

Connected to the Land:

Social Resilience and Vulnerability Assessment of Land-Based Livelihoods in the Gunnison Basin, Colorado



Report for the Nature Conservancy and
The Gunnison Climate Working Group

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Background for Project

The author of the report is a PhD student at the University of Alaska, Fairbanks. She is part of an interdisciplinary program called Resilience and Adaptation (RAP), an Integrative Graduate Research and Education Traineeship (IGERT) program funded by the National Science Foundation. As part of her graduate program, she was required to complete an 8-week practicum project. She designed this project with Betsy Neely at the Nature Conservancy as her practicum. She spent two weeks in May 2011 planning for the project and networking with Nature Conservancy staff in Boulder Colorado. The majority of interviews were completed in July 2011 in Gunnison, Colorado. She attained funding for the project through the National Science Foundation funded Resilience and Adaptation IGERT program, with additional support for lodging during July from the Nature Conservancy. She presented the results of her research to the Gunnison Climate Working Group on October 26, 2011 and presented a public lecture to Western State students, faculty and project participants in Gunnison on November 11, 2011. The final report was completed on November 28, 2011.

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Connected to the Land: Social Resilience and Vulnerability Assessment of Land-Based Livelihoods in the Gunnison Basin, Colorado

Executive Summary: Corrine Noel Knapp

Introduction. Climate change projections suggest that the Gunnison Basin region will become warmer and precipitation may shift to the fall and winter. If these projections are correct, it will impact both ecosystems and the human communities that depend upon them. The Gunnison Climate Working Group has recently completed an ecological vulnerability assessment for the Gunnison Basin, to identify the species and ecosystems that are most vulnerable to climate change. While this is a critical step for conservation planning, the assessment will be incomplete unless it takes into account how climate change will impact local economies and human behavior, as these factors respond to climate change to shape habitats, ecological processes, and the abundance and quality of ecosystem services. This project addresses this need by assessing the resilience and vulnerability of land-based livelihoods to climate change, identifying critical ecosystem services each livelihood relies upon and suggesting adaptation strategies that may benefit livelihoods and ecosystems.

Methods. I conducted 36 interviews with ranching (19) and recreation-based business representatives(16) and one water expert. Ranching operations were split between cow-calf and cow-calf-yearling operations, with several ranches also selling hay. Recreation-based businesses included hunting, mountaineering and fishing guides, outdoor gear stores, Crested Butte Mountain Resort, hospitality businesses and trail-based businesses. Interviews were recorded, transcribed and analyzed with the qualitative data analysis tool, NVIVO, to understand quantitative and qualitative patterns across the interviews.

Results. The project builds a story about the resilience of land-based livelihoods by assessing community characteristics, existing stressors/threats, and current coping/adaptation strategies. These factors provide a baseline to gauge community resilience and vulnerability. Participants were then asked to reflect on the opportunities and challenges posed by two climate scenarios, and suggest actions that could be taken now to increase the resilience of livelihoods and the ecosystems they rely on in the future.

Context. Participants were asked to define and then describe their community. Ranchers and recreation-business owners both described the Gunnison Basin population as articulate, well educated and community-minded. Both groups also recounted a deep affection for the area and the community. Ranchers reported that their community as cohesive and supportive around common threats, but independent in daily actions. Ranchers also talked about tension between old and new landowners and the agricultural and recreational components of the local economy. The recreation community described a community of people who are increasingly working together, but who have a history of tension and conflict over different types of land use.

Existing Stressors. Participants were asked what were the most challenging threats and stressors they faced currently. Ranchers described more numerous and common threats. At the top of their concerns was the potential listing of the Gunnison sage-grouse, followed by economics, environmental groups and population and recreation pressure. The top concerns for recreation-based businesses were the economy, followed by other concerns including distance from population centers and increased recreation pressure.

Weather. Participants were asked to list the weather events that are most challenging for their businesses. The top weather impacts mentioned by recreation-based businesses and ranchers were drought and inadequate snowpack. The timing of runoff is also a critical weather-related impact for both recreation and ranching businesses. Several of the participants mentioned an increased occurrence of dust on snow events, which influence melt off times and snow-based recreation. For ranchers, two other significant weather windows are during spring calving and the late fall/early winter when they desire

Goals	
1.	Document characteristics that contribute to the resilience and vulnerability of land-based livelihoods to climate change in the Gunnison Basin.
2.	Identify which ecosystem services and their associated quantity, quality and timing each livelihood is dependent upon and to document potential tipping points of concern.
3.	To identify adaptation strategies that would benefit both ecosystems and community residents.

moderate weather for calving and grazing. Finally, participants described how weather fluctuations and perceptions in other locations impacted the local economy. Examples included droughts in other locations influencing local prices for beef and/or hay and heat waves increasing tourist pressure locally.

Current Adaptations. Both participant groups respond to current stressors with strategies that vary across time (short and long-term) and organizational level (individual and community). Ranchers demonstrate more long-term adaptations than recreation-based business owners, including placing conservation easements on their land, securing private land for ranching, and developing water resources. Both ranchers and recreation businesses described efforts of collaboration around natural resources and education. Ranchers also talked about coordinating water use with their neighbors, using high-intensity low-duration grazing systems to build organic matter and integrating their operation vertically to have more control over stages in production. Recreation businesses talked about taking advantage of multiple seasons by selling gear for each season or providing different guiding activities depending on the season, cutting costs and increasing the regulation of recreation activities. Short-term solutions for ranchers included selling cattle, buying hay, moving cattle, and maintaining flexibility to changing conditions. Businesses described short-term adjustment of inventory and providing recreation information services to help their clientele find the best place to pursue their activity given current conditions. These findings suggest that ranchers, as a homogenous and adaptive community, have more similar adaptation strategies and demonstrate a wider range of strategies than recreation-based businesses.

Climate Change Scenarios. In each interview, I explained the two climate change scenarios that Western Water Assessment has drafted for the Gunnison Basin: moderate and extreme. I described how projections show an increase in temperature for both summer and winter and a shifting in precipitation to the winter, with drier springs and summers. After describing the scenarios, I asked participants to reflect on the opportunities and challenges they could see if projections were true. Both sets of participants could see a potential upside to climate change. Many participants felt that a slightly warmer climate and more winter snow would be beneficial. Challenges participants described were knowing how to interpret climate change projections, increased drought and change in the timing and speed of runoff. Participants were also concerned about an increase in extreme weather events, dust on snow events and fire risk.

Discussion. I will speak briefly about the resilience of the ranching and recreation communities, potential tipping points and thresholds of concern and climate change adaptation strategies suggested by participants.

Resilience. The ranching community has high levels of resilience to climate change as demonstrated in adaptive strategies for dealing with the extreme and variable climate, a strong community and a long history in the region. However, they are vulnerable to climate change due to their dependence on public lands, perceived lack of support from other community members, and multiple stressors. Recreation businesses are mixed in their resilience to climate change. The more resilient businesses have diverse livelihood strategies that do not depend on a single season for their income. Many businesses are vulnerable due to the economic recession and their dependence on tourists and the ski area.

Tipping Points and Thresholds. Interviews suggested four primary thresholds of concern to participants:

- 1. Increase in drought.** Drought has impacts that are felt throughout a single year (insufficient stock water, low rangeland production, low hay production, potential for curtailing of public lands leases) and across years (expenses for purchasing hay, sales of cattle). Ranchers were concerned that several drought years in a row could make it challenging for them to stay in business, especially if the Gunnison sage-grouse is listed and agencies are required to be more conservative during drought years.
- 2. Change in the timing of runoff.** Both recreation-based businesses and ranchers were concerned about a change in the timing of runoff. Earlier or faster runoff may make it challenging for ranchers to irrigate and for fly-fishing and rafting guides to operate.
- 3. Increase in extreme weather events.** Recreation-based businesses were very concerned about increases in extreme weather events, which could make it difficult for tourists to travel to the Gunnison area and increase weather-related dangers including an increase in dangerous stream-

crossings, avalanches and fire. Extreme snowfalls or cold spells can also be challenging for the ranching community to keep cattle healthy and well fed.

