic factors, like a need to produce enough to cover debt, the cost of inputs, and living expenses. The "community" and "should reduce" variables are both log-transformed to correct skewness.

Chapter 4 - Results

Question 1 Results

The first research question was concerned with the elements of culture (values, belief, and norms) that affect decision-making. How do values and beliefs in the NEP affect producer's normative attitudes regarding groundwater conservation?

The results indicate two overarching themes. First, beliefs in the New Ecological Paradigm are extremely important in determining attitudes regarding water conservation. For the entire sample, NEP beliefs were significant to every attitude measured except one: "I already limit my groundwater usage as much as possible." This is an important finding because it shows that people's beliefs matter independently of economic interests, constraining structural and environmental factors, or the future of the farm. The prominence of beliefs confirms Drummond and Fischhoff's (2017) assertion that beliefs can become entrenched. They intensify as people learn new information along confirmation biases. While we know that values work to construct environmental beliefs (Inglehart 1995; Dietz et al. 2005), beliefs, in this case, can take on a life of their own in determining attitudes about water conservation.

Secondly, the attitudes of irrigators and dryland operators are differently affected by beliefs. In fact, the NEP holds greater explanatory power over norms for irrigators than it does for dryland operators, whose values and beliefs both affect their decision-making. This is consistent with the cultural foundations of the VBN framework because it suggests that our behaviors (in this case, irrigation practices) are not just decisions we make, but norms reinforced by values and beliefs which differ based on those norms. This also reinforces Sanderson and Curtis' (2017) finding that irrigators and dryland operators represent different cultural foundations.

Table 8a: Coefficients from Regression of Five Values, Beliefs in the New Ecological Paradigm (NEP), and Other Independent Variables on Three Attitudes Regarding Groundwater Conservation

	Model 1	**Model 2**	**Model 3**
	Groundwater should be used	Groundwater levels are a problem for my family	Groundwater levels are a problem for my community (ln)
Self interest	0.221***	-0.0655	-0.0267
	[-0.0718]	[-0.0784]	[-0.0292]
Environmental altruism	-0.0176	-0.0819	-0.0272
	[-0.0771	[-0.0844]	[-0.0314]
Humanistic altruism	-0.0851	-0.0912	-0.0129
	[-0.076]	[-0.0831]	[-0.0309]
Traditional	-0.0158	-0.000501	-0.0271
	[-0.0609]	[-0.0663]	[-0.0247]
Openness to change	0.0397	0.145*	0.0445
	[-0.0735]	[-0.0803]	[-0.0299]
NEP	-0.236***	0.363***	0.132***
	[-0.0614]	[-0.0674]	[-0.025]
Farm size	-4.12E-05	0.000131***	4.75e-05***
	[-0.0000358]	[-0.0000392]	[-0.0000145]
Birth year	0.000754	-0.000606	-0.000684
	[-0.00404]	[-0.00442]	[-0.00164]
Gender	-0.0118	0.121	0.12
	[-0.189]	[-0.207]	[-0.077]
Education	0.041	0.00789	0.0144
	[-0.0433]	[-0.0478]	[-0.0176]
Politics	-0.0163	0.143***	0.0530***
	[-0.0426]	[-0.0464]	[-0.0173]
Income	-0.0429**	-0.0234	-0.0147*
	[-0.0215]	[-0.0233]	[-0.00864]
Percent income from farming	0.00118	-0.00394**	-0.00146**
	[-0.00148]	[-0.00162]	[-0.0006]
Generations	0.0184	0.0224	-0.00352
	[-0.0639]	[-0.0695]	[-0.0259]
Successor	0.104***	-0.00528	0.00621
	[-0.03]	[-0.0329]	[-0.0122]
Constant	0.87	3.454	2.045
	[-7.88]	[-8.629]	[-3.189]

Observations	532	537	539
R-squared	0.114	0.093	0.101

Standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

In model 1, the attitude that groundwater should be used is positively affected by self-interest. It is negatively affected by the NEP and income, which is to be expected. Those who believe in environmental stewardship and have enough income to afford to take steps toward water conservation that may hurt them financially would be less likely to support using groundwater. Despite the fact that this attitude seems present-oriented, those who have a successor, and would be most motivated to be future-oriented, are more in agreement that groundwater should be used.

Models 2 and 3 show that the attitude that groundwater levels are a problem for my family and community are positively affected by the NEP, farm size, and politics. Although the New Ecological Paradigm is associated with left-leaning politics, more conservative people tend to agree with this particular attitude, which may represent the family and community-oriented language, which resonates with conservative politics. Large farm size may give producers a unique perspective, allowing them to see the magnitude of depletion on a community level. Larger percentages of farming income negatively affected the attitude that depletion is a problem for family or community, which suggests that some amount of behavioral control is at play for those who depend entirely on farming, and who cannot afford to have this attitude because their income is cushioned by something outside of production. Some contradictions exist between Model 1 and Models 2 and 3. Income negatively affects the belief that groundwater should be used, and also negatively affects the attitude that depletion is a problem. Those with higher incomes may have the ability to "buy" alternative water sources, or problem-solve in other ways that their resources afford them. There also appears to be a disconnection between what those with higher incomes do not see as a problem and what they are willing to consider as solutions. These attitudes are more nuanced than whether or not groundwater conservation is important, which further confirms the salience of weighing values and beliefs in decision-making.

Table 8b: Coefficients from Regression of Five Values, Beliefs in the New Ecological Paradigm (NEP), and Other Independent Variables on Three Attitudes Regarding Groundwater Conservation

	Model 4	Model 5	Model 6
	I feel personally responsible for groundwater depletion	I should reduce my groundwater use (ln)	I already limit my groundwater usage as much as possible
Self interest	0.0119	-0.0167	-0.259***
	[-0.0712]	[-0.0317]	[-0.0639]
Environmental altruism	-0.101	0.0214	0.112
	[-0.0769]	[-0.0342]	[-0.0684]
Humanistic altruism	0.00458	0.00566	0.064
	[-0.0766]	[-0.0339]	[-0.068]
Traditional	-0.138**	-0.0723***	0.112**
	[-0.0612]	[-0.0271]	[-0.0541]
Openness to change	0.0373	-0.00275	0.157**
	[-0.073]	[-0.0324]	[-0.0649]
NEP	0.145**	0.0865***	-0.0227
	[-0.0613]	[-0.0272]	[-0.055]
Farm size	2.54E-05	2.66e-05*	6.33E-06
	[-0.0000355]	[-0.0000157]	[-0.0000315]
Birth year	-0.00904**	0.00338*	0.00207
	[-0.004]	[-0.00178]	[-0.00357]
Gender	-0.0624	-0.172**	-0.271
	[-0.188]	[-0.085]	[-0.169]
Education	0.0664	0.00729	-0.035
	[-0.0431]	[-0.0191]	[-0.0388]
Politics	-0.0508	-0.00615	0.119***
	[-0.0422]	[-0.0188]	[-0.0378]
Income	0.0142	-0.00514	-0.0101
	[-0.0211]	[-0.0094]	[-0.0189]

Percent income from farming		0.00132		0.00057		-0.000744
	[-0.00147]		[-0.000654]		[-0.00132]	
Generations		-0.00881		-0.012		0.0244
	[-0.0633]		[-0.0282]		[-0.0569]	
Successor		0.0436		-0.0137		0.0111
	[-0.0298]		[-0.0133]		[-0.0268]	
Constant		19.70**		-5.495		-0.374
	[-7.806]		[-3.472]		[-6.969]	
Observations		534		525		526
R-squared		0.06		0.078		0.077

Standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Model 4 shows that feeling personally responsible for groundwater depletion is negatively related to traditional values and birth year, and positively related to the NEP. Since this attitude mashes together two sometimes opposing viewpoints (traditional values and environmental altruism), the negative relationship to traditional values suggests (1) that beliefs are more salient in forming this attitude than their underlying values, and (2) that apparently opposing viewpoints can be held together and even reinforce each other.

Model 5 shows that the attitude that "I should reduce my groundwater usage" is negatively impacted by traditional values, and positively affected by NEP. This confirms the expected normative attitude outcome of beliefs. Like in models 2 and 3, farm size showed a positive relationship to the reduce attitude.

Model 6 showed that "I already limit my groundwater usage as much as possible" was negatively affected by self-interest, and positively affected by traditional values, openness to change, and conservative politics. Again, this presents a contradiction, as openness to change and traditional values are assumed to be opposing viewpoints, so it is odd that they would show a similar effect on this attitude. Instead, this might show that people can hold both values and that they may assess their own limits in ways that are inconsistent with their values.

Table 9a: Irrigators Only- Coefficients from Regression of Five Values, Beliefs in the New Ecological Paradigm (NEP), and Other Independent Variables on Three Attitudes Regarding Groundwater Conservation

	Model 1	**Model 2**	**Model 3**
	Groundwater should be used	Groundwater levels are a problem for my family	Groundwater levels are a problem for my community
Self interest	0.103 [-0.106]	-0.142 [-0.115]	-0.0624 [-0.0454]
Environmental altruism	0.091 [-0.11]	-0.201* [-0.12]	-0.0606 [-0.0473]
Humanistic altruism	-0.101 [-0.0946]	-0.148 [-0.103]	-0.0383 [-0.0407]
Traditional	-0.0317 [-0.0844]	0.106 [-0.0914]	-0.00255 [-0.0361]
Openness to change	0.105 [-0.109]	0.232* [-0.119]	0.0788* [-0.047]
NEP	-0.272*** [-0.0892]	0.348*** [-0.0969]	0.140*** [-0.0383]
Farm size	-6.82E-07 [-0.00006]	0.000128* [-0.0000653]	5.92e-05** [-0.0000258]
Well capacity	-3.36E-07 [-0.0000201]	-8.30e-05*** [-0.0000219]	-3.31e-05*** [-0.00000864]
Birth year	-0.00408 [-0.00593]	-0.002 [-0.00643]	-0.00264 [-0.00254]
Gender	0.0585 [-0.405]	-0.248 [-0.441]	-0.117 [-0.175]
Education	0.105 [-0.0649]	0.11 [-0.0705]	0.0462* [-0.0279]
Politics	-0.0341 [-0.0597]	0.0617 [-0.0648]	0.042 [-0.0256]
Income	-0.0723** [-0.0284]	-0.0106 [-0.0305]	-0.0125 [-0.0121]
Percent income from farming	-0.000478 [-0.00243]	-0.00163 [-0.00261]	-0.000987 [-0.00103]

Percent income from irrigated farming		0.0106***		7.65E-05		0.000258
	[-0.00282]		[-0.00305]		[-0.00121]	
Number of irrigated acres		-0.0607		0.145		0.0261
	[-0.1]		[-0.108]		[-0.0428]	
Generations		0.0997		0.0228		0.0405
	[-0.095]		[-0.103]		[-0.0407]	
Successor		0.105**		0.0169		0.0159
	[-0.0427]		[-0.0464]		[-0.0183]	
Constant		10.02		5.559		5.697
	[-11.56]		[-12.55]		[-4.96]	
Observations		272		276		276
R-squared		0.18		0.166		0.177

Notes: Standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 2 shows the same six models for irrigators only. Three control variables were added to this subset to account for possible differences: well capacity, percent income from farming, and number of irrigated acres (log-transformed to correct skewness). As is the case with the entire sample, irrigators show that NEP is the most salient variable in each attitude.

In model 1, the attitude that groundwater should be used was negatively affected by the NEP and income, but positively affected by the percentage of income from irrigated farming and having a successor.

Among irrigators, “groundwater levels are a problem for my family” is negatively affected by environmental altruism and positively affected by openness to change, NEP, and farm size. Similarly, “groundwater levels are a problem for my community” is positively affected by openness to change, NEP, and education.

