Weather, Climate, and Rural Arizona: Insights and Assessment Strategies

A Technical Input to the U.S. National Climate Assessment

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CLIMAS Climate Assessment for the Southwest	ARIZONA COOPERATIVE EXTENSION

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Acknowledgments

This study was funded by the Climate Program Office of the National Oceanographic and Atmospheric Administration (NOAA). We would like to thank the Arizona residents who participated in the group discussions for giving their time, for their lively discussions, and for the tremendous insights into how rural residents understand, respond to, and plan for weather and climate in their daily lives which they provided. Most especially we would like to thank the County Extension Directors and Agents who shared their time and knowledge of their counties with us and made it possible for these discussions to happen. We are also very appreciative of the logistical and administrative support provided by University of Arizona Cooperative Extension administration and the core office of the Climate Assessment for the Southwest.

Executive Summary

This report describes the results of a study by an interdisciplinary team at the Climate Assessment for the Southwest (CLIMAS), one of 11 Regional Integrated Sciences and Assessments Centers (RISAs) funded by the Climate Program Office of the National Oceanographic and Atmospheric Administration (NOAA). The goal of the RISA Program is to support research that addresses complex climate-sensitive issues of concern to decision-makers, policy-makers, planners, and managers at a regional level. CLIMAS, the RISA for the region that includes Arizona and New Mexico, promotes participatory, iterative research involving scientists, decision makers, resource users, educators, and others who need more and better information about climate and its impacts. This particular study was funded by a 2010 grant from NOAA to each RISA to conduct one-year exploratory research projects designed to contribute to the National Climate Assessment process currently being developed by the U.S. Global Change Research Program. The research took place between February and November 2011 and was designed to accomplish two goals: 1) to learn how rural Arizonans understand, plan for, and respond to weather and climate in their daily lives, information that can help federal agencies provide climate-related information and programs that better meet their needs; 2) to assess the role that University of Arizona Cooperative Extension can play in the process of assessing climate service needs, and providing programs to enhance adaptive capacity.

This report is targeted at authors of chapters for the 2013 National Climate Assessment, particularly the chapters on Rural Communities, Adaptation, and the Southwest region, and members of the National Climate Assessment Development and Advisory Committee with the goals of addressing three of the eight topics that are priorities for the 2013 NCA. First, for the Engagement, Communications, and Evaluation topic, the report provides a case study illustrating climate change-related issues faced by rural residents in Arizona, including private landowners/producers (e.g. ranchers and farmers), state and federal natural resource managers and local government and planning officials, at this point in time. The study was designed to use ethnographic methods to elicit the perspectives and ideas of rural residents and decision makers, while sidestepping the political sensitivity of the topic of climate change in the U.S. at this time. Second, for the Adaptation topic, the report provides a case study that illustrates how rural Arizona residents approach adaptation, including how they typically respond to and plan for weather-and climate-related events, how they are responding to climate changes they are currently experiencing, and their ideas about how to better plan for or respond to climate variability and change in their communities. Third, for the Sustained Assessments and Research Needs topic, the report identifies a "path forward" for sustaining the assessment activities we have undertaken by assessing the capacity of University of Arizona Cooperative Extension to be an ongoing partner in the NCA process and to assist in ongoing climate adaptation and mitigation efforts and education at the local level, and by suggesting how, nation-wide, Cooperative Extension could become a partner in the NCA process. The report also provides a detailed description of the research methodology used and the rationale behind it in order to contribute to the development of an ongoing, consistent, and replicable approach to national-scale climate assessment which can incorporate the advantages and policy relevance provided by qualitative research, in particular by the traditional ethnographic methods of cultural anthropology.

The key findings for each of these topics are summarized below.

Engagement, Communication, and Evaluation

1. Rural Arizonans are highly attuned to weather and climate. Participants in the study displayed a high awareness, not only of current weather and climate conditions, but of past and projected conditions as well. They were familiar with and used a variety of weather and climate information sources, and many have their own rain gauges or weather stations at home.

2. Their perceptions of weather and climate are shaped by many factors: among them, geographic location, current weather conditions; recent or remembered extreme weather events; knowledge of conditions in the past; length of residence; and occupation.

3. The weather/climate-related topic that emerged as by far most important for rural Arizonans is water. Among specific weather/climate phenomena, rain is discussed the most, including rainfall seasonality, lack of rain, and changes in rainfall patterns. However, at this time, drought and wildfire are the topics that generate the most concern.

4. Short-term drought impacts ranchers more than any other group because of its effects on vegetation and water sources for cattle. Drought also has extreme impact on forest health and fire danger. Farmers' concern about drought is related to the source of their irrigation water. Many feel they are more impacted by a perceived recent change in climate variability and in the frequency of extreme events like hot and cold temperature extremes, wind events and shifts in growing season length.

5. Rural Arizonans are aware of a variety of climate changes, including changes in rainfall patterns both in time and space, more intense rainfall and localized flooding events, increased temperature extremes, an increase in the frequency of extreme wind events and an increase in the intensity, duration and frequency of drought conditions.

6. Their attitudes toward climate change attribution vary. A minority of those who participated in the study accept it fully because of the climate changes they have experienced. Many, having experienced the extreme variability of climate in Arizona, or being aware of the political sensitivity of the issue of climate change and the policy recommendations associated with it, are hesitant to attribute the changes they are experiencing to human causes. Most would like to learn more about climate variability and change.

Adaptation

1. Rural Arizonans seldom use the word "adaptation," and while they are constantly adjusting to the arid to semi-arid, highly variable climate of Arizona, they are more likely to think of their actions as a normal response to living in a variable climate.

2. Rural Arizonans are avid consumers of weather and climate information, while remaining skeptical about its accuracy. To improve their weather- and climate-related planning, they would

like information tailored to their specific area, better local-scale precipitation monitoring, and National Weather Service websites that are easier to use. More accurate and localized short-term forecasting of extreme weather events would help them plan for events that will immediately affect their daily lives; general intermediate-term climate projections of about ten years would help farmers and local-level planners make decisions about investing in expensive machinery or infrastructure; and general longer-term projections would help agricultural producers, resource managers, and local government planners begin thinking about future planning and adaptation possibilities.

3. In addition to weather and climate, ranchers, farmers, resource managers, and local-level officials take many factors into account in their planning including such factors as cost of inputs, market prices for their products, availability of water, property taxes, government policies, environmental regulations, and public perceptions. Because decision-making is so complex and information about future climate conditions are so uncertain, participants suggested that the best approach to integrating climate change into planning would be to address the legacy of past maladapative natural resource management and development activities (e.g. forest health conditions and water resources planning) within the context of a changing climate.

4. Participants' main suggestions for how to adjust to the climate changes they are experiencing fall into two major categories: water conservation and educating people about how to live in the Arizona environment (i.e. reducing exposure and vulnerability to Arizona weather and climate). Three less prominent categories include: landscape restoration; local level planning, especially for water and drought, and broader institutional reform that would allow more flexibility at the local level.

5. Factors that impede local adaptation initiatives include: lack of confidence that climate change is permanent (i.e. belief that recent changes experienced are part of a natural cycle); lack of resources; and structural barriers such as environmental regulations, government policies, and tax and rate structures that do not allow for the needed flexibility at the local level. In particular, participants noted the challenges that rural communities, who are a political minority, face having their concerns taken into account in national-level legislation and policy that affect rural landscapes.

Sustained Assessments and Research Needs

1. By working through University of Arizona Cooperative Extension, a small interdisciplinary team was able to accomplish an ethnographic study for the purpose of climate assessment in rural Arizona with minimal resources. The type of information generated is essential to climate assessment and climate adaptation research because it provides insight into how climate change is experienced and responded to at the individual and local level, through non-economic values, and into similarities and differences between and within counties in the same region that indicate how they could be impacted unequally by changes in climate and through broad-based policies aimed at responding to climate change.

2. This study indicates that Cooperative Extension, which has existed as a nationwide organization that connects knowledge developed at state land-grant universities with people who

can use it since 1914, and maintains a network of university-trained Extension agents in counties nationwide, is uniquely positioned to extend the National Climate Assessment process and products to rural communities. However, the Cooperative Extension System across the country has lost much of the regular federal and state funding traditionally relied on for support, so a recommitment to funding and/or exploration of new funding mechanisms is required to sustain this partnership.

1. Introduction

This report describes the results of a study by an interdisciplinary team at the Climate Assessment for the Southwest (CLIMAS), one of 11 Regional Integrated Sciences and Assessments Centers (RISAs) funded by the Climate Program Office of the National Oceanographic and Atmospheric Administration (NOAA). The goal of the RISA Program is to support research that addresses complex climate-sensitive issues of concern to decision-makers, policy-makers, planners, and managers at a regional level. CLIMAS, the RISA for the region that includes Arizona and New Mexico, promotes participatory, iterative research involving scientists, decision makers, resource users, educators, and others who need more and better information about climate and its impacts. This particular study was funded by a 2010 grant from NOAA to each RISA to conduct one-year exploratory research projects designed to contribute to the National Climate Assessment process currently being developed by the U.S. Global Change Research Program. Dr. Michael Crimmins, Climate Science Extension Specialist and Associate Professor at the University of Arizona, and a CLIMAS Investigator, proposed a qualitative study that would work through University of Arizona Cooperative Extension (UACE) to assess the climate service needs and adaptive capacity of rural residents in each of Arizona's fifteen counties. Dr. Julie Brugger, an anthropologist with experience working in the rural American West, was hired to design and carry out the qualitative research. The study was designed to accomplish two goals: 1) to learn how rural Arizonans understand, plan for, and respond to weather and climate in their daily lives, information that can help federal agencies provide climate-related information and programs that better meet their needs; 2) to assess the role that UACE can play in the process of assessing climate service needs, and providing programs to enhance adaptive capacity.

Rural residents are an often overlooked minority in the U.S.[1] The 2010 census showed that only about 17% of the U.S. population lives in rural areas (Lal et al. 2011). In addition, less than 3% of the workforce is involved in primary resource production (McCarthy 2002). Median household income is less in rural than in urban areas – $40,135 versus $51,522 in 2009 – and the poverty rate is higher – 16.5% versus 14.9% in 2010 (USDA Economic Research Service). In the western U.S., distinguished by a largely arid to semi-arid climate and a high proportion of public land,[2] resource-based rural economies have been declining since the last quarter of the twentieth century, as a result of decreasing commodity prices, horizontal integrations in agriculture and resource extraction industries, globalization, and reduced trade barriers. Meanwhile, the West's aesthetic landscapes, vast public lands, and lower real estate prices are attracting more tourists, recreationists, and urban migrants who view the landscape in terms of its amenity value rather than as ancestral home and a source of livelihood as do many lifetime residents. As the rural West shifts from a resource-based production economy to an amenity-based consumption economy, tourism, recreation, and real estate are becoming the main local industries (Walker 2003). Because the first two typically offer low-paid service employment,

[1] The USDA Economic Research Service uses several different definitions for "rural" in the statistics it provides. For the purposes of this study, we use a vernacular, rather than a technical definition. Rural areas are those that are not urbanized, have a low population density, and a high proportion of agricultural land, rangeland, or public lands.
[2] The federal government owns 671.8 million acres (29.6%) of the territory of the United States and most of it is in the West, where over 50% of the land is federally owned (Vincent et al.2004).

while the latter generates tax increases, longtime rural residents are struggling to make ends meet. At the same time, increasing numbers of amenity migrants from urban backgrounds, whose worldviews and values differ from those of longtime residents, are challenging established community identities. In addition, the media and popular culture, which are dominated by urban worldviews, are likely to represent rural producers as overusing or mismanaging natural resources, and to represent rural residents more generally in demeaning ways. Geographers Jarosz and Lawson (2002) argue that the latter "redneck" discourse serves to obscure the increasingly uneven development between rural and urban areas and the sharpening of class differences it is producing. This is the predicament of many of the people who are producing the food we eat and managing the natural resources we use.

The social, economic, and political challenges already facing rural communities in the American West are heightened in the Southwest[3] by the fastest growing population in the nation, limited water resources, and an arid and highly variable climate. In Arizona population has grown by 24% since 2000 (only Nevada's grew faster), 40% between 1990 and 2000, and 35% the decade before that (USDA Economic Research Service). This exceptional population increase is occurring despite Arizona's extremely limited water resources. The constraints imposed by aridity have so far been overcome by the development of large-scale, federally-subsidized water importation and transport systems and by significant groundwater overdraft (Colby and Jacobs 2007). However, there is mounting evidence that these water management systems are running up against physical, economic, and ecological limits that constrain the expansion of water supplies, at the same time that climate change threatens current supplies (Gleick 2010; Overpeck and Udall 2010). This situation is made worse by the fact that Arizona continues to have one of the highest poverty rates by state in the nation, and the poor are among the most vulnerable to water shortages.

The climate of Arizona is exceptionally unique and important to all aspects of life and commerce in the state. A seasonal-transitional climate characterized by two distinct wet seasons with intervening dry periods creates exceptional variability in precipitation and temperature levels throughout the annual cycle (Figure 1). Winter season rainfall typically comes from large-scale frontal storms delivering low-intensity precipitation to broad areas. The summer season is dominated by convective rainfall related to monsoon thunderstorm activity. These thunderstorms can produce large amounts of rainfall over short periods of time and typically only impact very small spatial areas (Goodrich et al. 1995).

Dramatic topographic relief across the state adds to this variability by creating a diverse range of climatic regimes governed by elevation-temperature and elevation-precipitation relationships. Higher elevation locations receive on average ten times more precipitation and are tens of degrees cooler than the lowest elevation areas of the state (see Figures 2 and 3).

Arizona also experiences high levels of interannual precipitation variability related to the El Niño-Southern Oscillation (ENSO). This periodic shift in sea surface temperature patterns across the equatorial Pacific Ocean impacts the winter storm track, moving it south towards

[3] Considered here to include California, the Great Basin, and the Colorado River Basin (the states of California, Nevada, Utah, Arizona, and parts of Wyoming, Colorado, and New Mexico) because their arid portions have similar climate and interdependent hydrological resources (Cayan et al.2010).

Arizona during El Niño events creating wetter-than-average conditions and northward away from Arizona during La Niña events with drier-than-average conditions. The frequency of El Niño and La Niña events also varies at decadal scales, producing longer-term pluvial and drought periods that can also last for decades. Tree-ring reconstructions of precipitation variability across the Southwest indicate that decadal cycles between droughts and pluvials have dominated the interannual variability in Arizona climate over the past 1000 years (Sheppard et al. 2002). Several distinct periods of climate have impacted Arizona in very diverse ways over just the last sixty years. A shift towards to more La Niña events and drier winter conditions in the 1950's led to widespread drought and impacts to water resources across the state. A subsequent shift towards more frequent El Niño events in the mid-1970's led to a very wet period that last until the mid-1990's. During this period, much of Arizona experienced record wet conditions, several floods of record, and dramatic shifts in vegetation with many new invasive species taking hold (Crimmins and Comrie 2004). A subtle shift back towards more frequent La Niña events occurred in the late 1990's leading to the return of drought conditions similar to the 1950's that continues to persist. Drought conditions peaked in 2002 with extreme to exceptional drought conditions impacting the entire state. According to the NOAA National Climatic Data Center the period of June 2001 through May 2002 was the driest on record for southeast Arizona compared to observations dating back to 1895. These conditions led to extensive drought impacts across the region including enhanced wildfire activity, diminished streamflow, lake and reservoir levels and impacts to rangeland resources including limited forage production and numerous dry stock ponds (NCDC 2009).

Climate change is a growing concern across the Southwest U.S. as the region has already experienced significant warming of just over 1°C since the middle of the last century (Karl et al. 2009; Overpeck and Udall 2010). Breshears et al. (2005) have shown that the current drought is indeed similar to the 1950's period, but is occurring with warmer conditions creating additional water stress and leading to additional impacts to vegetation including widespread tree mortality across much of Arizona. The frequency of protracted drought episodes like the one that continues to impact Arizona is expected to increase into the future due to anthropogenically driven disruptions to the Earth's climate system and global circulation patterns (Hoerling and Kumar 2003; Seager et al. 2007). Winter season storm activity is expected to decrease across the southwestern U.S. as the mid-latitude jet stream retreats north with the expansion of the East Pacific subtropical high pressure system due to an enhanced Hadley cell circulation (Seager et al. 2007; Solomon et al. 2009). It is less certain how summer precipitation from the North American Monsoon system will change across the southwestern U.S. (Dominguez et al. 2010). Regardless of the lower confidence in summer precipitation projections, there is high confidence that temperatures will continue to increase up to 3 to 6° C across Arizona by century's end, with greatest warming in the summer season (Karl et al. 2009). Higher temperatures will lead to increased evapotranspiration rates and increasing aridity in all seasons (Hoerling and Eischeid 2007). As a result, the combination of higher temperatures and less certain precipitation patterns could lead to more intense, frequent, and longer lasting drought conditions in the southwestern U.S. and Arizona in particular.

This study investigates the ways that rural Arizonans are experiencing and responding to these broad regional trends. CLIMAS investigators have already completed in-depth studies of vulnerability to climate variability in rural communities in southeastern Arizona (e.g. Finan and

West 2000; Finan et al. 2002; Vásquez-León et al. 2002; Vásquez-León 2007). However, we aimed for a study that covered a larger geographical area and included the most significant sectors in each county, and could be accomplished by a smaller research team in a shorter period of time. The next section describes the methodology we developed to accomplish these goals. We describe the methodology in detail in order show how it can contribute to an ongoing, consistent, and replicable approach to national-scale climate assessments and to identify a "path forward" for the assessment activities this study has initiated and priority resource requirements to sustain them.

The remainder of the report is organized as follows. Section 3, County Profiles, provides an overview of the climate, physical geography, land use and ownership, and social and economic status of each county where research was carried out. The indicators used are informed by the ethnographic component of the research (described in the next section) and provide a snapshot of background conditions in each county at the time of the research. They are used to provide a nested-scale analysis, which relates results from analysis of county-level ethnographic data to both intra- and extra- county dynamics: that is, heterogeneity within the county and broader scale social, economic, and political processes that shape demographic patterns, economic development, and resource use. The indicators also facilitate cross-region comparison and same region comparison over time in subsequent national assessments. Section 4, Results of Group Discussions, is a summary of the results of the ethnographic component of the research and describes: how the rural Arizonans who participated in the study perceive weather, climate, and climate change; the impacts of weather, climate, and climate change which they reported; and the ways they are currently responding to these impacts. Section 5, Conclusions, summarizes the contributions of this study to the National Climate Assessment.

2. Methodology

This section describes in detail the research design for this project, and the rationale behind it, in order to inform development of a strategy to support an ongoing, consistent, and replicable approach to national-scale climate assessment which can incorporate the advantages and policy relevance provided by qualitative research, in particular by the traditional ethnographic methods of cultural anthropology. Long-term in-depth fieldwork is the "foundation" of cultural anthropology because it allows the researcher to develop rapport with the group being studied and understanding of the physical environment they live in and the complexities of their social world. This experiential knowledge makes it possible to grasp what they experience as meaningful and important and why (Bernard 2002, Creswell, 1998, Emerson et al. 1995). Anthropologists Sepez et al. (2006) point out that this type of understanding is valuable for federal policy formulation because it provides information about the specifics of communities of place that can be impacted unequally by broad-based policies, including their interactions with the local environment, the ways they participate in and are shaped by broader political economic processes, their internal heterogeneity, and their non-economic values. However, the time and fieldwork commitments of ethnography are in tension with the large geographic scale, the need for more rapid results, and the budget constraints of many federal programs.

Researchers studying adaptation, adaptive capacity, and vulnerability to climate change specifically also emphasize the need for "ethnographic, in-community methods" to identify the conditions or risks that community members see as significant, rather than those assumed by researchers, and the individual and collective decision-making processes they use to address these risks, including the factors and processes that constrain their choices (Smit and Wandel 2006: 289). We agree that qualitative research is essential to climate adaptation research in the U.S. because it can reveal how the unique experiences, viewpoints, values, and concerns of a particular group shape both their perceptions of and attitudes toward climate change and their adaptation strategies, especially in view of the political sensitivity of the topic of climate change in the U.S. The short time frame and limited budget for the study, and the broad geographical area to be covered, were significant factors shaping our research design. Thus, it can usefully inform the National Climate Assessment process, which faces similar constraints.

For the smaller-scale vulnerability studies cited above (Finan and West 2000; Finan et al.2002; Vásquez-León et al. 2002; Vásquez-León 2007), anthropologists at CLIMAS developed a methodology called "rapid ethnographic assessment," which entails three components: 1) a review of relevant literature and secondary sources to obtain contextual information on the community; 2) a series of concentrated site visits by the research team to obtain approval from the communities and identify potential informants representing key economic and public service sectors; and 3) in-depth interviews with representative stakeholders (Vásquez-León et al. 2002). These studies provided in-depth understanding of vulnerability to climate variability and change for specific sectors in a small geographical area. For their study, Finan and West (2000) reported that seven researchers spent a total of at least 40 days in the research site over a period of six months.

Anthropologists Sepez et al. (2006) discussed how they met the challenges of conducting qualitative research over a very large geographical scale in order to meet the requirements for a social impact assessment of fishery management actions in legislation governing NOAA's National Marine Fisheries Service, the federal agency responsible for managing the nation's marine resources. To address the challenges of profiling more than 2,200 recognized fishing communities in the four states within the Pacific and North Pacific management regions, while maintaining some of the "intimacy" that the traditional ethnographic methods of anthropology provide, Sepez et al.(2006) developed a method that combined: 1) selecting fewer, bit more broadly representative communities; 2) team research in selected communities for a period of two and a half to three weeks; and 3) compiling socioeconomic and fishing indicators from a list informed by site visits, which illustrated meaningful local conditions and had already been collected. This approach made it possible for them to compile baseline information about a large number of communities, and to recognize community and regional specificities and commonalities, as well as the ways they are internally heterogeneous. It also enabled them to nest community information within both macro and micro scales of analysis, which is particularly important for social science that supports the formulation of policy since key variables often cut across geographic and regulatory scales. However, to implement this approach required a team of at least seventeen researchers and a considerable investment in time and travel.