4. **Increase in recreation pressure.** Participants felt that climate change in other areas could lead to an increase in tourism in Gunnison, as people flee hotter temperatures elsewhere. Increased recreation pressure may make it more difficult for recreation businesses to continue to offer a quality experience and may lead to further conflicts regarding multiple use landscapes.

Climate Change Adaptation Strategies. Participants suggested several strategies that they felt would increase the resilience of livelihoods and the ecosystems they rely upon.

1. **Increased flexibility on public lands.** The most common strategy was increased flexibility from land management agencies. Climate change projections suggest shifts in the timing and availability of natural resources including precipitation, runoff and forage production. Participants described how current leases are fairly rigid, and feared that this rigidity would lead to a mismatch between the quality and quantity of resource and resource use.
2. **Collaboration.** A second important strategy would be to foster collaboration between different stakeholders to jointly envision and plan for the future. Participants talked about the importance of collaboration in order to generate creative and viable solutions that would benefit ecosystems and communities.
3. **Gunnison sage-grouse research.** A third strategy, given the concerns of both ranching and recreation-based businesses about the potential listing of the Gunnison sage-grouse, would be to fund more holistic and systematic research and adaptive management experiments to identify the primary factors influencing sage-grouse population decline so that ranchers and recreation businesses can find ways to sustainably coexist with Gunnison sage-grouse.
4. **Ability to regulate water.** Participants were interested in strategies that increase their access to and ability to regulate water flow, including water development and expansion of water-trading agreements.
5. **Increase general resilience.** In addition, several ranchers and recreation businesses suggested the need to increase the resilience and health of the system to make it more able to cope with climate change. Suggested strategies included restoration of streams, use of grazing systems that increase cover and organic matter in soils and bringing wildlife numbers in line with the capacity of rangelands.
6. **Plan for increased recreation.** Participants also felt that climate change projections may increase recreational pressure in Gunnison Basin as people shift recreational use from fire-prone and hotter areas to the higher elevations of the Gunnison Basin. A strategy suggested to address this would be proactive planning and development of regulations to deal with the potential for increased recreation pressure in the future.

Conclusions. Climate change will impact both livelihoods and ecosystems in complex and interconnected ways. In order to understand the best strategies for climate adaptation planning, it is critical that we understand how ecosystems and livelihoods might respond to changes and what types of opportunities and challenges arise from these changing dynamics. This report will help to inform the climate adaptation strategies that the Gunnison Climate Working Group is currently working to develop.

For more information on climate change projections, the ecological vulnerability assessment or the complete social resilience report see: <http://conserveonline.org/workspaces/gunnisonclimatechange>

For any questions about this report please contact Corrie Knapp at cnknapp@alaska.edu

Introduction

Purpose and Need

Climate change projections for the Gunnison Basin suggest that it will become warmer, with more precipitation falling in the winter and less during the spring and summer. If these projections are correct, there will be rippling impacts for both the ecology and economies of the region. The Gunnison Climate Working Group (GCWG), a group of public and private partners formed in 2010 to understand the threats posed by climate change, identify strategies to reduce adverse impacts and promote coordinated implementation of these strategies. The Nature Conservancy (TNC) and GCWG have completed an ecological vulnerability assessment in the Gunnison Basin to understand how climate change may impact ecological processes, species and ecosystems and to inform the development of climate adaptation strategies (Neely et al. 2011). While this is a critical step for conservation planning in a time of change, the assessment will be incomplete unless it takes into account how climate change will also impact local economies and human behavior, as these factors respond to climate change to shape habitats, ecological processes, and the abundance and quality of ecosystem services. Ecosystems are increasingly understood as systems whose structure and function are influenced by humans, and which cannot be understood without considering human interactions (Ellis and Ramankutty 2008). In order to assess these interactions, I conducted a social resilience assessment of livelihoods in the Gunnison Basin that rely most heavily on natural resources and whose actions potentially have the largest impact (either positively or negatively) on resources of interest to TNC and the GCWG.

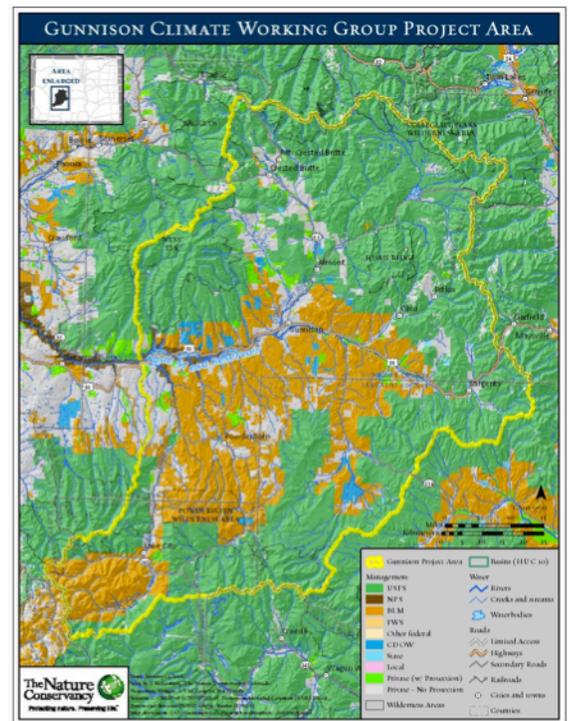


Figure 1. Map of the Gunnison Basin Study Area included in this social resilience assessment

Regional Overview

The Gunnison Basin vulnerability assessment project area includes the majority of Gunnison County and a portion of Hinsdale and Saguache Counties (Figure 1). The data provided here are for the three-county area since that is the resolution at which the data were available. The total population of these three counties is 23,009 [Gunnison: 15,394, Hinsdale: 548, Saguache: 7,067] (Department of Local Affairs 2010 a and b). All of these counties have seen a slight growth (1-2% /year) in population in the past few years, with Gunnison County increasing 47% since 1990 (Cheng 2006). Gunnison County has seen a significant decrease in school-aged children, and retirement aged population is expected to double by 2020 (Cheng 2006). The landscape in the Gunnison Basin is primarily public lands [Gunnison: 78%, Hinsdale: 94%, Saguache: 70%] including both US Forest Service and the BLM (Figure 1). The National Forest Service supports about 12% of all jobs in Gunnison and Hinsdale Counties (Cheng 2006).

The tri-county area has historically been dominated by traditional Western economies such as ranching, mining and forestry, but is increasingly driven by retirees and tourism. For the three-county region, traditional jobs still dominate (25%) followed closely by tourism (23%) and retirees (11%). In a county-specific analysis, tourism leads in Gunnison (27%), retirees lead in Hinsdale (42%) and traditional industries lead in Saguache (45%) (Department of Local Affairs 2010 a and b). For the purpose of this assessment, I focus on ranching and tourism/recreation due to their large influence on the local economy and the dependence of these livelihoods on natural resources.

While agriculture for these three counties accounts for only 10% of the jobs, it impacts 96% of private land and 89% of National Forest Service lands (Cheng 2006) and has the largest economic multiplier for the local economy (Tadjion 2006). Over 27% of private lands in the Gunnison Basin are connected through leases to grazing allotments on public lands (Ferriday 2004). Recent research has shown that the

Gunnison Basin ranching community has a culture of innovation, due to good agency-rancher relationships and ranchers who access information through multiple means (Kennedy 2007). Ranching is a valuable component of the current economy and the heritage of the region, in addition to being one of the most widespread types of land use. Successful climate adaptation strategies will need to take ranching livelihoods and grazing land use into account if they are going to be successful.