Table 9b: Irrigators Only- Coefficients from Regression of Five Values, Beliefs in the New Ecological Paradigm (NEP), and Other Independent Variables on Three Attitudes Regarding Groundwater Conservation

	Model 4	Model 5	Model 6
	I feel personally responsible for groundwater depletion	I should reduce my groundwater use	I already limit my groundwater usage as much as possible
Self interest	-0.152	-0.0703*	-0.14
	[-0.107]	[-0.0407]	[-0.0881]
Environmental altruism	-0.164	0.0271	0.096
	[-0.111]	[-0.0424]	[-0.0917]
Humanistic altruism	0.108	0.0497	0.105
	[-0.0958]	[-0.0365]	[-0.0791]
Traditional	-0.0378	-0.0398	0.186***
	[-0.0849]	[-0.0324]	[-0.0701]
Openness to change	0.0432	0.0234	0.102
	[-0.11]	[-0.0421]	[-0.0911]
NEP	0.241***	0.0869**	-0.0463
	[-0.0901]	[-0.0344]	[-0.0746]
Farm size	9.56E-05	2.58E-05	-1.74E-05
	[-0.0000607]	[-0.0000231]	[-0.0000501]
Well capacity	-4.48e-05**	-1.10E-05	2.49E-05
	[-0.0000203]	[-0.00000775]	[-0.0000168]
Birth year	-0.0108*	0.000544	-0.00542
	[-0.00598]	[-0.00228]	[-0.00494]
Gender	-0.254	-0.496***	-0.528
	[-0.41]	[-0.157]	[-0.339]
Education	0.133**	-0.0188	-0.0196
	[-0.0655]	[-0.025]	[-0.0544]
Politics	0.011	0.00587	0.0726
	[-0.0602]	[-0.023]	[-0.0498]
Income	0.0141	-0.000922	-0.0246
	[-0.0284]	[-0.0108]	[-0.0234]
Percent income from farming	-0.00268	0.000913	0.00133
	[-0.00243]	[-0.000927]	[-0.00201]
Percent income from irrigated farming	0.00497*	-0.000628	-0.00259
	[-0.00283]	[-0.00108]	[-0.00234]
Number of irrigated acres	0.0777	0.0561	-0.0533
	[-0.101]	[-0.0384]	[-0.0833]

Generations	0.0682	-0.00634	-0.0335
	[-0.0957]	[-0.0365]	[-0.079]
Successor	0.0309	-0.00285	0.0694*
	[-0.0431]	[-0.0164]	[-0.0356]
Constant	22.46*	0.16	15.11
	[-11.66]	[-4.447]	[-9.628]
Observations	276	276	275
R-squared	0.116	0.143	0.122

Notes: Standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Among irrigators, “I feel personally responsible for groundwater depletion in my area” shows a positive relationship with NEP and a negative relationship with well capacity. “I should reduce my groundwater usage” is negatively affected by self-interest, well capacity, and gender (female), and positively affected by NEP. “I already limit my groundwater usage as much as possible” is positively impacted by traditional values and having a successor.

Table 10a: Dryland Operators Only- Coefficients from Regression of Five Values, Beliefs in the New Ecological Paradigm (NEP), and Other Independent Variables on Three Attitudes Regarding Groundwater Conservation

	Model 1	**Model 2**	**Model 3**
	Groundwater should be used	Groundwater levels are a problem for my family	Groundwater levels are a problem for my community (ln)
Self interest	0.335***	0.0394	0.0125
	[-0.0969]	[-0.107]	[-0.0363]
Environmental altruism	0.0139	0.0625	-0.00212
	[-0.113]	[-0.125]	[-0.0424]
Humanistic altruism	-0.0223	-0.181	-0.0175
	[-0.132]	[-0.146]	[-0.0494]
Traditional	-0.0534	-0.0685	-0.0426
	[-0.0861]	[-0.0951]	[-0.0322]
Openness to change	-0.126	0.0721	0.017
	[-0.0984]	[-0.109]	[-0.0368]
NEP	-0.0962	0.265***	0.0739**
	[-0.0844]	[-0.0939]	[-0.0316]
Farm size	-8.32E-05	0.000152***	5.99e-05***

	[-0.0000515]	[-0.0000572]	[-0.0000193]
Birth year	0.00798	-0.000215	0.00199
	[-0.00581]	[-0.00643]	[-0.00216]
Gender	-0.0248	-0.0459	0.106
	[-0.213]	[-0.235]	[-0.0797]
Education	0.04	-0.101	-0.0117
	[-0.0587]	[-0.0666]	[-0.0219]
Politics	0.0387	0.185***	0.0364
	[-0.0594]	[-0.0653]	[-0.0221]
Income	-0.016	-0.017	-0.00649
	[-0.0327]	[-0.0361]	[-0.0122]
Percent income from farming	-0.00299	-0.00474**	-0.00124*
	[-0.002]	[-0.00222]	[-0.000749]
Generations	-0.108	0.0537	-0.026
	[-0.086]	[-0.0948]	[-0.0322]
Successor	0.137***	-0.0643	-0.0187
	[-0.0427]	[-0.0472]	[-0.0159]
Constant	-13.28	3.376	-2.809
	[-11.31]	[-12.5]	[-4.189]
Observations	249	250	252
R-squared	0.163	0.115	0.1

Standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Dryland operators tell a different story. In model 1, only self-interest and having a successor have an effect on whether people think that groundwater should be used. Both variables show a positive relationship. Self-interest and having a successor make dryland operators more likely to support using groundwater. Unlike among irrigators, the NEP has less of an effect on this attitude.

In model 2, dryland operators show that NEP, farm size, and conservative politics have a positive effect on the attitude that groundwater levels are a problem for the family, whereas percentage of income from farming has a negative effect on this attitude. A similar pattern emerges in model 3, except that politics no longer has a significant effect on the community level that it did on the family level.

Table 10b: Dryland Operators Only- Coefficients from Regression of Five Values, Beliefs in the New Ecological Paradigm (NEP), and Other Independent Variables on Three Attitudes Regarding Water Conservation

	Model 4	**Model 5**	**Model 6**
	I feel personally responsible for groundwater depletion	I should reduce my groundwater use (ln)	I already limit my groundwater usage as much as possible
Self interest	0.15 [-0.0918]	0.0356 [-0.0503]	-0.368*** [-0.097]
Environmental altruism	0.0638 [-0.108]	0.0404 [-0.0589]	0.175 [-0.112]
Humanistic altruism	-0.147 [-0.132]	-0.0838 [-0.0719]	0.0494 [-0.135]
Traditional	-0.237*** [-0.086]	-0.0976** [-0.0469]	0.0146 [-0.087]
Openness to change	0.0456 [-0.0929]	-0.00378 [-0.0508]	0.196** [-0.0963]
NEP	0.107 [-0.0806]	0.117*** [-0.0439]	0.0246 [-0.0851]
Farm size	-2.42E-05 [-0.0000488]	1.76E-05 [-0.0000265]	4.54E-05 [-0.0000505]
Birth year	-0.00911* [-0.0055]	0.00453 [-0.003]	0.0075 [-0.00575]
Gender	0.101 [-0.201]	-0.0636 [-0.112]	-0.203 [-0.212]
Education	-0.0525 [-0.0558]	0.00937 [-0.0306]	-0.0116 [-0.0593]
Politics	-0.0980* [-0.0562]	-0.00658 [-0.0309]	0.158*** [-0.059]
Income	-0.0341 [-0.031]	-0.0271 [-0.017]	0.012 [-0.0324]
Percent income from farming	-0.000701 [-0.00191]	-0.000678 [-0.00104]	-0.00198 [-0.002]
Generations	-0.0522 [-0.0814]	-0.00576 [-0.0446]	0.125 [-0.0865]

Successor	0.0720*	-0.0124	-0.0231
	[-0.0403]	[-0.0221]	[-0.0428]
Constant	20.51*	-7.814	-11.7
	[-10.69]	[-5.838]	[-11.18]
Observations	247	238	240
R-squared	0.157	0.106	0.122
Standard errors in brackets			
*** p<0.01, ** p<0.05, * p<0.1			

Among dryland operators, traditional values, birth year, and conservative politics negatively impacted the personal responsibility for groundwater depletion attitude. This suggests that although conservative ideologies and traditional values tend to coincide with a belief in personal responsibility, being a dryland operator absolves producers of that responsibility when they perceive conservation as an individual, rather than structural problem. Successors positively impacted this attitude. Model 5 shows that dryland operators' attitude that "I should reduce my groundwater usage" is negatively impacted by traditional values and positively impacted by the NEP. Model 6 shows that self-interest is associated with an attitude that there is still more that could be done with regard to water conservation, whereas openness to change and conservative politics are associated with an attitude that a limit has already been reached- that "I already limit my groundwater usage as much as possible".

Question 2 Results

How does the environment affect culture? Does environmental change affect producer's values, beliefs, and norms regarding water conservation? Does culture change as producers adapt to climate change?

Several key themes emerge in the following findings. First, environmental conditions seem to affect attitudes directly even as they influence underlying, more permanent parts of culture, such as values and beliefs. For example, attitudes that groundwater depletion is a problem for families and communities seems directly influenced by the amount of groundwater available, and by shortages in other parts of the hydrologic cycle. Producers living in cold and wet climates held this attitude less intensely than those who experience dry soil, less precipitation, and warmer temperatures. These climatic conditions also appear to be directly related to cultures that value openness to change.

Secondly, major differences emerge in the ways that environmental conditions manifest into values for dryland operators and irrigators. Cold and wet environments are related to less environmental altruism and more humanistic altruism in irrigators alone. These environments also related to irrigators being less traditional and less open to change, which highlights the complexity of traditional values. Like Baldwin and Lammers (2016) suggest, traditionalism may be more related to temporal focus- in this case, the idea that the climate is important for this year's production- than it is to feelings of nostalgia for the past or an unwillingness to change. By contrast, this means that dry and hot environments, which we are likely to experience more, in addition to greater extreme weather events, are likely associated with less humanistic altruism and more environmental altruism in irrigators. This brings up a major concern and several questions. Decreasing humanistic altruism within a situation of increasing inequalities could be problematic as water rights are contested. It will be important to find solutions that allow water to be used fairly and equitably, while being respected and preserved as something outside of capitalist ownership and outside of the elements of the treadmill of production. Will it be too late to foster environmental altruism when the climate has already become dry enough and hot enough to necessitate it? Furthermore, will environmental altruism and humanistic altruism become more closely connected as people begin to realize that caring for the environmental might be the only way to care for the most vulnerable people, dispossessed people, and all future people?

The following table shows the effect of the three climate variables on the first three values (self-interest, environmental altruism, and humanistic altruism) in the entire sample.

Table 11a: Coefficients from Regression of 3 Climate Variables on 3 Values

	Model 7	**Model 8**	**Model 9**
	Self interest	Environmental altruism	Humanistic altruism
Cold/Wet	-0.00529	-0.0528	-0.0438
	[-0.0527]	[-0.0498]	[-0.0495]
Precipitation (mm)	-0.000178	0.000277	0.000424
	[-0.000341]	[-0.000323]	[-0.000321]
Storage (acre feet)	-1.91E-09	7.73E-11	-1.34E-09
	[-0.00000000176]	[-0.00000000167]	[-0.00000000165]
Farm size	-2.46E-05	-2.64E-05	-5.36e-05*
	[-0.0000337]	[-0.0000319]	[-0.0000317]
Birth Year	-0.00755**	-0.00745**	-0.0127***
	[-0.00374]	[-0.00353]	[-0.00351]
Gender	-0.0315	0.131	0.139
	[-0.179]	[-0.169]	[-0.168]
Education	-0.00672	-0.0225	-0.0559
	[-0.0397]	[-0.0375]	[-0.0373]
Politics	0.0626*	-0.115***	-0.118***
	[-0.0351]	[-0.0332]	[-0.033]
Income	0.0545***	0.0192	0.00772
	[-0.0196]	[-0.0185]	[-0.0184]
Percent Income from farming	0.000179	-0.000468	-0.000185
	[-0.00139]	[-0.00131]	[-0.00131]
Generations	-0.00919	-0.0195	-0.0707
	[-0.059]	[-0.0558]	[-0.0554]
Successor	-0.0102	-0.0208	-0.0222
	[-0.0284]	[-0.0269]	[-0.0267]
Constant	14.51**	15.06**	25.53***
	[-7.259]	[-6.863]	[-6.816]
Observations	484	484	484
R-squared	0.037	0.057	0.107

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The following table shows the effect of the three climate variables on the last two values (traditional and openness to change) and beliefs in the NEP in the whole sample.