The research design for our draws on insights from both the CLIMAS anthropologists' work on climate vulnerability assessment and Sepez et al's thoughtful consideration of how to combine the advantages of ethnographic research with the need to cover a large geographical area. We used ethnographic methods to gain access to some of the advantages of long-term in-depth fieldwork in rural Arizona for understanding the significance of weather and climate in residents' lives and their approaches to adaptation. However, while we did not propose to cover as large a geographic area as Sepez et al, we were much more constrained by team size and time than either the CLIMAS anthropologist or Sepez et al. To overcome these limitations, we employed two strategies. First, the researchers themselves were already familiar with the social and cultural context in which the study took place, by virtue of previous research, work experience, or long-term residency in the region. Second, we worked through University of Arizona Cooperative Extension to gain access to the experiential knowledge and relationships that long-term in-depth fieldwork provides.

Nationwide, Cooperative Extension was established by the 1914 Smith-Lever Act to connect scientific knowledge developed at state land-grant universities with people who can use it. A unique feature of its organization is that university-trained Extension agents reside in each county statewide. As local residents, they are able to develop rapport and ongoing relationships with a broad spectrum of other local residents, familiarity with the physical and social environment, and experiential knowledge that gives them a deep understanding of local issues, values, and concerns. In addition, Extension agents often do "needs assessments," using mail surveys, workshops, focus groups, or are guided by their Extension advisory board to identify issues of concern to local residents and develop strategies to address them. Finally, many studies have found that Cooperative Extension is the most trusted source of information in rural areas (e.g. Fernandez-Gimenez et al.2005, Iowa Farm and Rural Life Poll 2011 Summary Report[4]). By working with county Extension agents, we were able to access the knowledge, social relationships, and trust they have developed without the personnel and time commitments needed to develop it ourselves.

Our data collection methods combined: 1) employing a research team composed of a climate scientist and a social scientist who have worked in the rural West; 2) working through University of Arizona Cooperative Extension to organize a discussion group in each county, and; 3) compiling physical geographical and current socioeconomic indicators for each county. Our list of indicators is informed by the ethnographic research and designed to estimate conditions of interest in the county, at a specific point in time, for the purposes of a national-scale climate assessment focused on rural communities, and to use data that are readily available. Conditions of interest for a national-scale climate assessment focused on rural communities should include current climate and environmental conditions, the status of significant resource production and management activities, including farming, ranching, forestry, mining, and tourism, land ownership and use, the status of infrastructure, and current socioeconomic status, with a focus on vulnerable populations, such as the very young, very old, and poor. However, many of these are not readily available.

The list of indicators we have selected is shown in Table 1. Indicators for physical geography, such as climate, land use, land cover, and topography, are displayed in maps. Appendix 1

[4] http://www.soc.iastate.edu/extension/farmpoll/2011/PM3016.pdf

describes the procedures used to produce the maps. Values for demographic and economic indicators are drawn from the U.S. Census Bureau and the U.S. Department of Agriculture Economic Research Service. Our research design takes advantage of the fact that Cooperative Extension is organized at the county level and socioeconomic data is also readily available at that scale. County characteristics were estimated using data from discussion groups and interviews with county Extension agents. Word frequencies were produced using the word frequency counter at http://writewords.org.uk/word_count.asp.

To learn how rural Arizonans understand, plan for, and respond to weather and climate in their daily lives, we conducted semi-structured group discussions with eight to twelve local residents in the most rural of Arizona's fifteen counties. Aware of the controversial nature of the topic of climate change, we planned to avoid it by simply asking people to talk about the significance of weather and climate in their lives. Our goal was not to find discussion participants who were a random or representative sample of county residents, but to achieve an amicable and balanced discussion and to identify some of the ways that rural Arizonans are thinking and acting proactively about climate variability and change. To organize the discussions, we began by visiting the Extension agents in each county to conduct an in-depth interview and to discuss a time and location for the group discussion and a list of potential participants who were local 'opinion leaders.' To gain an overall view of the county, we relied on the Extension agents' experience, and in the interviews asked them to describe the county and the main concerns of residents. We asked the agents to identify potential participants from among the groups they considered significant in their county and for whom weather and climate are a significant factor in their work or lives, such as, ranchers, farmers, natural resource managers, local government officials, environmental organizations, private enterprise, and home gardeners, and from among lifetime and multi-generational residents. We also asked them to select participants whom they felt would contribute constructively to the discussion. The local residents who work with Cooperative Extension are often among the more progressive in adopting innovation in their respective groups, and are actively seeking out new knowledge, which Extension can provide. Studies on the diffusion of innovations, undertaken to improve the effectiveness of the Extension Service, refer to them as "early adopters" (Rogers 1962). These studies also show that early adopters are often 'opinion leaders' in their communities who influence innovation adoption of others. For the purpose of climate assessment, early adopters are likely to be among those who are thinking proactively about planning for climate variability and change, and their participation should provide better insight into early adaptation initiatives on the ground.

To organize the group discussions, we worked with the county Extension agents to select a date, time, and location for the discussion in their county. In each case but one, we held the discussion during a working lunch, which we provided. At the agent's discretion, either he/she or we extended an invitation to the potential participants by phone, email, or, in one case, regular mail. Our response rate was high due to potential participants' existing knowledge of or relationship with Cooperative Extension. Most of those invited responded, and most who responded accepted the invitation unless they had a conflict with the selected date. We were unable to invite Native American participants because of tribal rules governing research, although we had one Extension employee who is also Native American, and one federal employee who works on a reservation. The discussion groups consisted of eight to twenty participants with members from the groups listed in Table 2.

The discussions were digitally recorded for later transcription to text files. Both researchers and the Extension agent took part in the discussion and our social scientist acted as facilitator. The guideline for discussion questions and prompts is shown in Table 3. The questions were designed to be open-ended and to elicit participants' understanding of weather and climate rather than focus on topics of importance to the researchers. We began with an introduction in which we described the project and asked participants to fill out a one-page information sheet to get important information on their backgrounds that might not come up in the discussion, such as length of residence in the region. We found that initiating the discussion with an initial go around where participants introduced themselves and explained, or told a story about, how weather and climate affect their lives was an ideal icebreaker and got the discussion off to a lively start. There was little need for further questions or guidance after initiating the discussions in this way. An interest in weather and climate is something all participants had in common and all had something to add to the discussion. As one participant put it: "My God, this is rural America, and weather is important to us" (P5Gi)! Without prompting or mention of "climate change," changes in weather and climate were brought up in every group and discussion of their potential impacts followed. Some groups pursued discussion of "climate change" or "global warming," revealing different levels of acceptance or agnosticism among the group. If necessary, we prompted for information about how participants currently take weather and climate into account in their planning, and for ideas about what else could be done. Participants would frequently turn to our climate scientist for information about weather and climate or clarification of information they had received elsewhere. In this way, the discussion groups also provided an opportunity for informal climate science education as it related to participants' specific interests or concerns.

We analyzed the textual data from the discussion groups using both qualitative and quantitative methods. Grounded theory is a qualitative approach to analyzing qualitative data described by Creswell (1998), Ryan and Bernard (2003), and Bernard and Ryan (2010). It uses an iterative process involving successively more focused rounds of coding the text to identify themes and categories of themes, identifying relations among themes and categories, and linking themes and categories to build theoretical models. Themes can be induced from the data or can arise from the researcher's prior theoretical understanding or the questions in an interview protocol. Because we were interested in learning about how discussion participants understand weather and climate, changes they have experienced, how weather and climate affect their lives, and how they plan for and respond to weather and climate, we began by coding for climate and weather in general, and for specific weather and climate phenomena in the meteorological categories of precipitation, wind, and temperature, with additional categories added as needed. We also coded for impacts and for activities that could fall under the category of adaptation, broadly understood.

We also used word frequency counts, a quantitative method for analyzing textual data. Figure 7 is a graphical representation of the most frequent words used in all of the county discussions combined.[5] We combined qualitative and quantitative analysis of the ethnographic data with

[5] We used Tagxedo (http://www.tagxedo.com/app.html) to produce this word cloud, eliminating the most common words and those that were a byproduct of the transcription process. This program does not allow the combining of similar words, such as rain, raining, rained, etc., as does the word frequency counter program, so this graphic reflects the dominant weather- and climate-related topics somewhat differently than Table 5.

analysis of qualitative and quantitative data from county indicators, using the different types of data and analysis to validate and reinforce each other. County indicators also facilitate comparison across counties and time. This report describes the major categories and themes, and the relationships among them that emerged from our analysis, and which are most salient to a national climate assessment. We will delve more deeply into the results of this study in subsequent papers for publication in academic journals.

This case study provides a snapshot of weather- and climate-related issues faced by rural Arizona residents, and their approaches to adaptation, at a specific point in time. For the purpose of a national climate assessment, it aims to look past survey results and regional trends and summaries to hear individual stories and to put a human face on climate change and adaptation. While more in-depth historical research would be needed in order to better understand how historical processes of environmental and social change have shaped and continue to shape local experience in a particular place, this snapshot adds crucial insights about rural Americans, a group that includes only 17% of the American population, but occupies 80% of U.S. territory (Lal et al.2011), and whose viewpoint is likely to be underrepresented in a national climate assessment. While there are many different rural stories, in our analysis we look for patterns and generalizations. What we present in this report is selected to illustrate both the common elements and the diversity of perspectives, and we rely heavily on participants' own words to give a better understanding and feeling for their common and divergent perspectives. We summarize comments made by many different individuals and discussions that occurred across groups throughout the text, while quotes from specific individuals are identified by unique participant numbers cited in parentheses.

3. County Profiles

A general overview of the physical geography and the socioeconomic characteristics of the study area provides an understanding of the physical and social context in which climate change is unfolding in Arizona, as well as the context for the ethnographic analysis which follows in Section 4. Although dominated by a seasonal-transitional semi-arid climate, the Arizona landscape is highly variable in elevation, giving rise to large differences in local temperatures, rainfall, and ecosystems. As a result Arizona's counties are very diverse climatically, geographically, and ecologically, as well as socioeconomically, and this diversity is reflected in the weather- and climate- related topics on which the discussion group for each county focused. Table 4 shows the date and location for each discussion group and physical characteristics of that location; Figure 4 shows the location graphically. Arizona has only fifteen counties; as a result, some of them are very large and there is also much diversity within them. Indicator maps for temperature, precipitation, land use, and land ownership (Figures 1-6) illustrate the both the inter- and intra-county physical diversity. Table 5 shows the values of the demographic and socioeconomic indicators by county. To capture some of the inter-county diversity more descriptively, we also provide a brief verbal overview of each county where discussion groups were held. The information in these overviews is drawn from county indicators, group discussions, interviews with county Extension agents, and the researchers' own knowledge as Arizona residents. These overviews also illustrate how the contextual knowledge necessary to the ground ethnographic research was gained through the research process.

Cochise County

Cochise County lies in the high desert of southeast Arizona and has a cooler climate than most of southern Arizona. It borders Mexico and has the largest Hispanic population of any county where we conducted research (32.4%). Historically mining and ranching were the predominant modes of livelihood, and the Copper Queen, which gave birth to the historic town of Bisbee, was once the most productive copper mine in Arizona. Tombstone, another historic town is famous as the site of the gunfight at the OK corral. With its historic sites, cooler climate, and other natural amenities, recreation and tourism has become an important industry, and it is also attracting a large retirement population. The Fort Huachuca army base is contributing to the rapid growth of Sierra Vista. Cochise County has the highest average family income of the counties in the study, and the highest proportion of private land of any county in Arizona (41%); much of this is in ranching and farming. Ranchers in Cochise County, and throughout Arizona, practice a form of transhumance, moving their herds between lower elevation pastures in the winter, often on land they own, and higher elevation pastures in the summer, often on National Forest, Bureau of Land Management, or state trust lands. Farming became important in the 1950s when low-cost groundwater pumping became available. Increased pumping costs as groundwater was depleted and energy costs rose forced many farms out of production in the 1970s. Farmers that remained adapted more efficient irrigation techniques and greater crop diversity. The county is the most diverse agriculturally in the state, with ranching, fruit and nut orchards, field crops such as corn, cotton, and alfalfa, higher value field crops such as vegetables and chiles, and vineyards, all within its borders (Vásquez-León et al. 2002). It is fifth in agricultural sales in Arizona. According to the Extension agent interviewed, the main issues for residents at this time are the economy, border issues, water (in Sierra Vista), and the education system.

Coconino County

Coconino County, located in north central Arizona, is the second largest county in the U.S. behind San Bernardino County in California. Much of it lies at higher elevations on the Colorado Plateau. The highest point in Arizona and part of the largest contiguous Ponderosa Pine forest in the continental U.S. are located in Coconino County. Five Indian reservations are located all or partly within it and it has a relatively large (27.3%) Native American population. Formerly, its economy was based on the lumber, railroad, and ranching industries (Sheridan 1995). Today recreation and tourism is a significant sector of the economy due to the presence of the Grand Canyon National Park, the Arizona Snowbowl ski resort, four national forests, and other sites of natural and historic interest. Construction was a big industry but has been hard hit by the recession. Ranching is still a significant part of the rural economy and several very large ranches exist. Northern Arizona University (NAU) is located in Flagstaff, the largest city and county seat. Coconino County has the lowest median age (30.6) and the largest percentage of college graduates (31.3) of the counties in the study, probably due to the presence of NAU. Water supply is an issue in some rural areas where there is neither surface water, nor accessible groundwater. Ranchers in these areas depend on rain-filled tanks to water their livestock. According to the Extension agent interviewed, the main issues for residents at this time are the economy, property values, and job security.

Gila County

Gila County is distinguished by National Forest in the north and west, the San Carlos Apache reservation in the east, copper mining in the south, ranching throughout, and very little private land. While Globe and the southern part used to dominate economically and politically, Payson and the north have grown rapidly in recent years, due to recreation, tourism, and second homes, and have now overtaken it in population and affluence. Gila County has the lowest unemployment (7.6%) of the counties in the study. The north has been more affected by the recession because it was more dependent economically on the construction industry, which has dropped. In the south, mining is doing well because copper prices are up. However, mining is not as labor-intensive as it used to be, so the mines do not provide as many jobs as they did in the past. According to the Extension agent interviewed, the main issues for residents at this time are the economy, having a livable community, and forest health. Water is an issue in the north, where the Salt River Project has surface water rights and there is not a good groundwater supply, but not in Globe, which does have a good groundwater supply. Payson, which has a "toilet-to tap" water system is a national leader in water conservation.

Graham County

Graham County has the smallest population (37,220) of the counties in our study. Located in southern Arizona at lower elevations than Cochise County it is also the second warmest and driest after Pinal County. The population is concentrated in and around the city of Safford, which was originally settled by Mormons beginning in the mid-19th century (Finan et al.2000). Mining is important in the county, as well as commercial agriculture, especially cotton. It has the highest proportion of population employed in agriculture of the counties in the study. There is also a ranching community and a growing population of "ex-urban" small acreage homeowners. According to the Extension agent interviewed, the main issues for residents at this time include "just surviving." Water is also a critical issue since the recent adjudication of Native American water rights in the Gila Water Settlement will affect the amount of surface water the city of Safford, agriculture, and the mines can use. Another concern is that, as a rural county with a very small population it is politically weak, and the community will have to learn how to work together to be able to sustain itself.

Mohave County

Mohave County, located in the northwest corner of the state, is the fifth largest county in the U.S. Overall, it is the driest county of those in our study and has the highest proportion of land administered by the Bureau of Land Management. Ranching is a major land use. Mohave County has been experiencing a high rate of population growth as a result of its proximity to Las Vegas and the availability of cheap land. The Colorado River forms part of its western border and its largest population centers are located along the river, as well as some irrigated agriculture. These cities obtain their water from the Colorado, but their water rights are junior to downstream agricultural rights in Yuma County. The largest city in the county is Lake Havasu City, a planned community located on the river, which has a high retiree population and records some of the highest temperatures in the U.S. Most of the rest of the county obtains its water from groundwater and there are concerns about groundwater supplies. According to the Extension agent interviewed, the main issue for residents at this time is "surviving." There is a high foreclosure rate and population growth has dropped off significantly.

Navajo and Apache Counties

Navajo and Apache Counties are dominated by Indian reservations in the north and south with a band of National Forest in between. The largest stand of Ponderosa Pine in the continental U.S. extends from Coconino County through these two counties. Along with Coconino, they are also the three counties in the U.S. with the greatest amount of Indian reservation land within their borders. Native Americans are the dominant racial group in Apache County (72.9%) and only slightly less numerous than whites (43.4%) in Navajo County. Mormons established communities in the region beginning in the mid-19th century (Sheridan 1995). These two counties are among the poorest in the nation, with high poverty rates and low levels of education, and are designated areas of persistent poverty by the USDA ERS. Navajo County is somewhat better off due to the existence of cities and towns in the forested belt where recreation, tourism, and second-home ownership have become important industries. Ranching is a major land use throughout the counties. According to the Extension agent interviewed, the main issues for residents at this time are mistrust of the federal government, jobs, education, lack of cultural understanding between Native and non-Native populations, and the state of the county's natural resources. In 2002, the Rodeo-Chediski fire, at that time the largest ever in Arizona burned 467,000 acres, mainly in Navajo County, and many Navajo County communities had to be evacuated. In 2011, the Wallow fire exceeded that record, burning 538,000 acres, mainly in Apache County, and forcing the evacuation of several Apache County communities.

Pinal County

Pinal is overall at the lowest elevation of the counties in the study and has the warmest climate. It is unique among the counties in the study, being sandwiched between the large population centers of Phoenix and Tucson. As a result, it may be the most economically diverse. It has the highest population, the highest population density, and the highest growth rate among the counties in the study. Many residents commute to jobs in these cities. It also has more industry, including Abbot-Ross and Frito-Lay, and among the counties in the study has the greatest percent employment in manufacturing. The county was less hard hit during the housing collapse because people moved in from elsewhere to find cheaper rentals. The county is also third in agricultural sales in Arizona behind Yuma and Maricopa, with the majority of cropland in cotton. In the eastern part of the county, which is mostly rangeland, mining is the main industry and ranching the main land use. Much of the western part is Indian reservation. According to the Extension agent interviewed, the main issues for residents at this time are the economy, education, the drought, and transportation, in that order. Interstate 10 has not expanded to meet the needs of commuters. Water is also a big issue in the county, which obtains most of its water supply from groundwater, and there are concerns about groundwater supplies and recharge rates.

Yavapai County

Yavapai County is divided into a western and eastern portion by a range of mountains, with the Verde River flowing from the western portion to the eastern. A significant proportion of its land is national forest (38%). There are population centers in each portion, Prescott in the west and Verde Valley in the east. Both have become "retirement havens." People move there for the natural environment, climate, and clean air. There are a lot of golf courses, summer visitors, and seasonal residents. Yavapai County has the highest white population (97.5%) and the highest median age (49.2) of the counties in the study. Construction and development were a mainstay of the economy but have gone downhill. Agriculturally, livestock grazing on public or private land is the main activity. There is also some acreage under cultivation in the Verde Valley,

irrigated by senior water rights on the Verde River. According to the Extension agent interviewed, the main issue for residents at this time is water. The Salt River Project has surface water rights in the county (junior to Verde Valley irrigators); the western portion gets its water from groundwater; and there is contention over water between the western and eastern portions of the county. Other issues are recreation, environment, schools, public safety from wildfires, and community sustainability.

Summary

Arizona is still widely pictured as a place of sunshine, desert, and the saguaro cactus. While this picture gets the sunshine piece right, Arizona is a much more environmentally diverse state, ranging from the Sonoran desert, home of the saguaro, in the south, to high plateaus, snowy winters, and extensive pine forests in the north. This diversity, and a rich mineral endowment, have led to different livelihoods and lifestyles in rural areas of the state, which will be impacted differently by climate change. In the past, Arizona's economy rested on the five C's, which are represented on the state seal, and which every child used to learn in school: cattle, citrus, climate, copper, and cotton (Sheridan 1995). Today, only climate, which fuels tourism and the rapid population increase, is still a main driver of the state's economy. However, as we have seen, three of the other C's are still important in rural areas of the counties in the study: cattle, copper, and cotton. Copper and cotton are found in counties in the southern part of the state, while there are cattle ranches in every county. Climate change will affect all of these.

The counties in the study also share some commonalities. Despite the fact that they are predominantly rural, the service industry is the largest employer in all of them, and only in Graham County is more than 10% of the population employed in agriculture. In all of them except Cochise, less than 25% of the land is privately owned (MC: Is this correct? Need pie charts of land ownership by county), the majority being public land or Indian reservation. Finally, reflecting climate as an economic driver, population is increasing in all of them, although it has slowed down significantly in all but Pinal since the economic downturn.

In this overview, we have attempted to capture both some of the diversity of Arizona's counties and some of their similarities using county indicators and profiles in order to better understand how climate change will affect rural residents. For a deeper understanding, as well as a glimpse into the ways that rural Arizonans have adapted to climate variability, how they are thinking about climate change, and what they are doing about it, we now turn to the results of the ethnographic portion of the study.

4. Results of Group Discussions

We begin with a discussion of how a broad range of rural Arizona residents (see Table 2) understand weather, climate, and climate variability and change in a climatic context of high temperatures and aridity, a bimodal seasonal precipitation pattern, and extreme background variability. In section 4.2 we summarize the most significant impacts of weather and climate brought up during the group discussions and their differential impact on different groups. In section 4.3 we consider how rural Arizona residents respond to and plan for weather and climate variability and change.

