

Rancher and farmer perceptions of climate change in Nevada, USA

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Abstract Farming and ranching communities in arid lands are vulnerable to the adverse impacts of climate change. We surveyed Nevada ranchers and farmers ($n=481$) during 2009–2010 to assess climate change related knowledge, assumptions, and perceptions. The large majority of this group agreed that we are in a period of climate change; however, only 29 % of them believed that human activity is playing a significant role. Female ranchers and farmers hold more scientifically accurate knowledge about climate change than do their male counterparts, regardless of Democratic or Republican affiliation. Partisan affiliation, political ideology, and gender have strong impacts on climate change knowledge and perceptions. Republican, conservative and male rural residents view climate change as a low national priority, less important to themselves, and less harmful to their communities. Female ranchers and farmers are more concerned about the negative impacts of climate change. We found that only 4 % of our subjects ($n=299$) attribute local environment changes to climate change or global warming. The knowledge gained from this study will help researchers and natural resource managers understand how to best communicate about climate change with rural communities, and support policy makers in identifying potentially effective adaptation and mitigation policies and outreach programs.

1 Introduction

Climate change poses potentially adverse consequences for the ways humans interact with natural resources, including water, land, ecosystems, and health (IPCC 2007). Farming and ranching communities, especially those operating with scarce water resources, are sensitive and vulnerable to the adverse effects of climate change due to their strong dependence on

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agricultural production for their livelihood (Campbell 1999). Public opinion and risk perception regarding climate change is playing an increasingly important role in shaping environmental policy and the modification of management systems (Brody et al. 2008), and can greatly influence politics and climate policy formulation (Leiserowitz 2005). Examining the perceived importance of climate change impacts and differences in knowledgebases among various stakeholder groups will help researchers and policy makers delineate effective communication and education channels, which could ultimately reveal new and potentially beneficial insights into behavioral changes (Bord et al. 1998; O'Connor et al. 1999).

A significant body of national and regional public opinion surveys regarding climate change has been conducted in the U.S. (e.g. O'Connor et al. 1999; Leiserowitz 2005, 2006; Kellstedt et al. 2008; Leiserowitz et al. 2009; McCright 2010; McCright and Dunlap 2011). The majority of these surveys link concerns and risk perceptions about climate change or global warming with socioeconomic, demographic, ideological, and other individual characteristics. This includes state-level surveys of Michigan and Virginia residents (Dietz et al. 2007), surveys in New Hampshire and Michigan (Hamilton 2010), and surveys in Virginia, California, Mississippi, and Pennsylvania (Borick and Rabe 2010).

However few studies have focused on the climate change knowledge, beliefs and perceptions of farmers and ranchers. Limited examples are surveys of 19 rural counties by Hamilton and Keim (2009), interviews of farmers and ranchers in Arizona (Coles and Scott 2009), and vulnerability analysis in Nevada (Safi et al. 2012). International surveys of rural residents include in Senegal (Mertz et al. 2009), Australia (Fleming and Vanclay 2010), and Scotland (Barnes and Toma 2012). Although focus group interviews can provide more in-depth insight regarding climate change perception, the interviews are usually confined to local levels with a limited sample size. Climate change surveys of agricultural producers at a regional level, which ask similar questions as those found in state or national surveys, will provide consistent grounds for comparison and coherent assessment of climate change knowledge, belief, and perception.

The literature manifests significant theorizing regarding interactions between specific variables and knowledge, beliefs, attitudes, and stakeholder perceptions pertaining to climate change. Sample factors include identity, ideology, attitudes, and demographics. Party affiliation represents a broader social identity and psychological attachment, and thus, often determines individual's positions regarding particular issues (Miller and Shanks 1996). Research has demonstrated the influence of partisanship on climate change perceptions and policies. For example, Malka et al. (2009) reported that among democrats, increased climate change knowledge yielded more climate change concern.

Political orientation or ideology is often a significant variable for explaining pro-environmental beliefs and attitudes. Conservatives are more likely than liberals to endorse our society's prevailing worldview or Dominant Social Paradigm (Dunlap and van Liere 1984). Persons of liberal political ideology (and Democrats) demonstrate more scientific knowledge about climate change, and perceive climate change as a greater risk than do their conservative (and Republican) counterparts (McCright 2010, 2011).

Among demographic factors, gender is an important explanatory variable in relation to environmental knowledge, perception, and concern, including climate change. Past research has indicated that, in general, men show greater scientific knowledge than do women (Arcury et al. 1987; Hayes 2001). It has been theorized that men have historically commanded the scientific and technological dimensions of society, and women have been socialized to the more ecologically important roles of mother and nurturer, and are thus, less informed about scientific developments. Further, women are generally more concerned

about environmental issues and problems, especially those posing health and safety risks to themselves, their families, and community members (Brody 1984; Davidson and Freudenburg 1996). Females tend to perceive climate change a higher risk (O'Connor et al. 1999; McCright 2010). Two explanatory sociological perspectives are gender socialization theory and social roles theory. The former supports social conventions, values and expectations conferred to boys and girls through socialization into their society's dominant culture. The latter emphasizes women's inevitably closer ties to natural phenomena via their nurturing and reproductive roles. Literature also suggests that gender differences in levels of scientific knowledge do not necessarily lead to a greater environmental concern among women than men (Davidson and Freudenburg 1996; McCright 2010).

Other factors have been linked with climate change perceptions. Borick and Rabe (2010) found that public views on climate change are being shaped by personal observations, meteorological events, and physical changes on the earth, together with demographic variables such as partisan affiliation. Leiserowitz (2005) reported that Americans generally consider climate change as causing harm to geographically and temporally distant people, places, and other species.