Table 11b: Coefficients from Regression of 3 Climate Variables on 2 Values and Beliefs in the New Ecological Paradigm (NEP)

	Model 10	**Model 11**	**Model 12**
	Traditional	Openness to change	NEP
Cold/Wet	-0.0365	-0.105**	-0.0326
	[-0.0521]	[-0.0517]	[-0.0491]
Precipitation (mm)	-7.31E-05	-0.000622*	3.76E-05
	[-0.000337]	[-0.000335]	[-0.000318]
Storage (acre feet)	-1.10E-09	-1.93E-09	-7.61E-10
	[-0.00000000174]	[-0.00000000173]	[-0.00000000164]
Farm size	2.19E-05	-1.84E-05	-5.33e-05*
	[-0.0000333]	[-0.0000331]	[-0.0000314]
Birth year	-0.0016	-0.0052	-0.00215
	[-0.00369]	[-0.00366]	[-0.00348]
Gender	-0.00681	0.0375	0.0897
	[-0.177]	[-0.176]	[-0.167]
Education	-0.0287	0.101***	-0.0972***
	[-0.0392]	[-0.0389]	[-0.0369]
Politics	0.0970***	-0.110***	-0.297***
	[-0.0347]	[-0.0344]	[-0.0327]
Income	0.0212	0.0410**	0.000597
	[-0.0193]	[-0.0192]	[-0.0182]
Percent Income from	-0.00265*	0.00182	-0.000756
farming	[-0.00137]	[-0.00136]	[-0.00129]
Generations	-0.0165	-0.052	-0.0581
	[-0.0583]	[-0.0578]	[-0.0549]
Successor	-0.0056	-0.0196	-0.0194
	[-0.0281]	[-0.0279]	[-0.0264]
Constant	2.952	10.79	6.385
	[-7.168]	[-7.116]	[-6.754]
Observations	484	484	484
R-squared	0.031	0.069	0.191

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Living in an area with greater precipitation, lower temperatures, and greater soil saturation (cold and wet) negatively impacted openness to change. These might be areas that are less affected by the drying and warming trends of climate change. They may still feel as though resources are plentiful, which makes them less open to change than they might be if they were feeling the shortages more intensely. Therefore, people may feel less pressure to change their attitudes or practices in cold and wet areas.

The following table shows the effect of the three climate variables on three of the measured attitudinal norms (groundwater should *not* be used, groundwater levels are a problem for my family, and groundwater levels are a problem for my community) in the whole sample.

Table 11c: Coefficients from Regression of 3 Climate Variables on 3 Attitudes

	Model 13	**Model 14**	**Model 15**
	Groundwater should be used (rev)	Groundwater levels are a problem for my family	Groundwater levels are a problem for my community (ln)
Cold/Wet	-0.0316	-0.293***	-0.120***
	[-0.0616]	[-0.0645]	[-0.0237]
Precipitation (mm)	-8.26E-05	-0.00176***	-0.000654***
	[-0.000399]	[-0.000418]	[-0.000153]
Storage (acre feet)	-1.86E-09	-4.25e-09**	-2.03e-09**
	[-0.00000000206]	[-0.00000000216]	[-0.000000000791]
Farm size	2.97E-05	5.64E-05	1.59E-05
	[-0.0000394]	[-0.0000413]	[-0.0000151]
Birth year	0.00164	0.00585	0.00132
	[-0.00437]	[-0.00457]	[-0.00168]
Gender	0.138	0.19	0.155*
	[-0.209]	[-0.219]	[-0.0804]
Education	-0.107**	-0.0068	0.00545
	[-0.0464]	[-0.0486]	[-0.0178]
Politics	-0.0752*	0.0115	-0.00225
	[-0.041]	[-0.043]	[-0.0158]
Income	0.0415*	-0.021	-0.0156*

	[-0.0229]	[-0.024]	[-0.00878]
Percent Income from farming	-0.00182	-0.00219	-0.000886
	[-0.00163]	[-0.0017]	[-0.000624]
Generations	-0.0634	0.00853	-0.0066
	[-0.069]	[-0.0722]	[-0.0265]
Successor	-0.0953***	-0.0257	0.00186
	[-0.0332]	[-0.0348]	[-0.0128]
Constant	1.334	-7.008	-1.023
	[-8.483]	[-8.885]	[-3.257]
Observations	484	484	484
R-squared	0.05	0.098	0.124

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As expected, "groundwater levels are a problem for my family" is an attitude closely connected to "groundwater levels are a problem for my community". A cold/wet climate, high levels of precipitation, and greater groundwater storage all negatively impact these two attitudes.

The following table shows the effect of the same three climate variables on the last three of the measured attitudinal norms (I feel personally responsible for groundwater depletion, I should reduce, and I already limit as much as possible) in the whole sample.

Table 11d: Coefficients from Regression of 3 Climate Variables on 3 Attitudes

	Model 16	**Model 17**	**Model 18**
	I feel personally responsible for groundwater depletion	I should reduce my groundwater use (ln)	I already limit my groundwater use as much as possible
Cold/Wet	-0.0686	-0.0247	-0.0536
	[-0.0598]	[-0.0263]	[-0.0533]
Precipitation (mm)	-0.000719*	-0.000198	-0.000193
	[-0.000388]	[-0.00017]	[-0.000345]
Storage (acre feet)	-9.80E-10	-3.91E-10	-2.16E-09
	[-0.000000002]	[-0.000000000878]	[-0.00000000178]
Farm size	1.55E-05	3.03e-05*	5.57E-06
	[-0.0000383]	[-0.0000168]	[-0.0000341]
Birth year	-0.00858**	0.00299	0.00122
	[-0.00424]	[-0.00186]	[-0.00378]

Gender	-0.0952	-0.186**	-0.239
	[-0.203]	[-0.0893]	[-0.181]
Education	0.0417	-0.0169	-0.0328
	[-0.045]	[-0.0198]	[-0.0401]
Politics	-0.119***	-0.0551***	0.0824**
	[-0.0398]	[-0.0175]	[-0.0355]
Income	0.011	-0.00917	-0.0188
	[-0.0222]	[-0.00976]	[-0.0198]
Percent Income from	0.00195	0.000355	-0.000724
farming	[-0.00158]	[-0.000693]	[-0.00141]
Generations	-0.00644	-0.00997	0.00387
	[-0.067]	[-0.0294]	[-0.0596]
Successor	0.0444	-0.0186	0.0044
	[-0.0323]	[-0.0142]	[-0.0287]
Constant	19.84**	-4.174	1.779
	[-8.24]	[-3.618]	[-7.335]
Observations	484	484	484
R-squared	0.045	0.05	0.027

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Consistent with the other findings, precipitation negatively affects feelings of personal responsibility for groundwater depletion.

Irrigators

Looking at the effects of climate on irrigators alone, we can expect that they would be less impacted by climate variations since they have the means to have “rain when they want it”. Nevertheless, they may be keenly affected by the financial strain of groundwater depletion and feel more responsibility for changes in soil saturation than their dryland counterparts. In this group, I also control for well capacity, percentage of income from irrigated farming, and the number of irrigated acres.

Table 12a: Coefficients from Regression of 3 Climate Variables on 3 Values (Irrigators)

	Self interest	Environmental altruism	Humanistic altruism

Cold/Wet	-0.0207	-0.154**	-0.106
	[-0.0778]	[-0.0706]	[-0.0745]
Precipitation (mm)	-7.79E-05	0.000601	0.00113**
	[-0.000509]	[-0.000461]	[-0.000487]
Storage (acre feet)	-1.38E-09	1.70E-09	4.17E-10
	[-0.00000000241]	[-0.00000000219]	[-0.00000000231]
Farm size	3.77E-05	-4.97E-06	-3.19E-05
	[-0.0000551]	[-0.0000499]	[-0.0000527]
Well capacity	-3.08e-05*	-3.47e-05**	-5.41e-05***
	[-0.0000179]	[-0.0000162]	[-0.0000172]
Birth year	-0.00117	-0.00393	-0.0115**
	[-0.00526]	[-0.00477]	[-0.00504]
Gender	0.217	-0.088	0.323
	[-0.379]	[-0.343]	[-0.363]
Education	-0.0837	-0.0792	-0.0716
	[-0.0572]	[-0.0519]	[-0.0548]
Politics	0.0850*	-0.0898**	-0.120***
	[-0.0474]	[-0.043]	[-0.0454]
Income	0.0416	0.0259	0.0133
	[-0.0256]	[-0.0232]	[-0.0245]
Percent Income from	-0.0036	-0.00113	-0.000959
farming	[-0.00222]	[-0.00201]	[-0.00212]
Percent Income from	0.00691***	0.000814	0.0032
irrigated farming	[-0.00251]	[-0.00227]	[-0.0024]
Number of irrigated	0.0095	0.0935	0.162*
acres (ln)	[-0.0892]	[-0.0809]	[-0.0854]
Generations	-0.0259	-0.0063	-0.105
	[-0.0872]	[-0.079]	[-0.0835]
Successor	-0.015	-0.00453	-0.0235
	[-0.0392	[-0.0355]	[-0.0375]
Constant	1.864	7.583	21.71**
	[-10.26]	[-9.297]	[-9.822]
Observations	259	259	259
R-squared	0.091	0.089	0.175

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Looking at irrigators alone, some relationships appear that did not appear in the entire sample. Living in a cold and wet climate shows a negative relationship with environmental altruism. Precipitation is positively associated with humanistic altruism. This is consistent with McCright and Dunlap's (2011) argument that people use their values to filter how they interpret climatic conditions. It also resonates with the assertion that the environment shapes our values that Hamilton et al. (2013) found occurring in rural Oregon where forest fire-threatened areas created location-specific beliefs that varied with the rurality, politics, and livelihood ties to the land of local people. Inglehart and Baker (2000) stressed the importance of "postmaterialism" in developing environmental concern that is specific to a place. The finding that people feel freer to value humanity when they have their own needs met is consistent with this view, although it is complicated by the fact that favorable environmental conditions influence less value placed on the environment.