4.1 Perceptions of weather and climate

The participants in this study were selected by Extension personnel because weather and climate are significant factors in their lives, therefore it is not surprising that in the group discussions they displayed a high awareness, not only of current weather and climate conditions, but of past and projected conditions as well. As one farmer explained, "Everything we do is based on the climate" (P17Coch). A rancher expressed the significance of weather and climate similarly: "My whole life is centered on climate. And I'm obsessed with rainfall, precipitation, temperature, wind, to an extent that most people would find unhealthy" (P15Coch). Likewise, a forest manager affirmed, "I stay very in tune to what's happening daily, what's happening weekly, what's happening monthly, because everything we do in the forest is weather dependent" (P3NA). The discussions revealed that most participants were familiar with and used a variety of weather and climate information sources (see section 4.3), and that, in addition, many had their own rain gauges or weather stations at home. Moreover, participants were aware that most people are not affected by weather and climate, and particularly by drought and lack of water, to the extent they are. One participant explained the difference between the situation of rural and urban residents this way: "Part of it's because it's so easy. You don't have to work for the water, you go turn the faucet on and it's there, it's easy. It kind of fits with the further you get removed from knowing where food comes from, knowing how the water cycle works, knowing any of that stuff, and it's easy, and you get complacent" (P3Y). However, as we shall see in this and the following section, different types of rural residents still perceive weather and climate, and are affected by them, in different ways.

Analysis of the group discussions indicates that rural Arizonans' perceptions of weather and climate are shaped by many factors: among them, geographic location, current weather conditions; recent or remembered extreme weather events; knowledge of conditions in the past; length of residence; and occupation. The fact that the weather and climate-related topics brought up in each group discussion, and the attention focused on them, were affected by the location and timing of the discussion, not only reflects the different physical geography of each location, but also indicates that perceptions are shaped by current weather conditions and recent extreme weather events. Table 6 shows the significant weather and climate events that occurred or were occurring during the period of research and were brought up during the discussion, as well as significant weather and climate events of the past that were mentioned. Table 7 shows the date of the discussion and the top five word frequency counts for each county. The latter reflect the weather and climate-related topics on which the discussion for each county focused. They are affected by location and recent weather and climate events, as well as by the occupations of the participants for that county. So for example, words related to "ranch" and "cattle" were prominent in the discussion in Mohave County where two of the eight participants were ranchers, and one worked extensively with ranchers. The complete list of weather- and climate-related word frequency counts reflects the way that recent weather- and climate-related events shaped the discussion in each county. These recent events combine with significant weather and climate events in the past to shape participants' understanding of "normal" weather, climate, and climate variability.

One illustration of the interaction between significant weather and climate events and the timing and location of the group discussions is the fact that the all of the discussions were held during an ongoing drought and a La Niña year, and drought emerged as a major concern of participants. In contrast, the in-depth studies of vulnerability to climate variability in rural communities in southeastern Arizona published by Finan and West (2000) and Vásquez-León et al. (2002), based on research conducted more than a decade earlier, just after a very wet winter with the 1997-98 El Niño and just prior to the very dry period that began to emerge in 2001, reported much less concern with drought. However, drought was very prominent in the Vásquez-León (2007) study, conducted between the fall of 2002 and the fall of 2003, one of the driest water years on record in Arizona. More specifically, the Cochise County discussion was held in the spring, and there people brought up the lack of rain the past winter and the extremely windy spring. The other discussions were held during the summer months, and discussion of the erratic nature of the current monsoon rains was more prominent. The period of record-breaking below freezing temperatures, which hit southern Arizona during the first week of February 2011, wreaking havoc with water infrastructure and killing both native and non-native vegetation, received significant attention during the discussions in the southern Arizona counties of Cochise, Graham, Pinal, and Gila, but was scarcely mentioned in the north where cold temperatures are common in the winter. Fire is particularly prominent in the discussions for Coconino and Navajo-Apache Counties, where a large proportion of the land is forested, and where the 2002 Rodeo-Chediski Fire, at the time the largest in Arizona history, burned 467,000 acres, mainly in Navajo County, the Schultz Fire threatened Flagstaff in Coconino County in June 2010, and the 538,000 Wallow fire, the largest in Arizona history, ravaged Apache County in June 2011. In Pinal County, the warmest and driest of those in the study, dust received a great deal of attention. The discussion there also took place after the large haboob that hit Phoenix on July 5th, pictures of which were broadcast nationally.

How length of residence and occupation shape perceptions of weather and climate is reflected in the way that longtime or lifetime residents and participants in agriculture and ranching characterized the climate in contrast to discussion participants who had moved in more recently. The former group was likely to refer to the variability of the climate and its extremes of drought and floods. For example, a longtime resident of Coconino County told the group about a discussion of weather he found in the memoirs of an early northern Arizona resident who had worked for the Forest Service:

> And he had his little notation on weather. He says, "The weather in northern Arizona, I've lived my whole life here, and the only consistency I ever found was its inconsistency." That really does capture it, you know. We could have heavy, heavy snows for three years, and then, you know, we just got through a seven year drought. And you look at the tree-ring dating, and you can see the vacillation that goes on (P6Coco).

A longtime resident of Navajo County brought up a course on weather he had taken at Northern Arizona University many years earlier, in which his instructor was talking about "normal" weather: "He said, 'Recognize that normal is nothing but averaging the extremes.' And that has always stuck with me. It explains this country very well. Very well" (P3NA). Recognition that they live in a climate of extremes is also evinced by this comment: "As a developer, all I was worried about were floods, because of floodplain issues. And now [as a farm manager] we're

worried about the drought. It seems like it's one extreme or other in this world" (P8GR). A lifetime resident of northwest Arizona who works with ranchers explained:

> Well, the thing that we've always got in the back of our mind is drought, and the impacts of drought. The thing of it is, we all want to have better days; we know the eighties were pretty wet, but it kind of made us lackadaisical about drought. But now we're back in drought. And we overreact a little bit to drought, you know. It starts raining, people suddenly forget about drought, but drought's always on the back of our mind here. Basically, seven out of ten years, we're going to be in a drought year, and it's almost become a normal, where drought is normal here (P1iM).

And several longtime residents of Graham County agreed that they "pray for rain" every day.

However, in a climate of extreme background variability, people still look for predictability. Our discussion participants used the term "normal" to describe the weather conditions they expected from past experience or climate statistics. One participant reminded his group of Mark Twain's saying: "Climate is what we expect; weather is what we get." But participants more often spoke in terms of "normal": "normal" patterns of variability, "normal" droughts, "normal" seasonal temperatures, and "normal" precipitation. "Normal" temperatures and precipitation were conceived of in relation to knowledge of the past or seasonal and annual averages. Several participants felt these "normal" patterns were being disrupted, variability was increasing, and extremes were becoming more extreme. For example, "I think there is a lot less predictability. I've only been here eleven years in Apache County, but I've lived in Arizona all my life. And you can't count on weather and climate as much as you used to" (P7NA). A farmer expressed concern because:

> I think the last five years in farming, there probably hasn't been a normal year yet. A very late frost this year and last year both, just really late cold weather, well into April, end of April, first part of May, that seriously affect the germination of our cotton crop. … So it's general weather patterns that to me are a big concern, and just it seems like a change in the seasons. Seems like we're getting much later springs and unfortunately we've had later falls as well (P8Gr).

And a rancher described the changes he was experiencing saying:

> I guess I could say things in the last year or so have gone extreme. Had extreme winds this spring, like I've never seen; last winter we had a winter like you can't believe. The winter before that we had no snow to speak of; last year, we had the Cowpunchers Rodeo in Williams, it rained seven inches in three days. Those kind of things; the fires (P5Coco).

When we present participants impressions of how weather or climate have changed, whether from memory, accounts of ancestors or other longtime residents, or local lore, it is important to keep in mind that what is significant is not whether their impression are correct and are borne out by official data, but that the changes they describe indicate departure from an ideal past when farming, ranching, and other activities were easier to manage, which could be for a variety of reasons in addition to weather and climate.

In contrast, to longtime or lifetime residents, discussion participants who had moved to Arizona more recently brought up aspects of the climate that were more constant, and which they contrasted with the places they had come from and viewed as an amenity, such as Arizona's blue

skies, warmth, and sunshine; being able to spend more time outside than where they came from; being able to know what to wear without looking outside; and being able to plan a picnic six months in advance. Several of the newer residents described the learning curve they went through when they first moved to Arizona, such as getting used to not having green lawns and to seeing cows grazing in places that looked to them like there was nothing for them to eat. But longer term residents complained that many new residents are not trying to adapt to the climate of Arizona and are trying to grow exotic things like bananas and mangoes or plants they used to be able to grow where they came from.

A lifetime Arizona resident from Cochise County pointed out that it is this understanding of climate as amenity that has made it the "economic engine that drives the state." As a result, the state economy "has become a kind of one trick pony. And that's why the state is in a depression state now, because real estate development and real estate sales, and promotion of Arizona's climate and so forth, encouraged *so* many people to come here that the industry became building for the people that would come." And they built "houses that are *totally* inappropriate for this climate. And they're there because they're fast and cheap and easy to build, and you can do it with unskilled labor. … And I often wonder, how could we *dare* invite somebody else to come here until we kind of clean up the mess that we've made" (P15Coch). We discuss the impacts of this understanding of climate further in Section 5.

The weather/climate-related topic that emerged as by far most important for rural Arizonans, judging by its relative frequency in the group discussions, is water (see Table 7 and Figure 7). As one participant from Cochise County put it: "There's a lot of different components to climate, but the water piece is really foremost in most people's thoughts when we talk about climate" (P9Coch). Since water scarcity is an impact of the climate we discuss it in the next section.

Among specific weather/climate phenomena, rain was mentioned the most, including monsoon, fall, winter, and spring rain, lack of rain, and changes in rainfall patterns (see Table 7). Monsoon or summer rains were the most frequently discussed. Longtime residents frequently compared today's monsoon rains with those "when I was a kid." For example, a multi-generation Mohave County rancher remembered that, "When I was a kid, I could guarantee it, from middle of July, to the first part of September. We'd get rain probably every week. But our weather pattern has changed. I don't know what caused it, but something is definitely causing our, our monsoons not to form" (P4M). A lifetime resident of southeast Arizona reminisced:

> When I was a kid, you could set your clock; at four o'clock, during the monsoon season, it rained. And then it rained for an hour, and every day from end of June through September some years. I grew up over in the Chiricahua Range over there, and Rucker Creek ran to the highway. Turkey Creek, Rock Creek, they all ran. Year-round. Whitewater Creek had water in it, all the way into Mexico. San Pedro ran. Full-time. And those don't run anymore. They used to get enough snowpack in the Chiricahuas. … All your springs up on top of the Chiricahuas, Slide's Peak, all those springs that were up along in there, they ran. I mean, you'd have a three-quarter inch, one inch pipe just running a full stream, you know, four-five gallons a minute, they don't do that anymore. There's no water, and there's rarely a snowpack anymore (P6Gr).

Other changes in the monsoon that were mentioned, in addition to changes in its reliability and timing, are a change in spatial variability and an increase in the intensity and destructiveness of microbursts. For example, ranchers in northwest Arizona have built a system of dirt tanks to water their cattle on the range. These tanks are filled by hard, fast, and copious monsoon rains. Ranchers have become aware of the increased spatial variability of the monsoon rains because in some areas the tanks no longer get filled and there is no water for their cattle. As evidence for the increased intensity of microbursts, Mohave County participants mentioned that culverts which used to be able to handle monsoon runoff are being overrun, causing closure of and damage to a major highway.

Ranchers, in particular, also mentioned changes in winter and spring precipitation patterns. For example, a Cochise County rancher explained:

> We depend upon what the book says about climate: a bimodal climate where forty percent of the moisture falls in the winter months. And the last six years, that's only happened once – last year. I'm still waiting for my winter moisture. All these storms that go through in the winter time pass north of us (P15Coch).

In Arizona, ranchers depend on both summer and winter rains to produce different types of vegetation that cattle feed on in different seasons. Ranchers also take advantage of the spatial variability of precipitation and the fact that higher elevations receive more rainfall to move their herds to areas that have received rainfall and will be producing forage. In addition to lower elevation land they own, they often have grazing permits on higher elevation land managed by the Forest Service. However, these strategies can fail when both winter and summer precipitation fails.

Here the discussion of changes in rainfall patterns blends into the second most discussed weather/climate phenomenon: drought. And discussions of drought tended to lead into a consideration of the length of the current one, which several participants identified as beginning in 1996. A second Cochise County rancher brought up this concern in his response to the comment above:

> Because I'm fourth generation I've had a lot of things that have been passed down to me about ranching in this bimodal system, how we handle it. But one of the things that I heard was that every now and then we would miss a growing season. … But what happened is, as we started drying out in the nineties and I started really watching it for my operation, as we started going into extended drought, was we could stand the loss of one of those growing seasons. And, as we were going along, the first thing I knew, we could stand the loss of any two consecutive, either a summer and a winter or a winter and a summer. But then comes along 2003. We had a poor start to one and then we totally missed three growing seasons. And we liquidated our herd of cows, which means that eighty percent of your gross income is gone that year. And it's tough (P16Coch).

As this rancher explained, because of the inherent variability of the climate, Arizona ranchers have devised ways to weather the loss of one growing season. However, the current drought has exceeded the length of those experienced by three previous generations of Cochise County ranchers and their methods of coping. This rancher was able to find temporary employment elsewhere to weather the 2003 crisis, but the drought is still affecting his operation. He went on to explain that in some places on his ranch the vegetation has recovered well since then, while in

others there is no regeneration and he hasn't been able to put cows on it. We summarize the discussion of the impacts of drought in the next section.

Here we want to point out that while drought is considered "normal," the length of the current one led participants to consider whether the climate was changing. Both the ranchers' comments above and the following conversation from the Pinal County group discussion illustrate this concern.

> I'm really concerned with the answer to the question, is this really a drought, or is this just normal? And we don't know yet (P10P).
>
> I share [P10P]'s fears. Are we in a drought, or are we actually looking at a new normal? I can sit home and just watch the news at night, and every other day we're breaking a high temperature record, and the previous high temperature was set back in 1897. And two nights from now, I'm going to go break another one that's been there since 1920" (P9P).
>
> Again, talking about is this the norm now. I've always, and I still wonder all the time, is this…? They talk about global warming all the time, is this just a historical cycle that we've gone through over millions and millions of years, is this just part of that process, or is there something that is really causing these climate changes, such as the greenhouse gases and everything else? How much is there to that? Not being a scientist, I can't answer that question, but it certainly enters my mind. Is it another cycle or not? (P12P).

In this conversation, the topic of "global warming" is cautiously brought up. Attitudes toward the topic of global warming or climate change varied in the group discussions. While participants did not hesitate to mention changes in rainfall, temperatures, length of drought, and overall variability they have experienced, some, as illustrated above, hesitated to label these "climate change," as this term has been framed by the dominant discourse, which includes human causation, apocalyptic future scenarios, and the need for immediate government action to address it. Participants who were more accepting of this understanding of "climate change" were also hesitant to use it because they were aware of its politically charged nature. Thus, one participant who was describing the effects of drought on water resources ended his description with a query: "So you're seeing those deep wells up in that area also declining with the drought, and with global warming, it's going to get worse. Can I say global warming? Climate change" (P7Y)? Another participant pointed out that, regardless of one's own position on climate change, it may be counterproductive to use it when working with local communities:

> First of all, in this community, you better not come in here and start about global warming. Because they will shut you off. You know, whether it's happening, or it's not happening, it really has, I mean, that's not the question. It's how do we deal with what we got today? And how do we, and within a reasonable period of time, what is the expectation of the weather that we're going to have to deal with in the short run? Next, one, two, three, four, ten year period (P1iGr)?

Some participants did not hesitate to use these terms. For example, the first Cochise County rancher quoted above confidently stated:

> I think what I've seen in my lifetime is a change away from the really reliable storm monsoons that I remember as a child. And I've thought about my own memories about this a lot, thinking that, "No, you just imagined it that way because that was your childhood." But now in looking back at records you really do see that there was a wetter time when it was more reliable. So I am, without apologies, a believer in climate change. I believe that I've lived and experienced climate change in my lifetime (P15Coch).

He told the group that he is experimenting with new plant varieties to address the possibility of an even drier climate and the loss of the types of winter vegetation ranchers have used to. These types of comments often opened up the group discussion to a deeper consideration of the topic of climate change, where participants would turn to co-author Crimmins to answer specific questions they had about it. Later in the Cochise County discussion, a woman who had moved there in the 1980s and worked for Extension in water conservation education spoke about what she had learned about the continually changing landscape from Extension, the variety of climate changes she had seen since she lived in the county, and changes in the monsoon rains that her elderly neighbors remember:

> And so I know things are changing. While I was serving on the City Council, I would go to the National League of Cities, and we would talk to people from other places around the country about global warming, climate change, and they would say what a big fraud it was. And they would tell me that I didn't know what I was talking about, and if you believed any of that stuff you were just full of it. I don't know if those people still believe that. But you *can't live* in a place like Arizona and not see the damage done by the bark beetles to the manzanitas. I go on Fort Huachuca and I see that all the cottonwoods are dying. You just get stuff coming from all over the place. And we know that things are changing and we have to adjust and adapt (P11Coch).

However, in the extremely variable climate of Arizona, the most prevalent attitude toward climate change combined a recognition that the climate is changing with uncertainty as to its cause, and a desire to learn more. The following statements illustrate this attitude.

> The argument out there for global warming is that man causes it, is it just cyclical, who knows? But it is a big concern of mine, being raised in Arizona for so many years, I have seen it get consecutively warmer and warmer, and periods of, and Arizona's always been drought, flood, drought, flood, but it just seems to be the droughts last longer, the floods seem to really get worse (P6Y).

> The questions is when you look at this, everything's cyclic. How big is the cycle that we're looking at? I mean we humans have such a gnat's attention span. If you looked at a ten thousand year cycle, you know, I, I had a boss who was a geologist once, you know, and things that I, me and my ten million barrel a day thought process doesn't work well when you're looking at millennia. You know, that's just, the sedimentation is overwhelming. And that's what we have to look at is, you have to be cognizant of what the true cycle is. So we're going for a ten-year dry spell? You know, four years out of every ten, it's dry. You start looking at the historic records you have, what was this place like forty million years ago? Well, it was under water, so that doesn't count. It was *really* wet back then. So what is the truth, what is the truth of climate change (P10Gi)?

> I see a lot of support for what we [Extension] do. And climate change in particular, I think what I've seen is a lot less people questioning as to its validity and whether it's a real thing now. They might not like the term climate change or sustainability but I think they at least realize that it's something that's real and they're going to have to work into their vocabulary with other words if they can't use the words that I just used. And given that we have a fairly conservative audience here, that's the group of people that are really most resistant to accepting climate change in my opinion and I think they're ah, beginning to think otherwise. I don't think it's as much of a political football as it used to be (P1iY).

A general consensus across the discussions is that you do not need to know what is causing the changes in order to try to do something about their impacts. In subsequent sections we will see how climate change raises concerns for agricultural planning and natural resource management, where managers need to be able to look into the future.

Other weather/climate phenomena that played a significant, but less prominent, role in the discussions include floods, wind, dust, changing temperatures, and the El Niño-Southern Oscillation (ENSO). The discussions indicated that some flooding of roads is considered normal during the monsoon season, but the increasing intensity of microbursts is causing flooding beyond what is considered normal. There were no major flooding events during the research period, nor have there been in the recent past, however participants often referred to floods they remembered, especially those of 1983 and 1993. Floods were most often mentioned in Graham County and there one participant pointed out how much past floods have shaped local expectations about the future, which poses a challenge to planning for current climate conditions:

> And what drove this community, you can pretty much show it from 1972 to 1995, was the wettest period of time in this part of the world for five hundred years. Okay. You go back, from the '30s to the early '70s was probably one of the drier cycles! Okay. An adult's working life is thirty to forty years, so if you spend all your time in one climatic scenario, you think that way. And then when it makes a shift, you don't shift! You think it's going to rain. You're back there! You're still expecting it to be like it always was. And it never does, because it's moved on, and you're gonna die before it changes. And the adults in this community are living in the flooding period! The community was raised when it flooded all up, and people still talk about it. And they keep wondering, "When, when is it gonna rain?" "When's it gonna do this" (P1iGR)?

Wind came up in the discussions where participants agreed that it had been an extremely windy spring and discussed the effects that wind had on mood, spring planting, and especially fires. Participants in several county discussions felt that the springs in general were windier than they used to be. Wind and drought are also related to dust. Dust came up in the discussions in Coconino and Pinal Counties in relation to its role in causing closure of the interstate highways that traverse these counties; I40 and I10. The haboob that hit Phoenix July 5th came up in the Pinal County discussion, but one longtime resident remembered that dust storms were more frequent in the past: "I grew up in Las Palmas, so I could sit on the front porch, and watch the dust storm come up from Eloy, and watch the haboobs develop. And then when the news came out with this big haboob that hit Phoenix, it's like, you know, this was the way it was back in the

‘80s every night. You know, what’s the big fricking deal” (P3Pi)? Dust was also a concern for farmers and ranchers in Cochise and Pinal Counties who are held responsible by EPA regulations for dust blowing off their private property.

Finally, participants also displayed familiarity with ENSO and how El Niño and La Niña are projected to affect winter rainfall in their region. For example, a local official responded to our opening question with this statement: “The biggest weather related event that I can remember is the Wallow Fire. Weather played a huge part in that, I think, coming off of a La Niña year and low winter [precipitation]” (P6NA). With respect to the 2011 fire season, a forest manager stated: “Next year, with La Niña coming here, we’re going to have a repeat of the same thing” (P12Gr).