There is scientific consensus that human-induced climate change (i.e. burning of fossil fuels) is happening and will continue into the future (IPCC 2007). The global climate is already warming at a rapid and unprecedented rate. In the past few decades global average temperature was the highest of any period over the last 1,000 years (Mann et al. 1999). The scientific community has maintained that there is a significant anthropogenic contribution to climate change (IPCC 2007). However, as indicated by O'Connor et al. (1999) and Lorenzoni et al. (2007), the scientific community has not fully and effectively communicated the science of climate change, and, where possible, potential adaptation and mitigation scenarios to the general public. It is important to note that interpretations of science are mediated by societal values, personal experience, and other factors (Lorenzoni et al. 2007). Thus, some researchers have argued that focusing on familiar local landscapes might be more productive when examining lay knowledge of climate change, and it is wise to seek new communication channels (Brace and Geoghegan 2010). Farmers and ranchers are a unique and valuable target group in that they typically have been working on the land for generations and have accumulated personal observations and built knowledgebases on local landscapes over a long period.

Many farmers and ranchers belong to families which have worked the land for multiple generations, and they have had consistent opportunities to closely observe environmental change. Thus, it could be argued that this group should be expected to demonstrate enhanced understanding of climate change. A primary way that our research contributes to the knowledgebase is by assessing climate change knowledge and perceptions of Nevada farmers and ranchers and exploring whether local environmental change is attributed to anthropogenic climate change. We ground our investigations in questions and data found in previous national climate change surveys to ensure 'broader impacts.' One interesting finding of this study is that, despite the aforementioned connection of ranchers and farmers to their environment, many of the responses do not deviate significantly from results found in national surveys.

Nevada is an arid to semi-arid state with an agricultural community which could be impacted by climate change. The driest state in the U.S., Nevada is projected to suffer rising average temperatures and more frequent droughts due to climate change (CIER 2008). Thus, water availability will be diminished. Based on latest population projections (www.census.gov/population/www/projections/stproj.html), Nevada is the fastest-growing state between

2000 and 2030 with a projected growth rate of 114 %. In fact Nevada was the fastest-growing state in the U.S. percentage-wise from 1950 to 2010 (650 % from 1950 to 1990, 66 % from 1990 to 2010, and 35 % from 2000 to 2010, www.census.gov).

Building on the aforementioned theories, we attempt to answer the following questions:

- 1) What is the climate change knowledgebase and what are the perceptions of rural Nevadans, and what factors drive divergent views?;
- 2) What do Nevada's farmers and ranchers perceive to be the impacts of climate change, and what are the factors influencing such perceptions?; and
- 3) What are the observed local environmental changes that may be related to climate change?

The knowledge gained from this research will aid researchers and natural resource managers in understanding how to best communicate climate change science and effectively perform outreach with the potentially vulnerable Nevada ranching and farming communities living in mostly arid and semi-arid environment. This paper also gives voice to local knowledge acquired through generations of experience of working on the land.

2 Study area and methods

2.1 Study area

Nevada is located in the Southwest United States, and lies primarily within the Great Basin, a large desert area. Nevada's topography is characterized by numerous mountain ranges running north–south, with wide and relatively flat basins in between. Nevada has an average annual rainfall of 178 mm, ranging from 107 mm to 1,000 mm. The mean annual temperatures vary from 4 °C in the northeast, to 10 °C in the west and central areas, and to 18 °C in the south. Monthly average temperatures range from –6.9 °C to 40.3 °C. Nevada's leading agricultural industry is cattle and calves (39.2 %, farm cash receipts, 2010), and the major agricultural crops are hay, onions, potatoes, wheat, and garlic (<http://www.ers.usda.gov/StateFacts/NV.HTM>).

2.2 Survey techniques and data

Nevadan rural communities were surveyed in two phases (December 2009 and September 2010). The surveys were mailed to 1,871 farmers and ranchers, from a list collected from a partner university program. The list represents the majority of the ranching and farming community (USDA 2010). Each survey packet included an eight-page questionnaire with 43 questions, a cover letter, and a prepaid return envelope. The survey was approved by our Institutional Review Board. In total, 481 surveys were returned ($n=321$ for the first wave, and $n=160$ for the second). The response rate was 26 %. The second wave using the same questionnaire, represented a repeated contact attempt, and served to increase the response rate.

2.3 Measures

Table 1 and Online Resource 1 present the measures, coding, and basic descriptive statistics for variables in this study.

Table 1 Coding and basic descriptive statistics for variables in the study

Variable	Coding	N ^a	Mean	Std Dev
Age	21 to 95 (in years)	474	61.75	13.27
Gender	1 (male) to 2 (female)	478	1.26	0.44
Marital status	1 (single/divorced/widowed) to 2 (married)	475	1.84	0.37
Education	1 (less than high school) to 4 (Bachelor's degree or higher)	476	3.3	0.78
Party affiliation	1 (Republican), 2 (Independent), 3 (Democrat)	422	1.39	0.73
Political ideology	1 (very conservative) to 5 (very liberal)	456	1.89	0.96
Agricultural income	1 (less than \$25,000) to 4 (more than 1 million dollars)	425	1.72	1.06
Agricultural type	1 (farming), 2 (ranching), 3 (both), 4 (other)	457	2.25	0.91
Year ^b	1 (2009) and 2 (2010)	481	1.33	0.47
In a period of climate change	1 (disagree) to 3 (agree)	470	2.40	0.82
Cause of climate change: Role of human activity	1 (disagree) to 3 (agree)	467	1.75	0.88
Climate change as a national priority	1 (low priority) to 3 (high priority)	474	1.58	0.76
Personal importance of climate change	1 (not important) to 2 (important)	454	1.69	0.46
Timing of climate change ^c	1 (never), to 6 (100 years), and 7 (not sure)	441	3.87	2.59
Perceived climate change impact index ^d	Index (0–4)=average of the eight variables	433	2.25	0.92