Tourism and recreation are large contributors to the greater Gunnison Basin economy (23%) and are dependent on ecosystem services such as clean water, wildlife and recreational opportunities. A recent state economic development report lists increasing tourism activity as one of the top five goals for both Gunnison and Saguache counties (OED 2011 a, b and c). A business owners survey conducted in 2011 shows that business owners cite quality of life, recreation and geography as the main reasons why they are in Gunnison and they see tourism/recreation as the biggest area of potential economic growth (Gunnison County 2011). Tourism and recreation are current drivers of the local economy as well as perceived core components of future growth. It is important to assess how climate change might impact these industries in the future.

Climate Change Projections

Gunnison is situated in a high mountain valley with moderate temperatures during the summer (60-80 F) and cold temperatures during the winter (-20 - 11F). The city of Gunnison receives about 11 inches of precipitation a year, while surrounding mountains may receive 15-40 inches depending on topography and elevation. Small amounts of precipitation fall year round, with the maximum average precipitation coming as monsoon rains in July and August (Weather Channel 2011). Average annual temperature demonstrates significant variation on a year-to-year basis, but has increased consistently during the past thirty years (Barsugli and Mearns 2010). Annual stream flow in the Gunnison River is variable and there are no perceptible trends. Project participants suggested regular drought cycles every 7-15 years. Climate change projections suggest that the Gunnison Basin is likely to experience increased temperatures, and changes in the timing and type of precipitation within the next fifty years (Barsugli and Mearns 2010).

Western Water Assessment and the National Center for Atmospheric Research have drafted two scenarios of change: one moderate and the other extreme (Barsugli and Mearns 2010). Under the moderate scenario, it is projected that there will be an overall increase in temperature of 4.5 degrees F (winter increase 3.6F, summer increase 5.4F). Overall precipitation will likely remain the same, but may shift towards the fall and winter (Mearns 2010). Increased temperature and changes in precipitation are likely to have several impacts to local hydrology: stream flow may likely decrease from 5-10%, snow may fall later and melt earlier (est. 1 week), and lower amounts of water may be stored in the soil in summer and fall. In the extreme scenario, temperatures will likely increase by 5.4 F (winter increase: 3F, summer increase: 7F). It is projected that there will also be an overall decrease in precipitation by 10% (during the spring (-15%), summer (-20%) and fall (-10%)). This would impact local hydrology, leading to overall stream flow decrease by 20-25%, later snowfalls in winter and earlier melts in the summer (est. 2+ weeks), and even less moisture stored in soils in the summer and fall. Over the past several decades, actual global climate change has exceeded the extreme scenario and would be the most likely future change in the absence of major changes in global human behavior.

Resilience and Vulnerability to Changes in Ecosystem Services

All people depend on clean air, water and healthy ecosystems to survive, but these connections are more direct for individuals who make their living directly off the land. Projected changes in temperature and precipitation may change the supply of ecosystem services in ways that impact both ecosystems and human communities (Shroter 2005). Ecosystem services can be defined as the benefits nature provides to humanity; including provisioning (food, water, energy), regulating (pollination, purification of air/water), supporting (primary production) and cultural services (inspiration, recreation) (Costanza 1997). Ranchers and recreational interests (ski resort employees, fishing guides, hunting guides) depend on ecosystem services and have different ways of utilizing and valuing these services, which lead to different vulnerabilities to change (Chazal 2008). Vulnerability can be defined as "the state of susceptibility to harm from exposure to stresses associated with environmental and social change and the absence of capacity

to adapt” (Adger 2006). This project will look at the exposure, sensitivity and adaptive capacity of land-based livelihoods to changes in ecosystem services.

While vulnerability looks at weaknesses in human-natural systems, resilience is a way to gauge its strengths. Resilience is commonly defined as the ability of a social-ecological system to absorb a variety of shocks and to sustain and develop its fundamental function, structure, identity and feedbacks through recovery or reorganization in a new context (Gunderson and Holling 2002, Folke 2006). Wide ranges of qualities have been attributed to resilient systems or individuals. System properties that have been suggested to foster resilience are 1) adaptive capacity, 2) biophysical and social legacies that contribute to diversity and provide proven pathways for recovery, 3) the capacity of people to plan for the long term in a context of uncertainty and change, 4) a balance between stability and innovation and 5) the capacity of governance systems to adapt to changing needs (Chapin et al 2009, Gunderson and Holling 2002).

Both resilience and vulnerability seek to assess the adaptive capacity of the system. Adaptive capacity is the ability of individuals and groups to respond proactively to a changing environment. Adaptation has its roots in biological literature, where “to adapt” can be defined as the ability to survive a crisis or change in environmental conditions (Mazness 1978). In this context, adaptation is linked to the ability to survive, and is a quality assessed at the individual level. Publications increasingly consider the interconnection between social and ecological subsystems and the way that management practices influence resources, which in turn effect human communities and livelihoods (Hamilton et al 2000). Adaptive capacity in this context is defined as conservation of important and valued system processes and relationships. This project seeks to understand the adaptive capacity, vulnerability and resilience of ranching and recreation-based livelihoods to climate change in the Gunnison Basin (Table 1).

Table 1. Three approaches to foster sustainability in a context of change with characteristics of each. Adapted from Chapin et al. 2009

Vulnerability
Exposure
Sensitivity
Adaptive Capacity
Adaptive Capacity
Diversity (biological, ecological, cultural)
Social learning
Ability to experiment and innovate
Ability to implement solutions
Resilience
Adaptive Capacity
Legacies that provide seeds for renewal
Ability to plan for change
Balance between stabilizing and creative renewal
Ability of governance systems to adapt

Objectives

1. Document characteristics that contribute to the resilience and vulnerability of land-based livelihoods to climate change in the Gunnison Basin.
2. Identify which ecosystem services and their associated quantity, quality and timing each livelihood is dependent upon and to document potential tipping points of concern.
3. To identify adaptation strategies that would benefit both ecosystems and community residents.

Methods

In order to understand the region, I conducted a document review regarding the social, economic and cultural context of the Gunnison Basin. This review (summarized in the regional overview above) identified two important categories of people to interview: individuals engaged in the recreation community and individuals engaged in ranching. My sampling design was purposive, meaning that I identified a list of potential participants that would be representative of the population I was interested in (Berg 2007). The list of potential participants was compiled through conversations with GCWG participants. I supplemented this list through snowball sampling, meaning that I asked each participant for names of other community members I should speak with. The goal of the sampling was to speak with a diverse group of people who were able to represent the various ranching and recreation businesses in the Gunnison Basin region.

I was able to conduct 36 interviews with ranching representatives (19) and recreation representatives (16) and one expert on water issues in the Gunnison Basin (Table 2). Although exact numbers of businesses were not available, local experts suggest that my sample represents about a third of all area ranchers (personal communication: Cochran, J. November 11, 2011). and a fourth of all local recreation businesses (personal communication: Jackson, B. November 11, 2011). Ranching representatives included fifteen ranchers and four agency representatives. Recreation representatives included fourteen business owners and two agency representatives. Ranching operations were cow-calf (47%) or cow-calf-yearling (53%) operations, with several ranches selling hay. Two participating ranchers had married into long-term ranching families, but the rest of the ranchers (86%) were members of families that have been ranching in the Gunnison Basin for two generations, and 53% of them were third generation or more. Since most of the interviewees were over 50, this means that these families often include five or six generations in ranching. About half of the ranchers interviewed had been ranching for over forty years. Most of the ranchers interviewed (73%) made their incomes entirely in ranching. Agency representatives were interviewed from the BLM, USFS, NRCS and a wildlife consultant working for the county.

Recreation-based businesses included hunting, mountaineering and fishing guides, outdoor gear stores, Crested Butte Mountain Resort, hospitality businesses and trail-based businesses. I was able to interview business owners in Gunnison (36%), Crested Butte (43%), Almont (7%), Elk Creek (7%) and Lake City (7%). Most of these business owners (78%) made their income entirely from their associated business, and 57% of them have been in business in the area for at least 10 years with 21% in business for over 40 years. Agency representatives were interviewed from the BLM and USFS. I was able to speak with a diverse group of ranching and recreation interests and feel like they are representative of the community as a whole.