To summarize, rural Arizona residents are highly attuned to weather, climate and climate variability, but their perceptions are shaped by specific location, current climate conditions, recent or remembered extreme weather events, knowledge of conditions in the past, length of residence; and occupation. In these group discussions, which took place during an extended drought, the weather/climate phenomenon of most interest to them is rain – whether it would rain, when, and where and how much it had rained – and the phenomenon that concerns them the most is drought. They are acutely aware that weather and climate patterns they are accustomed to are changing: the current drought is lasting longer than expected; rainfall is more “spotty”; and temperatures, variability, and extremes are increasing. However, in a context of extreme climate variability and political sensitivity of the topic of climate change, most are still wondering whether this is just another cycle among those they have experienced, and are hesitant to attribute these changes to anthropogenic climate change. At the same time, they are concerned about the impacts that these changes are having on their lives, livelihoods, and communities, and may continue to have in the future, and motivated by ties to place and identity, and strong rural values of independence and self-reliance (Brugger 2009), to take steps to address them. The next section summarizes the impacts of weather and climate phenomena and climate changes discussed by participants.

4.2 Impacts of weather and climate

In discussions of the impacts of weather and climate, impacts on water resources received the most attention, while drought also received a great deal of attention and provoked the most concern. Water scarcity in the region is an effect of the arid climate. In the U.S. Southwest, the expansion of large-scale, centralized, and federally subsidized water management systems have allowed agricultural production and urban concentrations to expand in unprecedented ways for such an arid region. However, there is mounting evidence that current water use in the region is unsustainable: water management systems are running up against physical, economic, and ecological limits that constrain the expansion of water supplies. At the same time, climate change and population growth heighten the threat to current supplies (Gleick 2010; Overpeck and Udall 2010).

In the context of ongoing drought, participants pointed out many ways that drought impacts water resources. However, because of the complexity of water governance in Arizona, drought

affects different types of water users in different areas in different ways. Where water supply is from surface water and water rights are governed by the doctrine of prior appropriation, users with senior water rights are less impacted by drought. However, those with junior rights may lose access to water when supplies are low during drought. Thus, in Graham County, the city of Safford depends on a spring for much of its water supply, and farmers depend on surface water flow from the Gila River, both of which are impacted by drought. Additionally, farmers are concerned about the recent adjudication of Indian water rights on the Gila River. Because Native American rights are senior to theirs, farmers' allotments may be negatively impacted. In Yuma County, farmers also irrigate with surface water, but they have senior rights on the Colorado River.[6] Thus, according to one of a participant who lived part-time in Yuma County, farmers there "hate it when it rains," because "they like to be able to control how much water they put on their property, and when they're going to pick it, and when it rains, and it turns those fields to mud, they get mad as hell, because they tear up that ground and then have to go back and re-laser plane it" (P9Gi). Likewise, a municipal water manager from Mohave County, stated that, "Quite frankly, the drought over the last ten to twelve years here, it doesn't affect our consumption much, because we're wholly dependent on the Colorado River" (P8M).

On the other hand, in Arizona, groundwater belongs to the person who owns the land where it is being pumped. Therefore, groundwater users are less concerned about drought and water rights. Drought increases water use and pumping costs, but does not immediately impact supply. However, increased groundwater pumping combined with decreased runoff during a drought raises concerns about the amount and recharge rate of groundwater supplies. Thus, in Cochise and Pinal Counties, which are heavily to totally dependent on groundwater for municipal and irrigation water supplies, water users are more concerned about groundwater supplies and recharge rates than drought. Water resources for farmers are also impacted by population growth and urban expansion in the region. Agriculture currently accounts for 80% of water consumption in Arizona and is likely to incur transfers away from it to meet municipal and industrial demands (Colby and Frisvold 2011). Regardless of their water supply, the small- and mid-range farmers in the group discussions were also concerned about the security of their water supply in the face of these pressures.

In contrast to areas that have either surface or groundwater supplies or both, in Coconino County, many rural residents have access to neither. They depend on water harvesting and purchasing and hauling water from nearby cities and other sources, which may be cut off during severe drought.

Municipal water suppliers are also affected differently by drought. The Salt River Project (SRP) is the nation's third largest public utility and one of Arizona's largest water suppliers, supplying electricity, water to municipal drinking water treatment plants, and irrigation water for urban and agricultural use in the greater Phoenix area. It was established in 1903 as the nation's first multipurpose reclamation project established under the National Reclamation Act and has water rights on the Salt and Verde Rivers which are senior to all but Indian tribes and irrigators in the Verde Valley.[7] Drought affects runoff in these rivers, thus affecting SRP's water supply. An SRP water manger explained how drought has affected SRP's water supply:

[6] We did not organize a group discussion in Yuma County, but we include this example for contrast.
[7] http://www.srpnet.com/about/history/Default.aspx, accessed 2/8/2012.

> We always planned on median flow from the river, the fiftieth percentile. So you would expect you'd get more than that half the time, and less than that half the time. That's kind of like normal, right? Well, since 1996, it has been so inherently dry, we no longer plan for median, we plan to receive the lower quartile. So you expect to get more than that twenty-five percent of the time. But you know what? For the last ten years, we've been mostly right, so it makes our planning much, we look like we're geniuses now, because we're not wrong on the downside as much as we used to be. … We were playing catch-up too many times, saying, "Oh, we, we thought we had this much water supply, but we actually have less, so we have to cut." And it's a lot easier to tell everyone up front, you only have half a glass of water, than to tell them you have a full glass and then have to cut it back. So it just became easier to plan for dry, and if it's wet, no one cares if it's wet. I mean, everyone is happy if it's wet. You can change it higher all you want (P5NA)!

On the other hand, a water manager for a private water provider, which supplies water all over Arizona, and which depends on groundwater supplies, described the impact of drought differently: "We haven't seen a tremendous effect on a lot of our wells as far as the static level of the water, and the pumping levels. You do see that in some, but it seems like throughout the years, even when we weren't in the drought stages, you'd see that." Meanwhile, his company has seen a drop in per capita residential water use and a decrease in overall water delivery since about 2008 as a result of both "different regulating agencies" that "have strived to advertise conservation" and the economic downturn. His company itself is "into water conservation. We get out the message to people; we get the message out educationally to students" (P12P).

Climate-induced water scarcity also impacts future economic development in Arizona, even in areas where water supply appears to be plentiful and secure right now due to senior water rights, massive feats of technology and engineering that transport water from elsewhere to where it is wanted, or pumping of groundwater. A Coconino County participant explained:

> We have limited water supply, and there's a lot of growth occurring in the state. We have an over-allocated river in the broader sense, with the Colorado and all the Western Regional States, and the implications of climatology, of weather in a regional sense, is a big factor. It plays into local discussions as far as should we grow, should we not grow, how do we grow; it plays into economic development discussions, what is the most appropriate type of industry that we have within the community. It's kind of like the silver bullet everybody wants for the West: a high-paying, high-tech, low water using, low impact to resources industry to come in, that's what's right for our town and everybody else. But it is the western conversation that occurs and that everybody's competing with each other on (P6Coc).

However, more concern was expressed about drought than about limited water resources. Ranchers and northern Arizona participants expressed the most concern because the impacts of drought are more consequential for them, while the level of concern for farmers and water managers depended on the source of their water supply, as described above. Ranchers are the first to be affected by drought because both summer and winter precipitation are essential to produce forage for their cattle. To indicate the significance of rain for ranchers, and the impact of its spatial variability, one rancher quipped: "The way to tell a good ranch manager from a bad

one is it's the guy that got the rain" (P5Coco). Ranchers in the discussion groups explained that while cattle on the Arizona range can graze on annual and perennial grasses and forbs, browse on oak brush and mesquite, and even eat prickly pear cactus, all of these will be affected by an extended drought. Without green feed, cows aren't conditioned well, many don't breed back, and calf weights are low, affecting not only this year's, but future, income. Dirt tanks don't fill up or their water quality is low, also affecting the cattle's condition. Since drought causes vegetation to die back, when rain finally does come, it can cause heavy erosion, making it difficult or impossible for vegetation to recover. In an extended drought a rancher might have to purchase feed, lease grazing land elsewhere, or sell part or all of his/her herd. To replace a herd when conditions improve is not only expensive, but it takes time for new cows to learn how to graze the country. A participant who works with ranchers pointed out that, despite these vulnerabilities, ranchers in Arizona have an advantage over those in Texas, who were dealing with extreme drought in 2011, because "they don't see this type of activity to the level that we see regularly. So it's the same impact, but a different response, because of our repeat. And we usually have a flood in the same drought years" (P7Gi).

Participants in northern Arizona counties were especially concerned about the impact of drought on forest health and the potential for and severity of wildfire. Their concern was stoked by the experience of increasingly large, intense, and difficult to contain wildfires in Arizona in recent years: the 467,000-acre Rodeo-Chediski in 2002; the 248,000-acre Cave Creek Complex in 2005; and the 538,000-acre Wallow Fire in 2011. Two thousand eleven was an exceptional year for wildfires in Arizona: at the same time that the Wallow Fire was threatening communities in Apache County in June, the Monument Fire forced evacuations near Sierra Vista, and the 223,000-acre Horseshoe Two Fire devastated much of Chiricahua National Monument, both in Cochise County. Wildfire is a concern in both northern and southern Arizona, however there are more highly populated areas surrounded by forest in the former, so the potential for loss is greater. Participants discussed the multiple impacts of drought on forests and the ways they interact with and reinforce each other.

Drought and warm temperatures dry out trees and undergrowth making them easier to burn. Drought stresses trees and makes them more susceptible to bark beetle. Warmer temperatures allow more breeding cycles for the beetles; their population expands and they spread more rapidly. Beetle-ravaged trees burn more easily. Warmer temperatures also mean that snow melts earlier and the fire season starts earlier, so that fire seasons in different regions of the country are beginning to overlap, making limited fire fighting resources more difficult to share among regions. Drought also affects cone crops, and the recruitment of new tree seedlings, impacting forests far into the future.

Participants pointed out that past management of National Forest lands in Arizona has contributed significantly to the wildfire problem. When the first settlers arrived in northern Arizona, they found the largest stand of ponderosa pine in the world (Sheridan 1995). Fire was part of the ecosystem that produced the savannah-like ponderosa forests, with large tree size, low tree density per acre, and a rich understory. When the Forest Service took over management of these forests, they adopted a policy of maximum yield, which was based on growth rates too short for forests in a semi-arid region, and a policy of fire suppression. This resulted in a forest composed of what participants referred to as "dog-haired thickets" of trees. The trees are

stressed and unhealthy due to over-competition, making them more susceptible to beetle, drought, and fire. In addition, the canopy is too dense to allow enough sunlight and moisture to reach the ground and produce the rich grazing that ranchers used to find. When trees could no longer reach the size that lumber mills needed, the logging industry declined. Changing perceptions of forests as places for recreation rather than production dealt logging the final blow. Now most people think that the forests are supposed to look the way they do and they resist both logging and the thinning and controlled burning needed to reduce fire danger. Participants pointed to the forests on Indian reservation land, which have been managed more holistically, using selective logging and prescribed fire, to show what more healthy forests should look like.

In addition to these conditions, the spread of the Wallow Fire was aided by strong spring winds. A participant who was a seasoned fire fighter and who fought the Wallow Fire described how fighting fires under these conditions has changed the rules of the game:

> And you talked earlier about fires, hitting old fire scars? That didn't stop it or slow it down this year. If you look at the heel of the Wallow Fire, even on the heel there was some other stuff that was a little newer. One thing we've never seen up until this year, is I've never seen fire run downhill against the wind, like it did this year. And so, we have fire behavior analysts and long-term analysts on our big fires that basically have models that tell us what's going happen, and what you can expect that day, basically for your personal safety. And starting at the Horseshoe Two Fire, those guys just threw their hands up and walked away, and basically sat in their cars, because they went and looked for new data, and stuff that they could reconcile to make better judgment calls, and they just don't have it. They just don't have it (P4Gr).

The implication here is not only that wildfires are becoming increasingly large and intense, but that the knowledge and skill used to control them in the past may not applicable be under these new conditions.

In addition to the danger to lives and property, the economic losses, and the profound ecological changes these huge fires produce, participants described other impacts. A Navajo County resident, who was not physically impacted by the Wallow Fire, described its emotional impact:

> On the personal side, getting to see some of the [Wallow] fire and some of the things that took place over there, it's pretty personally devastating for me to see and feel that. … There was still quite a bit of green grass out there, and certain areas were looking great. But certain areas were just nuked. And it was, I mean, you just feel it in the heart, you know, everything kicking in. It was hard to go through, and we only saw a small, I mean, it was a whole day out in the woods, but we only saw a very small percentage of that (P8NA).

Even when wildfires do not occur, closing national forests due to extreme fire danger impacts recreationists and local economies that depend on forest recreation.

Finally, while efforts (described in Section 4.3) are underway to mitigate fire danger by reducing fuels in the forest, participants involved in them expressed concern about how effective their efforts will be in a climate that is also changing:

> One of my concerns going forward is, we're doing a lot of forest restoration activities, and a lot of planning for forest restoration to get the forest back to whatever the natural range of variability was. And the question that I have is, are we going forward into a

> climate that's going to resemble anything that we had within that natural range of variability? As far as long-term, are we thinning enough? I don't know. Are we thinning appropriate to what the climate's going to be giving us? And then, how wildlife is going to respond to that is going to be an interesting question (P4NA).

Drought not only impacts vegetation in the ways described above, participants are also concerned because, although native vegetation is well adapted to dry conditions, long-term drought can cause potentially permanent shifts in vegetation. In southern Arizona, as a Cochise County participant explained:

> We see changes in plant communities because we've been in drought for, well the 2002 drought is a perfect example. There are several sites in Santa Cruz, and in particular Graham County on one of the ranches I work with, and I think we'd see it in other places if we had long enough data sets. We had a complete shift in the grass species. Not of the types that were out there, but the amounts of species. So, where we had curly mesquite as the dominant species on the site, now it's spruce-top gramma or something like that. So the plants are still in the community but that 2002 drought killed all the very short-rooted grasses. The deeper-rooted grasses lived. And when it rained again they came out on top. And so, is that good or is that bad? How do you interpret that data? And it wasn't livestock grazing. It was climate that made that shift. And is it going to shift back (P14iCoch)?

In contrast, at the higher elevations of northern Arizona participants were concerned with a shift in tree species. A Coconino County participant who works with private landowners to help them protect their homes against wildfire brought up this "potential shift in vegetation":

> There's a lot of folks that we work with that are kind of on the margin between piñon and juniper. Right now, a lot of it's pine because of the wet cycle we've been through, but you see the piñon and juniper in amongst it. And so, what it did in the fifties, which there apparently was a shift in the piñon-juniper transition zone line, I think a lot of private land pivoted back towards piñon, in the drought in the fifties. The record says there was a shift in the piñon-juniper boundary in the highlands. I do know that the archaeology shows that Elden Pueblo at one time had a lot more piñon, so over time, there probably has been periods where there's been a lot less pine and more piñon-juniper. So that's definitely out there, the juniper could become more prevalent in some areas (P4Coco).

Participants also described the impacts of temperature extremes and increasing temperatures. Participants from southern Arizona counties described many impacts of the extended period of record-breaking freezing temperatures that occurred during the first week of February 2011. Many native species, such as saguaro and prickly pear were killed, as well as drought-tolerant non-native species used in landscaping, such as Queen palms and eucalyptus. Farmers had to replant cotton. Parts of Tucson experienced a shortage of natural gas and many homes were without heat for days. Pipes froze and burst across the region, causing a great deal of damage and depleting plumbing supplies. They compared that freeze to others, which did not last as long or occurred with snow on the ground, and did less damage.

While farmers are less vulnerable to drought than ranchers, they are more vulnerable to extreme cold and wind, which participants in farming felt are increasing. As a result of more

unpredictable weather and changing seasonality, horticulturists and home gardeners are beginning to build greenhouses.

Participants also brought up some impacts of increasing temperatures. A woman who was raised in Cochise County, moved away, and came back lamented: "This year, last year was so bad. Now I dread summer. Because a summer with no rain, and it's been high heat. And I just dread it. But that was my favorite part of the year growing up. And that's what I *thought* I would be coming back to. After thirty-five years it just wasn't" (P12Coch). Another participant who owns rental homes anticipated having to install air conditioning in his rental properties because swamp coolers no longer work and, "that's the first thing they ask nowadays, 'Do you have air conditioners in your houses'" (P1GR)? One of the things a participant from Mohave County said that he has noticed over the last ten years is that overnight temperatures are higher than they used to be: "The overnight low temperatures, especially during monsoon season, are higher than they have been by about three or four, five degrees than they were twenty, thirty years ago. … Well, that means the evaporation, the ET rates are even higher than they probably used to be" (P8M). Increasing summer temperatures may reduce the amenity value of Arizona's climate. Participants from northern Arizona reported that temperatures in winter are also increasing. A man from Apache County reported that:

> Old-timers in St. Johns, I've heard it from several, used to say, 'Yeah, we used to hang a side of beef on the north side of our house; it would keep it preserved for as long as we needed.' But it's not even close anymore in the wintertime. Even in January I've walked out with shorts and a tee-shirt, and it's been nice and balmy (P7NA).

A man from Coconino County remembered that, when he was younger the ground used to freeze in the winter.

Increasing temperatures are also impacting agriculture and horticulture. For example, fruit trees bloom earlier and are more likely to be impacted by late frosts. The ideal growing season for crops such as cotton also seems to be changing. Higher evapotranspiration rates increase the need for irrigation.

As they did for the case of fire, participants pointed out how weather and climate interact with other factors, such as past management, to create the impacts they are experiencing today. A Coconino County participant pointed out: "There's a lot of management issues that we deal with here, whether it's range management or forest management or maybe agricultural practices, that are part of the ecological history that probably may determine more of what we're seeing now than climate. And we think climate can exacerbate or amplify existing stressors on the system" (P7Coco). Cochise County participants attributed the loss of tobosa grass flats that provided productive grazing in the past to development in the area that has changed the direction that the flood waters needed to produce the grass have gone. Development was also seen as a contributing factor in Yavapai County where the flow of the Verde River has been decreasing due not only to drought, but to increased pumping of groundwater.

Informed by our analysis of the group discussion data, we coined the term "emergent extremes" to describe the way that problems arise due to the co-occurrence of unprecedented weather and climate extremes, such as long-term drought and elevated temperatures, in a socioeconomic context that developed during different climate conditions. This term suggests that the impacts

of weather extremes, such as the record-breaking February 2011 freeze in southern Arizona, and the extremely dry and windy spring of 2011, should be considered along with other factors.

This section has summarized the most significant impacts of weather and climate variability and change on rural Arizonans as described by discussion participant. In the next section we will learn about the many ways they are responding to and planning for these impacts in their daily lives.

4.3 Adaptation

The discussion in the preceding two sections has illuminated the ways that rural Arizonans experience weather and climate across the state, changes they are aware of, and their greatest concerns about the impacts of climate variability and change. In this section we consider how they are currently responding to and planning for weather and climate variability and change, and summarize discussion participants' suggestions for what could be done further to help them adjust to changing conditions. We label this section and the activities discussed here 'adaptation,' although participants themselves seldom used the term. The IPCC Fourth Assessment Report defines adaptation to climate change as: "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007: 809). Here we are using the term differently. Rather than a systems-level approach to understanding adaptation, we are approaching the process from the point of view of individuals who are experiencing and adjusting to climate variability and change in their daily lives. From this point of view it is possible to see that 'adaptation' is not something new that rural Arizonans will have to undertake in the face of climate change, but a process in which they are constantly engaged in order to live in a hot, arid, and highly variable climate. This perspective also provides insight into how institutions, resources, and activities at broader scales might support ongoing local level adaptation processes.

4.3.1 "Living with the climate"

While participants in the group discussions who are involved in farming, ranching, and natural resource management described the ways they are continually adjusting to wet and dry cycles and reacting to extremes of temperature, precipitation, and wind, they seldom used the term 'adaptation' to refer to their activities. They did use the term to refer to the ways that Native Americans were able to live and support a large population in the region, and to the ways that wildlife and vegetation respond to wet and dry cycles. However, the following statement, which illustrates how farmers are adjusting their practices in the current dry cycle, is a notable exception:

> All the decisions that we make are based on the climate to some extent. Both short term and long term. I mean, we pump water for a living. You know, we're in an extended drought. We had a decent year last year, but we're still in an extended drought, so we're chasing water down. We do a lot different farming practices than we use to do. We work the ground less. We leave more cover on the ground so we don't lose moisture. We've changed a lot of our equipment needs. We've put drops closer together. We've put drops, instead of being rain birds that are ten feet in the air, we've

> got drops on our sprinklers that are eighteen inches to three feet off the ground. Instead of being a hundred or two inches apart, we went to sixty inches apart, now we're at thirty inches apart. So we've made a lot of adaptations, just based on trying to conserve moisture as much as we can to get the biggest bang out of the buck that we can for the water that we pump. Most of our water is deeper than it used to be. And so we're trying to get as much out of it as we possibly can. We farm with a lot more trash so we conserve the moisture. We work the ground less, as a rule in the winter, as well as in the summer. We do less operations on the farm. Mostly, not entirely, due to moisture concerns, but an awful lot of it is. It creates other issues for us. But anyway, everything we do is based on, on the climate (P17Coch).

When this farmer used the term, here and elsewhere in the discussion he pointed out that his "adaptations" are not entirely due to the climate, but to related issues, such as lowering groundwater levels, perceptions of farmers as "the bad guy" because they are using so much water, and EPA regulations that hold landowners accountable for dust blowing off their property, which are politically charged issues in the region. His use of the term illustrates the fact that "adaptation" takes place in a context shaped by many more factors than climate, thus the actions an individual takes may be gauged to address these factors in addition to climate.

Longtime residents generally referred to the ways their activities are attuned to a highly variable climate in a matter-of-fact way, illustrated by the statements, "It's all a part of where you are" (P7Coch); and:

> This is what we've got. Doesn't matter how we got here, global warming or not, this is what the weather is. And how do we deal with it, and how do we live in this environment, whether it's the Southwestern states, or another part of the country? I think that would make more sense to people than to get into the political realm of, is it really global warming, or is it not global warming (P2Y).