^a Numbers vary because of missing data

^b The “Year” variable was used in regression models to examine whether there are any possible influences from the two separate waves of surveys

^c Modified from Leiserowitz et al. (2009) by adding the seventh scale of “not sure”

^d The index was the average of the eight variables of the perceived climate change impacts on: 1) You personally; 2) Your family; 3) Your surrounding ranching/farming community; 4) People in the U.S.; 5) People in other modern industrialized countries; 6) People in least-wealthy countries; 7) Future generations of people; and 8) Plant and animal species. The coding for each of the eight variables is: 0 (don't know), 1 (not at all) to 4 (a great deal)

2.3.1 Climate change knowledge

We inquired how ranchers and farmers thought about the following statements: “I believe that we are in a period of climate change” (Statement #1), and “I believe that human activity has been playing a significant role in recent climate change” (Statement #2). While for regression models the second statement was selected as the knowledge index, as it was related to the primary cause of contemporary climate change (role of human activity). Therefore, it serves as a more accurate measurement of scientific climate change knowledge.

2.3.2 Importance and temporal dimension of climate change

We asked survey respondents to indicate whether climate change was a national priority (low—1 to high—3 scales) and whether it was important to the respondent personally. Regarding the timing question, respondents were asked, “When do you think climate change will begin harming people in your ranching/farming community?”

2.3.3 Perceived climate change impacts

Nevada farmers and ranchers were asked to rate how much they thought that climate change would negatively impact the eight categories in Table 1. Following the method adopted by McCright (2010), we created a perceived climate change impact index as the average of the eight variables for use in regression analysis. This index had a Cronbach's alpha (a coefficient of reliability of scale items) of 0.94 ($n=434$), much higher than the 0.70 threshold value.

2.3.4 Sociodemographics

Social and demographical variables included age, gender, marital status, education level, agricultural income, political party identification, and political ideology.

2.4 Analysis

Statistical analyses were all performed using SAS, version 9.2 (SAS Institute Inc. 2008). Nonparametric statistical methods used included Spearman rank correlation analysis, Wilcoxon rank sum test, and Goodman–Kruskal Gamma test statistic (Siegel and Castellan 1988). The Gamma statistic (G) was used to measure associations between two ordinal scaled variables with many tied observations (e.g. gender and scientific knowledge of climate change). We also conducted several multivariate ordinary least squares (OLS) regression analysis to determine the contribution of the variables to the perceived climate change impact index, including demographic variables, political variables, and the knowledge index. The VIF (variance inflation factor) option in SAS was used to diagnose multicollinearity in multiple regression models. Each of the independent variables had a VIF value less than 10 (ranging from 1.0 to 1.2). Thus no high levels of multicollinearity were identified. P-values less than 0.05 were considered statistically significant.

3 Results and discussion

3.1 Climate change knowledge

Sixty-one percent of our study group ($n=470$) believed or strongly believed that we are in a period of climate change (Online Resource 2, 61 % and 62 % from both waves). This percentage was higher than those from recent national polls, 57 % (in 2009) and 59 % (in 2010) (Pew Research Center 2010), but lower than those from some surveys done before 2009 (70 %–79 % from 2006 to 2008, Pew Research Center 2010; 69 % to 75 % in 2008, Borick and Rabe 2010). Regarding the cause of climate change, only 29 % of Nevada's farmers and ranchers ($n=467$, 29 % for both waves) believed that human activity has been playing a significant role in recent climate change. However, this percentage was lower than the national polls (34–50 % from 2006 to 2010, Pew Research Center 2010), and was lower than the 36 % indicated by Borick and Rabe (2010). A large difference exists between the two knowledge statements listed above (61 % vs. 29 %). Examination of the survey revealed that 44 % of those who agreed with Statement #1 ($n=288$, pooled sample of the two waves) disagreed with Statement #2.

Qualitative analysis revealed that many of those surveyed believed that contemporary climate change is natural, noting, for example, “Natural climatic cycles.” While some respondents labeled climate change as “conspiracy” theories, or, “Propaganda,” or “Hot

air from academia and Washington D.C. politicians—mainly Al Gore.” Another statement was that, “I believe certain groups are using the current cycle to further a progressive, socialist, big government agenda.” These opinions supported the findings identified from a national survey (Leiserowitz 2005, 2006). We suspected that the wording of Statement #1 might have some impacts on the responses, since most surveys used “global warming” instead of “climate change” (e.g. McCright 2010). The phrasing of “a period of climate change” in Statement #1 was also somewhat ambiguous in terms of the extent of the period (years or centuries).

Gender, marital status, and education had a moderate effect on an individual’s scientific knowledge of climate change. The strongest factors influencing one’s acceptance and knowledge of climate change were partisan affiliation and political ideology. While party and political ideology were significantly correlated (Spearman’s rank correlation test, $r=0.47$, $P<0.0001$, $n=421$). Both Democrat and Independent farmers and ranchers were more likely than Republicans to believe that that we are in a period of climate change. Democrats were over four times as likely as Republicans to view that human activity has been playing a significant role in recent climate change.