One potential weakness of the sampling strategy is a bias towards community leaders. GCWG members recommended individuals who were already active community leaders. These individuals may have different perceptions and suggestions for adaptation strategies than less engaged community members. Two methods I used to address this were snowball sampling and interviews with agency personnel. Snowball sampling helped to identify other community members who were not in leadership roles while interviews with agency employees provided information about a broader range of businesses. While I was able to interview an array of recreation-related business owners, I was unable to connect with a representative of the rafting community. While other recreation businesses spoke of the potential impacts of climate change on rafting businesses, I was unable to collect direct information from these businesses.

The interview guide (Appendix 1A) was developed to understand the participants' current business and community context, dependence on the environment, the impact of past weather events, their perception of how projected changes might impact them and suggestions they have about how they might adapt to a changing climate. I utilized three primary approaches to sustainability in social-ecological systems (Table 1), and the factors associated with each. Questions in the interview guide were chosen based on their ability to elicit broad information about these topic areas. Questions were kept open-ended in order to collect information without prescribing the exact content and themes that emerged. Fraser has suggested that qualitative and integrative assessments may be the best method for understanding interconnections between social and ecological systems (Fraser 2003).

Interviews were transcribed, coded and analyzed with the qualitative data analysis software NVIVO in order to track these themes, and other characteristics of interest, across the interviews. I started my analysis with a list of codes based on theory and prior literature regarding resilience and vulnerability. I supplemented this list with emergent codes as I analyzed the interviews. The coding process thus included both deductive and inductive approaches as I worked from pre-existing categories and added to them as suggested by the interviews (Bernard 2009). I organized the resulting coding reports into tables in order to assess themes of interest. Once preliminary results were drafted, I searched the transcripts for negative cases in order to assure that preliminary results correctly reflected the interviews.

Table 2. Description of Interview Participants

	Sex	Age	Location	Operate for	Generations	Type	Description	Income from business
1	M	35-50	Crested Butte	10-40y	0	Rancher	Cow-calf-yearling	All
2	M	50+	Gunnison	>40y	4	Rancher	Cow-calf-yearling	All
3	F	35-50	Gunnison	>40y	0	Rancher	Cow-calf-yearling	> Half
4	M	35-50	Taylor Park	<10y	2	Rancher	Cow-calf	> Half
5	M	50+	Gunnison	>40y	4	Rancher	Cow-calf-yearling	All
6	M	50+	Gunnison	>40y	3	Rancher	Cow-calf-yearling	All
7	M	35-50	Gunnison	10-40y	4	Rancher	Cow-calf-yearling	< Half
8	M	50+	Powderhorn	10-40y	4	Rancher	Cow-calf-yearling	All
9	M	35-50	Tomichi	10-40y	2	Rancher	Cow-calf-hay	> Half
10	M	50+	Tomichi	10-40y	2	Rancher	Cow-calf	All
11	M	50+	Gunnison	>40y	3	Rancher	Cow-calf	All
12	F	50+	Gunnison	>40y	2	Rancher	Cow-calf	All
13	M	50+	Gunnison	>40y	3	Rancher	Cow-calf-yearling	All
14	F	35-50	Gunnison	<10y	2	Rancher	Cow-calf-hay	All
15	M	50+	Gunnison	>40y	3	Rancher	Cow-calf	All
16	M	50+	Gunnison	10-40y	0	Ranch-Agency	NRCS	NA
17	M	<35	Gunnison	<10y	0	Ranch-Agency	BLM	NA
18	M	50+	Gunnison	<10y	0	Ranch-Agency	Consultant/stockers	NA
19	M	50+	Gunnison	10-40y	0	Ranch-Agency	USFS	NA
20	M	35-50	Crested Butte	10-40y	0	Recreation	Recreation daycamp & motorized advocate	All
21	M	35-50	Crested Butte	10-40y	0	Recreation	Outdoor shop & bike advocate	All
22	M	35-50	Gunnison	10-40y	0	Recreation	Professional athlete and bike advocate	< Half
23	M	35-50	Crested Butte	<10y	0	Recreation	Ski Resort	All
24	M	50+	Crested Butte	>40y	0	Recreation	Ski shop	All
25	M	35-50	Gunnison	<10y	0	Recreation	Outdoor shop	All
26	M	50+	Lake City	>40y	0	Recreation	Ski hut business	< Half
27	M	50+	Almont	10-40y	0	Recreation	Fly fishing shop & guide	All
28	M	35-50	Crested Butte	<10y	0	Recreation	Lodging	All
29	M	50+	Gunnison	<10y	0	Recreation	Hunting/Horse Guiding	< Half
30	M	50+	Gunnison	>40y	0	Recreation	Hunting Guide	All
31	M	35-50	Crested Butte	<10y	0	Recreation	Mountain Guide	All
32	M	35-50	Gunnison	<10y	0	Recreation	Fly fishing shop & guide	All
33	M	35-50	Elk Creek	10-40y	0	Recreation	Fishing	All
34	M	35-50	Gunnison	<10y	0	Recreation-Agency	USFS	NA
35	F	35-50	Gunnison	<10y	0	Recreation-Agency	BLM	NA
36	M	50+	Gunnison	10-40y	0	Water	Water Conservancy	NA

Results

The literature related to resilience suggests that a system can have both general and specific resilience (Smit and Wandel, 2006). Adaptive capacity can also be seen in this context: comprised of both specific adaptive capacity to specific threats, and more general adaptive capacity. While the project is primarily focused on the response of stakeholders to changes in climate, they are also vulnerable to a suite of other changes (water transfers, rising land values, market competition and regulations). It is important to identify these baseline pressures and vulnerabilities in order to assess the impact of climate change in the context of other pressures and challenges. Previous studies have found that adaptation planning and initiatives are often most successful when climate change is “mainstreamed” or considered along with other social and environmental pressures (Smit and Wandel 2006). This section will begin with a discussion of the characteristics of these livelihoods and the threats/stressors they identified during interviews.

Defining the Context

Gunnison Basin Population and Community Context. Participants were asked to define and then describe their community. Participants described general community characteristics (discussed in this section) and more specific characteristics of their self-identified communities (discussed in the following section). Ranchers and recreation-business owners both described the Gunnison Basin population as articulate, well educated and community-minded. Both groups also reported a deep affection for the area and the community. Many ranchers have deep, multiple generational connections to the landscape, while many recreation-based businesses were drawn to the area for its beauty. These place-based connections were common in interviews and may provide cohesion when planning for the future.

Our heart is here and we are very tied to this landscape and the community.
-Gunnison Basin Rancher

Despite these commonalities, ranchers in the area recounted tension with other community members. Many talked about a disconnection between the agricultural landscapes on the south side of the basin with the recreation-based economy in the north. Almost half of the ranchers interviewed (47%) expressed tension between the wider community and area ranchers. Ranchers described feeling vulnerable because they didn't have consistent support from the broader Gunnison community.

People do not like cows. They say they like cows but they like seeing them out in the meadows as they drive by but if they are on the highway they are mad and if they are on the trail they are mad.
-Gunnison Basin Rancher

Both groups talked about the important role of children in creating community. Children served an important function of connecting people who may have dissimilar interests. One rancher explained how he provided spring fieldtrips to his ranch for school children and how this has improved education and exposure to ranching. All participants saw the next generation as an important connector between the diverse user groups in the Gunnison Basin.

There are so many kids in this community and the number of kids has really grown lately and there is so much to do and the kids have so many things going on (more than I do) so that has done more than anything---just follow what the kids are doing.
-Recreation Business Owner

Defining Participants' Personal Communities. Each participant was asked to define the community that they felt most a part of. They were asked to describe their community, how it functions and discuss community leadership. Participants usually identified a group of people with similar livelihoods (ranchers talked about ranchers) or people with similar recreational pursuits (owners of sporting goods stores talked about a skiing community, fly-fishing guides talked about other fishermen).