In this report, we refer to this attitude as "living with the climate." It is in evidence when ranchers explain that, although they "depend upon" the bimodal climate, "things that have been passed down" about ranching in this system help them make it through a missed growing season. It is in evidence when participants accept it as normal to have to drive the long way around when washes are running full and making roads impassable during a monsoon downpour, but display concern about the more infrequent hurricane-driven fall storms that can cause major flood events. However, exceptional drought is challenging ranchers' long-standing strategies and the increasing intensity of microbursts during the monsoon is becoming a concern for ranchers, emergency managers, and other residents. The attitude of "living with the climate" is also in evidence when participants contrast how they used to do things with how they do things now, such as building "houses that are *totally* inappropriate for this climate" (P15Coch). For example, Cochise County participants discussed how they used to build houses before air-conditioning:.

"Living with the climate" also comes into focus when newer residents describe a process of adjusting to the climate which they went through when they first moved to Arizona. Here we present one of those "adaptation stories" at length:

> I had no idea that there was an issue with water until I moved to Arizona. Because where I grew up there was more than enough water and if you just dug about thirty feet in the ground you had more than enough. And it didn't dawn on me, having grown up somewhere else, that water was such a big deal. … And so as a kid myself growing up

> in the Midwest where lawns are everywhere, it's one of those big mind shifts that we had. And my husband and I just constantly look and our yard and think, "This place just looks awful." How are we going to do something to cover up that it's just sand burrs and cockleburs and prickly stuff and such? And we talk about xeriscape and we talk about other things, but yet I say to him, "But it has to be a yard!" You know? We still have that shift in thinking: what it should look like outside of your house, and how do you adjust that with the lack of rain, and what you can grow, and what you shouldn't be growing, and how much water you should be putting on things and you shouldn't be putting on things. I have a rainwater harvest tank. I had to *explain* in Nebraska what one of those things was, why I would want to do that, and how I would even get water into it in Arizona. So, it's this mind shift, from my perspective, to being able to see things from a perspective you've been seeing it from for decades and generations in some cases. My family also raised cattle. But the 420 acres of one of the pastures that we put the cows out on, well, their bellies parted the grass. And so I look at the ranch land out here and I scratch my head and think, "How does anything live off of that?" because I still have a perspective from a different location. And I still wonder. And I have no idea. I have such great respect that it's been able to happen. So I'm in that learning curve of all of the things that, you know, I'm not planting cottonwoods in my back yard because I've learned not to. And I live by Water Wise low water use tree guide because I don't know if I don't have somebody who's told me. … So it's been a big journey from not *thinking* about water to having it be a day-to- day concern on how we use it (P18Coch).

This story brings out the taken-for-grantedness of the way longtime rural residents see the landscape and live with water scarcity, as well as the "mind shift" required to live in an environment different than what one is used to.

4.3.2 Weather and climate information sources and needs

Because weather and climate have such a great impact on their lives, rural Arizonans use a variety of sources to obtain information about past, present, and future conditions to help them plan for these impacts. Information sources have proliferated since the CLIMAS in-depth studies of vulnerability to climate variability in rural communities in southeastern Arizona investigated sources of and needs for weather and climate information among study participants over a decade ago (Finan and West 2000; Vásquez-León et al. 2002). Finan and West (2000) reported that in general study participants in the Middle San Pedro River Valley relied on local radio and TV news and weather stations, The Weather Channel, and the Farmers' Almanac; electricity providers obtained daily minimum and maximum temperature from the Tucson Airport and historical degree heating and cooling days from NOAA; while ranchers consulted ranch community radio broadcasts, the National Weather Service, TV reports, professional livestock publications, and collected their own data using numerous rain gauges across their land. Vásquez-León et al. (2002) reported that farmers consulted The Weather Channel, subscribed to the DTN service (Data Transmission Network: a private company that offers real-time weather information and other products to farmers), visited the National Weather Service website, monitored satellite images, purchased information from a private meteorological service, and combined information from these sources with their own experience. In both studies, participants reported taking the El Niño seasonal forecast into account. In both studies

also, participants expressed a need for more accurate forecasting tailored to their area, more local rainfall data, and more easily accessible NOAA websites.

While our study did not systematically seek to elicit weather and climate information sources and needs, discussion participants invariably offered this information. A surprising number of participants collected their own weather data at home. They also mentioned their own experience, local knowledge, and old timers as sources of information. However, with Internet access now more widespread in rural areas, the most frequently mentioned source of information for historical and forecast information was NOAA's National Weather Service websites, with little mention of radio and TV, and no mention of The Weather Channel. However, while several participants mentioned that they consulted NOAA weather forecasts every morning, participants were also aware that in Arizona forecasts aren't all that reliable: "I don't think most people trust that very much. They'll say, 'Well, let's wait and see.' Because, well, there are predictions of rain, and then it never comes. 'Cause it's so scattered" (P1iCoch). Participants also mentioned new sources of information on past and current conditions, such as AZMET and Rainlog. AZMET, the Arizona Meteorological Network, began operation in 1986. It was created and is maintained by University of Arizona Cooperative Extension to provide meteorological data and weather-based information to agricultural and horticultural interests operating in southern and central Arizona. AZMET data are collected from a network of automated weather stations located in both rural and urban production settings, summarized in a variety of formats, and compiled into special reports, such as the Phoenix Area Turf Water Use Report and Weekly Cotton Advisories (http://ag.arizona.edu/azmet/). AZMET fills a gap left when the National Weather Service was prohibited from issuing agricultural forecasts in 1996 (Vásquez-León et al. 2002). Rainlog.org is another brainchild of UACE. It is a cooperative rainfall monitoring network for Arizona in which volunteers with a rain gauge and Internet access post daily rainfall totals at their location. Rainlog responds to agriculture's and resource managers' need for up-to-date rainfall information from more locations in a climate where rainfall is highly spatially variable.

Participants were also knowledgeable about paleoclimate data that trace wet and dry cycles in the distant past and the availability of seasonal forecasts. Some found ENSO forecasts useful. For example, one rancher explained, "If you can tell me it's gonna be a mild winter, I spend about half on energy and protein in the winter. If you tell me it's gonna be a cold winter, I spend lots more making sure my cows have enough feed and protein to survive the cold and stay healthy (P6Coch). However, some participants expressed the opinion that ENSO forecasts were less reliable than they used to be. A forest manager described the change he has noticed:

> Well, that's something I've noticed too over the last decade, kind of when the Pacific Oscillation thing went to the dry cycle. Every prediction that's come out has always erred; it was higher than it actually turned out to be. Monsoons always turned out to be wimpier than they were predicted, and when we have an El Niño, it turns out to be a pretty anemic El Niño. It seems like we're in that cycle that, it's always less than what we're kind of thinking. And I remember in the late eighties and early nineties it was the opposite; it was always, you know, if you predicted an El Niño, it was pretty wet, and that's really switched now. And the monsoons, the same deal. … But, and if we're relying on historical record, some of these cycles are longer than our history. So even

> without possible climate changes, it's difficult to predict. And then when we throw that in… (P12Gr).

And an emergency manager gave an example of what could happen if he depended too much on the ENSO forecast:

> I'll give you an example, because I sat through a two-hour meeting with the National Weather Service, and it was it was like a product call-in type thing. And they put it up on the screen, so we had all the emergency responders and everybody from around the state, we sat there for two hours, for them to tell us, nothing against the National Weather guys, I really like 'em, I sat there for two hours for them to tell us it's going to be a drier and warmer winter. And then we went to a deep freeze. So that really messed with our… Okay, we're thinking drier and warmer, okay, we don't need this, that, or the other thing. Next thing you know, we're going into a deep freeze. I mean, that just, emergency management is like, "Uhh, now what do we do?" We were planning for this, and then… (P3P)

Vásquez-León et al. (2002) also gave an example of a farmer who sustained substantial losses because he based his planning on a seasonal forecast. They point out that when people make decisions based on forecasts that turn out to be unreliable they are likely to lose faith in the reliability of forecasting in general.

Discussion participants also expressed some of the same information needs that were expressed in the earlier CLIMAS studies: specifically, a need for NOAA websites that are easier to figure out and easier to use; a need for a "one-stop" website that has all the information about conditions in the recent past (snowpack, rainfall, temperatures) from various sources in one place; a need for forecasts more specific to their local area; and a need for more precipitation data and for all the organizations and home weather station operators collecting it to work together to make it available online in the same format. These comments discussion participants indicate that NOAA has not responded to suggestions offered in the earlier reports:

> There's something about meteorological or weather or climate websites, they're made for people with an IQ of a hundred and ninety-seven. And you have to be a computer *gizzard* to understand anything. They are so complex, and they are so confusing, that on an average day, I mean there's certain places I go to, but the bulk of it I ignore. And the one that I really liked, they did away with (P1Gr)!

> And it is really frustrating to me that when Phoenix does the weather forecast, I can watch this huge blob coming towards [where I live], and nothing's said, there's no warnings. We've had some, I remember oh, two years ago, on December seventh there were eighty mile an hour winds, and it was driving rain, and the rain came through the windows of my sliding windows, and, I mean, it was just a mess, and I had power out for five days and all kinds of stuff. There was *no* forecast that warned us about anything like that (P9Gi).

With respect to the need for more accurate long-term forecasting there were two schools of thought. One is represented by this comment:

> It's a huge impact, because you guys [climatologists] can really set a direction of where government at the local level would go, if science was better, and you had a little better handle on it, at least fifty percent of the time. If you knew what it was going to be for

> the next ten years, are we starting a pattern of one direction or the other, or is it going to get worse, is it going to maintain, is it going to get better, precipitation-wise? You know what I mean? Because that drives, do we okay this subdivision now, because we believe that the water situation will be okay? Does SRP okay allowing more water to stay in the Verde? And if you're gloom, and if you're wrong and your science is wrong, and you say we're going into extreme drought, and it doesn't happen, you've lost all your credibility with everybody. … It greatly affects economic development (P6Y).

We refer to this way of thinking as "adapting to the edge," because it assumes that better long-range climate forecasting will reduce the risk of decisions and allow people to plan right up to what the climate and resources will allow. In contrast, "living with the climate" is represented by this comment about forecasting from the same county discussion: "Wouldn't it be neat if NOAA, or whoever it is, would say, 'Your climate sucks here; you've been in a drought for a long time; and you better conserve what open space you have, you need to conserve your water, and you better, you know, because it's not going to get any better for the next thirty years'" (P4Y). This school of thought accepts the extreme variability of the climate and the limitations of climate forecasting and suggests that we concentrate on activities that reduce vulnerability and exposure to weather/climate, which doesn't require accurate predictions of the future. The school of thought one subscribes to might be associated with the motivation for one's activities. The first speaker was a local government official who is motivated by a desire to encourage economic growth in his county; the second was a small farmer who is motivated by attachment to place and to a particular lifestyle to just stay in business.

Before there was more accurate forecasting and so much weather and climate information on the Internet, farmers and ranchers kept weather records to help them plan seasonal activities, and gathered to discuss prospects for the coming season. Some of the benefits of these sources of weather and climate information have been lost as information has become more readily available. A participant from Gila County remembered that her husband's father, who farmed in Casa Grande, used to meet in a restaurant there to discuss with other local farmers how the amount of water behind Coolidge Dam was going to affect their irrigation. She remarked: "It's so amazing to think that, in some ways, getting together for breakfast over in Coolidge is probably more accurate than some of the stuff on the internet right now" (P9Gi). A participant who works with ranchers responded: "It's true. I've looked at every map and technology we have and I can find out more on the telephone what's going on with the neighbors, or the other ranch over there, and when their green up was, and how green they are" (P7Gi). "And if they keep a journal, most farmers do, you know. So, what's going on, you get more than you get by going on the internet" (P9Gi). These comments suggest that, in addition to more in-depth information for a particular area that is suited to the user's specific needs, what has also been lost is the local knowledge and the relationships that helped farmers and ranchers survive in this extremely variable climate.

One participant made a distinction between three types of forecasting needs that usefully summarizes the discussion: "that real short-term stuff"; "the intermediate": and "the longer term stuff" (P1iGR). "That real short-term stuff, be sure you predict it right. … That short-term information affects people's lives." To illustrate this point he described how the record-breaking and long-lasting freeze in early February 2011 affected local residents, who were caught

"flatfooted" because, in his opinion, the National Weather Service didn't "predict it right." "The intermediate" is around ten years and helps farmers to make economic decisions about whether to invest in expensive technology, like drip irrigation or expensive harvesting machinery. While forecast need to be "clear and concise in the very short-term," and "somewhat realistic in the intermediate," for "the longer term stuff, if we are truly shifting away and we're going to go into an extremely dry period of time, and I don't know that the climate people can say that with any certainty, … the long-term, all you can do is say this is our best judgment. 'The last thirty or forty years isn't coming back, folks'" (P1iGr).

"The longer term stuff" would also help ranchers, resource managers, and emergency managers because current policies and planning are based on the last thirty or forty years, timescales that are too short to take longer climate cycles into account. We have seen how ranchers, wildfire fighters, and forest managers are concerned that the knowledge they use to manage rangelands, fight fires, and restore forests may no longer be applicable under changing conditions. Here, a riparian manager expresses how long-term forecasts could help him:

> This ties to, what are the expectations for these systems? … If we're going into an extended, extended, extended drought, and … we're going to fight to the death over riparian management, when the reality is, they're probably going to shift, we're not going to have these massive canopied riparian areas, because there's not going to be enough water there on a natural basis. But because the people coming out of the schools have been taught that riparian is the holy grail of lands, they're gonna fight that. But if we are in fact shifting away from the weather regimes and the long-term climate regimes that are conducive to these systems, and they're going to change, then we need to recognize that. … That's the kind of the long-term the help the policymakers [need to] do more reasoned judgments (P1iGR).

Resource managers are now able to see the negative effects of resource extraction and management activities carried out without an awareness of the extreme variability of Arizona climate, and would like to be able to better take it into account in current planning.

4.3.3 Current weather- and climate-related planning

In this section we summarize the ways that members of some of the groups who participated in the discussions – ranchers, farmers, forest managers, water managers and users, emergency managers, and industry – take weather and climate, past, present, and future, into account in their day-to-day and longer term planning. The discussion brings out significant differences between these groups, in vulnerability to climate variability and change, and in capacity to plan and respond.

Ranchers and farmers mentioned many factors they take into account in their planning in addition to weather and climate, including cost of inputs, market prices for their products, availability of water, property taxes, government policies, environmental regulations, and public perceptions. In addition, studies have shown that non-economic values, which ranchers often describe in terms of a "ranching lifestyle" play a significant role in their decision-making (Gentner and Tanaka 2002; Sayre 2004). With regard to weather and climate, ranchers in the discussion groups explained that, although their planning is based on the expectation of a bimodal climate, because rainfall is highly spatially variable, or may not come at all, they are

"always in a state of drought" somewhere on their ranch (P5Y). As a result, their main management tools are moving their cattle to where it has rained and there is forage, making sure pastures have sufficient recovery time after grazing, ensuring an adequate water supply and quality for their cattle, and reducing herd size when forage is insufficient. However, the ability of ranchers who use public lands for grazing to use these tools can be constrained by federal land management policies. One participant told a story that illustrates how federal land management policies set at the national level affect ranchers in this region of highly variable rainfall:

> One of the experiences I had here, working with the [name of] Ranch, in 2002, the Forest Service asked all the ranchers to remove all their cattle on all the allotments. And so the owner asked me to go out there and look at things with him. And he had had rain. He had one spot on the ranch that had close to two thousand pounds per acre of forage, just tremendous. He had some death of the more shallow root species on a south-facing slope, where an old roadbed was, and that's kind of what they were basing their decision on, not looking on the whole ranch. So we collected some data that was put to the ranger, and said, "I think you ought to rethink this, here's some data." He wasn't willing to get away from the party line. They made the rancher remove all his cattle. About a month later, they brought in people from all over the forest and from the region, went out there, and one of the rangers said, "Well, this is cow heaven." And they couldn't understand why he was being asked to remove his cattle. So eventually he got 'em back on, reduced amount, but I guess my point of that story is that you can't sit in an office somewhere and look at satellite data and make on the ground decisions. You just cannot do that. You can make some assumptions, you can get some general ideas, but you need to go out and ground truth things, because things can be quite variable just within a short distance, with the way our monsoon moisture is so convection driven (P2Gi).

With the management tools they have available, ranchers are more interested in knowing where on their ranch it has rained and how much, than on weather and climate forecasts. Information about how much precipitation has occurred is also necessary for ranchers (and farmers) to be eligible for drought assistance from the federal government. Ranchers find information about ENSO somewhat useful, because it can help them to decide how much supplement to buy in the winter and how many yearlings to retain. They are also concerned about the length of the current drought because, while they have strategies to get through the loss of one or two growing seasons, the knowledge and practices they have developed may not be sufficient to cope with more prolonged drought. Rangeland monitoring is a tool that ranchers can use to evaluate the effects of their grazing management and their progress toward management goals. University of Arizona Cooperative Extension has been providing Arizona ranchers and natural resource agency staff with formalized training and assistance in rangeland monitoring since the 1990s (Fernandez-Gimenez et al. 2005), expanding from 100,000 acres monitored at the beginning of the program to 1,123,710 in 2011 (P2iGi). Rangeland monitoring could also be used to provide information about the effects of long-term drought and changes in precipitation patterns on vegetation, and to give ranchers and to get a better idea of future conditions they may have to deal with.

Most farmers in Arizona depend on irrigation to water their crops.[8] While they are less immediately impacted by precipitation variability than ranchers, farmers in the discussion groups explained that they need to monitor precipitation to know how much irrigation to apply. Farmers who depend on surface water can be impacted by reduced stream flows during drought, especially if they do not have senior water rights. These farmers explained that about the only planning they can do at that point is to plant less. A small farmer who flood irrigates from the Verde River explained that they have taken steps to reduce evaporation, like lining their ditches with cement and covering them, and that, "when you flood irrigate like we do, most of that water goes back into the watershed" (P4Y). Farmer who depend on groundwater are less impacted by drought, but, as we have seen, still take steps to reduce water usage and conserve moisture in their fields. Farmers are more impacted than ranchers by short-term weather events, such as freezing temperatures or wind during spring planting season and freezing temperatures or heavy rainfall during the fall harvest season. In the first case they can put off planting or replant; and in the second they may be able to harvest earlier if these events are predicted. Seasonal forecasts may help them decide what to plant. A Graham County participant mentioned a cotton farmer who planted lettuce when a warm winter was forecast, and "made a killing" (P7Gr). But he also pointed out that he was a large farmer and could afford to take a risk that could put a smaller farmer out of business if the forecast was wrong. Vásquez-León et al. (2002) found that groundwater irrigators in southeast Arizona were most likely to consult crop prices to decide what to plant. The "intermediate" range forecasts of about ten years, mentioned, above, can help farmers make decisions about investing in expensive equipment and infrastructure. To help with farmers plan for "the longer term stuff," UACE is experimenting with drought- and heat-resistant varieties of crops to help farmers adjust to a potentially drier and hotter future.

A forest manager quoted above explained that "everything we do in the forest is weather dependent" (P3NA). However, in response to recent large-scale wildfires, large-scale die-offs due to beetle infestations, and the possibility that both may be exacerbated by climate change, forest managers in Arizona are actively developing new long-term approaches to forest management. Subsequent to the 2002 Rodeo-Chediski Fire, Arizona Cooperative Extension facilitated the organization of the White Mountain Stewardship Group, which took on a ten-year contract with the Apache-Sitgreaves National Forest to thin 150,000 acres in the wildland-urban interface to protect communities surrounded by national forest. Figure 8 shows before and after photographs of some of this work. This project is credited with protecting some Apache County communities from being destroyed by the even larger 2011 Wallow Fire (Davis 2011). It project served as a testing ground for a much more ambitious restoration project, the Four Forest Restoration Initiative, known as 4FRI, in which Apache-Sitgreaves has joined with the Tonto, Coconino, and Kaibab National Forests and a diverse group of stakeholders with the goal of collaboratively planning and carrying out landscape-scale restoration of ponderosa pine forests in northern Arizona. According to the 4FRI website:[9]

> The overall goal of the Four Forest Restoration Initiative (4FRI) is to restore the structure, pattern and composition of fire-adapted ecosystems, which will provide for fuels reduction, forest health, and wildlife and plant diversity. A key objective is doing this while creating sustainable ecosystems and industries in the long term.

[8] Vásquez-León et al.(2002) have an excellent summary of the ways that farmers growing a variety of crops in southeast Arizona are impacted by weather and climate and the kinds of planning they do.
[9] http://www.fs.usda.gov/4fri, accessed 01/25/2012

> Appropriately-scaled businesses will likely play a key role in the effort by harvesting, processing and selling wood products. The restoration-based work opportunities are expected to create jobs across northern Arizona.

Arizona Cooperative Extension has also facilitated programs to thin forests on private property in other counties, known as Wildfire Survivable Space in Yavapai County; as the Rural Communities Fuels Management Partnership in Coconino County; and as Firewise in Navajo and Gila Counties. To broaden these efforts, some municipalities have passed ordinances that set tree density standards on private property or developed incentive programs to encourage them. However, as we have seen, forest managers are concerned that, with climate change, these efforts may not be enough.

Water managers who participated in the discussion groups provided insight into some of the types of planning that water providers do. Like farmers, their planning is shaped by their water source. We have seen how drought affects those who depend on surface water and those who depend on groundwater differently. Those who depend of surface water, as an SRP manager explained, use historical information about streamflow in their planning; but since 1996 it has been so dry that they have had to change the approach they had previously been using. They also use information about snowpack to predict amount of streamflow; adding information about particulate matter can help them understand how fast it will melt. Those who depend on groundwater would like information about how much is available in their area in order to be able to plan. Those who depend on groundwater may also be affected by the 1980 Arizona Groundwater Code, which recognized the need to manage finite groundwater resources and designated five areas with heavy reliance on groundwater as Active Management Areas (AMAs). Discussion participants in Pinal County, which is in one of the AMAs, brought up several ways they are affected. These areas are required to develop progressively more rigorous management requirements for agricultural, municipal and industrial water users. In addition, the Modified Non-Per Capita Conservation Program requires large municipal water providers in AMAs to implement water conservation measures that result in water use efficiency in their service areas.