Such strong associations were not observed for any other demographic categories except political ideology, noting that political ideology was significantly correlated with political party affiliation. This was consistent with previous research on the partisan gap in climate change opinion nationwide (Dietz et al. 2007; Dunlap and McCright 2008; McCright and Dunlap 2011). Further, the polarization was statistically validated by Spearman’s rank correlation analyses ($r=0.21$, $P<0.0001$, $n=414$ for party and Statement #1; and $r=0.42$, $P<0.0001$, $n=412$ for party and Statement #2). Very similar significant correlation coefficients were calculated for each of the two waves. The correlation coefficient between party and cause of climate change was almost the same as that from Gallup survey in 2008 (Pearson coefficient of 0.344; Dunlap and McCright 2008).

A greater percentage of women than men believed that climate change is happening (69 % vs. 58 %, Online Resource 2), and that it is mainly caused by human activities (45 % vs. 24 %). The overall relationship between gender and Statement #1 was significant ($G=0.18$, $n=468$, $P=0.03$). The G was 0.23 ($n=313$, $P=0.03$) and -0.09 ($n=155$, $P=0.29$, non-significant) for the two waves, respectively. For gender and Statement #2, female ranchers and farmers hold more scientifically accurate knowledge about climate change than do their male counterparts ($G=0.30$, $n=464$, $P<0.001$; $G=0.31$ and 0.29 for waves # 1 and #2). This is consistent with the findings on climate change for national surveys from McCright (2010, Gamma, both $P<0.001$), but is opposite of what has been found with other measures of environmental knowledge (Arcury et al. 1987; Hayes 2001; Coyle 2005).

We noticed that gender was also correlated with political ideology ($r=0.20$, $P<0.0001$, $n=455$) and party ($r=0.15$, $P=0.002$, $n=421$). To assess the relative importance of political variables vs. gender, we further calculated the gamma G between Statement #2 and political variables with the pooled sample for making consistent comparisons. The G was 0.67 ($n=412$, $P<0.001$) between party and Statement #2. While for political ideology and Statement #2, the association was also profound ($G=0.65$, $n=445$, $P<0.001$). Thus, this research showed that the gender divide in climate change knowledge was not overwhelming, although statistically significant, compared to differences based upon such demographic variables as political ideology and party (Dunlap and McCright 2008; McCright 2010).

We performed additional analysis on 369 responses with Wilcoxon rank sum tests after deleting records that lacked values for gender, party, and political ideology. We still observed that a higher percentage of women than men believed in the anthropogenic cause of contemporary climate change (45 %, $n=82$; vs. 23 %, $n=287$). There were statistically

significant differences between females and males in terms of party ($P=0.002$) and political ideology ($P<0.0001$). No significant differences were identified for education, age, and income variables. Among Republicans, 32 % of those female ($n=60$) believed Statement #2, a much higher percentage than of their male counterparts at 14 % ($n=250$). Female and male Republican farmers differed by political ideology ($P=0.007$). Regarding Democratic farmers, 82 % of women ($n=22$) agreed with Statement #2, which is slightly higher than men at 78 % ($n=37$). No significant differences existed by demographic and political variables.

To further understand why Republican women accept climate change science more than their male counterparts, we compared the Republican farmers and ranchers who agreed with Statement #2 (19 females, 36 males) against those who didn't agree with it (41 females, 214 males). Among Republican women significant differences were detected for education ($P=0.03$) and political ideology ($P=0.002$). Among Republican men, significant differences were also found for education ($P=0.046$) and political ideology ($P=0.002$).

Thus, this study shows that female farmers have more scientifically accurate views on the cause of climate change than the male farmers, and this finding tends to refute arguments that men are more grounded in science and technology than women (e.g. Coyle 2005). Political ideology and party affiliation are two important variables, which is consistent with the finding from McCright (2010). Furthermore we found that another important variable is educational attainment, which helps explain why Republican women have different views than Republican men. Again, this challenges the facile assumption that previous authors have often made about men and women's relation to science.

3.2 Importance and temporal dimension

3.2.1 Importance of climate change

Sixteen percent of Nevada's farmers and ranchers ($n=474$) stated that climate change should be a top (3 %, by wave, 4 % vs. 2 %) or high (13 %, by wave, 13 % vs. 11 %) national priority. The percentages were much lower than 21 % and 33 % from a national survey (Leiserowitz et al. 2009). While 59 % perceived it as a low priority (30 %) or not a priority (29 %), much higher than 17 % from Leiserowitz et al. (2009).

The relationships between perceived priority level and selected demographic variables (party, political ideology, and gender) were all strongly significant ($G=0.66$, 0.71 , and 0.41 , respectively; all $P<0.0001$). Almost the same significant relationships were also identified for each of the two waves. While perceived priority level is not significantly related with age, education, or income, except with income for wave #2 ($G=-0.30$, $n=146$, $P=0.01$). Thus, Republican, conservative and male ranchers and farmers tended to view climate change as a low national priority. This group of people belonged to climate change "naysayers," defined by Leiserowitz (2005), which considered climate change a very low or nonexistent danger, and required low or no governmental intervention.

Sixty-nine percent of farmers and ranchers ($n=454$, Online Resource 3) said that climate change was either extremely, very, or somewhat important to them personally. Those percentages were very similar to a national data (Leiserowitz et al. 2009). By contrast, 31 % said that the issue was not at all important to them personally, much higher than 11 % from a national survey (Leiserowitz et al. 2009). Significant relationships were found between the perceived importance and party affiliation ($G=0.64$), political orientation ($G=0.59$) and gender ($G=0.45$; all $P<0.0001$). Almost the same results were obtained for each wave. Republican, conservative and male ranchers and farmers considered climate change unimportant to themselves.