The Ranching Community. Ranchers described a cohesive and supportive community that works together around common concerns such as rising elk populations or the potential listing the Gunnison sage-grouse. These common threats provide incentive for the ranching community to work together, but

their daily operations are fairly independent. Ranchers discussed how community members shared resources and tasks including lending equipment, providing help, giving support in family emergencies and sharing advice. While ranchers still work together, several of the older ranchers reported how sharing has decreased in recent years.

Ranchers expressed tension between old timers and new, mostly wealthy and absentee owners. Ranchers explained how new owners often came in with less knowledge of local conditions, different goals for their operations and new ideas. Community norms, such as the ability to gather cattle off a neighbors land or hunt on neighbors' property, were changing. While some found this threatening, others saw absentee owners as a potential benefit to the community, by bringing in new ideas. Some ranchers felt that new landowners protected land from development, while others speculated that new owners valued the land primarily as an investment and didn't have the same sense of community as traditional ranching families. Despite a history of internal cohesiveness, new and absentee owners have led to growing rifts within the ranching community.

The ranching community was divided about whether there were an adequate number of leaders. About half (47%) of the ranchers interviewed felt overtaxed with leadership responsibilities. Despite this, community members felt they were lucky to have younger ranchers taking on leadership roles. The Gunnison ranching community has a motivated and capable group of leaders, but leaders often feel overwhelmed by their responsibilities.

We are connected in terms of being at the same meetings and trying to stop the listing of the sage grouse together and try to do things like that where it is more of a join forces to fight a problem.
-Gunnison Basin Rancher

The Recreation Community. Recreation-business owners described a community of people who are increasingly working together, but who have a history of tension and conflict. While community members have a strong sense of place and passion for their activity, these passions can create conflict over land use. Business owners in Crested Butte also spoke of a split between wealthy quality-of-life residents and business owners and working members of the community, which creates tension in many public meetings about what Crested Butte should look like or how it should develop. Recent attempts at collaboration include educational efforts between the mountain biking community and ranchers, and a new motorized recreation advocacy group. A quarter (25%) of the community explicitly mentioned the importance of ongoing collaboration. The recreation community is invested in the place and activities that provide both their recreation and their livelihoods. While tensions have existed around different land uses, the community is trying to work together towards solutions that will benefit all.

There are a lot of advocates here and they are all very passionate: it is a passionate community and they are trying to protect their stuff and then there are other people who are trying to figure out a way to make this community work.
-Recreation-Based Business Owner

Recent attempts at collaboration include educational efforts between the mountain biking community and ranchers, and a new motorized recreation advocacy group. A quarter (25%) of the community explicitly mentioned the importance of ongoing collaboration. The recreation community is invested in the place and activities that provide both their recreation and their livelihoods. While tensions have existed around different land uses, the community is trying to work together towards solutions that will benefit all.

The organization that connects many recreation-based businesses together is the local Chamber of Commerce. The Chamber provides a way for recreation-based businesses to pool resources, market the Basin as a recreation destination, and increase tourism. However, when asked if similar recreation businesses collaborated or worked together, few expressed open collaboration and most saw similar outfits as competitors. Recreation-based business owners expressed appreciation for the ski areas efforts to improve the base area and diversify summer options (addition of the terrain park). They saw these efforts as adding to the attraction of Crested Butte. While this was true, they also saw the ski area as a competitor for tourist spending on recreation activities and lodging. Recreation businesses primarily work together through the Chamber of Commerce, rather than coordinating with similar businesses.

Current Threats and Stressors

Participants were asked what were the most challenging threats and stressors for their livelihoods currently (Table 3). Ranchers described more numerous threats, and threats that were common to a larger proportion of their population. At the top of their concerns was the potential listing of the Gunnison sage-grouse (100%), followed by economics, environmental groups and population and recreation pressure (73% each). The top concerns for recreation-based businesses were the economy (62%),

followed by other concerns including distance from population centers (50%) and population and recreation pressure (37%). Ranchers and recreation business owners (37% each) described weather as a stressor, which will be discussed in the following section. Ranchers and recreation-based business owners shared several common stressors, but often were mentioned more frequently by one group than the other.

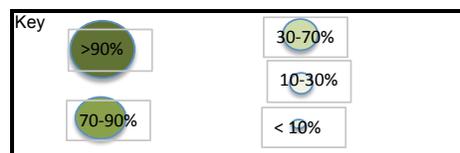
The dominant stressor expressed by each member of the ranching community was the potential listing of the Gunnison sage-grouse. The majority of ranchers agreed that sage-grouse populations had decreased in the past several decades, but felt that this decrease was not linked to grazing pressure. Several (31%) mentioned the need for predator control to regain populations. Many felt that the Gunnison sage-grouse were a lever that environmentalists were using to end public lands grazing (73%). A common observation from ranchers was that grazing was the easiest public land use to control, and therefore it was often curtailed before any other land-uses. Almost all of the ranchers expressed the feeling that if the Gunnison sage-grouse was listed, ranchers would lose their access to public lands. As one stated, “Our biggest concern is the sage-grouse and we feel we’re going to completely lose access to federal grazing permits once it gets listed.” This dominant stressor provided a very real potential obstacle that made it difficult for ranchers and others to consider and plan for potential climate change. As one agency employee stated, “Everyone gets so focused on this one little bird that they are missing out on a lot of the other things.” Recreationists also felt that the sage-grouse might impact public lands access (25%), but it was a less common and pronounced concern.

The dominant stressor for the recreation businesses was the economy. Interviews were conducted in the summer of 2011, and some of the recreation businesses were feeling pinched due to the recession, a cold spring, and high runoff, which negatively impacted fly fishing guides. One recreation-based business stated, “We are a resort town and weather is becoming a challenge but the biggest challenge I think is the up and down nature of a resort-based economy. It is feast or famine and that is a big challenge: how to keep the balance.” Connected to this concern was the distance of Gunnison from population centers. As a destination resort, most recreation businesses rely on tourists to provide income. Several participants felt that Gunnison wasn’t business-friendly and that the locals didn’t support local businesses adequately. Ranchers also cited economics as a primary stressor. Many ranchers talked about increased overhead and temptations to sell land or water for high profits. As one rancher described, “Some still have some economic woes and everyone is struggling with that because it isn’t a high cash flow business. It is a high equity business.” The economic value of both land and water are high, making it difficult for ranchers to decide to choose to stay in business and deal with a suite of stressors.

Ranchers and recreation business owners were concerned about population growth, but for different reasons. Ranchers were concerned about a transition to a recreation-based economy, and all the increased public land conflicts this might entail, while recreation-based businesses were concerned with their ability to continue to provide a high-quality experience with growing numbers of recreationists. Recreation businesses were concerned with maintaining continued access to key areas and providing a good experience. As one recreation-based business owner stated, “I would think that population growth will have a larger impact on recreation than climate change, because you have to disperse those people. You can’t keep cramming more people in the same place.”

Table 3. Percentage of Gunnison Basin participants discussing the following threats and stressors to land-based livelihoods.

	Ranchers n=19	Recreation n=16
Threats and Stressors		
Community attitude towards ranching		
Distance from large towns		
Challenging economics		
Elk populations		
Environmental groups		
Federal Land Management Agencies (under staffed)		
Harsh winters		
Lack of leadership		
Population and recreation pressure		
Potential listing of the Gunnison sage grouse		
Time for participation in local issues		
Water		
Weather		



Other threats and stressors unique to the ranching community included community perspectives on ranching (47%), elk (42%), and water resources (16%). As mentioned earlier, ranchers express tension with other community members and paradigms that are rooted in more urban environments. Ranch owners feel threatened by different value sets that question the value of agriculture and the acceptability of basic agricultural practices. Ranchers have also seen increases in elk population, distribution and behavior that impact ranching practices. They partially blame these changes on trophy ranches that act as refuges, inadequate management and increased recreation pressure. Ranchers expressed concern that agency employees were cutting grazing permits in order to maintain land health instead of working for healthier, and smaller, elk populations. Ranchers have experienced several drought years where water has been called out by downstream senior water rights. Although this usually has occurred after irrigation of hay meadows, it has made some ranchers concerned about future water supply. Ranchers are the largest water-right holders in the Gunnison Basin (personal communication, Jim Cochran November 11, 2011), and given the suite of current stressors, they are tempted to sell water rights. As one rancher described, “the reality is that given enough pressure from the outside to put you out of business you only have two things: your land and your water.”