Most of the water resource planning strategies that participants discussed were aimed at water conservation or demand management at the individual or municipal level. They mentioned various ways that water providers and municipalities are encouraging water conservation through consumer education, local ordinances that regulate the amount of lawn or the types of plants allowed, or economic incentives to lower water use. Some municipalities have separate systems for drinking water and outside water to conserve more clean water for drinking water. Rainwater harvesting, using greywater for landscaping and flushing toilets, and low-water plumbing fixtures and appliances are encouraged. The use of purified sewer water is becoming more widespread. Payson in Gila County has one of the highest water conservation rates in the nation because they obtain much of their water supply in this way. Many golf courses have irrigation systems tied to their own weather data system, or use AZMET to schedule irrigation if they do not. They also have less area in fairway and more in the rough, which ids cactus and native plants. Landscaping with native plants was first promoted, and continues to be, in Arizona Cooperative Extension's Master Gardener Program. Many participants were already practicing these water conservation strategies in their own lives and would like to see them become more widespread.

Local government officials' climate- and weather-related planning focused on emergency management for droughts, floods, severe wind, and wildfire. Participants in Mohave County praised their system of flood control gauges, available online, improvements to roads in anticipation of stronger downpours, and well-trained county personnel who understood where and how specific weather events would affect the community. A Coconino County local government official noted that, "the [National] Weather Service has been very helpful in the area with our emergency operation centers. They've improved tremendously in the last couple years on how much they work together with us" (P6Coco); while a Pinal County emergency manager experienced being "inundated" with emails notifying him of weather alerts (P3Pi). Mohave and Pinal County participants appreciated the efforts of their Local Drought Impact Group (LDIG) to come up with a drought plan for their counties. The idea for an LDIG in each Arizona county initially came out of the Arizona Department of Water Resources in 2006, and envisioned that they would be coordinated by local representatives of Arizona Cooperative Extension and County Emergency Management and supported by ADWR's Drought Program. However, as a result of subsequent defunding of ADWR and lack of resources in ACE to carry out this "unfunded mandate," only two of the LDIGS have continued to function. In addition, emergency managers are challenged by drought planning in ways they are not by planning for other emergencies, as this emergency manager explained:

> I know when there's a flood, what to do. I can activate the plan. [Holding up draft of drought plan.] When do we activate this? When's the trigger point? I've got trigger points on everything; a Hazmat incident happens, chemical releases, I'm activated, I'm ready to roll. Tornado touches down in Eloy, okay, we know that's the trigger point. What's the trigger point for a drought? With the rains and everything else coming, what about the reverse side of this thing? What is the trigger point, when do we stop people from using water (P3P)?

Representatives of manufacturing and the construction industry also mentioned ways they can plan activities around short-term forecasts. A Pinal County resident pointed out that Frito-Lay, in his county, has gone to a significant reliance on solar. In addition, several participants mentioned the promise that the decreasing costs of green building hold for a construction industry that will build structures that are more appropriate for the climate.

However, with an apt analogy, one participant brought home the point that increased variability is making any kind of weather-and climate-related planning based on past conditions more difficult:

> When you're talking about projections, I relate it a lot to business. You know, a lot of your businessmen had to shorten their projection time. You used to be able to project five years, and ten years, where you'll be. So you put your business plan in place for that five year, ten year period, and you've had to come down quite a ways because the times are different. I think the weather is a lot the same the way here lately. You know, instead of a ten-year projection, you're doing five years, two and a half, and sometimes you're even doing thirty days, and sixty days, [because those longer windows used to be more stable]. The economy used to be more stable, you could project out, you know. I remember, I bought a business twenty-five years ago, and I projected what my sales would be with my business plan for five years down the road. And I was within five

> thousand dollars of that projection by the business plan I had put in place. You can't do that now. And so I relate that a lot to the weather because it's being so erratic and spotty like they're saying, bouncing around so much. I think you take the historical statistics to develop your plan, of course, but I think you have to be careful to plan or project too far down the road, because, I mean, it's just so erratic. And this year's proven it. This last five years have proven it weather-wise (P7Gr).

4.3.4 Local-scale approaches to climate change adaptation

Given the variability of the climate, the ongoing drought, the changes they have experienced, and their concerns about these, discussion participants had many suggestions about what could be done to live better with the climate and to live with climate change. Many are already putting these suggestions into practice in their own lives (as described in the previous section) and would like to see them become more widespread; many favored education to encourage this process, while others favored economic incentives or regulation. This observation highlights the difficulty of labeling adaptation as reactive or proactive. Other suggestions would require changes in tax structures, environmental regulations, or government policies to implement. Most of these suggestions are changes that could be made at a local scale, the scale that people feel they have the most control over and the most ability to change. Participants' suggestions provide a glimpse into how rural Arizonans are currently thinking about the types of changes they could make, or would like to be able to make, in their lives, communities, and immediate environment to adjust to the changing climatic conditions they are experiencing, while maintaining what they most value about living in this particular place: a thought process that can be seen as the first step in the process of human adaptation to climate change.

Most of the suggestions fall into two major categories – water conservation and education – and three less prominent categories: landscape restoration; local level planning, and broader institutional reform, with much overlap between categories. Since water was the climate-related topic that received the most attention, it is not surprising that the greatest number of suggestions fall into this category. Most frequently mentioned were ways to encourage home and business owners to use less water: including landscaping with native plants; water harvesting; low water use toilets; and recycling greywater. Also suggested were: increasing water rates and municipal laws that mandate water-conserving practices. Many of the suggestions in the first group are not difficult to implement and can be implemented by individuals, giving them a sense of efficacy when they do; while implementing suggestions in the second group requires collective effort and institutional coordination and change.

Educating people about how to live in this environment played a major role in people's thinking about what could be done, especially in light of the fact that so many Arizona residents have come from somewhere else. Education suggestions included educating people in all the water conservation practices mentioned above; basic education about climate and climate variability in Arizona, especially using historical and tree ring data to show climate variability in the past. Many participants suggested that Cooperative Extension would be an ideal venue for these types of education programs. Several participants pointed out that bringing up the potentially disruptive topic of "climate change" is not necessary: simply making it clear (for example, by using graphical displays) that here in Arizona temperatures have been rising, and that Arizona

was in a wet period in the 1980s and has now entered a dry period of indeterminate length, should be enough to make people understand the cause of some of the things they are seeing.

Farmers and ranchers suggested educating people, especially those from urban backgrounds, about the benefits of farming, ranching, and open space. One farmer described a recent experience he had to illustrate why this is necessary:

> One of the issues that we have when we all talk about rural Arizona, that means something completely different to y'all than it means to me. And one of the things just recently that I heard, years ago when we were plowing everything and we were working the ground because that's what we thought we needed to do, everybody worried about the dust. Now, for different reasons and for really good reasons, we're leaving a lot more trash, we're farming with more trash, and making a lot less trips over the fields most of the time. I'm paying guys now to go to my neighbors and clean up corn shucks that are blowing off my fields in these fifty mile an hour winds, because we leave them there to conserve moisture and to keep the dirt from blowing off the fields. The only place it blows off at our place are the roads. And there's nothing we can do about that short of watering 'em. Now I've got neighbors that are ready to lynch me because in their flower beds, and around the, you know, in their fences and that… I'm gonna end up fencing 640 acres to try to keep my corn shucks on my farm. And maybe I need to do that. I'm not saying I'm not somewhat at fault. But I've had this conversation with a couple of lovely little old ladies right across the road that just were gonna kill me. And as I tried to explain to them all the things that we're trying to do, I mean essentially most of the people, they don't want a farm there anymore. … Someday we won't farm because there's gonna be people that don't want us to farm, because we're using the water. But we're also feeding 142 people. Again it's a tradeoff. Because those people move out to rural Arizona because they like the skies, and they like the rains, they like all these things. My farm was there in the middle of nowhere. … Now I'm the bad guy, of course rightly so, we are pumping the water out, there is no doubt that we're all chasing water down. But it is, it's a dilemma. I look at it, yeah I'm making a living but I'm also feeding everyone at this table and a whole bunch of more people. … Everybody wants to eat; everybody wants to buy American, God love 'em, but the interesting thing is that the same people that move here, they don't like the motors, cause we're pumping water; they don't like us, they like to drive by and see the fields, but they don't want us farming. They don't like the dust. They don't like the weeds. They wanted to talk to the county about paving more roads. They want less taxes. They want more movie theaters. They want the ballet. This whole thing is like, what you wanna know is, "Why the hell don't you move back to Phoenix?" … I guarantee it, half of you here have different visions of what rural Arizona is. And I'm not sure they don't, I think they clash, a *lot*, in some respects (P17Coch).

In counties where wildfire is a major concern, participants suggested educating residents, especially new residents, about the risk of wildfire and the need for thinning and controlled burns to reduce it, and educating recreationists about forest closures due to fire danger, since public opposition to cutting trees, to smoke, and to closures is a significant factor constraining the use of these protective measures. Participants also suggested adding education about water issues, climate change, and the benefits of farming and ranching to school curricula.

Restoring forest health to reduce fire risk and increase productivity was the top suggestion in northern Arizona counties. While efforts are already underway, participants emphasized that they need to be on a much larger scale. In Cochise County, ranchers suggested recognizing the ecological value of floodwater patterns that have disrupted and attempting to restore them, as well as changing the property tax structure to incentivize restoring native grassland on former farmland where water rights were cancelled, and which is now used for grazing in order to retain the agricultural tax exemption. Several participants pointed out that many of the resource management problems facing us today are not because of climate change, although they may be exacerbated by it, but are often due to past management practices. While it would be helpful to understand the effects of climate, since we can't easily affect the climate, we can still work on what we can control. For example:

> I've got a comment or, maybe it's a question, or, maybe it's just a can of worms, but it's stuff that people assert is caused by climate change, I think is part of the reason that there's so many climate doubters, is there's so many assertions that, "Oh, that's because of climate change." And there's a lot of management issues that we deal with here, whether it's range management or forest management or maybe agricultural practices, that are part of the ecological history that probably may determine more of what we're seeing now than climate. … Climate is exacerbating it but only contributing a certain amount. There's still too many elk, not enough fire in the right places, or not enough fences, as an example (P7Coc).

> We can't affect the weather very well, we can't affect the climate, so we have to work on these other effects that we can control. And they're much more urgent today because of the drought than they would've been otherwise (P7Y).

A fourth category of suggestions involved local level planning. For example, Mojave County participants pointed out that their county did not have a county water plan, and felt it was a high priority. The Mohave County and Pinal County Local Drought Impact Groups are working to develop drought plans for their counties, but participants from counties that do not have active LDIGs suggested that their counties should be working on a drought plan. Disaster planning to meet changing conditions was also suggested. Mohave County has installed flood gauges, which can be monitored via the Internet, which will improve emergency flood response and reduce vulnerability to increased flash flooding due to more intense microbursts. Participants suggested enhancing this system with cameras and a siren system to give residents early warning of impending floods.

Many suggestions were offered for how ranchers could plan for a warmer and drier climate, including developing water sources to supplement rain-filled tanks, grass banking, and conservation easements. The following monolog illustrates how a rancher might think about adapting to changing conditions:

> Up at the climate workshop, one of the first speakers was [an agency scientist]. She did a good job presenting the science and I was thinking, "Well, okay, so it's gonna get hotter. We can accept that. So can we mitigate that?" And I thought, "Well we could mitigate that somewhat in rangeland environments and we could do some things like leaving more litter on the ground to help prevent as much evaporation." That's one

> thing we could do, one mitigation thing we could do. So I think we could deal with some of the temperature effects. But the precipitation, if we have a reduction in both temperature and precipitation, that would be much more difficult to mitigate. And I think the jury's still out on whether or not our precipitation is going to decline here. I think there's agreement based on science that more temperature is gonna cause more evaporation. Well then, let's look at ways we can address some of that evaporation on rangelands. What can we do? Are there some strategies that we can use? In certain pastures that we may have? Maybe if we have a pasture with that has a lot of south facing slopes that livestock could use, maybe we might use it a little differently than we have in the past. Maybe we don't want to make it so vulnerable to the effects of temperature. Maybe we use it at a different time of the year when it wouldn't be as risky for that. And maybe we use other pastures in a different time of year. You know? There's just lots of possibilities that people could think about if they really put their mind to it. And, things like we gotta create more forage out there, we gotta get the herbaceous more of an opportunity, so, you know, the thinning thing. We need to increase the production, maybe try to reduce some of the draw on moisture that trees are causing by getting them to more sustainable amounts. Because most of this country has just grown up so much. Trees. There's too many trees (P2iGi).

In this thought process, the rancher begins with the tools he already has and is able to use and tries to figure out new ways to use them to adjust to new conditions. Then his thinking broadens to consider new tools that could be used – in this case, thinning – but which he is unable to implement on his own, and requires coordination with a federal land management agency, and change within the agency.

A final category includes suggestions that would involve changing environmental regulations, government policies, or tax and rate structures to provide more management flexibility or more incentives for local level adaptations. Some of the suggestions already mentioned would require these types of changes. Additional suggestion in this category include making air and water quality regulations set at the national level more flexible, so they can take into account the fact that this region is a desert: therefore there will be increased particulates (PM-10: particulates of 10 micrometers or less) in the air and, since water flow is low, there will be increased concentrations (TMDL: Total Maximum Daily Load). Federal laws also limit the scale at which the 4FRI is able to implement forest restoration. Currently the Forest Service can only guarantee a ten-year contract. However, contractors taking on restoration at larger scales will need to take out large loans, for which lending institutions require longer contracts. For the Forest Service to be able to offer longer contracts would, "take special legislation out of Congress to allow the agency to do that" (P3NA). Actions that participants suggested are also constrained by state regulations, for example: "Sewage rules in Arizona are written and administered by people that work in tall buildings in Phoenix. And it's real difficult to get them to understand what's happening in [rural areas]" (P5Gi).

Several other suggestions that do not fall into these categories include producing more solar energy, although participants expressed concern about how much water concentrated solar power projects use; and green building or building houses the way they used to in the region, although participants expressed concern about the expense.

4.3.5 Challenges to adaptation

Participants also discussed a number of challenges to their suggestions for what to do in the face of prolonged drought and changing climatic conditions. One challenge is what several participants referred to as "human nature." One aspect of "human nature" is that people don't like to change. This aspect is reflected in statements such as:

> People very strongly want to do what they've always done. And the answer you must hear, and that I hear as well, the, 'We've been doing this for a hundred years, it's never been a problem!' And that's very hard to overcome. … All of us have a vested interest in maintaining the way things are right now, and people, all of us, don't willingly embrace changes that are going to decrease the things that we now take for granted and enjoy. And that's a very hard sell. … I mean it's the same thing that just pervades all aspects of the way we live, and govern (P8Y).

Participants also felt that Westerners, Arizonans even more so, and rural Arizonans in particular, have an "independent mindset" (P1NA), and don't like being told what to do, especially on their private property, and are likely to resist regulation.

Another challenge is that the whole topic of climate change is controversial. As noted above, several participants agreed that it is not necessary to bring up "climate change" or "global warming" to motivate people to change their behavior; they just need a better understanding of the variability of climate in Arizona. Others were concerned that this approach would lead to inaction:

> If you can believe that it's not anthropogenic, then you don't have to make any changes, this is just a cyclic thing, and we don't have to worry about it. And, I think that's not really the case, but I think that's the rationale you would get. We have a problem that we've generated ourselves, and continue to generate, and that we're going to continue to make worse over the long term. And I think the sooner we all understand that, the better off we're going to be. But we can't begin to try to deal with the problem if we refuse to, if we deny it (P8Y).

Not only is the topic of "climate change" controversial, it can also be overwhelming, as the following statements illustrate:

> I think it does help to have a distinction between natural climate variability and then, you throw climate change in on that, but whenever I talk about climate change, I feel helpless. It's like, I can't do anything about it. It's a summation of all of humans' efforts and the earth as well. I mean, the Earth's climate's been changing since there's been an earth. So, I really think we do better when we focus on natural variability (P5NA).

> I think there's a very large part of the population that is so busy with the day-to-day things of living, that they're all forty year olds who are raising families and trying to do a job, make it work for them, and that takes everything they've got. And, I know I think back to when I was at that age, and golly, there were certainly interesting political things going on, I just didn't have time to be concerned. … You know, raising kids, and trying to be successful in a job takes all you got. And so it's very hard to reach that part of the population (P8Y).

A major challenge for rural Arizonans in adjusting to changing climatic conditions that came up in the discussions is what we refer to as issues of scale, both physical and temporal. As the previous discussion has made clear, participants felt that the actions they would like to take, which are informed by their experience and understanding of the specific place they live, are constrained by regulations and policies made at the national or state level, and from the perspective of the urban majority, which do not make sense in the context of their lives.

Issues of scale also include actions that need to be taken at a broader scales than participants feel they have the ability to influence. For example, participants pointed out that the scale of restoration needed for the 4FRI is by economic factors such as the lack of facilities to process the biomass that would be removed, the lack of a market for it, and the length of contracts needed. They also mentioned the fragmentation of land ownership, which is another large scale issue facing forest and rangeland restoration projects. The intermingling of federal land, both Forest Service and Bureau of Land Management, state land, private land, and Indian reservation land, governed and managed in different ways, makes it difficult to take advantage of the efficiencies gained by increasing the scale of restoration to landscape and watershed levels.
A temporal scale issue is brought up in the following statement: while we have some ideas about how to move forward under changing climatic conditions, what do we about the legacy we have inherited from the past, not only in terms of land management practices, but also in terms of the construction industry?

> And you know, if education is one piece, and policy is another piece, and incentives for doing the right thing is another piece, how do you get the person that's living in a stick frame house with two-by-four stud walls and R-11 or R-9 insulation, that's running their air conditioning unit nine months out of the year, twenty-four hours a day, and drawing off the grid, how do you somehow create an industry that goes back in and retrofits these houses with twelve inch wall (P15Coch)?

In addition, as we have seen, the temporal scale of climate variability and change poses a challenge for planners who typically work with knowledge of conditions over the last thirty or forty years, and for ordinary people whose concerns about the future may be shaped by extreme weather events in the past. A Graham County participant explained how thinking in his community has been shaped by big floods in the past:

> All I have to say is, our community mentality's been framed by floods. Because you had five or six floods from the early seventies to the mid-nineties, and a lot of our thinking was framed by what are we going to do on the next flood. And a lot of our thinking's still is framed by when we're going to get another flood. But what we're living in is probably the rule rather than the exception now. It's probably going to be this dry for a long time and floods are going to be rather few and far between. Oh-five really wasn't a flood, we had eleven thousand cfs in the valley. That's nothing compared to, like I said, eighty-three was a hundred and thirty-two thousand. Ninety-three was eighty-seven thousand. The big water in oh-five, well that was nothing compared to what it was. But our thinking is framed, the adults grew up in that period, "Well it's always going to rain, it's going to flood." I don't think that's the case. … Our thinking is still not there yet in terms of how we manage our resources in our community (P1GR).

This statement also suggests that, similar to the adaptation story told by the woman who moved to Arizona from the Midwest, in which she had to go through a "mind shift" to adjust her "perspective from a different location" to living in Arizona, longtime Arizona residents, and even whole communities, may have to go through a "mind shift" to adjust their perspective from a different time to living in a changing climate. Like her, rural Arizonans are still in "the learning curve," but unlike her, they have no guides to point the way.

Finally, throughout the discussions participants indicated that trying to meet their needs for weather and climate information using existing Internet websites presented a major challenge because the websites are poorly organized, difficult to use and understand, and not user-friendly. In the words of one participant, they are "designed for the guys that designed 'em, or they're designed for guys who've had training." They want "just the basic climate data, weather data," "simple stuff," localized for their area, "simply laid out" (P1Coco), and all in one place. They are not asking for new types of information, for downscaled, long-term climate projections for their region, but to have information that helps with day-to-day planning, and which is already available, be more accessible. While other studies have informed NOAA of these needs (e.g. Vásquez-León et al. 2002), the efforts the agency has made to improve the usability of their website have apparently been unsuccessful.

4.3.6 Supporting adaptation in rural communities

In section 4.3 we have presented the process of adaptation to climate change from the point of view of rural Arizonans. The discussion illuminates the ways that they are constantly adjusting to climate variability in their daily lives, currently adjusting to the changes they are experiencing, and positioning themselves to adapt to these changes if they turn out to be long lasting. In light of this analysis, we suggest that the definition of adaptation to climate change given by Pelling (2011: 39) is more useful than that given by the IPCC: "the process through which an actor is able to reflect upon and enact change in root and proximate causes of risk." This understanding of adaptation to climate change approaches it from the bottom up, rather than at a systems level. It recognizes the role of human agency and ingenuity in "human systems" and is more conducive to generating support for local level initiatives than to imposing direction from higher levels. Smit and Wandel (2006) argue that this bottom-up approach to adaptation analysis is needed to develop "practical adaptation initiatives" that take into account local understandings of vulnerability and adaptive capacity, local experience and knowledge, and local decision making processes.

In addition, using ethnographic methods for climate assessment and adaptation analysis provides a real-time view into the process of human adaptation to climate change, and will contribute to developing a better theoretical understanding of the process. In this case study, we begin to understand how rural Arizonans who live in an arid climate of extreme background variability experience the climate, what is "normal" for them, how they detect change from "normal," and, if they are impacted by the change, how they begin to think about what to do. We see how they first make changes in their own lives that are relatively easy and cost-free to implement. They are also win-win: even if the climate doesn't get hotter and drier, they will be better off and better able to "live with the climate." Arizona Cooperative Extension supports "living with the climate" with program such as Firewise, Waterwise, and Master Gardeners.