3.2.2 Temporal dimension of climate change

Thirty-two percent of our respondents ($n=444$) thought that climate change is having significant impacts on people in their ranching/farming community (27 %) or will within the next 10 years (5 %). Each of the two waves showed similar percentages (34 % vs. 29 %). The findings were lower than those from Leiserowitz et al. (2009) in their national survey (34 % present tense and 13 % future tense). In fact, the IPCC (2007) stated that moderate changes to natural systems due to climate change will occur in North America in the early decades of this century. While 61 % of survey respondents (59 % and 63 % for the two waves) said that climate change would never create dangerous impacts for them, or they were not sure about the timing of impacts (24 % and 37 %, respectively). Leiserowitz et al. (2009) reported a smaller percentage (15 %) believed that people in the U.S. will never be harmed by climate change.

We did not find any significant statistical relationships between perceived timing and social demographic variables for either a pooled sample or either of the two waves. Sixty-five percent of liberal farmers and ranchers ($n=34$) said that climate change is harming people now, while for conservatives, Democrats, and Republicans the percentages were 21 % ($n=327$), 51 % ($n=59$), and 22 % ($n=296$). Sixty-eight percent of conservatives ($n=327$) and Republicans ($n=296$) selected “Never” or “Not sure.” This means that climate change policy making which relies on farmer and rancher support for creation or implementation should not be future-oriented, as at this time there is evidence that a future tense argument is assumed to be false or at least weakly supported. Evidence regarding the farmer subgroup tendency to not believe in future impacts of climate change is found in the nearly 3/4 of the subgroup who said it will “never happen” or “not sure.”

3.3 Perceived impacts

Nevada ranchers and farmers believed that climate change would bring “a great deal” of harmful impacts to all the categories (around 20 % to 29 %, Fig. 1) except for the first two—themselves (13 %) and their families (14 %). When “a moderate amount” and “a great deal” categories are combined, the percentages are very similar, 37 % and 50 %, almost the same for each of the two waves (34 %–51 %).

Leiserowitz et al. (2009) reported that for Americans in general, global warming or climate change was a greater threat to other species, people and places far away in time and space (61 % to 62 %), but not so serious of a harmful threat to themselves (32 %) or their

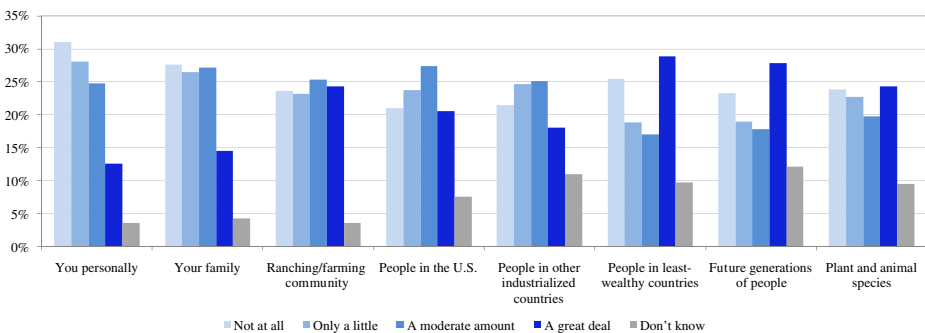


Fig. 1 Perceived climate change impacts. $N=438-445$

families (35 %). Thus, Americans displaced the hazard spatially, though not in time (e.g. not future-oriented). In contrast to a national baseline (Leiserowitz et al. 2009), our data here show empirically that double the percentage of our study community sees climate change only as a threat to poor persons living elsewhere, rather than in their own location.

In contrast to global climate change, higher ranking national issues (e.g. the economy, health care) and environmental issues (e.g. clean air, clean water) were more easily understood as having direct local impacts (Leiserowitz 2005). This can help explain our findings that only 13 % and 14 % of Nevada farmers and ranchers felt that climate change would incur a great deal of negative impacts on themselves and their families. Indeed, the recent severe economic recession and financial systems crisis, which burgeoned in the U.S. in late 2007, dominated the media during our survey time periods.

However, our research further found that half of farmers and ranchers perceived a great deal or moderate amount of harmful climate change impacts on their ranching and farming communities and people in the U.S., which were the highest percentages among the eight categories. This may demonstrate that in contrast with the general public, farmers and ranchers have strong interactions with weather and climate physical systems due to their dependence on agricultural production and their way of life. As emphasized by Rosenberg (1992), agriculture has always been vulnerable to losses caused by unfavorable weather events and climatic conditions, for example, drought, flooding, or severe temperature changes.

Gamma tests revealed that each of the eight impact variables was significantly related with party ($G, 0.35\text{--}0.45$, all $P < 0.0001$), political orientation ($G, 0.30\text{--}0.43$, all $P < 0.0001$), gender ($G, 0.31\text{--}0.42$, all $P < 0.0001$), and marital status (except for impacts on people in the U.S., $G, -0.19\text{--}0.29$, all $P, 0.001\text{--}0.03$). Therefore a significantly large percentage of conservative, Republican, male, and married ranchers and farmers tended to perceive that climate change would bring only a little or no harmful impacts.