Only 36% of ranchers and 37% of recreation based businesses described weather as a current stressor. Since this question was asked in a relatively good weather year (no drought, good moisture), weather was ranked as less important in comparison to more tangible and immediate concerns. Many participants described the last drought period as nearly ten years prior (2000-2002). Many of those citing weather as a stressor were referring to a recent harsh winter (2007-2008) that was challenging for both ranchers (21%) and recreation-based businesses (12.5%).

Weather

Participants were asked to describe the ideal weather year for their business. This question was asked to identify desired conditions and compare these desires to climate change projections (see Appendix 1B; Figures 2 and 3). Ideal conditions for ranchers included high snowpack, gradual melt-off, warm daytime temperatures at the beginning of the growing season, frost-less nights at both the beginning and end of the summer, adequate moisture during the growing season, adequate stock water on rangelands, monsoon rains during the summer, dry weather for haying and then a moderate winter in terms of temperature and snowfall in low lands. Recreation based businesses were more variable in their ideal weather, but generally wanted high snowfall during the winter, moderate summer temperatures, low fire risk, and limited extreme weather events. This information will be explained in more detail in the discussion.

Participants were also asked an open-ended question about what weather events were the most challenging for their businesses. The responses reflect emergent categories mentioned by participants. The top weather impacts mentioned by recreation-based businesses and ranchers were drought and inadequate snowpack, which interact with each other (Table 4).

Drought. Ranchers were unanimous (100%) in the strain that drought could have on their operations. Ranchers described how a drought year given adequate snowpack could be tolerated, whereas a drought year with little snowpack means inadequate water for irrigation and therefore less hay for feeding in the winter. Few ranchers have enough private ground to graze livestock, so loss of public lands due to dry water sources can also pose a significant challenge. Drought is also a challenge for recreation businesses (60%), which are concerned about fire danger, quality of trails during drought, wildflower quality and monsoon rains for river levels (for fishing and rafting). Business owners described how summer recreationists like to have campfires and will avoid areas with fire restrictions. Business owners also talked about drought leading to poor mountain biking trails. Many tourists come to the Gunnison Basin for its gorgeous displays of wildflowers, which could be diminished by drought. Finally, participants discussed how both rafting and fly-fishing guides rely on monsoon rains for the best conditions for guiding.

Inadequate snowpack. As might be expected in a community dependent upon skiing, adequate snowfall is critical for a range of recreation-based businesses (80%). Snowpack at the right time can increase

business for recreation businesses across the Basin. As one business owner explained, “When it gets cold and the snow starts falling, that is when the business starts picking up.” However, too much snow can also be a bad thing, both for ranchers (63%) and the recreation industry (60%). For ranchers, massive snows at low elevations can be hazardous for cattle and make it challenging to feed. For recreation businesses too much snow can also be a challenge—making it difficult for tourists to travel to the area.

Runoff timing. The timing of runoff is also a critical weather-related impact for both recreation (40%) and ranching businesses (68%). For ranchers, they need the water to come off when they are able to use it for irrigation (meaning that cattle are on spring rangelands and not private hay-grounds) and before it is “called” by down-stream users. The timing and rate of runoff also impacts river-based recreation such as rafting and fly-fishing. In addition, high runoff can create problems for hikers as landslides increase the need for trail maintenance and high river flows can make stream crossings dangerous. Several businesses described the challenge of late runoff, where remaining snow curtails early season recreation activities.

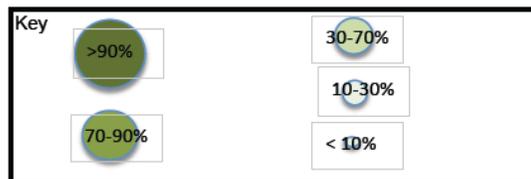
Dust on snow. Several of the participants mentioned an increased occurrence of dust on snow events (10% ranchers, 10% recreation), which influence melt off times and the snow-based recreation experience. As one participant explained, “It (dust on snow) affects the melt off and makes it happen quicker and earlier. That is a big problem.” While dust on snow events currently occur later in the spring, they can have a negative impact on the recreation experience. As one participant explained, “The dust is interesting because it is a hard product to ski on and waxing is brutal with it because it is very abrasive and there isn’t much you can do. You can’t do anything.”

Weather windows. For ranchers, two other significant weather windows are during spring calving (26%) and the early fall (10%). Ranchers hope for moderate weather during March and April, because their income depends on the survival of calves. As one rancher described, “Probably the most important one, and the other things we can survive, but if it is really cold and rotten and miserable in March and April, when those calves die they are gone. That is the most important window.” Ranchers also hope for a delay in snow until late November or early December. A mild, snow-free fall extends the period when cattle can forage and decreases the need for feeding hay. As one rancher described, “Feed-wise, the snow period from mid-Nov to mid-Dec is critical. It makes a difference whether the cows are grazing or if you are feeding 20 bales of hay a day, which is expensive.”

Extreme cold. Known as “the icebox of Colorado”, Gunnison has some of the lowest temperatures in the lower 48. Ranchers and recreation businesses alike acknowledged this challenge, but felt that it was a characteristic that they had learned to live with. Several took the cold for granted and expressed an ability to live with it as a predictable part of the climate. As one said, “Sure, we put up with terrible winters and a lot of cold weather, but it isn’t the kind of stuff that a guy can’t work through”. Despite this statement, others talked about the financial impacts cold winters could have on ranching operations. As one rancher

Table 4. Percentage of Gunnison Basin participants who talked about these weather impacts to land-based livelihoods.

	Ranchers n=19	Recreation n=16
Drought		
Inadequate snowpack		
Extreme cold		
Timing of runoff		
Lack of spring moisture (stockwater, spring range, wildflowers)		
Extreme snowfall		
Dust on snow		
Cold during calving		
Thunderstorms		
Too wet/rainy		
Early fall snowstorms		
Weather in other places		



acknowledged, “A cold winter is a lot (more expensive). You are feeding more hay, it is hard on equipment.”

Weather in other places. A final impact that both ranchers and recreation businesses described were the impacts of weather fluctuations and perceptions in other locations. Ranchers described how droughts in other beef producing regions led to higher local prices. A similar situation was true for hay: “This is an extremely high hay market this year because of the droughts to the south, but in some years you can hardly put it up for what you can sell it for.” Recreation businesses also described how increased high temperatures in other places have increased recreation pressure in the Gunnison Basin. As one business owner described, “we aren’t seeing dramatic changes but summer has changed in other areas and we have more and more people looking for relief and to come to the mountains and escape and get up to Gunnison County and Crested Butte.”

Current Adaptations

Ranchers in the Gunnison Basin face weather impacts, the potential listing of the Gunnison sage-grouse, economic stressors and tension with the local community. Recreation businesses struggle with economics, increased recreation pressure and distance from population centers. In addition to these background concerns, they must deal with current weather impacts and potential future impacts of climate change. Participants have responded to stressors with three groups of strategies: long, medium and short-term adaptations (Table 5). Long-term adaptations consider actions that take a longer time to perform and have a longer impact, while short-term adaptations can be done quickly, but only have a short-term impact.

Long-term adaptations. Ranchers demonstrate more long-term adaptations than recreation-based business owners. Ranchers in the Gunnison Basin have been proactive with developing a local land trust, working with other land trusts, and putting conservation easements on their ranches (68%). Many ranchers are also working on acquiring, leasing or trading land so that they can maintain their herds if grazing on public lands is more restrictive than currently (47%). This additional private land also serves as a buffer for months with low forage supply in the spring. Ranchers are also looking to develop water on their private and leased lands in order to make them usable for a larger proportion of the year (47%).