Table 12b: Coefficients from Regression of 3 Climate Variables on 2 Values and Belief in the New Ecological Paradigm (NEP) (Irrigators)

	Model 10	**Model 11**	**Model 12**
	Traditional	Openness to change	NEP
Cold/Wet	-0.186**	-0.190**	-0.11
	[-0.0746]	[-0.0771]	[-0.0694]
Precipitation (mm)	-0.000286	-0.000468	0.000253
	[-0.000488]	[-0.000504]	[-0.000453]
Storage (acre feet)	-1.31E-09	0	1.30E-09
	[-0.00000000231]	[-0.00000000239]	[-0.00000000215]
Farm size	-9.24E-06	6.26E-05	-1.71E-05
	[-0.0000528]	[-0.0000546]	[-0.0000491]
Well capacity	-1.00E-05	-1.86E-05	-4.07e-05**
	[-0.0000172]	[-0.0000178]	[-0.000016]
Birth year	-0.000662	-0.00177	0.00472
	[-0.00504]	[-0.00521]	[-0.00469]
Gender	-0.0741	0.733*	-0.126

	[-0.363]		[-0.375]		[-0.337]	
Education		-0.037		0.111*		-0.0778
	[-0.0549]		[-0.0567]		[-0.051]	
Politics		0.0982**		-0.0995**		-0.281***
	[-0.0455]		[-0.047]		[-0.0423]	
Income		0.0198		0.0228		0.0132
	[-0.0245]		[-0.0253]		[-0.0228]	
Percent Income from		-0.00279		-0.000731		0.00012
farming	[-0.00212]		[-0.0022]		[-0.00197]	
Percent Income from		0.0006		0.00516**		0.00132
irrigated farming	[-0.0024]		[-0.00249]		[-0.00223]	
Number of irrigated		0.123		-0.0199		0.0112
acres (ln)	[-0.0855]		[-0.0884]		[-0.0795]	
Generations		-0.0443		-0.0598		0.000791
	[-0.0836]		[-0.0864]		[-0.0777]	
Successor		0.00117		-0.0325		0.018
	[-0.0375]		[-0.0388]		[-0.0349]	
Constant		0.801		3.221		-7.765
	[-9.831]		[-10.16]		[-9.139]	
Observations		259		259		259
R-squared		0.08		0.113		0.214

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Cold and wet climates contribute negatively to traditional values and openness to change. This brings up new questions about why this might be since traditional values usually represent an opposition to change. These two values were designed in the survey to be opposites of each other, but it is possible that tradition represents something additional to the respondents that goes beyond just being less open to change. Perhaps they emphasize respect for the elderly or traditions in family life when they think of traditionalism, but innovation in their farming practices, professional adaptation, or business changes are excluded from that. Considering Morton et al.'s (2016) observation that farming identity is intertwined with soil quality adaptability, it is also possible that observing and adapting to the weather are such integral parts of producers' identities that this behavior is considered traditional to farming, even as it represents an openness to change.

Table 12c: Coefficients from Regression of 3 Climate Variables on 3 Attitudes (Irrigators)

	Model 13	**Model 14**	**Model 15**
	Groundwater should be used (rev)	Groundwater levels are a problem for my family	Groundwater levels are a problem for my community (ln)
Cold/Wet	-0.0262	-0.358***	-0.140***
	[-0.0903]	[-0.0941]	[-0.0369]
Precipitation (mm)	-0.000106	-0.00204***	-0.000842***
	[-0.00059]	[-0.000616]	[-0.000241]
Storage (acre feet)	-1.84E-09	-5.12e-09*	-1.81E-09
	[-0.0000000028]	[-0.00000000292]	[-0.00000000114]
Farm size	-2.01E-05	6.37E-05	3.00E-05
	[-0.0000639]	[-0.0000666]	[-0.0000261]
Well capacity	-1.90E-06	-5.96e-05***	-2.49e-05***
	[-0.0000208]	[-0.0000217]	[-0.00000848]
Birth year	0.00405	0.00358	-0.000567
	[-0.0061]	[-0.00636]	[-0.00249]
Gender	-0.214	-0.154	-0.0977
	[-0.439]	[-0.458]	[-0.179]
Education	-0.155**	0.125*	0.0436
	[-0.0664]	[-0.0692]	[-0.0271]
Politics	-0.0432	-0.0512	-0.0163
	[-0.055]	[-0.0573]	[-0.0225]
Income	0.0731**	-0.0205	-0.0141
	[-0.0296]	[-0.0309]	[-0.0121]
Percent Income from	0.000722	-0.00013	-0.00024
farming	[-0.00257]	[-0.00268]	[-0.00105]
Percent Income from	-0.0113***	-0.000369	0.000122
irrigated farming	[-0.00291]	[-0.00303]	[-0.00119]
Number of irrigated	0.0678	0.0902	0.00535
acres (ln)	[-0.103]	[-0.108]	[-0.0423]
Generations	-0.128	0.0331	0.0414
	[-0.101]	[-0.105]	[-0.0413]

Successor	-0.0804*	0.0189	0.0191
	[-0.0454]	[-0.0474]	[-0.0185]
Constant	-3.089	-3.01	2.71
	[-11.9]	[-12.4]	[-4.858]
Observations	259	259	259
R-squared	0.127	0.195	0.203

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Among irrigators, all three climate variables show a significant negative relationship with groundwater levels being a "problem for my family". Cold and wet climates with high precipitation also negatively impacted groundwater levels being a "problem for my community".

Table 12d: Coefficients from Regression of 3 Climate Variables on 3 Attitudes (Irrigators)

	Model 16	**Model 17**	**Model 18**
	I feel personally responsible for groundwater depletion	I should reduce my groundwater use (ln)	I already limit my groundwater use as much as possible
Cold/Wet	-0.13	-0.0718**	-0.109
	[-0.0899]	[-0.0347]	[-0.0751]
Precipitation (mm)	-0.000425	-8.87E-05	-0.000116
	[-0.000588]	[-0.000227]	[-0.000491]
Storage (acre feet)	-3.07E-09	-9.50E-10	-5.20e-09**
	[-0.00000000279]	[-0.00000000108]	[-0.00000000233]
Farm size	6.94E-05	2.07E-05	-3.57E-05
	[-0.0000636]	[-0.0000246]	[-0.0000531]
Well capacity	-3.46e-05*	-8.57E-06	2.55E-05
	[-0.0000207]	[-0.000008]	[-0.0000173]
Birth year	-0.00956	0.000768	-0.00894*
	[-0.00608	[-0.00235]	[-0.00508]
Gender	-0.171	-0.502***	-0.451
	[-0.438]	[-0.169]	[-0.365]
Education	0.144**	-0.0271	0.0031
	[-0.0661]	[-0.0255]	[-0.0552]
Politics	-0.0998*	-0.0487**	0.0725
	[-0.0548]	[-0.0212]	[-0.0458]
Income	0.00188	-0.00681	-0.0315

	[-0.0295]	[-0.0114]	[-0.0247]
Percent Income from farming	-0.00168 [-0.00256]	0.00106 [-0.000989]	0.00124 [-0.00214]
Percent Income from irrigated farming	0.00565* [-0.0029]	-0.000703 [-0.00112]	-0.00307 [-0.00242]
Number of irrigated acres (ln)	0.0294 [-0.103]	0.0488 [-0.0398]	-0.00594 [-0.0861]
Generations	0.0565 [-0.101]	-0.0225 [-0.0389]	-0.107 [-0.0841]
Successor	0.0216 [-0.0452]	-0.00698 [-0.0175]	0.057 [-0.0378]
Constant	21.12* [-11.85]	0.242 [-4.578]	22.09** [-9.898]
Observations	259	259	259
R-squared	0.093	0.11	0.089

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Cold/wet climates are negatively associated with the attitude that “I should reduce my groundwater usage”. Groundwater storage is negatively associated with the attitude that “I already limit my groundwater as much as possible”. This relationship may indicate that climate constraints are felt less intensely and therefore people’s decision-making is less restricted when groundwater is plentiful. It is also interesting to note that those with less well capacity feel less responsible for depletion, which may suggest that their smaller amount of groundwater usage allows them to feel as though they are not the ones to blame for depletion- that large-scale irrigators are much more at fault.

Dryland Operators

Because dryland operators have adapted to the climate through their dryland practices, it is expected that their “moral framing” would legitimize these norms (Adger et al. 2012); it is also expected that they would relate to the land on multiple levels outside of the business orientation they hold toward it (Sanderson and Curtis 2017). Therefore, I expect dryland operators' values, beliefs, and attitudes to be more affected by climate than irrigators' because they are more at the mercy of precipitation, temperature, and ground saturation; and because they hold overlapping identities as producers, consumers, stakeholders, and recreators. It can also be expected that their dryland practices are a reflection of climate change adaptations they have already made, making their farms more diverse or resilient. At the same time, certain climates allow dryland strategies more readily than others, so it is a difficult comparison to make.

Table 13a: Coefficients from Regression of 3 Climate Variables on 3 Values (Dryland Operators)

	Model 7	**Model 8**	**Model 9**
	Self interest	Environmental altruism	Humanistic altruism
Cold/Wet	0.0408	0.0361	0.00744
	(0.0751)	(0.0700)	(0.0644)
Precipitation (mm)	-0.000282	8.21e-05	-0.000231
	(0.000492)	(0.000458)	(0.000422)
Storage (acre feet)	-2.32e-09	1.32e-09	-1.48e-09
	(2.71e-09)	(2.53e-09)	(2.32e-09)
Farm size	-7.86e-05	-3.40e-05	-7.73e-05*
	(5.31e-05)	(4.95e-05)	(4.55e-05)
Birth Year	-0.0112*	-0.00926*	-0.0112**
	(0.00596)	(0.00556)	(0.00512)
Gender	-0.111	0.0206	-0.104
	(0.220)	(0.205)	(0.188)
Education	0.114*	0.0402	-0.0171
	(0.0585)	(0.0545)	(0.0501)
Politics	0.0482	-0.137***	-0.101**
	(0.0539)	(0.0502)	(0.0462)
Income	0.0724**	0.0130	0.00564
	(0.0326)	(0.0304)	(0.0279)
Percent Income from farming	0.00221	0.00178	0.000358
	(0.00206)	(0.00192)	(0.00176)
Generations	0.0165	0.00112	-0.0258

	(0.0863)	(0.0805)	(0.0740)
Successor	-0.0194	-0.0589	-0.0524
	(0.0440)	(0.0411)	(0.0378)
Constant	21.27*	18.82*	23.32**
	(11.54)	(10.76)	(9.901)
Observations	214	214	214
R-squared	0.072	0.076	0.083

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13b: Coefficients from Regression of 3 Climate Variables on 2 Values and Belief in the New Ecological Paradigm (NEP) (Dryland Operators)

	Model 10	**Model 11**	**Model 12**
	Traditional	Openness to change	NEP
Cold/Wet	0.0823	0.000337	0.0482
	(0.0787)	(0.0726)	(0.0682)
Precipitation (mm)	0.000142	-0.000748	-0.000147
	(0.000515)	(0.000475)	(0.000446)
Storage (acre feet)	-8.61e-10	-4.81e-09*	5.80e-10
	(2.84e-09)	(2.62e-09)	(2.46e-09)
Farm size	1.83e-06	-0.000106**	-5.98e-05
	(5.56e-05)	(5.13e-05)	(4.81e-05)
BirthYear	-0.00566	-0.00783	-0.00958*
	(0.00625)	(0.00576)	(0.00541)
Gender	-0.0681	-0.181	-0.101
	(0.230)	(0.212)	(0.199)
Education	-0.0306	0.116**	-0.109**
	(0.0612)	(0.0565)	(0.0530)
Politics	0.102*	-0.107**	-0.313***
	(0.0565)	(0.0520)	(0.0489)
Income	0.0213	0.0738**	-0.000611
	(0.0341)	(0.0315)	(0.0295)
Percent Income from	-0.00260	0.00314	0.000795
farming	(0.00215)	(0.00199)	(0.00186)
Generations	-0.00119	-0.0382	-0.0475
	(0.0904)	(0.0834)	(0.0783)
Successor	-0.0200	-0.0158	-0.0927**
	(0.0461)	(0.0425)	(0.0400)
Constant	10.81	16.11	21.64**

	(12.09)	(11.15)	(10.47)
Observations	214	214	214
R-squared	0.033	0.106	0.245

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Despite the fact that it seems as though dryland operators would be less affected by groundwater storage than the other two climate variables, there is a slight negative relationship between groundwater and openness to change.