Table 2 shows the standardized regression coefficients from multiple regression models. These models were used to examine the effects of four types of variables on the climate change impact index: Demographic variables (Model A); Agricultural activities (Model B); Political variables (Model C); and The knowledge index (Model D, also the fully specified model). The latter model was constructed when former model variables were controlled for. No significant timing effect was identified for any of the four models due to the two survey waves. Additionally, across all the models gender had a statistically significant negative effect. Female ranchers and farmers were more concerned regarding the adverse impacts of climate change. With the presence of basic demographic variables and agricultural activities (Models A and B), only gender was statistically significant. While Models A and B accounted for only 6 % or 7 % of the variance in the dependent variable (Adjusted R^2). When the political variables were introduced (Model C), the gender effect was somewhat mitigated, although significant. Political ideology had the strongest significant negative effect on perceived climate change impact, indicating that conservatives tended to view climate change as a non-harmful threat. Party affiliation and marital status became significant at the 0.05 level, reflecting that non-married and Democratic rural residents were more worried about the negative impacts. The explanatory power of the model was increased to 25 %.

After the knowledge variable (cause of climate change) was added, Model D displayed a much stronger effect from this variable ($P < 0.001$). The adjusted R^2 increased from 0.25 for Model C to 0.44, meaning that the regression model significantly predicted perceived climate change impacts and explained 44 % of the variance. Climate change knowledge had a strong, positive effect on climate change impacts, and respondents with greater knowledge about climate change perceived greater negative impacts. Political ideology

Table 2 Multiple regressions on perceived climate change impact index score

Independent variable	A	B	C	D
Age	-0.003	-0.003	-0.002	-0.002
Gender	0.62***	0.59***	0.38**	0.25*
Marital status	-0.19	-0.22	-0.28*	-0.20
Education	0.05	0.05	-0.04	-0.05
Agricultural income	0.03	0.03	0.09	0.07
Year	0.01	0.02	0.04	-0.005
Agricultural type		-0.07	-0.03	-0.01
Number of livestock		0.00	0.00	0.00
Area of farming and grazing land		0.00	0.00	0.00
Party affiliation			0.20*	0.003
Political ideology			0.38***	0.15**
Knowledge of cause of climate change				0.63***
F value	5.61***	3.78***	11.69***	23.77***
Adjusted R ²	0.07	0.06	0.25	0.44
N	384	376	350	343

Dependent variable: perceived climate change impact index

Entries are standardized regression coefficients

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

and gender remained significant, while their effects dropped to the significance levels of 0.01 and 0.05, respectively. Party affiliation and marital status were no longer significant.

The finding regarding the climate change knowledge variable supports the results of two recent climate change public opinion studies (Wood and Vedlitz 2007; McCright 2010). This was also consistent with the views of Davidson and Freudenburg (1996) and Hayes (2001) that greater environmental knowledge does not lead to lesser environmental concern. Indeed, increased climate change knowledge yields more climate change concern.

The impact of political ideology was consistent with the findings of national climate change surveys (Leiserowitz 2006; McCright 2010). Moreover, this research reveals that political orientation is the most important variable among such basic demographic factors as gender, party affiliation, and marital status. Our results for the effect of gender on perceived climate change impacts were similar to other national public opinion research (e.g. O'Connor et al. 1999; Leiserowitz 2006; McCright 2010). Women show greater concern about climate change than man, even after controlling for assessed climate change knowledge, party identification, and political orientation. The variable “party” was generally not included in most previous climate change research, except McCright (2010). McCright (2010) showed a much stronger significant effect from party affiliation at the national level ($P < 0.001$), while the weaker effect in Model D was believed to be mainly due to the significant correlation between party and political ideology ($r = 0.47$, $P < 0.0001$) as well as between party and climate change knowledge ($r = 0.42$, $P < 0.0001$).

3.4 Observed local changes

Stakeholder observations by those who come in deep contact with nature can prove valuable in myriad ways. In addition, the mere perceptions of such changes are also worth noting

from a policy perspective, as perceptions shape levels of support for public policy. The top three observed impacts were decreased snow packs (48 %), less surface water in lakes and rivers (44 %), and increased soil dryness (39 %), all related to decreased precipitation and lowered water tables. The next two responses were increased wildfire and less flowing water from springs (both 37 %). Twenty-two percent noticed increased summer temperature and 15 % perceived warmer temperature in winter.

We further asked respondents to explain the causes of these changes (Online Resource 4). The top two explanations were natural cycles (34 %) and mismanagement of public forest and range lands (18 %, e.g. by the Bureau of Land Management and Forest Service). Only 4 % of rural Nevadans ($n=299$) attributed local environment changes to climate change or global warming.

Regarding the mismanagement comment, some respondents pointed out that more wildfires are due to decreased livestock grazing by sheep and cattle (allowing fuel load buildup), and poor logging and fire suppression policies. They believed that more grazing by large animals should be adopted to reduce fuel for fires. One related comment was “over grazing before 1950, and under grazing after 1950.” Obviously, drier and hotter conditions are more conducive to fires as well. Some rural residents indicated that wild horses are destroying the range land.

Several respondents reported that the encroachment of pinyon and juniper trees leads to less water flow and lower water tables, which is in agreement with the scientific finding that woodland expansion decreases available surface and subsurface water (Huxman et al. 2005). Regarding over-population/development, some respondents mentioned that dewatering activities of mining companies affected the springs; and others said that less surface water was because of increased upstream storage. This research found a large discrepancy of viewpoints in terms of explaining local environmental changes, for example, the natural pattern argument (34 % of respondents), vs. climate change (only 4 %).