Both ranchers (16%) and recreation businesses (25%) described efforts of collaboration around natural resources. Both groups felt like it was critical to bring diverse interests together to come to creative solutions. Both also talked about improving the resilience of ecosystems through restoration of riparian areas, working for healthy elk populations and grazing sustainably. Several recreation-businesses described recent ski area investments in snowmaking and infrastructure for year-round activities, which both helped to diversify recreation activities (13%).

Medium-term solutions. The most commonly cited medium-term adaptation was education about different types of land use, whether sharing the benefits of ranching to the community (44%), or exposing people to new recreation activities (13%). Both participant groups discussed marketing as a way to generate more business or receive a higher price for goods and services. Ranchers also talked about

Table 5. Percentage of Gunnison Basin participants who described using the following adaptations to deal with current threats.

		Ranchers n=19	Recreation Business Owners n=16
Type of adaptation	Current adaptations		
Long-term	Conservation easements		
	Land acquisition		
	Water development		
	Collaboration		
	Improve resilience of ecosystems		
	Invest in infrastructure		
Medium-term	Education		
	Coordinating water use		
	Diversify year-round money making		
	High intensity, low duration grazing systems		
	Marketing		
	Regulation of recreation		
	Cutting costs		
Short-term	Vertical integration		
	Selling cattle		
	Buying hay		
	Moving cattle		
	Be flexible in mangagement		
	Adjust inventory		
	Provide information on recreation opportunities		



coordinating water use with their neighbors in order to make sure that everyone received the water they needed when they needed it (13%), using high-intensity low-duration grazing systems to build organic matter (15%) and integrating their operation vertically to have more control over stages in production (5%). Recreation businesses talked about taking advantage of multiple seasons by selling gear for each season or providing different guiding activities depending on the season (18%), cutting costs (7%) and increasing the regulation of recreation activities (7%).

Short-term solutions. Short-term solutions help ranchers and business owners make rapid shifts to respond to stressors. When ranchers are currently faced with drought, they often choose to either sell cattle (74%). Selling cattle removes the pressure to the resource and the expense of feeding supplemental food. This short-term solution can have long-term impacts if operators are unable to buy cattle to rebuild their herd. If they can afford it, ranchers may also consider buying additional hay or supplements to help cattle get through challenging times (47%). Ranchers also discussed moving cattle more frequently in order to make sure they were getting the nutrition they needed and that the resource was not being damaged (37%), and maintaining flexibility to changing conditions (31%). Businesses described short-term adjustment of inventory based on weather or trends in gear (13%) and providing recreation information services to help their clientele find the best place to pursue their activity given current conditions (13%).

These current practices allow ranchers and recreation businesses to adjust to stressors and survive. This assessment may miss some alternative, maladaptive options people in land-based livelihoods may choose. For instance, one rancher talked about how the loss of access to public lands may lead to more intensive use of private lands. In addition, ranchers may choose to sell all or part of their resource base. This could occur through parceling of sections of the ranch, sales of water rights or completely liquidating their ranching assets either to retire or start a new ranch elsewhere. Recreation businesses may choose to ignore permit restrictions, go out of business, or move their business elsewhere. Since we primarily interviewed active ranchers and business owners we may not have adequately captured these less desirable options because our population did not include people who have gone out of business or moved out of this area.

These adaptations suggest that ranchers, as a homogenous and adaptive community, have more similar adaptation strategies and demonstrate a wider range of strategies than recreation-based businesses. Both groups are responding to current stressors with strategies that vary across time (short and long-term) and organizational level (individual and community). When thinking about future climate change adaptation strategies it is important to design a range of strategies across different spatial, organizational and temporal scales.

Climate Change Scenarios

Climate Change Trends

As described in the introduction, Gunnison is situated in a high mountain valley with moderate temperatures during the summer (60-80 F) and cold temperatures during the winter (-20 - 11F). The city of Gunnison receives about 11 inches of precipitation a year, while surrounding mountains may receive 15-40 inches depending on topography and elevation. Small amounts of precipitation fall year round, with the maximum average precipitation coming as monsoon rains in July and August (Weather Channel 2011). Average annual temperature demonstrates significant variation on a year-to-year basis, but a

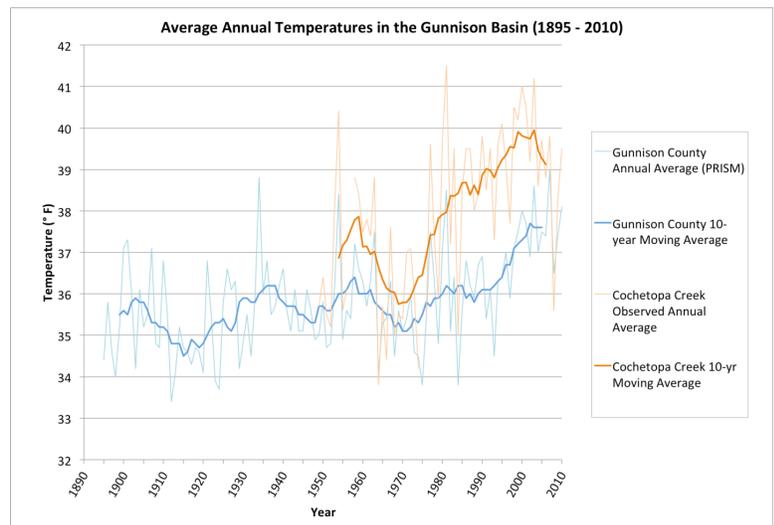


Figure 4. Annual Average Temperature in the Gunnison Basin. The annual average and 10-year moving average temperature for Gunnison County (blue) computed from the PRISM dataset, uses a statistical model to blend temperatures at observing stations to create a county-wide average. For comparison, the temperatures at the Cochetopa Creek Cooperative Observer Network site are shown. This site is identified by the Colorado Climate Center as having a record of consistent observation quality (Neely et al., 2011).

consistent increase during the past thirty years (Figure 4: Barsugli and Mearns 2010). Many locations in the west have experienced changes in hydrology including reductions in snowpack, earlier melt off and a change of precipitation from snow to rain, but these changes have been less apparent in Gunnison, which is both higher in elevation and colder than many other locations (Barsugli and Robertson 2011). Currently, annual stream flow in the Gunnison River is variable and there are no perceptible trends. Long-term residents have experienced droughts every 7-15 years. Climate change projections suggest that the Gunnison Basin is likely to experience increased temperatures, and changes in the timing and type of precipitation within the next fifty years (Barsugli and Mearns 2010).

Perceptions of Climate Trends

Prior to sharing the climate change projections, I asked both ranchers and recreation business owners to describe any weather-related trends that they had perceived during their time in the area. It is important to note that participants were a mix of long and short-term residents. While most ranchers had lived in the Basin their whole lives (86%), few recreation-based business owners were raised in Gunnison (19%) and only half (57%) had been in Gunnison for over 10 years. The following perceptions need to be understood as a reflection of mixed temporal experience within the Basin.

I asked this question prior to explaining the climate scenarios in order to not bias their responses and understand how participants currently perceived climate. The most common answer to this question was that trends are very hard to notice (Ranchers: 53%, Recreation: 36%). Respondents were wary to share their perceptions, as they feared that they might be flawed. For instance, one participant stated, “People say the winters aren’t like they used to be and I don’t know if I buy it or not. I think our brains remember the bad ones.” Participants in general were hesitant to share their personal perceptions about the weather.