Table 13c: Coefficients from Regression of 3 Climate Variables on 3 Attitudes (Dryland Operators)

	Model 13	**Model 14**	**Model 15**
	Groundwater should be used (rev)	Groundwater levels are a problem for my family	Groundwater levels are a problem for my community (ln)
Cold/Wet	-0.0465	-0.157*	-0.0825***
	(0.0815)	(0.0869)	(0.0283)
Precipitation (mm)	-0.000164	-0.00158***	-0.000539***
	(0.000533)	(0.000569)	(0.000185)
Storage (acre feet)	1.02e-09	-9.32e-10	-9.97e-10
	(2.94e-09)	(3.14e-09)	(1.02e-09)
Farm size	0.000104*	6.80e-05	2.67e-05
	(5.76e-05)	(6.14e-05)	(2.00e-05)
Birth Year	-0.000927	0.00369	0.00334
	(0.00647)	(0.00690)	(0.00225)
Gender	0.139	-0.0508	0.128
	(0.238)	(0.254)	(0.0827)
Education	-0.131**	-0.103	-0.0132
	(0.0634)	(0.0677)	(0.0220)
Politics	-0.101*	0.0837	0.00699
	(0.0585)	(0.0624)	(0.0203)
Income	0.0145	0.00286	-0.00415
	(0.0353)	(0.0377)	(0.0123)
Percent Income from farming	0.00283	-0.00144	-0.000163
	(0.00223)	(0.00238)	(0.000775)
Generations	0.0830	0.0571	-0.0168
	(0.0937)	(0.0999)	(0.0325)

Successor	-0.134***	-0.101**	-0.0241
	(0.0478)	(0.0510)	(0.0166)
Constant	6.252	-2.532	-4.905
	(12.53)	(13.36)	(4.349)
Observations	214	214	214
R-squared	0.115	0.108	0.123

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The interconnectedness between groundwater and other elements of the hydrologic cycle is highlighted here, where there are negative relationships between cold/wet climates with high precipitation and the attitudes that "groundwater levels are a problem for my family" and community.

Table 13d: Coefficients from Regression of 3 Climate Variables on 3 Attitudes (Dryland Operators)

	Model 16	Model 17	Model 18
	I feel personally responsible for groundwater depletion	I should reduce my groundwater use (ln)	I already limit my groundwater use as much as possible
Cold/Wet	-0.00442	-0.00441	-0.0578
	(0.0784)	(0.0416)	(0.0786)
Precipitation (mm)	-0.000141	-0.000158	-0.000288
	(0.000513)	(0.000272)	(0.000514)
Storage (acre feet)	8.30e-10	0	8.89e-10
	(2.83e-09)	(1.50e-09)	(2.83e-09)
Farm size	-1.67e-05	3.30e-05	5.95e-05
	(5.54e-05)	(2.94e-05)	(5.55e-05)
Birth Year	-0.0107*	0.00292	0.00976
	(0.00622)	(0.00330)	(0.00624)
Gender	0.0767	-0.101	-0.207
	(0.229)	(0.121)	(0.230)
Education	-0.0708	-0.0240	-0.0524
	(0.0610)	(0.0323)	(0.0612)
Politics	-0.145**	-0.0600**	0.0588
	(0.0562)	(0.0298)	(0.0564)
Income	-0.0250	-0.0237	0.00357
	(0.0340)	(0.0180)	(0.0341)

Percent Income from farming	0.000325	-0.000775	-0.00131
	(0.00215)	(0.00114)	(0.00215)
Generations	-0.0561	0.0133	0.116
	(0.0901)	(0.0477)	(0.0903)
Successor	0.0922**	-0.0225	-0.0364
	(0.0460)	(0.0244)	(0.0461)
Constant	23.99**	-4.126	-15.06
	(12.05)	(6.384)	(12.07)
Observations	214	214	214
R-squared	0.091	0.038	0.053

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In summary, the findings from both research questions confirm the VBN theoretical framework by showing the prominence of producers' beliefs in water conservation decision-making, and revealing the complex ways those beliefs are connected to underlying values, like tradition.

Question one asked about how producers make decisions about water conservation. The results confirmed the hypothesis that differences in 6 normative attitudes relate to differing underlying values and beliefs. However, the results were more nuanced than this. They revealed that: (1) beliefs were the more important determiners of attitudes and that (2) attitudes among irrigators and dryland operators manifest beliefs differently.

The role of NEP beliefs in norm formation was the most prominent finding. In the inclusive sample, and among irrigators, NEP showed a significant relationship to all the attitudes except one. This resonates with the VBN theory where beliefs construct norms. NEP plays the greatest role in attitude formation among irrigators (Models 1-5) and plays a lesser role among dryland operators (Models 2, 3, and 5). The differences between irrigators and dryland operators with regard to their beliefs is interesting. It is not just that their beliefs are different (which they are), but the NEP holds greater explanatory power over norms for irrigators than it does for dryland operators. This is consistent with the cultural foundations of the VBN framework because it suggests that our behaviors (in this case, irrigation practices) are not just decisions we make, but norms reinforced by values and beliefs which differ based on those norms.

Question one results also highlighted the interesting ways that traditional values can both contradict and reinforce beliefs in the NEP and groundwater conservation attitudes. This clarifies an important part of the VBN theory. Even though values seem to lead into beliefs, and then into norms, there is not a single pathway. The same underlying value can justify seemingly opposing beliefs or norms when necessary.

Question two asked about how the environment affects culture (including values, beliefs, and attitudinal norms). The results partially confirmed they hypothesis that producers in colder, wetter climates present values that do not prioritize openness to change, beliefs in the Dominant Social Paradigm (DSP), and attitudes that reflect norms that are less concerned with groundwater conservation. This hypothesis rang truer for irrigators than dryland operators, and the climate showed a greater effect on attitudes than values and beliefs. Two overarching observations emerged: (1) Environmental conditions affect attitudes and underlying values such as openness to change and (2) traditional values looked different in different climates. The climate's effect on values intensified in irrigators over dryland operators.

First, environmental conditions seem to affect attitudes directly even as they influence underlying, more permanent parts of culture. For example, attitudes that groundwater depletion is a problem for families and communities seems directly influenced by the amount of groundwater available, and by shortages in other parts of the hydrologic cycle. Producers living in cold and wet climates held this attitude less intensely than those who experience dry soil, less precipitation, and warmer temperatures. These climatic conditions also appear to be directly related to cultures that value openness to change.

Secondly, major differences emerge in the ways that environmental conditions manifest into values for dryland operators and irrigators. Cold and wet environments are related to less environmental altruism and more humanistic altruism in irrigators alone. These environments also related to irrigators being less traditional and less open to change, which highlights the complexity of traditional values.

Chapter 5 - Discussion and Conclusion

Question 1 Discussion: How do producers make decisions regarding water conservation?

These 6 models show the effects of values and beliefs in a New Ecological Paradigm (NEP) on six attitudes regarding groundwater conservation. Several important observations emerge.

First, the importance of the NEP in its effect on every attitude is important. In the inclusive sample, and among irrigators, NEP shows a significant relationship to all of the attitudes except one. The only attitude to which it is unrelated asks about the limits of what can be done, not about what should be done. This resonates with the explanatory power of the VBN theory for environmental decision-making, particularly the part of decision-making involved in constructing norms and attitudes. The fact that it does not explain perceptions of limits suggests that the constraint of behavioral control, and the theory of planned behavior may also play a role in decision-making at the point that normative attitudes result in actions. NEP plays the greatest role in attitude formation among irrigators (Models 1-5) and plays a lesser role among dryland operators (Models 2, 3, and 5). This confirms Stern's (2000) VBN understanding of decision-making where the 5 guiding principles prioritize moral identities, so that beliefs can build upon them to form a paradigm about the environment and human's role within it. Since beliefs in the DSP and NEP appear as a collection of narratives, and taken together, they form worldviews (Pirages and Ehrlich 1974; Dunlap 2008; Pellow and Brehm 2013), it makes sense that these would appear most prominently in the VBN process. The observation that irrigators are even more affected by NEP beliefs extends Dunlap's (2008) argument for beliefs as a filter for norms because it suggests that the practice of irrigating is being justified by beliefs.

Secondly, traditional values seem to play a complicated role: they can both contradict and reinforce beliefs in the NEP and attitudes regarding groundwater conservation. Traditional values might help explain why dryland operators feel less personally responsible for groundwater depletion and less interested in reducing their groundwater use in comparison to their irrigator counterparts. Dryland operators may feel that individual responsibility is important, and that the responsibility to reduce lies with irrigators. In a similar vein, politically conservative dryland operators may adhere to traditional values that elevate the value of the family, affecting their attitude that "groundwater is a problem for my family".

Question 2 Discussion: How does the environment affect culture (values, beliefs, and normative attitudes)?

Climate plays an important role in shaping foundational elements of producers' culture- values, beliefs, norms, and attitudes regarding water conservation. This is consistent with evidence that environments shape human lifestyles, livelihoods, and cultures (Boserup 1970; Brown et al. 2019). Since we rely on these cultural elements of our worldview to make decisions, it makes sense that culture, and climate, by extension, would factor into decision-making, especially among people whose livelihoods depend on soil, precipitation, and sunlight. Although traditional values or conservative politics may prevent people from consciously adapting to climate change as a politicized concept, they likely still respond to climatic changes because it is what producers have been doing for thousands of years. These two realities may operate in tension with one another, helping people to set boundaries that seem objective to them, but are filtered through values and beliefs and manifesting in normative attitudes- helping them decide what decisions are worth it and what they can afford.

The particular brand of conservatism or traditionalism may be shaped by the environment itself. It is interesting to note that cold and wet climates and precipitation showed a negative effect on openness to change, which suggests that people are less open to change if the climate does not demand that they change or adapt. Among irrigators, a negative relationship between cold/wet climates and openness to change and traditional values suggests that possibly, people can adhere to traditional values in most areas of their lives, but still be willing to adapt to climate change; and that this type of complex worldview might be more common in warmer and drier environments. There are a few reasons why hot and dry environments might result in more traditionalism and more openness to change, which should be opposing values. (1) It is possible that traditional values include more than tradition (i.e. respect for the elderly) and that it is these other elements of traditionalism that are emphasized in these places, even as producers adapt their practices to fit hotter/drier environments. (2) It is possible that traditional values are perceived more favorably than openness to change because the second value includes elements of an exciting and varied life, which may be perceived as more selfish. (3) It is also possible that the anomaly is the result of values that just happen to exist in certain climates but were not constructed because of the climate. This particular study is only able to model one direction of the relationship where climate influences culture, not the other way around, which is also likely. (4) Morton et al. (2016) argue that climate adaptability is a part of farmer's identity. As a result, producers may perceive being open to changing their practices to accommodate climatic changes as deeply traditional to farming.

Attitudes seemed even more influenced by climate than values or beliefs. For example, in the whole sample, the attitude that "groundwater levels are a problem for my family" and "community" were both negatively influenced by all three climate variables. Colder/wetter soils, with higher precipitation, and greater storage showed less of a concern that "groundwater is a problem for my family" and "community". Higher precipitation was also related to less sense of personal responsibility for the groundwater depletion. It is interesting that the effect of climate weighs more heavily on attitudes than on values. It is possible that values and beliefs are retroactively affected by climate because it changes attitudes and norms.

Despite the fact that dryland operators are not pumping groundwater for irrigation, they showed significant relationships between climatic factors and the attitude that "groundwater levels are a problem for my family" and "community". This may suggest (1) that dryland operators are aware of the importance of groundwater to the entire hydrologic cycle; (2) that they are affected by poor municipal and drinking water quality; or (3) that they have already taken costly steps to adapt to climate change. If this data showed whether or not dryland operators had always been dryland operators, or if they had made conservation decisions and stopped irrigating in recent years, this would reveal more about why they consider groundwater levels a problem.