On one hand, the aforementioned results support the statement that the interpretations of science are mediated by societal values, beliefs, personal experience, and other contextual factors (Lorenzoni et al. 2007). On the other hand, the findings from our research challenge the assertions in the literature by Brace and Geoghegan (2010) that it is more productive to ask how people make sense of climate change and that a focus on the familiar local landscapes offers an opportunity to examine climate change. As summarized in Section 3.1, the strongest influencing factors for one’s acceptance and knowledge of climate change were political and ideological variables, rather than familiarity with local landscapes.

Furthermore, the literature suggests that the expansion of pinyon and juniper woodlands in the Great Basin by more than 60 % since 1860 was due to a combination of climate change, fire suppression, and overgrazing by livestock (Miller and Wigand 1994). However the largest group of our respondents (34 %) believed these local environmental changes were just natural cycles. These results confirm that there exists a gap between scientific research results and the perceptions and lay knowledge of farmers and ranchers. Familiarity with local landscape is not necessarily linked with scientific understanding of the causes of environmental changes.

We argue that to some extent it might be more appropriate to effectively communicate climate change science to the general public, including rural residents in Nevada, by adopting a dialogue model with a more engaged format rather than the traditional knowledge-deficit model emphasizing one-way knowledge flow (Hulme 2009). This echoes the conclusion from a national climate change survey (Kellstedt et al. 2008) that “the knowledge-deficit model is inadequate for understanding mass attitudes about scientific controversies.”

Additionally, because climate and climate change information, accumulation of data over a long timeframe, is difficult to understand (Brace and Geoghegan 2010). And, implications of global climate change at local and regional scales are spatially uneven due to local and regional complexity and variations (Yarnal 1998; Liu and Smith 2013). This further supports the fact that local temperature and rainfall variations can be experienced, but global climate change is far removed from direct experience (Bord et al. 1998). Space and time, as well as how they are experienced differently across sub-cultures, can seemingly make for inconsistencies in responses that appear illogical to researchers.

4 Conclusions

In this research we found that a majority of Nevada's ranchers and farmers indicate that we are in a period of climate change. However, only 29 % of them believe that human activity has been playing a significant role in recent climate change. This percentage is lower than those reported from national surveys. In agreement with the literature (Leiserowitz 2006; Borick and Rabe 2010; McCright 2010), we quantified how partisan affiliation and political ideology have strong impacts on climate change knowledge. Democratic ranchers and farmers are far more likely than Republicans to believe the occurrence and anthropogenic causes of climate change. Gender is also an important demographic variable. Nevada female ranchers and farmers possess greater scientifically accurate knowledge about climate change than do their male counterparts. These results support the findings from national surveys (e.g. O'Connor et al. 1999; Leiserowitz 2006; McCright 2010). Educational attainment helps account for why Republican women have more scientifically accurate views on the cause of climate change than Republican men. Female ranchers and farmers in Nevada express greater climate change concern, even after controlling for climate change knowledge. Rural Nevadans generally consider climate change as causing harm to geographically and temporally distant people, places, and other species. In summary, Republican, conservative and male rural residents in Nevada tended to view climate change as a low national priority, less important to themselves, and not harmful. It may be, given our results, that building bridges to trusted rural messengers and places of knowledge may be as important as simply more or 'better' education.

A large portion of Nevada's ranchers and farmers observed decreased snow packs and less surface water in lakes and rivers in their local environment. However over 30 % argued these were mainly due to natural normal weather and climate cycles, and only 4 % attributed observations to climate change or global warming. In addition to the related factors of partisan affiliation and political ideology, this supported the findings that global climate change is often far disconnected psychologically from the local experience (Bord et al. 1998)—and again, this also challenged us to seek effective channels for communicating climate change science to remote rural residents. A dialogue model rather than the traditional knowledge-deficit model might be a better option for engaging Nevada's ranchers and farmers (Hulme 2009). Additionally, we identified many comments explaining local environmental changes as a result of mismanagement. This requires further research and treatment from academia, land management agencies, and policy makers.

Future analysis will focus on researching potential spatial patterns of selected variables, and inquiry into whether geographic factors play an important role in shaping climate change perceptions. In-person interviews with selected farmer and rancher households are being prepared by the team to provide more data and greater context utilizing qualitative and quantitative methods.