As conditions persist rural residents are beginning to think about how to makes changes at broader scales, which are more costly and difficult to implement. Because they are used to so much variability in the climate, they are generally cautious about assuming the changes they are experiencing will be permanent. However, in this analysis we can see them beginning to consider the need for long-term adaptation options. Rural decision-makers do not have the financial and engineering resources of managers of large-scale urban systems; their caution may also be motivated by a desire to build more confidence in a "new normal" before committing what resources they have. Meanwhile, the water conservation, local planning, restoration activities, and other adjustments they are making to better "live with the climate" also reduce vulnerability to climate change.

Removing some of the roadblocks to broader scale adaptation activities suggested by discussion group participants would remove some of the cost and difficulty and allow them to proceed even without high confidence in the permanence of climate change. This might include providing financial and technical support to expand local adaptation initiatives and Extension programs; changing tax and rate structures to encourage local adaptation initiatives; and building more flexibility into regulations and policies made at the national or state level, and from the perspective of the urban majority, to allow more flexibility for local adaptations.

5. Conclusions

This report contributes to the National Climate Assessment in three major ways: 1) It provides a case study illustrating climate change-related issues faced by rural residents in Arizona, their approaches to adaptation, and the main challenges to adaptation they face; 2) It describes a methodology that can be used to incorporate qualitative research into an ongoing, consistent, national-scale consistent and replicable approach to climate assessment, and; 3) It assesses the capacity of Arizona Cooperative Extension as a partner network that can extend the NCA process and products to rural audiences and the role that ACE could play in facilitating adaptation to climate change, and more generally suggests how Cooperative Extension nationwide could fulfill these roles.

5.1 Results of the case study

Rural Arizonans are highly attuned to weather and climate in their daily lives, aware of changes in the climate, and concerned about the impact these changes will have on their lives and livelihoods, their communities, and their local environment. While the concept of climate change, as it has been framed by the dominant discourse, which includes human causation, apocalyptic future scenarios, and the need for immediate government action to address it, may not be widely accepted among study participants, the fact that the climate is changing is. Overall, the weather- and climate related topics that are most significant to rural Arizonans are water (how to use it wisely) and rain (e.g. whether it will rain, where it rained, how much it has rained, and how rain patterns have changed), but they are most concerned about drought and wildfire. However, their interests and concerns are shaped by geographic location, current

weather conditions, recent or remembered extreme weather events, knowledge of conditions in the past, length of residence, and occupation. In higher-elevation, forested regions of northern Arizona residents are most concerned about wildfire; while in southern Arizona rural residents are most concerned about drought.

Weather and climate impact different types of rural Arizona residents, such as ranchers, farmers, horticulturists, water managers, resource managers, and emergency managers differently. Thus, they will also be differentially impacted by the changes they have observed in rainfall patterns, increased variability, and temperature. They have devised ways to deal with current climate variability and extremes, but are challenged in different ways as these change. Ranchers are most impacted by drought, and while they have developed ways to operate in an arid and highly variable bimodal climate which enable them to withstand the loss of one of two growing seasons, they expressed concerned about the changes they have seen and the potential for more frequent and prolonged droughts, which would challenge their current adaptive capacity. Some ranchers who participated in the discussions are beginning to experiment with new strategies, such as solar water pumps and new varieties of plants.

Agriculture accounts for the vast majority of water use in Arizona. Colby and Frisvold (2011) point out that, thus far, management of the Colorado has proven resilient in the face of drought because of its large storage capacity, but climate change will put this resilience to the test. Although none of the farmers who participated in the discussion groups were Colorado irrigators, their irrigation arrangements also appear to have buffered them sufficiently from drought so far. Nevertheless, they still employ many water-conserving strategies. They are aware of public perceptions of them as "the bad guy" because they are heavy water users, and they are concerned that their irrigation water supplies are threatened by urban expansion and environmental programs. Farmers expressed more concern about extreme weather events, which may become more frequent with climate change in the region. Cotton farmers have experienced a shift in the growing season and have moved their planting later in response. Despite this, they were affected by a cold and windy spring in 2011 and many had to replant. However, they did not perceive these changes to be a threat to their operation at this point. Horticulturists and home gardeners, who do not have inexpensive irrigation water, are more concerned about drought. In southern Arizona they were highly impacted by the big freeze in early February 2011, and are concerned that extremes of heat and cold that can kill both native and non-native perennials might become more common.

Water managers work within a highly engineered and complex water management system in Arizona that has developed unsystematically over time to encourage agricultural development and meet the water demands of a rapidly expanding population in an arid climate (Reisner 1993; Sheridan 1995; Worster 1985). The managers of large scale municipal delivery systems who participated in the discussion groups did not express much concern about the effects that drought or climate change would have on their systems. SRP was "planning for dry," but like the Colorado system, appears to be resilient to drought so far. However, managers of smaller scale municipal water systems based on surface water were concerned about how the current drought would affect their water supply if it continues. In areas dependent on groundwater, where there is already concern about lowering water tables, participants were further concerned about the effect of drought and climate change on their groundwater supplies. As water users, participants

in all of the discussion groups, and from all occupations represented, practice water conservation strategies and encourage their further expansion and development.

Forest managers are operating in more of a crisis mode as a result of recent large-scale beetle infestations and wildfires in which the ongoing drought plays a significant role. More than any other group who participated in the discussions they are revising their way of thinking about management to address these issues, and are concerned that climate change may exacerbate the problems they are facing.

Local government officials and emergency managers have developed plans for responding to weather- and climate-related emergencies, such as floods, severe winds, and wildfire. However, they are challenged by planning for drought and for the water shortages that may ensue.

In addition to these groups, there are many Arizonans who live in rural areas for the quality of life it offers. They, as well as members of these groups, will be affected if the climate they consider an amenity and the places and the landscapes they have grown attached to change. These emotional attachments play a significant role in how rural residents adapt to a changing climate and landscape, however, they are more difficult to investigate and understand than the issues brought up in this discussion.

Rural Arizonans are constantly adjusting to climate variability in their daily lives, currently adjusting to the changes they are experiencing, and positioning themselves to adapt to these changes if they turn out to be long lasting. Factors that impede local adaptation initiatives include: lack of confidence that climate change is permanent; lack of resources; and structural barriers such as environmental regulations, government policies, and tax and rate structures that do not allow needed flexibility at the local level.

5.2 Utilizing qualitative methods for ongoing assessments

The methodology we developed for this study can be used to incorporate qualitative research into an ongoing, consistent, national-scale consistent and replicable approach to climate assessment. We suggest that climate assessment should incorporate some ethnographic research to "ground truth" scientific findings on the effects of climate change in a particular region and to identify practical adaptation initiatives. While ethnographic research is often seen as time consuming, costly, and difficult to replicate, by working through Cooperative Extension, we have been able to develop a replicable method that can be implemented by a small team, over a relatively short period of time and a large geographic scale. This method could be used to do ethnographic climate assessment research in a subset of states for each National Assessment cycle. Successive rounds of research will provide insight into how local experiences and perceptions of climate change and its impacts, and adaptation strategies, are changing.

5.3 The role of Cooperative Extension

University of Arizona Cooperative Extension is uniquely positioned to be a partner network that can extend the NCA process and products to rural audiences and facilitate adaptation to climate change in rural Arizona. This study has demonstrated some of the characteristics that equip it for these roles. First, university-trained Extension agents based in each county statewide have developed knowledge of local conditions and local concerns and ongoing relationships with rural residents which can facilitate replicable approaches to climate assessment, communication of climate science, and the development of practical adaptation initiatives that will help residents adapt to climate change. With their help, we were able to organize productive group discussions with a representative group of participants in nine of Arizona's fifteen counties in a short period of time. A local government official who participated in one of the discussion groups explained this capability of Extension this way:

> Cooperative Extension service is a bridge, it's a link. The people we know, people that live here, work here, on a long-term basis, and the fact that they help bring this together, and put this symposium together, and are going to duplicate it in other parts of the state, that's exactly one of the strengths of Cooperative Extension service (P10Pi).

To ensure its continuing ability to facilitate climate assessment on an ongoing basis, more support for UACE would be needed. Nationwide Cooperative Extension has lost much of the regular federal and state funding it has traditionally relied on for support. Meanwhile, UACE's unique capacity to connect with rural audiences has subjected county Extension agents to "unfunded mandates," which place further strain their already over-stretched capacity. As a partner in the U.S. Global Change Research Program and the federal home of Cooperative Extension, the Department of Agriculture could provide funding for this purpose.

Second, the raison d'etre of Cooperative Extension is to connect scientific knowledge developed at state land grant universities with people who can use it. Cooperative Extension has been identified as exemplary of a "boundary organization" that helps negotiate the boundary between science and decision making and which has definite responsibility and accountability to both sides of the boundary (Cash 2001). In addition, many studies have shown that Cooperative Extension is the most trusted source of information in rural areas (e.g. Fernandez-Gimenez et al. 2005, Iowa farmers). According to one Extension agent, one reason Cooperative Extension is it "does not have an axe to grind. They're not paid to have a position. They are totally independent. So people can trust us for nonbiased information" (P1Pi). This uniquely positions Cooperative Extension to extend NCA products to rural audiences.

Third, because of its flexible institutional structure, UACE is able to recognize and rapidly respond to emerging issues in rural communities. As one county Extension agent explained:

> Extension's strength is its flexibility. We've always been able to shift direction on a turn of a time. As long as the resources are there to support and sustain those kinds of things. Our life blood is being able to see new issues coming along and to adapt quickly to meet those issues. That's why Extension is so valuable. Because there is not anybody else that can do that. Why are we the only ones that can do that? Well, number one is that our mission is to address the issues, the big needs in the county. So we are focused on small areas. Well, they're not that small in Arizona. But we have a certain framed area of target that we're aiming at. Someone who is on a national level, they have to have a broad brush. We can be very specific, we can focus on the

> community needs. And every community has a different need. Another reason is because we have a flexible mission. Our objective is to identify. We are rewarded on identifying new issues and moving forward into those issues, taking initiative. And not everybody has that flexibility. Most government agencies are focused on very tight parameter of areas that they focus on: NRCS; Farm Service Agency is another; county government is more focused on non-agriculture issues. In fact they see us as their action arm on addressing issues. You look at private corporations which are in it for the profit, a lot of times in these small issues there's no profit in it. So they have no interest. Small companies or 501c3s may have an interest in a particular issue but they don't have the capacity or the focus or the desire even to incorporate the big picture; they're very focused on the delivery. I don't see anybody else in the county, I don't see anybody else in the state, I don't see anybody else in the nation that has the flexibility that Cooperative Extension does to meet changing issues. In a quick, and very efficient, way (P1Pi).

As a result, UACE was able to identify a need for programs like Firewise, the White Mountain Stewardship Group, Waterwise, Reading the Range, Master Watershed Stewards, and native landscaping with Master Gardeners, and implement them. These programs were not specifically designed to help rural resident adapt to climate change; rather they respond to residents' desire to learn how to better "live with the climate," thereby reducing vulnerability to climate change. To be more effective as local adaptation strategies, these programs need more support.

Cooperative Extension in other states has initiated climate change assessment research, offering further evidence of the capacity of Cooperative Extension to be a partner network that can extend the NCA process and products to rural audiences and facilitate adaptation to climate change in the rural U.S. Some examples include: a needs assessment conducted by Creighton et al. (2011) to determine the perceptions, understandings, and educational needs of private forest landowners in the Pacific and Inland Northwest regarding the impacts of climate change on western forests; and an interdisciplinary study by California Cooperative Extension designed to help Yolo County farmers plan for climate change (Haden and Jackson 2011).

Every U.S. state and territory has a land-grant university with a state Extension office and a network of county or regional offices. In addition to the Extension programs that discussion participants brought up, nationwide Cooperative Extension also provides program that address economics and community development, youth and families, and food, nutrition, and health. Nationwide Cooperative Extension shares the above characteristics, and with sufficient support, would be an invaluable partner network in extending the NCA process and products to rural audiences and facilitating practical adaptation initiatives at the local level nationwide.

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Figures

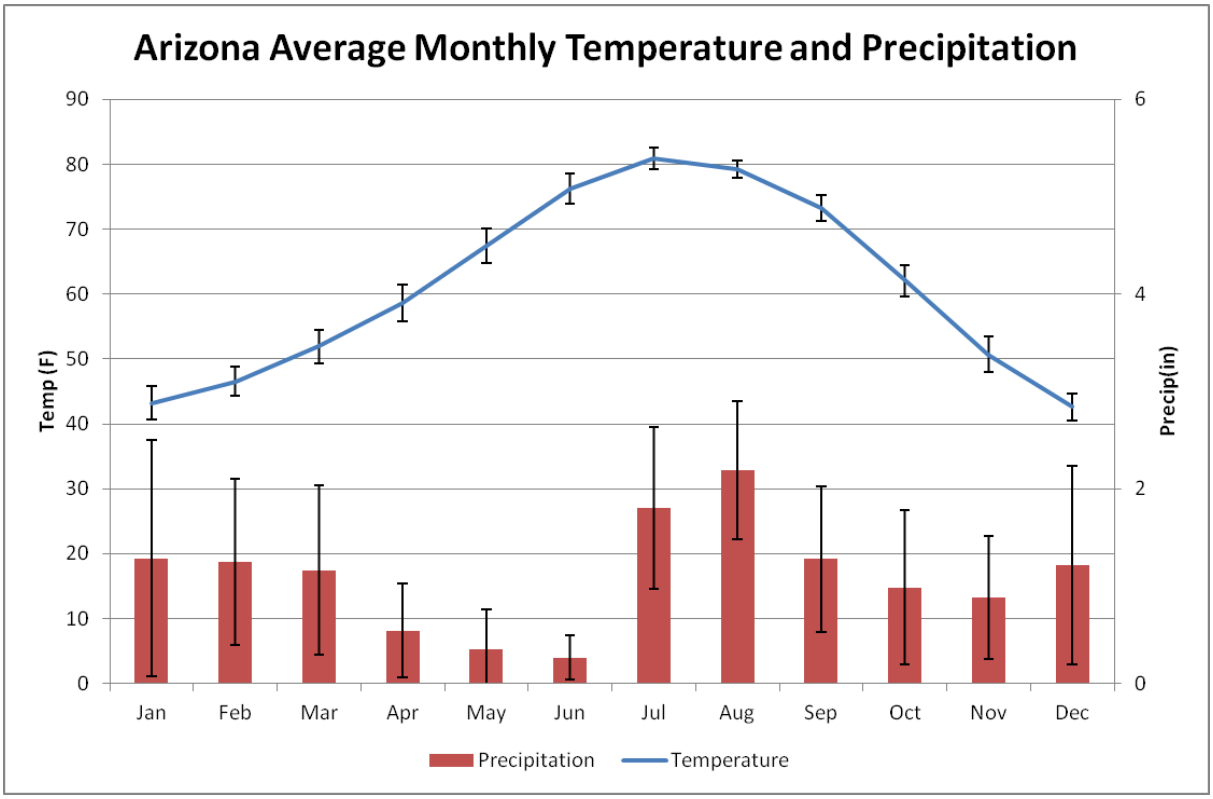

Figure 1. Average monthly temperature and precipitation for the state of Arizona (error bars indicate one standard deviation). Data source: PRISM Climate Group, Oregon State University.

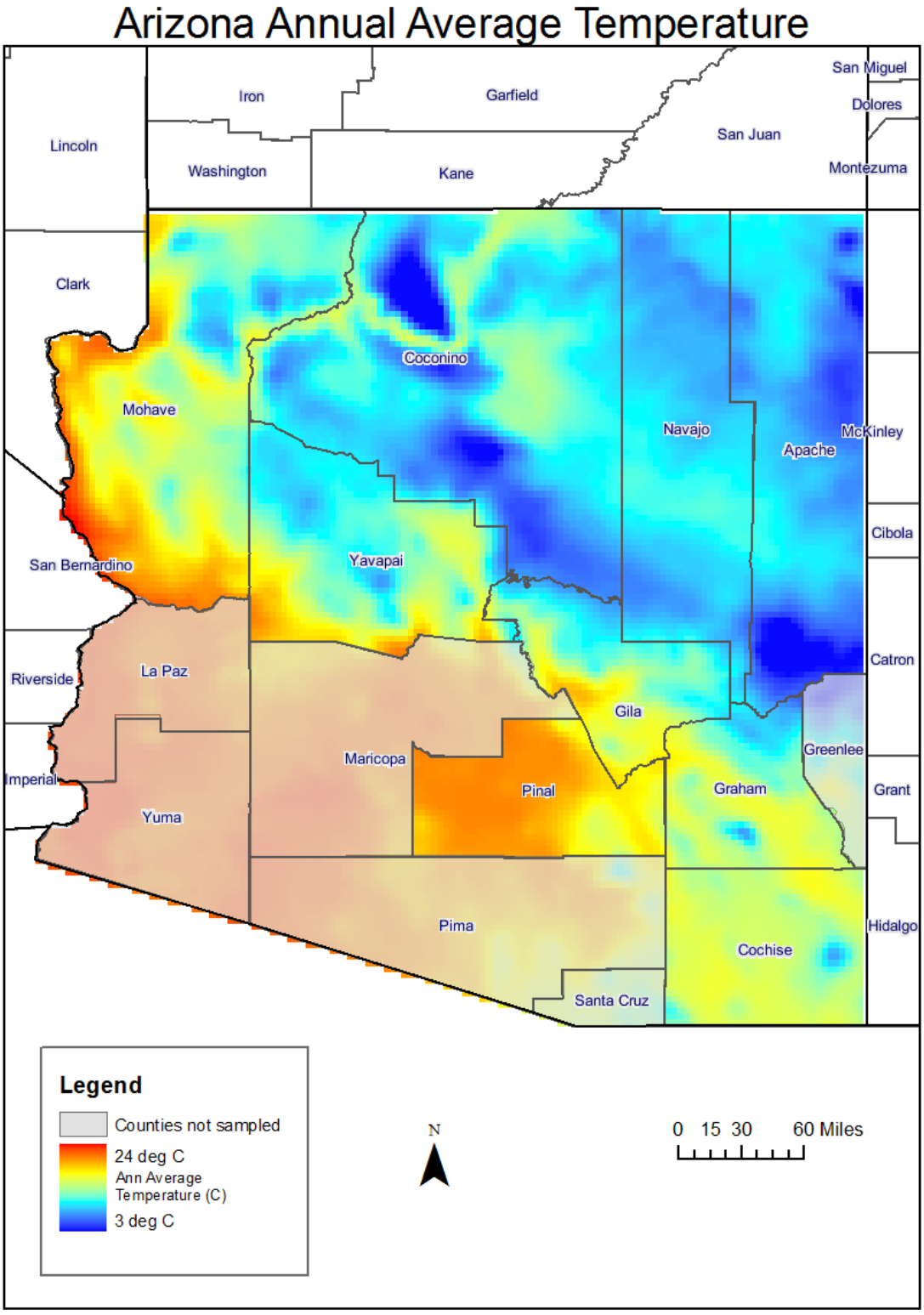

Figure 2. Long-term annual average temperature across Arizona depicted using 4km PRISM climate data (Data source: PRISM Climate Group, Oregon State University)

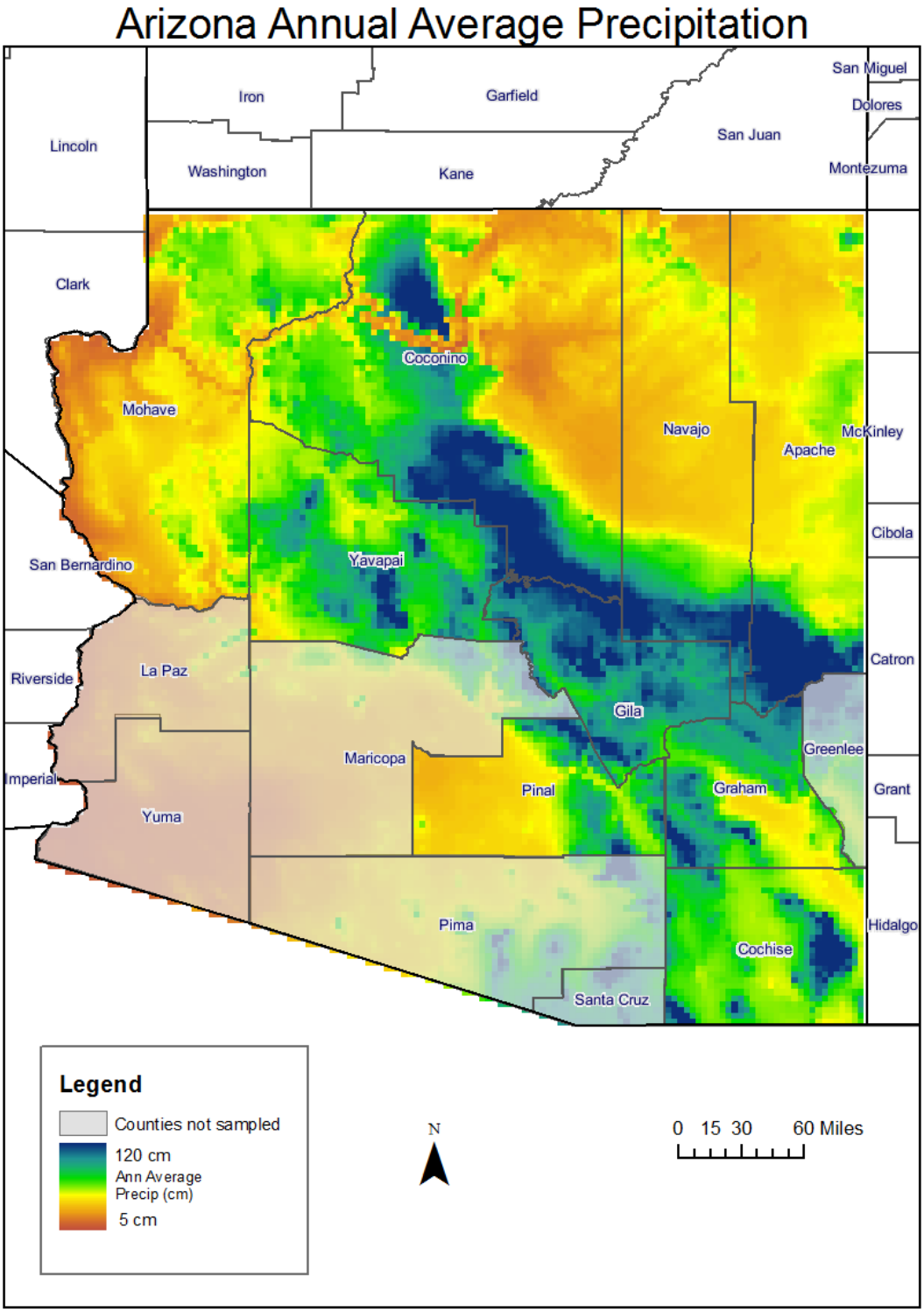

Figure 3. Long-term annual average total precipitation across Arizona depicted using 4km PRISM climate data (Data source: PRISM Climate Group, Oregon State University)