It could also be argued that the relevance of climate variables points to the economic foundation of decision-making, i.e. that people's attitudes and behaviors reflect cost-benefit analyses of the resources they have available and how they can most efficiently use them. The finding that "groundwater levels are a problem for my community" directly related to the soil saturation, temperature, and precipitation in an area seems to confirm this. However, the other findings suggest that decision-making is more complex than a cost-benefit analysis allows. The differences between irrigators and dryland operators who experience the same climatic conditions, and the wide variety in the way that traditional values coexist with this attitude, suggests that climate plays a more complex role- that people filter their experience of the climate through their cultural lenses, and that concepts of what is possible, practical, or affordable are all socially constructed. This complexity is consistent with what we know about norms and decision-making: that we display biases towards norms that fit us into society more seamlessly, that we archive our memories according to these biases (Stern 2018), and that cultural elements like values and beliefs make reason and emotion present contiguously with each other in what feels rational to us (Massey 2001).

Discussion

Several key findings from both research questions confirm the importance of integrating several decision-making models in explaining producers' water conservation decisions. Carolan (2005) described humans as physically and culturally part of a dynamic socio-ecological system. Thus, as our groundwater becomes less available, and less able to support consumption norms established though the Dominant Social Paradigm, and as the climate changes, our culture changes as well. While income differences among producers were not primary drivers of culture, it is important to note that the livelihood differences presented by those who rely completely on farming income and those who do not are vast. Social relations are only partially presented here because the data only includes producers. However, increased salination and drinking water contamination, and decreased biodiversity affects urban people who drink water, eat meat, and exist within a global economy where American agriculture produces surplus or feeds Chinese industry. In this sense, the physical properties of water define social class and relations (Kumar et al. 2017; Linton and Budds 2014).

Beliefs, emphasizing the Dominant Social Paradigm (DSP), which Dunlap (2008) described as essential to Euro-American culture in life, liberty, the pursuit of happiness, private property, subduing land for production, divine right, westward expansion, manifest destiny, the homestead acts, growing markets, "progress", and the violent dispossession of indigenous groups, primed European settler's worldviews to embrace major technological change after World War II (Pirages and Ehrlich 1974; Opie 2018). When center-pivot irrigation allowed corn, milo, wheat, and alfalfa to dominate a landscape that had been precarious and prone to drought; when land values and equipment costs increased and farmers became dependent on loans that mandated higher and higher yields; when government subsidies began incentivizing overproduction, overirrigation, and mandating participation in the treadmill of production; and when American food systems demanded that this system stay in place in order to provide people the types of products they expected, the beliefs in the DSP facilitated changes in norms to match each socio-environmental change, so that American capitalism ideals were intensified (Gould 2014). The Dominant Social Paradigm stands in direct contrast to beliefs in "the inseparability of human and nonhuman natures", which were held by many indigenous groups who interacted with the Great Plains seasonally and considered themselves as a part of sacred land and water (Pellow and Brehm 2013:229). The New Ecological Paradigm (NEP) revives aspects of these beliefs to include a "deep ecology" that decentralizes humans and recognizes the way that the DSP tends to "authorize oppression" by creating the structures for inequality based on gender, race, and indigeneity (Gould 2014; Gaard 1993).

This history confirms that beliefs are dynamic, so findings that shed light on adherence to or rejection of these paradigms are important. Beliefs with regard to the New Ecological Paradigm are very important to irrigators, and dryland operators to a lesser extent. Traditional values are also a key piece of the decision-making puzzle, partially because they represent conflicting motivators for conservation: an aversion to change and a distrust of government initiatives that may cause people to want to continue in irrigation practices that began in the 1950s and 1960s, and an elevation of family values and the elderly that may cause people to want to adopt practices that can ensure longevity and sustainability. This is an area where new questions emerge about how traditional values change over time and how they are reflected in the New Ecological Paradigm.

Among irrigators and dryland operators alike, climate affects culture in powerful ways. The inclusion of climate variables, in addition to values, beliefs, and norms, showed that climate, especially the water available in particular hydrologic systems, may shape the brand of traditional values that manifest in attitudes like "groundwater is a problem for my family" and "community". This is an important finding because it shows that values, which are some of the most stable parts of our cultural identities, are dynamic. They can be shaped by our environments. While it is difficult to conclude, from this evidence, that climate change changes people's values, it still seems consistent with that assertion since particular values emerge in response to the resources available in particular places as people adapt lifestyles that work in their regions. Dietz (2013) argued that the norms that comprise people's lifestyles and livelihoods are connected to and justified by identity. Therefore, understanding how traditional values, in this case, are uniquely shaped to justify norms that fit particular climates illuminates what Stern (2018) argued is an important cultural backdrop for moral decision-making.

The relevance of climate to attitudes such as "groundwater depletion is a problem for my family" also confirms Griggs' (2014) suggestion that climate has been constructing social structure on the aquifer for centuries and will continue to do so. Western water rights considered the climate, hydrology, and topography, private land access, and public land access of the time when they were being developed from the perspective of European settlers, who held manifest destiny ideologies and codified the "law of appropriation" into state laws.

Consistencies with the literature

This data suggests that traditional values are important to dryland operators and irrigators across the aquifer. Yet, whether those values get applied as a moral frame to justify or reject attitudes that enable adaptation depends on other factors such as culture, ecology, institutions, and identity. This is consistent with the assertion that values are adaptable (Dietz et al. 2005). Whether the public sees adaptation options as feasible, salient, and legitimate depends on the moral frame through which they understand the adaptation (Adger et al. 2012; Dietz and Whitley 2018; Chan et al. 2016). This can explain why, among irrigators in cold and wet climates, the more traditional people were, the less open to change they might be. However, in hot and dry climates, traditional values among irrigators did not prevent them from being open to change. Traditional values usually represent an opposition to change, but this is not necessarily the case, when change is deemed necessary (because of climate constraints) for family, faith, or tradition.

Traditionalism and politics were not as closely connected, when it comes to water conservation attitudes, as might be expected. This is consistent with the assertion that political ideology and partisan affiliation hold the strongest influence over climate beliefs and supersede evidence of changing conditions on people's perceptions (Arbuckle 2016). However, it challenges the assertion that political orientation is such a powerful indicator of attitudes because people use their values to filter information that is ambiguous to them (McCright and Dunlap 2011). That may be true in relation to highly politicized ideas like global climate change that people hear about on the news, but it might be less true with regard to local climate changes that producers understand from experience. This evidence helps to reconcile McCright and Dunlap's (2011) findings with Stern (2018) and Morton et al.'s (2016) findings that good farmers pay attention to the weather. The climate evidence from this study found that of the 4 climate indicators- precipitation, groundwater storage, temperature and PDSI (soil saturation)- PDSI held the most explanatory power, suggesting that "good farmers" are particularly in tune with climate changes related to soil saturation. The environment's effects on people's perceptions and worldviews in particularly apparent. This is consistent with Barnett et al.'s (2016) evaluation of loss and resiliency tied to the environment.

Clearly, one theory of decision-making is not explanatory enough in relation to this data. Dryland operators feel less personal responsibility for groundwater depletion than irrigators do, which can be explained through Ajzen's (1991) theory of planned behavior. Irrigators have more reasonable ability to affect change with regard to conservation than dryland operators who have already reached a limit by not contributing to depletion form irrigation. However, the role of values and beliefs within reasoned action, by creating the structures of what is "reasonable", is also important. Dryland operators still feel that groundwater depletion is a problem for their families and communities, and still feel some personal responsibility. This can be explained by Lakhan's (2018) argument that subtle shifts in perceived behavioral control, specific situational changes, attitudes, and moral norms occur to accommodate people's values. It can also be explained by the importance of values, beliefs, and norms in creating meaning around moral attitudes that are perceived as reasonable within environmental contexts (Sanderson and Curtis 2017; Greenwald and Banaji 1995). Furthermore, it suggests that dryland operators may realize that their attitudes regarding water conservation still matter if changes are to occur on a structural level. More qualitative research is needed to determine how they think about this.

The geographical differences in beliefs and attitudes that correspond to climate differences also resonate with the literature on the problem of local solutions to global problems (Hamilton et al. 2013). The producers surveyed here are more attuned to, and directly dependent on, groundwater, and therefore take the brunt of financial challenges associated with conservation; but we are all dependent on the global food system that it supports. Rural environmental concern is tempered by what Inglehart and Baker (2000) refer to as postmaterialism- it is constructed by the place, and it depends on the degree to which rural people are producers or involved in livelihoods directly dependent on natural resources. Yet, the interconnectedness of hydrologic systems demands that those who benefit from and those who do not benefit from postmaterial standpoints be united in strategies that conserve entire water systems from geographically scattered places, perhaps by sharing the financial burden of conservation.

Implications

Knowing the salience of beliefs and traditional values within those beliefs can help inform water conservation strategies as individual water districts decide on their management strategies and choose language to justify and explain them. The assumption that traditional values prevent changing beliefs in environmental conservation or revitalization is too simplistic, according to these findings. Instead, traditional values are malleable and able to justify a wide variety of attitudes and practices. Therefore, legislation and policy changes should recognize that traditional values are adaptable. Traditional values can support change when they make sense with local environmental knowledge and when they resonate with families' values and identities. More broadly, knowing that the climate affects water conservation attitudes can help institutions recognize the vital role they can play in enabling or preventing conservation by producers. If producers are open to changing their practices, and adaptable to environmental change, then institutions that support conservation on a structural level must enable them to adopt sustainable practices, elevating the needs of the environment, entire ecosystems, and local livelihoods over production for the current model of global beef production, etc.

We know that even when policy changes subsidize greater efficiency, it is possible for that efficiency to result in more depletion overall (Pfeiffer and Lin 2014), so the results of this study should also be used to ensure that policy changes do not just incentivize efficiency, but also incentivize restoration, conservation, and biodiversity. Since water is locally regulated, future water conservation hinges on lawmakers and regulators working out of these values, and not trying to justify western water rights and protect those who have been grandfathered into their rights.

However, understanding the attitudes of producers is only one piece of a much larger puzzle for policy change to occur. Consumers, the beef and ethanol industries, and each element of the treadmill of production are also responsible for the situation of debt, overproduction, and over-irrigation in which producers find themselves. Therefore, those advocating for and implementing policy change should consider these interconnected issues by compensating producers for lost livelihoods and incentivizing restorative agricultural practices. These types of changes have the potential to change actual practices, which the results of this study indicate could change values and beliefs.

These conclusions can help inform the scale of policy responses to groundwater depletion as well. If hydrologic systems are connected, but those experiencing the immediate effects in places like the Oklahoma panhandle are better culturally positioned to respond, then, perhaps responses should be coordinated at a higher institutional level than local water districts who cannot as easily see and respond to the big picture. Producers' attitudes are key components in changing regulatory institutions, but they cannot easily affect change if institutional and market pressures are against them. While First Peoples' voices are mostly absent from this data, their call to view water as sacred and untethered by personal property challenges the management strategies of imminent domain and western water rights that allowed over-irrigation in the last half-century (Tsosie 2007). Their view resonates with what producers and legislators now need to face. Their voices should be a part of this conversation as well.