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References

- Arcury TA, Scollay S, Johnson TP (1987) Sex differences in environmental concern and knowledge. *Sex Roles* 16:463–472
- Barnes AP, Toma L (2012) A typology of dairy farmer perceptions towards climate change. *Clim Chang* 112: 507–522
- Bord RJ, Fisher A, O'Connor RE (1998) Public perceptions of global warming: United States and international perspectives. *Clim Res* 11:75–84
- Borick CP, Rabe BG (2010) A reason to believe: examining the factors that determine individual views on global warming. *Soc Sci Q* 91(3):777–800
- Brace C, Geoghegan H (2010) Human geographies of climate change: landscape, temporality, and lay knowledges. *Prog Hum Geogr* 35(1):1–19
- Brody CJ (1984) Sex differences in support for nuclear power. *Soc Forces* 63:209–228
- Brody SD, Zahran S, Vedlitz A, Grover H (2008) Examining the relationship between physical vulnerability and public perceptions of global climate change in the United States. *Environ Behav* 40:72–95
- Campbell DJ (1999) Response to drought among farmers and herders in Southern Kajiado District, Kenya: a comparison of 1972–1976 and 1994–1995. *Hum Ecol* 27(3):377–416
- CIER (2008) Economic impacts of climate change in Nevada. The Center of Integrative Environmental, University of Maryland, 19p. Available at <http://www.cier.umd.edu/climateadaptation/Nevada%20Economic%20Impacts%20of%20Climate%20Change.pdf>. Accessed 26 April 2012
- Coles AR, Scott CA (2009) Vulnerability and adaptation to climate change and variability in semi-arid rural southern Arizona, USA. *Nat Res Forum* 33:297–309
- Coyle K (2005) Environmental literacy in America. Washington, DC: The National Environmental Education and Training Foundation. Available at <http://www.neefusa.org/pdf/ELR2005.pdf>
- Davidson DJ, Freudenburg WR (1996) Gender and environmental risk concerns. *Environ Behav* 28:302–339
- Dietz T, Dan A, Shwom R (2007) Support for climate change policy: social psychological and social structural influences. *Rural Sociol* 72:185–214
- Dunlap RE, van Liere KD (1984) Commitment to the dominant social paradigm and concern for environmental quality. *Soc Sci Q* 65:1013–1028
- Dunlap RE, McCright AM (2008) A widening gap: Republican and Democratic views on climate change. *Environment* 50(5):26–35
- Fleming A, Vanclay F (2010) Farmer responses to climate change and sustainable agriculture. A review. *Agron Sustain Dev* 30:11–19
- Hamilton LC, Keim BD (2009) Regional variation in perceptions about climate change. *Int J Climatol* 29: 2348–2352
- Hamilton LC (2010) Education, politics, and opinions about climate change: evidence for interaction effects. *Clim Chang*. doi:10.1007/s10584-010-9957-8
- Hayes BC (2001) Gender, scientific knowledge, and attitudes toward the environment. *Polit Res Q* 54: 657–671
- Hulme M (2009) *Why we disagree about climate change*. Cambridge University Press, Cambridge
- Huxman TE, Wilcox BP, Breshears DD, Scott RL, Snyder KA, Small EE, Hultine K, Pockman WT, Jackson RB (2005) Ecohydrological implications of woody plant encroachment. *Ecology* 86:308–319
- International Panel on Climate Change (IPCC) (2007) *Climate Change 2007: Synthesis Report*. Summary for policymakers from http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf
- Kellstedt PM, Zahran S, Vedlitz A (2008) Personal efficacy, the information environment, and attitudes toward global warming and climate change in the United States. *Risk Anal* 28:113–126
- Leiserowitz A (2005) American risk perceptions: is climate change dangerous? *Risk Anal* 25:1433–1442
- Leiserowitz A (2006) Climate change risk perception and policy preferences: the role of affect, imagery, and values. *Clim Chang* 77:45–72
- Leiserowitz A, Maibach E, Roser-Renouf C (2009) *Climate change in the American mind: Americans' climate change beliefs, attitudes, policy preferences, and actions*. Yale Project on Climate Change, New Haven, CT

- Liu Z, Smith WJ Jr (2013) Geography and climate change. In: Black BC, Hassenzahl DM, Stephens JC, Weisel G, Gift N (eds) *Climate change: an encyclopedia of science and history*. ABC-Clio, Santa Barbara, CA
- Lorenzoni I, Nicholson-Cole S, Whitmarsh L (2007) Barriers perceived to engaging with climate change among the UK public and their policy implications. *Glob Environ Chang* 173:445–459
- Malka A, Krosnick JA, Langer G (2009) The association of knowledge with concern about global warming: trusted information sources shape public thinking. *Risk Anal* 29:633–647
- Mann ME, Bradley RS, Hughes MK (1999) Northern hemisphere temperatures during the past millennium: inferences, uncertainties, and limitations. *Geophys Res Lett* 26:759–762
- McCright AM (2010) The effects of gender on climate change knowledge and concern in the American public. *Popul Environ* 32(1):66–87
- McCright AM (2011) Political orientation moderates Americans' beliefs and concern about climate change. *Clim Chang* 104:243–253
- McCright AM, Dunlap RE (2011) The politicization of climate change and polarization in the American public's views of global warming, 2001–2010. *Sociol Q* 52:155–194
- Mertz O, Mbow C, Reenberg A, Diouf A (2009) Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environ Manag* 43:804–816
- Miller RF, Wigand PE (1994) Holocene changes in semi arid pinyon–juniper woodlands: response to climate, fire, and human activities in the U.S. Great Basin. *Bioscience* 44:465–474
- Miller WE, Shanks JM (1996) *The New American Voter*. Harvard University Press, Cambridge
- O'Connor R, Bord R, Fisher A (1999) Risk perceptions, general environmental beliefs, and willingness to address climate change. *Risk Anal* 19:455–465
- Pew Research Center (2010) Little change in opinions about global warming. Available at <http://people-press.org/2010/10/27/little-change-in-opinions-about-global-warming/>
- Rosenberg NJ (1992) Adaptation of agriculture to climate change. *Clim Chang* 21:385–405
- Safi AS, Smith WJ Jr, Liu Z (2012) Rural Nevada and climate change: vulnerability, beliefs, and risk perception. *Risk Anal* 32:1041–1059
- SAS Institute Inc (2008) *SAS/STAT user's guide, version 9.2*. SAS Institute, Inc, Cary
- Siegel S, Castellan NJ Jr (1988) *Nonparametric Statistics for the Behavioral Sciences*, 2nd edn. McGraw-Hill, New York
- U.S. Department of Agriculture (USDA) Economic Research Services (2010) *Sate Fact Sheets: Nevada*. Available at: <http://www.ers.usda.gov/StateFacts/NV.htm>. Accessed 8 Nov 2011
- Wood BD, Vedlitz A (2007) Issue definition, information processing, and the politics of global warming. *Am J Polit Sci* 51:552–568
- Yarnal B (1998) Integrated regional assessment and climate change impacts in river basins. *Clim Res* 11:65–74