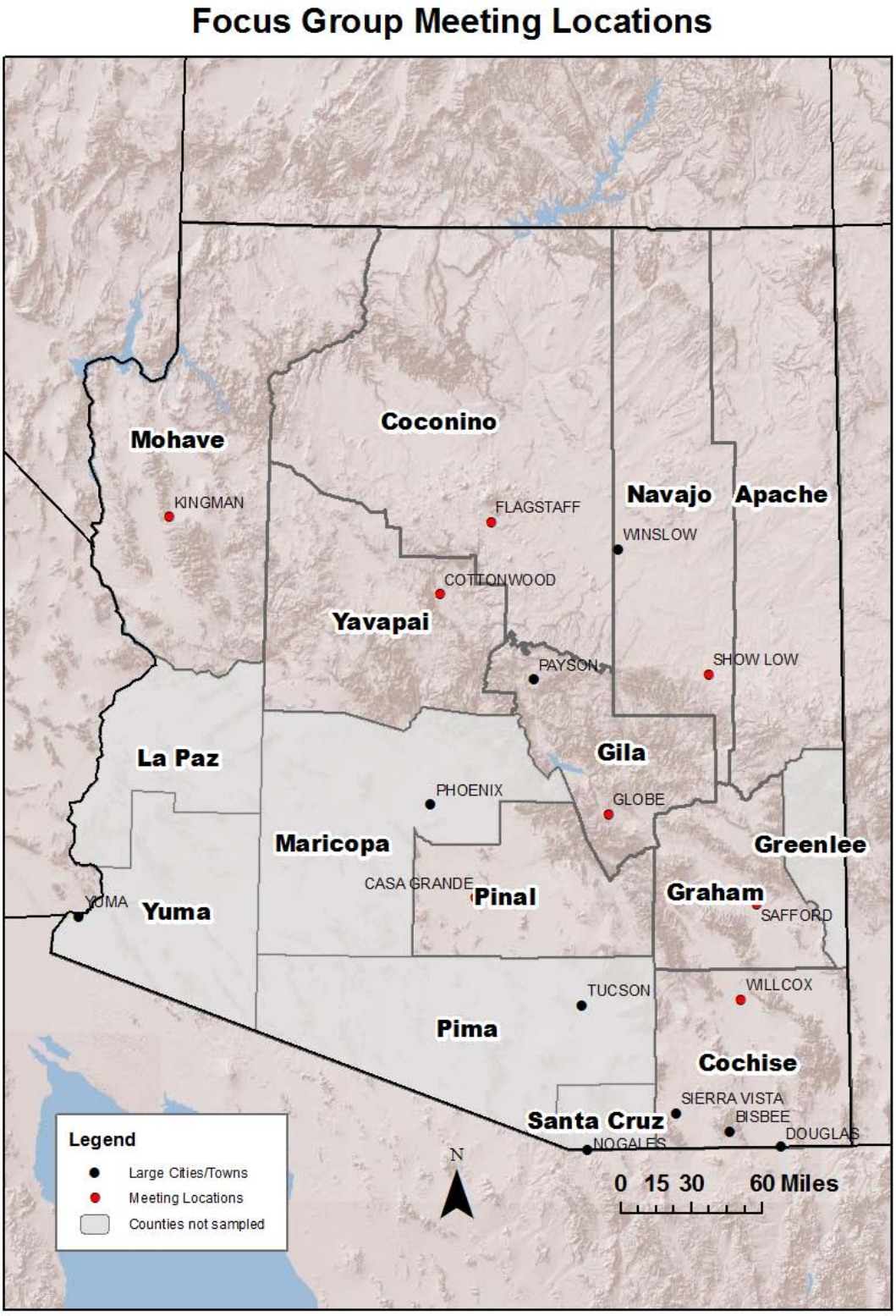

Figure 4. Meeting locations and major cities across Arizona (shading indicated topographic relief).

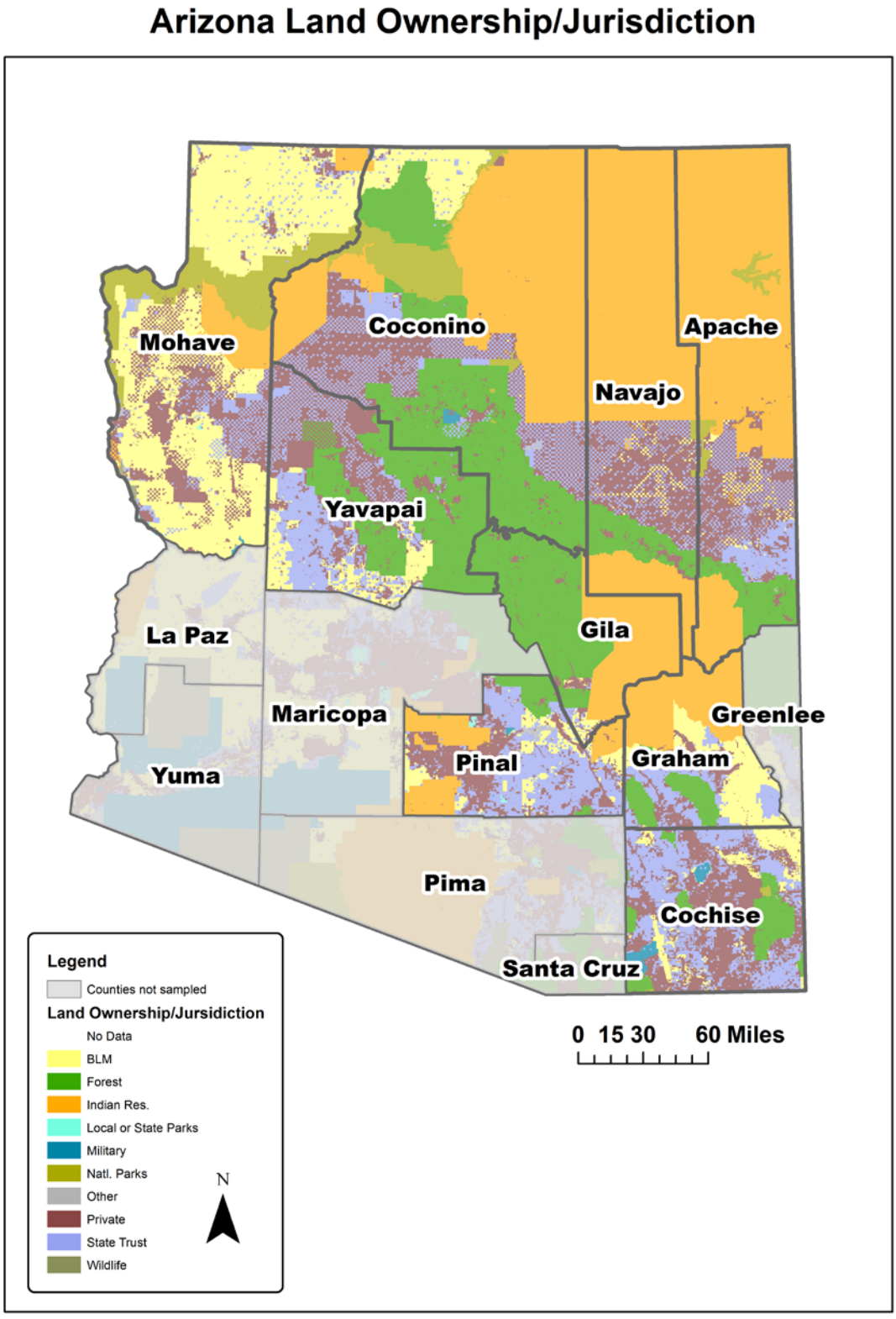

Figure 5. Land ownership and management jurisdictions across Arizona
(data: Southern Arizona Data Services Program, http://sdrsnet.srnr.arizona.edu/)

Figure 6. Land cover and land use across Arizona depicted using the 2006 National Land Cover Dataset (Data source: 2006 NLCD provided by U.S. Geological Survey, *http://www.mrlc.gov)*

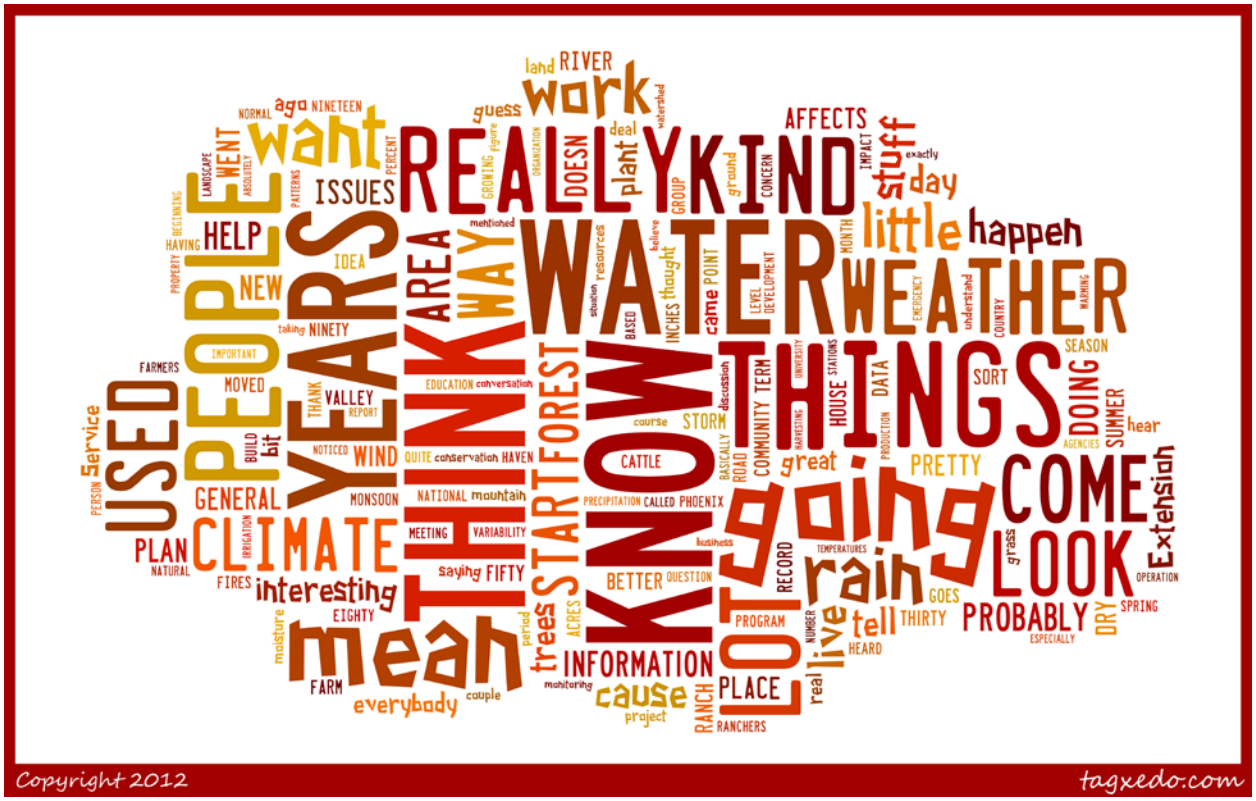

Figure 7: Word cloud representing most frequently used words in all discussions combined

Figure 8: Effect of thinning along Highway 260 in Navajo County (Photo by Steve Campbell)

Tables

Physical geography	Geographic boundaries Area Main population centers and transportation routes Elevation Average annual temperature Average annual precipitation Land ownership Land use Water supply USDA ERS Natural amenities rating
Demographic profile	Population Population density Population change Gender structure Age structure Racial and ethnic groups Education level
Economic profile	Per capita income Median family income Mean family income % home ownership % employment in agriculture, government, manufacturing, and services % unemployment % population below poverty leve % families below poverty line Number of farms (includes ranches) % land in farms (includes ranches) Ave. value of agricultural products sold
Characteristics	Verbal description with distinguishing characteristics Main concerns of residents
Discussion group	Date Location Elevation, average annual temperature and rainfall at that location Composition Most frequent weather- and climate-related words

Table 1: List of county indicators

Group by occupation	**Number of participants**
Ranching	11
Farming	7
Horticulture/Master Gardeners	5
Water managers	9
Emergency managers	4
Local government (city and county)	11
State agencies	2
Federal agencies	6
Environmental/conservation organizations	3
Cooperative Extension	26
Group by length of residence	
Lifetime and multi-generational residents	18
Longtime residents (20 years or more)	36
Residents (2 months-19 years)	34
Total number of participants	88

Table 2: Number of participants by group (some participants belong to more than one group).

Opening question	"Let's begin by going around the table and having each person give your name, tell us what you do, and explain one way that weather or climate affects your work or daily life, or that of people in the county, either in a positive or negative way."
Continuing questions	"Can you tell us any stories about when these things happened?" Prompt from pool of responses to first question and from list of events that [name of climate scientist] will supply: drought, flood, wind, good summer. E.g. "What about floods?" "When have floods happened?" "What did you do?" "Have you seen changes in weather patterns or frequency of events in the time you lived here or heard stories about how things used to be different?" "How have these changes affected you?" "What kind of planning do you do for these types of events?" "What would help you adjust to the changes you are experiencing?" "What role could Extension play in helping you plan or respond?"

Table 3: Discussion group guiding questions and prompts

County	Location	Elevation in feet	Average annual temperature in degrees Fahrenheit	Average annual precipitation in inches
Cochise	Douglas	4,006	62.4	14.2
Coconino	Flagstaff	7,000	46.0	21.35
Gila	Globe	3,510	62.2	15.90
Graham	Safford (Solomon)	2,917	63.9	9.02
Mohave	Kingman	3,333	61.6	10.35
Navajo-Apache	Show Low	6,347	50.4	16.42
Pinal	Casa Grande	1,398	70.2	8.39
Yavapai	Cottonwood	3,314	61.7	11.84

Table 4: Location and climatic conditions where discussions were held
(Data source: Western Regional Climate Center)

	Apache	Cochise	Coconino	Gila	Graham	Mohave	Navajo	Pinal	Yavapai	Arizona	US
Physical geography indicators											
Area in sq. miles	11,218	6,219	18,661	4,796	4,641	13,470	9,959	5,374	8,128	113,998	3,794,080
USDA ERS Natural Amenities rating	1-2	>3	2-3	>3	2-3	2-3	0-1	1-2	2-3		
Demographic indicators											
Population	71,518	131,346	134,421	53,597	37,220	200,186	107,449	375,770	211,033	6,392,017	308,745,538
Population density	6.39	21.30	7.22	11.27	8.06	15.04	10.80	106.71	25.98		
% population change 1990-2000	12.7	20.6	20.4	27.6	26.1	65.8	25.5	54.5	55.5		
% population change 2000-2010	3.0	11.6	15.6	4.5	11.2	29.2	10.3	109.4	26.1		
Median age	31.3	39.7	30.6	47.9	31.6	47.6	34.7	35.3	49.2	35.9	37.2
Largest racial groups by %	Native American 72.9; White 23.3	White 78.5; Other 9.9	White 61.7; Native American 27.3	White 76.8; Native American 14.8	White 72.1; Native American 14.4	White 86.9; Other 6.0	White 49.3; Native American 43.4	White 96.7; Other 11.5	White 97.5; Other 4.9	White 73.0; Other 11.9	White 72.4; Black 12.6
Hispanic or Latino ethnicity	5.8	32.4	13.5	17.9	30.4	14.8	10.8	28.5	13.6	29.6	16.3
% high school graduate or higher	73.5	86.5	85.7	85.3	83.5	85.3	82.0	83.5	89.0	85.6	85.6
% college graduate or higher	11.8	21.8	31.3	28.0	12.4	12.6	16.6	16.5	21.6	25.9	28.2
Economic indicators											
Median family income	30,744	50,873	42,130	38,315	42,152	42,582	46,743	50,110	40,274	46,789	60,609
Mean family income	39,165	61,380	55,948	48,316	50,461	55,737	55,756	57,569	52,112	62,838	79,338
% of homes owned	76.40	70.08	60.93	77.81	71.03	71.72	73.51	77.37	73.66		
% employed in agriculture	3.85	3.21	1.53	9.10	14.75	0.59	3.18	3.84	2.85		
% employed in government	11.97	15.14	6.73	10.15	10.31	5.44	9.42	7.94	4.41		
% employed in manufacturing	1.66	3.59	6.96	3.89	2.73	6.59	3.32	10.36	6.43		
% employed in services	55.73	52.71	57.20	49.18	44.80	55.43	50.73	47.66	54.15		
% unemployed	25.3	10.6	12.3	7.6	9.6	14.9	16.6	14.9	9.9	11.8	10.8
% populationbelow poverty level	34.2	16.0	25.9	18.6	19.6	17.7	27.6	13.7	19.2	17.4	15.3
% families below poverty level	30.0	11.1	17.0	10.8	16.3	12.0	22.1	8.8	12.5	12.5	11.3
Number of farms (2007)	4,243	1,065	1,597	279	343	334	2,949	785	756		
% land in farms (2007)	0.0	20.9	51.2	38.3	45.5	10.1	70.7	30.5	12.3	35.9	
Ave. value of agricultural products sold (2007)	2,975	109,981	no data	15,748	no data	55,783	15,779	1,018,867	no data		

Table 5: Socioeconomic indicators by county (Data sources: US Census Bureau; USDA Economic Research Service)

Current Events during study period (April-September 2011)	**Date**	**Overview**
Ongoing drought conditions	1999-present	Much of Arizona has been gripped in drought since 1999; drought conditions were intensifying across the region in the spring of 2011 due to a strong La Nina and record dry conditions across southern Arizona
Extreme cold event	February 3rd, 2011	A very cold arctic air mass settled into Arizona at the beginning of February allowing temperatures to plunge well below zero across all of Arizona. Many locations experienced their coldest temperatures in over 40 years, causing widespread infrastructure problems with freezing water pipes.
Large dust storm event/haboob	July 5th, 2011	A large dust storm (haboob) fueled by thunderstorm winds engulfed much of metropolitan Phoenix during the early evening hours of July 5th, 2011. This event was widely covered by news organizations and broadcast all over the world.
Monsoon season	July-August 2011	The 2011 Monsoon season (Jul-Aug) was exceptionally warm with highly variable amounts of precipitation across the state. Most locations observed below average seasonal precipitation totals.
Wallow Wildfire	May-June 2011	The largest wildfire event in the history of Arizona started on May 29th in the Apache-Sitegreaves Forest. It burned for several weeks eventually consuming over 500,000 acres of land.
Past Events		
'Dust Bowl'	1930's	Participants noted that family members discussed the impact of the 1930's Dust Bowl era on local activities. The epicenter of the impact of this event was in the central plains, but a severe drought in 1934 did extend into Arizona.
'50's Drought'	1950's	A string of dry winter associated with La Niña conditions in the Pacific Ocean brought widespread drought conditions to Arizona.
Snowstorm of 1967	December 1967	A series of strong winter storms impacted much of state bringing record snow amounts to many locations. Flagstaff recorded over 80 inches of snow in less than two weeks.
Floods of 1983	October 1983	A decaying tropical storm (Octave) brought record rainfall to southern Arizona and severe flooding to the region.
Floods of 1993	January-March 1993	A very wet winter fueled by El Niñno brought extensive rain and snow to Arizona and subsequent flooding on the Salt and Verde Rivers.
Rodeo-Chediski Wildfire	June 2002	One of the largest wildfire events in Arizona history (surpassed on ly by the recent Wallow Fire) burned over 300,000 acres in the White Mountains. Extreme drought across the region created extreme fire conditions during the fire event.

Table 6: Significant weather and climate events brought up in group discussions (Information sources: Tucson and Phoenix National Weather Service)

County	Date	Five most frequent weather- and climate-related words
Cochise	4/19/2011	water, climate, rain, farm, ranch-weather
Coconino	7/26/2011	forest, climate, water, fire, weather
Gila	8/12/2011	water, rain, weather, forest, ranch
Graham	8/2/2011	fire, water, rain, drought, weather
Mohave	7/20/2011	water, rain, ranch, cow, weather
Navajo-Apache	9/14/2011	water, forest, fire, climate, change
Pinal	8/23/2011	water, weather, storm, change, drought
Yavapai	7/27/2011	water, climate, drought, change, rain
All counties		water, rain, weather, climate, fire

Table 7: Word frequencies by county (hyphen indicates a tie)

APPENDIX I – Map creation and Data Sources

All maps were created using ESRI ArcGIS version 10. Data sources used were a combination of downloaded shapefiles and raster grids as well as several online web mapping services. Source information for each data set used includes:

- Basemaps and reference layers: DOI Bureau of Land Management Web Mapping Service at http://www.geocommunicator.gov
- Gridded precipitation and temperature data: PRISM Climate Group, Oregon State University at http://www.prism.oregonstate.edu/
- Land Cover: 2006 National Land Cover Database provided by the Multi-resolution Land Characteristics Consortium at http://www.mrlc.gov/
- County level reference information: Southern Arizona Data Services Program at http://sdrsnet.srnr.arizona.edu/