Limitations and recommendations for future research

Regression cannot prove causation, only correlation between variables. There must exist a theoretical basis for the influence of one variable on another. While the VBN model provides a theoretical basis, the statistical models limit the ability to say for sure, which direction each relationship flows. The causal flow may be difficult to determine since it is possible that dialectical relationships exist between elements of beliefs and identity, for example. Path analysis might be better able to show how each step in decision-making works, while showing the recursive relationships. However, for this question, path analysis limits the number of control variables that can be included while finding a good fit. Therefore, regressions show more aspects of the relationships more clearly, even as they limit the direction they can show the relationships moving. OLS regression limits the specificity of shape with which the models can explain the relationships between values, beliefs, and norms. There are likely feedback loops where attitudes reinforce values, and certain values, like traditionalism, are related indirectly to attitudes through beliefs, but also directly to certain attitudes like personal responsibility. OLS regression makes it difficult to model the complexity of the relationships that lead to decision-making, but it allows important control variables to be included, like likelihood of succession and the number of generations a farm has been in the family. Overall, it provides a more holistic, less intricate picture of the factors affecting the VBN relations that lead toward water conservation decision-making attitudes. It includes more of the necessary elements, but fewer of the multi-directional pathways between these elements.

Any quantitative study has to assume that humans follow rational or emotional patterns. However, humans are complex. We sometimes make decisions that are not rational or that are inconsistent with our values and beliefs. We have endless social influences that construct the realities we perceive and justify our behaviors. Social networks, and the conversations that producers have over and over at coffee, the store, and church inform their cultural narratives that shift beliefs and attitudes over the course of explanation, justification, and repetition (Simpson and Willer 2015; Arbuckle 2016). Therefore, an analysis of the factors included in the survey is incomplete and apt to change over time. These models are only an approximation of some of the major factors involved in environmental decision-making in this case.

Haidt's social intuitionist model of moral judgement suggests that emotional decision-making works on the level of intuition. This reverses the causal order of decision-making, suggesting that behaviors happen and then are justified, not the other way around. "People primarily use reasoning to justify their pre-conceived notions rather than to carefully weigh new information and make decisions based on that information" (Stern 2018:76). For this reason, it is difficult to determine the causal flow of decisions. Was the decision the result of values and beliefs, or was the decision made based on intuition and then justified by values and beliefs as an afterthought? It can be argued that intuition, because it occurs so quickly, and without cognition, is based on norms (cultural practices that we can do without thinking) and identity (which contains elements of our values and beliefs), so the causal flow may be messier than the model is able to depict.

Decision-making is constrained by political economies of agriculture

Stuart and Schewe's (2016) study of corn farmers suggests that decisions to mitigate climate change risk are also constrained by structural barriers, even when farmers are educated and incentivized to participate. In this case the barriers included contract farming in a tournament system rewarding maximum yields in a concentrated market. In general, "the political economy of agriculture reinforces greenhouse emissions and constrains farmers' abilities to participate in mitigation" (p.381). Similar barriers may exist for producers on the Ogallala who are educated and whose guiding principles would lead them toward water conservation decisions. They may then, work to re-frame their guiding principles, or justify decisions in terms of other values.

Practical Constraints

This survey is able to measure values that fall into the broad categories: biospheric, humanistic-altruistic, and egoistic values. However, it is not specific enough to measure specific biospheric values (how they elevate different parts of the environment or weigh them against each other, for example) or different humanistic-altruistic values (who they consider to be family, for example). It will also not be able to tell us the origin of certain values- whether they emerged from faith or tradition, and how they relate to identity, nationalism, masculinity, and intuition. These questions are better answered from a qualitative perspective. Still, the broad categories of values can provide a framework for understanding the motivation of large conservation decisions. The USGS climate data also contains some practical constraints. Although the data is longitudinal, the Ogallala producer survey with which it is merged is not. Therefore, climate data from only one year is included. This limits the ability to determine the role of climate change across time. It only allows conclusions about climate differences and their effects on culture across geography. This may provide some insight into how climate change over time effects culture because these cultures have clearly evolved over time to adapt to particular climates, but we cannot draw conclusions about culture in relation to climate change in particular counties.

This study is also limited in its ability to explain why certain values manifest differently in different groups. Qualitative research is needed to ask why certain values get elevated over others, and why attitudes change over time. This study did not include differences in livelihoods, other than dryland operation and irrigation and controlling for the percentage of income originating from farming and irrigated farming. However, two of the hallmarks of climate change are increasing variability and increasing fragmentation. Increased CO2 levels may increase plant efficiency, but leave them nutrient-poor, affecting the nutrition and health of the animals that consume them (Zhang et al. 2018). Climate change affects different types of producers differently, depending on the biodiversity of their landscape. Therefore, more research is needed to understand how differing experiences of climate change relate to different cultural changes.

Finally, this study is limited in its exclusion of Native American perspectives. Oklahoma alone holds land belonging to the Shawnee, Alabama-Quassarte, Apache, Caddo, Cherokee, Cheyenne, Arapaho, Potawatomi Nation, Comanche Nation, Delaware Nation, Eastern Shawnee, Iowa, Kaw, Kialegee, Kickapoo, Kiowa, Miami, Modoc, Muscogee (Creek) Nation, Ottawa, Otoe-Missouria, Pawnee Nation, Peoria, Ponca, Quapaw, Sac & Fox Nation, Seminole Nation, Seneca-Cayuga Nation, Shawnee, Chickasaw Nation, Choctaw Nation, Osage Nation, Thlopthlocco, Tonkawa, United Keetoowah Band of Cherokee, Wichita, Keechi, Waco, Tawakonie, and Wyandotte Nation (NCSL 2019). Other sovereign nations exist in each of the other States represented by this data. Most of these people are not represented in the data because they are displaced and because they are not producers or do not own water rights on reservation land. Other nations, like the Apache, Sioux, and Lakota, are focused on ongoing legal battles against the Dakota Access Pipeline and on lawsuits for broken treaty agreements. Some of the land atop the aquifer is still being contested in ongoing legal battles over broken treaties. Although First People's perspectives are outside the purview of this particular research question, they should be considered as keepers of water and natural resources in any policy and national conservation strategy decisions.

In the future, qualitative research could illuminate how the relationships between values, beliefs, and attitudes on groundwater conservation emerge, and how they change over time. This dataset explains how producers feel now, within this institutional context, but it does not explain to what extent they are constrained by the political economies of agriculture or the treadmill of production. More research is needed to explain how institutional changes might change attitudes. Would these producers feel differently if dryland agriculture or even diversified, restorative agroecology was better subsidized or incentivized by the state? What if producers could operate within an institutional context that allowed them to step off the treadmill of production and focus, instead, on food and sustainability, while still being able to provide for their families and protect their livelihoods, culture, and sense of place? This study helps illuminate the adaptability of attitudes toward water conservation decision-making, but there is much more to understand about what changes are possible with changing institutional contexts.

Conclusion

This study contributes several key findings to the conversation about how values, beliefs, and norms contribute to environmental decision-making by noting the ways that these elements of culture manifest in producers on the Ogallala aquifer. First, beliefs in the NEP are important in determining attitudes regarding water conservation. Secondly, the attitudes of irrigators and dryland operators are differently affected by beliefs. Third, environmental conditions affect attitudes most obviously, even as they also affect some underlying parts of culture like traditional values in irrigators. Finally, traditional values looked different in different climates. The climate's effect on values intensified in irrigators over dryland operators.

Understanding that producers' traditional values are adaptable is important as producers hold a great deal of power over how regional water districts are regulated. However, the ways in which producers may be limited by institutional and market pressures and the ways in which hydrologic cycles are global suggests that water depletion may be better regulated in a more centralized way that can be aware of the interconnectivities. Consumers, the beef and ethanol industries, and each element of the treadmill of production are also responsible for the situation of debt, overproduction, and overirrigation in which producers find themselves. Still, their perspectives are an important piece of a much larger puzzle in addressing aquifer depletion.

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Appendix A - Ogallala Aquifer Producer Survey

OgallalaWater.org

OPTIMIZING WATER USE TO SUSTAIN FOOD SYSTEMS

OGALLALA AQUIFER PRODUCER SURVEY: A Survey of Farmers in the Ogallala-High Plains Aquifer Region

The following questions are designed to help us understand your current farming practices and your opinions about farming, water, and community. Please answer each item by entering the information or circling the best response option. Your answers are confidential.

PART 1: Your Farm

What is the total number of cropland acres you planted in 2017, including land that you own and land that you rent from others? [Do not count land you own and rented out to other producers.]

1a. Total irrigated acres in 2017: ________________ Groundwater-irrigated acres: _______________ Surface water-irrigated acres: ______________	**b.** How many of your **irrigated** acres do you: Own: _______________ Rent: _______________	**c.** For what percentage of your **rented irrigated** acres do you make management decisions? __ __ __ %
2a. Total dryland acres in 2017: ________________	**b.** How many of your **dryland** acres do you: Own: _______________ Rent: _______________	**c.** For what percentage of your **rented dryland** acres do you make management decisions? __ __ __ %

3. How many cropland acres did you rent out to other producers in 2017? ___________________ acres

4. For what percentage of the land that you rented out to other producers in 2017 did you make management decisions?__ __ __ %

5. In the table below, please provide information for the crops that you harvested in 2017:

	Number of Dryland Acres Harvested	Number of Irrigated Acres Harvested
Corn Grain		
Corn Silage		
Wheat		
Soybeans		
Grain Sorghum Silage		
Milo / Grain Sorghum Seed		
Alfalfa		
Cotton		
Peanuts		
Other:		
Other:		
Other:		

6. Did you raise the following types of livestock in 2017? If yes, please record the number of head raised.

Types of Livestock	Raised in 2017? Yes	No	Number raised in 2017
a. Beef Cattle	1	2	
b. Dairy Cattle	1	2	
c. Hogs	1	2	
d. Other livestock (Please list types below.)	1	2	

7a. Was any of the land you operate originally owned by your (or your spouse's) parents?

1 = Yes ➔ 2 = No

7b. Including your generation, how many generations has your family farmed? 2 = 2 generations

3 = 3 generations
4 = 4 or more generations

8. Have you identified anyone within your family to continue farming after you retire?

1 = Yes, I have a successor in the family.
2 = Yes, I have a possible successor in the family. 3 = No, but I have a successor outside the family. 4 = No, there is no obvious successor.
5 = It is too early to know who will succeed me.

9. What county do you live in? ______________________________ 10a. How long have you lived in this county? ___ ___ years

b. How long have you lived in this state? ___ ___ years
11. How many of the wells that you currently operate are in the following well capacity categories,

measured in gallons per minute (GPM)? List the number of wells in each of the following ranges.

Well Capacity	**# of Wells**
a. Less than 200 GPM	
b. 200 to 300 GPM	
c. 300 to 400 GPM	
d. 400 to 500 GPM	
e. 500 to 600 GPM	
f. 600 to 700 GPM	
Well Capacity	**# of Wells**
g. 700 to 800 GPM	
h. 800 to 900 GPM	
i. 900 to 1,000 GPM	
j. 1,000 to 1,100 GPM	
k. 1,100 to 1,200 GPM	
l. More than 1,200 GPM	

12. How certain are you that you could reduce groundwater use beyond what you are using now?

(Circle the number that best reflects your answer.)

Cannot do it at all			Moderately certain I can		Very certain I can	
1	**2**	**3**	**4**	**5**	**6**	**7**

13. If you had a 25% decline in the quantity of water that you could apply to your crops, how would you change your production practices or operation? *(Circle all that apply)*

1 = Fallow a portion of land previously irrigated
2 = Plant dryland crops on a portion of the land previously irrigated
3 = Change crop mix to crops requiring less water
4 = Apply less water per acre of land planted in a given crop
5 = Utilize new technologies to improve efficiency
6 = Reduce input costs by planting lower quality seed
7 = Reduce input costs by downgrading or downsizing equipment
8 = Other (Please explain: ____)

PART 2: Water

14. In your farming operation, what is the current value of groundwater?

$ ____________________ Dollars per acre feet

15. Think ahead 50 years. Assuming you have the same quantity of groundwater in 50 years, what do you think the value of groundwater will be for your farming operation?

$ ____________________ Dollars per acre feet

16. Listed below are several statements about groundwater. Circle the number that best indicates how much you disagree or agree with each one.

	Strongly Agree	Disagree	Neutral	Agree	Strongly Agree
a. Groundwater should be used. Groundwater does no good in the ground.	1	2	3	4	5
b. Groundwater levels are a problem for my household/farm/family.	1	2	3	4	5
c. Groundwater levels are a problem for my community.	1	2	3	4	5
d. Looking back, there was more groundwater available in the past.	1	2	3	4	5
e. Looking to the future, there will be less groundwater available.	1	2	3	4	5
f. There was more opportunity to get ahead in the past.	1	2	3	4	5
g. There will be less opportunity to get ahead in the future.	1	2	3	4	5
h. I feel personally responsible for groundwater depletion in my area.	1	2	3	4	5
i I should reduce or minimize my groundwater use.	1	2	3	4	5
j. I already limit my groundwater use as much as possible.	1	2	3	4	5

17. For each statement below, circle the number that best indicates how much you disagree or agree.

Most people do not save more groundwater because . . .	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. …it would decrease their production.	1	2	3	4	5
b. …it would require more expensive technology.	1	2	3	4	5
c. …environmental regulations are too strict.	1	2	3	4	5
d. …water use regulations are not strict enough.	1	2	3	4	5
e. …they are self-interested/greedy.	1	2	3	4	5
f. …if they do not pump the water, someone else will.	1	2	3	4	5
g. …it takes too much effort to conserve groundwater.	1	2	3	4	5
h. …they do not want to change their irrigation practices.	1	2	3	4	5
i …they do not know what options exist to save groundwater.	1	2	3	4	5
j. Other reasons people do not save more groundwater:					

18. How serious of a problem is groundwater decline?

1 = Not at all serious
2 = Somewhat Serious 3 = Neutral
4 = Serious
5 = Very Serious

19. In your opinion, should groundwater from the Ogallala Aquifer be conserved, or saved?

1 = Yes 2 = No

20. Please indicate how strongly you disagree or agree with each statement below.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. Groundwater is important for the profitability of my agricultural production business.	1	2	3	4	5
b. Groundwater is important for the profitability of other agricultural businesses in my area.	1	2	3	4	5
c. Groundwater is important because it provides jobs and business opportunities in my community.	1	2	3	4	5
d. Groundwater is important because of connections to wetlands and streams where people in my community enjoy hunting and fishing.	1	2	3	4	5
e. Groundwater is important because it provides drinking water for farms and communities	1	2	3	4	5

21. Please indicate how strongly you disagree or agree with each statement below.

Groundwater should be conserved today so that…	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
a. …future generations in my area can enjoy the benefits I have experienced.	1	2	3	4	5
b. …my children and grandchildren can enjoy the benefits I have experienced.	1	2	3	4	5
c. …it is available to producers if commodity prices are higher in the future.	1	2	3	4	5
d. …it is available to producers if drought becomes more frequent in the future.	1	2	3	4	5
e. …jobs and business opportunities continue to be available in my community in the future.	1	2	3	4	5

22. Please indicate how strongly you disagree or agree with each statement below.

Groundwater should be conserved today so that…	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
a. …irrigated agriculture remains profitable on my farm in the future.	1	2	3	4	5
b. …irrigated agriculture remains profitable for other farms in my area in the future.	1	2	3	4	5
c. …people in my community can continue to hunt and fish in the wetlands and streams that are connected to groundwater.	1	2	3	4	5
d. …my area remains in compliance with water availability agreements between states.	1	2	3	4	5

23. Are you involved with leading, organizing, or advocating for any voluntary group efforts to conserve water? (For example: GMDs, LEMAs, or WCAs in Kansas; NRDs in Nebraska; or Groundwater Conservation Districts in Texas.)

1 = Yes
2 = No ➔ **If No, SKIP to question 25 on the next page.**

24a. IF YES: How long have you participated in these groups? ___ ___ years ___ ___ months

24b. IF YES: Please list the names of any voluntary group efforts that you are currently leading, organizing, or advocating for. ____

25. For each statement below, circle the number that best indicates how much you disagree or agree.

I don't get more involved with groups that are conserving water because…	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
a. …there's just not enough time in the day.	1	2	3	4	5
b. …I need to prioritize the success of my farm.	1	2	3	4	5
c. …I need to prioritize spending time with my family.	1	2	3	4	5
d. …traveling to group meetings is too burdensome.	1	2	3	4	5
e. …I need to avoid making too many commitments.	1	2	3	4	5
f. …I don't have anything worthwhile to contribute to a group.	1	2	3	4	5
g. …I prefer to focus on other issues.	1	2	3	4	5
h. …voluntary group efforts are not effective in solving problems.	1	2	3	4	5

The **Ogallala Aquifer** underlies portions of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming.

- • The majority of water from the Ogallala Aquifer is used for agricultural production, providing a key input to producing valuable crops such as corn and soy.
- • Groundwater stocks in many areas across the region are being depleted at a rate that could result in conversion to dryland (rain-fed) production or fallowing in those areas.

  Suppose that, to address groundwater depletion, your state was considering a **one-time charge of $[XX] per irrigation well,** that would be charged to all producers who use groundwater for irrigation in your area.

  - • This charge would be included in your 2018 local property taxes.
  - • The charge would finance an aquifer recharge program that would provide a 1-time increase in

    water in the aquifer, leading to an **average increase of [YY] gallons per minute** in additional well capacity in your area within 2 years.

26. Do you support the implementation of this program, which would cost you $[XX] per well to provide an average increase of [YY] gallons per minute in well capacity?

1 = Yes ➔ **If Yes, SKIP to question 29 on the next page.** 2 = No

27. IF NO: What is the maximum amount you would pay to gain [YY] gallons per minute within 2 years? $ ___________________

28. IF YOU ENTERED ZERO TO QUESTION 27:
What is the minimum amount you would have to be paid to support this program?
$_________________

PART 3: Your Views

29. How important is each of the following as a guiding principle in your life?

Circle the number of your answer for each item.

29. How important is each of the following as a guiding principle in your life?

Circle the number of your answer for each item.

	Not at all Important	Slightly Important	Moderately Important	Important	Very Important
a. Honoring parents and elders, showing respect.	1	2	3	4	5
b. Equality, equal opportunity for all.	1	2	3	4	5
c. Self-discipline, self-restraint, resistance to temptations.	1	2	3	4	5
d. A world of peace, free of war and conflict.	1	2	3	4	5
e. Respecting the earth, harmony with other species.	1	2	3	4	5
f. Authority, the right to lead or command.	1	2	3	4	5
g. A varied life, filled with challenge, novelty, and change.	1	2	3	4	5
h. Family security, safety for loved ones.	1	2	3	4	5
i Curiosity, interested in everything, exploring.	1	2	3	4	5
j. Influential, having an impact on people and events.	1	2	3	4	5
k. Social justice, correcting injustice, care for the weak.	1	2	3	4	5
l. Wealth, material possessions, money.	1	2	3	4	5
m. Protecting the environment, preserving nature.	1	2	3	4	5
n. Unity with nature, fitting into nature.	1	2	3	4	5

o. An exciting life, stimulating experiences.	1	2	3	4	5

30. Please indicate to what extent you disagree or agree with each of the following statements.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. Humans will always adapt to their natural environment.	1	2	3	4	5
b. People are severely abusing the environment.	1	2	3	4	5
c. People are meant to rule over the rest of nature.	1	2	3	4	5
d. Nature is strong enough to cope with the impacts of modern industry.	1	2	3	4	5
e. The earth is like a spaceship with very limited room and resources.	1	2	3	4	5
f. If things continue, we will soon experience a major ecological catastrophe.	1	2	3	4	5
g. The climate is changing.	1	2	3	4	5
h. Human activities are influencing, at least partly, the climate.	1	2	3	4	5
i People have the right to modify the natural environment to suit their needs.	1	2	3	4	5
j. The so-called "ecological crisis" facing us has been greatly exaggerated.	1	2	3	4	5
k. Plants and animals have as much right as people to exist.	1	2	3	4	5
l. My religious beliefs affect my views on water use.	1	2	3	4	5
m. Individuals do more to protect the environment than government.	1	2	3	4	5
n.. Overall, modern science does more harm than good.	1	2	3	4	5
o. We believe too often in science and not enough in feelings and faith.	1	2	3	4	5
p. We worry too much about the environment and not enough about jobs.	1	2	3	4	5

30. Please indicate to what extent you disagree or agree with each of the following statements.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. Humans will always adapt to their natural environment.	1	2	3	4	5

b. People are severely abusing the environment.	1	2	3	4	5
c. People are meant to rule over the rest of nature.	1	2	3	4	5
d. Nature is strong enough to cope with the impacts of modern industry.	1	2	3	4	5
e. The earth is like a spaceship with very limited room and resources.	1	2	3	4	5
f. If things continue, we will soon experience a major ecological catastrophe.	1	2	3	4	5
g. The climate is changing.	1	2	3	4	5
h. Human activities are influencing, at least partly, the climate.	1	2	3	4	5
i People have the right to modify the natural environment to suit their needs.	1	2	3	4	5
j. The so-called "ecological crisis" facing us has been greatly exaggerated.	1	2	3	4	5
k. Plants and animals have as much right as people to exist.	1	2	3	4	5
l. My religious beliefs affect my views on water use.	1	2	3	4	5
m. Individuals do more to protect the environment than government.	1	2	3	4	5
n.. Overall, modern science does more harm than good.	1	2	3	4	5
o. We believe too often in science and not enough in feelings and faith.	1	2	3	4	5
p. We worry too much about the environment and not enough about jobs.	1	2	3	4	5

PART 4: Background Information

The following questions are designed to help us understand more about characteristics of farmers in the region. Your answers are confidential.

31. What year were you born? __ __ __ __

32. Are you male or female?

1 = Male
2 = Female

33. What is the highest level of education you completed?

1 = Less than 9th grade
2 = 9th – 12th grade
3 = High school (or equivalency)

4 = Associate's (2-year) degree
5 = Bachelor's (4-year) degree
6 = Graduate/Professional degree

34. How would you describe your political orientation? *(Circle the number that best reflects your answer.)*

Very Liberal			Moderate			Very Conservative
1	**2**	**3**	**4**	**5**	**6**	**7**

35. How many people live in your household? a. Adults age 19 and older: ___ ___

b. Children under age 19: ___ ___
(If none, write 'Zero')

36. All things considered, do you think you are better or worse off than you were 5 years ago?

(Circle the number that best reflects your answer.)

Much Worse Off	Worse Off	About the Same	Better Off	Much Better Off
1	**2**	**3**	**4**	**5**

37. All things considered, do you think you will be better or worse off in 5 years?

(Circle the number that best reflects your answer.)

Much Worse Off	Worse Off	About the Same	Better Off	Much Better Off
1	**2**	**3**	**4**	**5**

38. What was your approximate household income from all sources before taxes in 2017?

1 = Less than $25,000
2 = $25,001 - $50,000
3 = $50,001 - $75,000
4 = $75,001 - $100,000
5 = $100,001 - $125,000
6 = $125,001 - $150,000
7 = $150,001 - $175,000
8 = $175,001 = $200,000
9 = More than $200,000

39. What percentage of your total household income comes from…

1. **Farming? ___ ___ ___ % of total income**

2. **Irrigated farming? ___ ___ ___ % of total income**

Thank you for taking the time to complete this survey.
If you have any additional comments that you would like to make, please feel free to write them below or on the back of the survey.

We greatly appreciate your help! Please place the survey in the postage-paid return envelope provided and mail it as soon as possible.