Once participants expressed these doubts, some of the same individuals went on to express perceptions of change. They talked about how both the winters and summers were warmer (10% Ranchers; 18% Recreation), spring was coming earlier (5% Ranchers; 12% Recreation), that they were seeing increased extreme weather (10% Ranchers; 6% Recreation) and dust on snow events (12% Recreation). As one participant stated, “I think overall the winters have not been as cold in the past 4-5 winters.” People told stories of bundling up for moving cattle in June, the novelty of swimming in July and the record low temperatures of winters in the past. Several also described how they feel that the spring is coming earlier. One remarked, “I think, this year was an exception, but I think generally things are getting earlier. People are turning water on earlier, things are starting earlier to adapt to an earlier run off, I think.” Both ranchers and recreationists addressed an apparent increase in extreme weather events, that was concerning to both groups. As one noted, “It seems like the weather is more volatile; the swings are more extreme.” A handful of participants spoke with concern about increased dust on snow events. As one long-time resident described, “I’ve noticed more wind and dust events than in the past. I have been here for 40 years and I will admit that.” While the percentages of total participants noting trends are low, it is important to note that some participants are noticing changes in weather over time.

Season	Moderate Scenario			More Extreme Scenario		
	Precipitation (percent)	Temp °F	Temp °C	Precipitation (percent)	Temp °F	Temp °C
Annual	~0.0	+3.6 to +5.4	+2.0 to +3.0	-10.0	+5.4	+3.0
Winter	+15.0	+3.6	+2.0	~0.0	+5.4	+3.0
Spring	-12.0	+4.5	+2.5	-15.0	+5.4	+3.0
Summer	-15.0	+5.4	+3.0	-20.0	+7.0	+4.0
Fall	+4.0	+4.5	+2.5	-10.0	+5.4	+3.0

Table 6. Two scenarios of seasonal precipitation and temperature changes from periods 1950-1999 to 2040-2060. These scenarios were developed for the Gunnison Climate Change Adaptation Workshop from the range of available global and regional climate model projections for central Colorado Rocky Mountains. Developed by Western Water Assessment.

Perceptions of Climate Change Scenarios

In each interview, I explained the climate change scenarios that Western Water Assessment and NCAR have drafted for the Gunnison Basin (Table 6). I described how projections show an increase in temperature for both summer and winter and a shifting in precipitation to the winter, with drier springs and summers. After describing the two potential scenarios, I asked both groups of participants to reflect on what these scenarios might mean for their livelihood and what types of opportunities and challenges they could see if projections were true (Table 7).

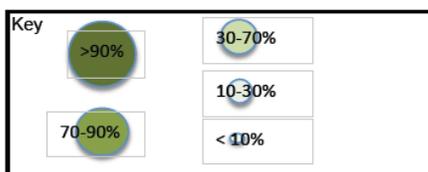
Opportunities. Both sets of participants could see a potential upside to climate change. Climate projections suggest overall warming, and many participants felt that a slightly warmer climate might be a benefit (Ranchers: 53%; Recreation: 38%). As one described, “this place is wicked cold and Gunnison even more so it doesn’t hurt anyone’s feelings if it is a little warmer in the winter.” The projections for more winter snow were welcome to both recreation business owners and ranchers (Ranchers: 68%; Recreation: 69%). One exclaimed, “I’ll take the snow over anything else. If summers are drier, so be it. If the springs are dustier, so be it. If the winters are bringing more snow, come on!” For most recreation businesses, there is a clear line between snow and profit. The ski area representative felt that this could potentially lead to a longer skiing season. Ranchers also saw the upside of more winter precipitation in adequate irrigation water in the spring (47%). As one rancher explained, “you’ll have high mountain snow so we’ll have irrigation. And Gunnison is set up for water storage. If we got high runoff early I think we would still capture it and you have that opportunity.” Ranchers also saw the potential for a longer growing season and the potential for new crops or a second cutting of hay (47%).

Challenges. One challenge that respondents faced with these projections is confusion about how to interpret them or what they would mean to their livelihoods (Ranchers: 42%; Recreation: 37%). As one participant succinctly stated, “Future climate change is an issue where you just don’t really know which way it is going to go.” Participants felt unsure about how they should or could respond to change. As one stated, “I can’t predict if it will be 5 degrees warmer in the summer and 3 in the winter even though that is what is projected. If we are going to get more moisture on the mountain that is great, but can I bet on it? I don’t want to bet my inventory on it?” Several expressed concern that they felt it was impossible to know enough to really plan for change, so they prioritized short-term planning.

The most common concern participants expressed was fear about increased drought, which would be likely given the projections (Ranchers: 68%; Recreation: 37%). The increase in dry conditions during the spring and summer made many ranchers worry about the ability to continue to use public lands, especially given the potential listing of Gunnison sage-grouse. As one stated, “They are probably going to be kicking us off that land anyway and that is the land that is more susceptible to drought and it is important because we need that intermediate range so that event would effect us and the sage-grouse.”

Table 7. Percentage of Gunnison Basin participants who suggested the following opportunities and challenges to climate change projections.

		Ranchers n=19	Recreation Business Owners n=16
Opportunity			
	Warm weather a benefit		
	Increased winter precipitation a benefit		
	Longer growing season-new crops?		
	More runoff (potential to capture)		
	Earlier season		
Challenge			
	Difficult to be sure about projections		
	Increase in drought		
	Timing and speed of runoff		
	Increase in extreme weather events		
	Increase dust on snow		
	Increase fire risk		



Given past experience with drought conditions, ranchers were also concerned that more frequent and severe droughts would force people out of business. As one stated, “If you had one of those every 5 years I don’t think you could survive it. You just can’t come back. You just can’t.”

Climate projections suggest the potential for runoff to occur 1-2 weeks earlier and have higher peaks in flow. Ranchers and recreationists alike were concerned about changes in the timing of early season runoff (Ranchers: 58%; Recreation: 12%). As one rancher expressed, “We turn cows out there in the spring and it is pretty arid up there and the stock water is all dependent on springs. When we have an early melt-off year in March off the south facing hills we have water troubles and the grass isn’t as good and things like that. That warmer spring won’t be great for us.” Recreation interests were also concerned about a more rapid runoff that might leave streams drier later in the summer. Low water levels would be bad both for rafting and the health of wild fish populations. As one fishing guide stated, “Water temps get high and the fish will still bite but at 72 we stop fishing because it is too much stress on the fish.” Projections also suggest increased extreme weather events, the potential for dust on snow and situations that could lead to increased fire frequency. Participants expressed concern about each of these issues (extremes: Ranchers: 11%; Recreation: 43%, dust on snow: Recreation: 6% and increased fire: Recreation: 18%).

Potential Future Adaptations

Finally, I asked participants to tell me what they thought could be done now in order to improve the resilience of their livelihood and the resources it depends upon given climate change projections. Ranchers and recreation businesses discussed similar climate adaptation strategies including increased flexibility by land management agencies, increased collaboration and communication between different user groups and increasing the health of the ecosystems that communities rely on (Table 8 and Table 10). These will be addressed in more detail in the discussion section regarding climate adaptation strategies.

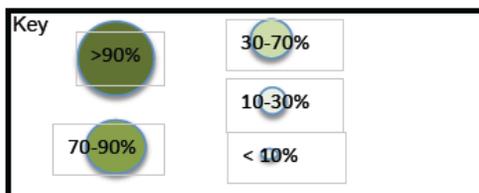
As we see climate change that flexibility is going to have to increase even more to where it is a cooperation and area of communication between all users; not just livestock people but recreation and all of it. You have to have the flexibility in order to make it fit the season or the resource and I would hope that would be the first step.
- Gunnison Basin Rancher

Discussion

Conservation organizations typically focus on conserving species, habitats or ecosystems and landscapes at risk. In relatively static ecosystems, this strategy has been successful, but climate change poses a unique threat to the stability of both ecosystems and society. In this context, it is critical to understand how projected climate change will influence both livelihoods and ecosystems in order to choose climate adaptation strategies that recognize opportunities to benefit conservation and livelihoods and also work to avoid challenges posed by the intersection of use and conservation values. For

Table 8. Percentage of Gunnison Basin participants who suggested the following climate change adaptation strategies.

		Ranchers n=19	Recreation n=16
Type of adaptation	Future adaptation strategy		
Resource	Increased water storage		
	Use private lands or leased lands more heavily		
Practices	Increased flexibility on federal lands		
	Improve the resilience of ecosystem		
	Utilize new crops		
	Diversify year-round recreation opportunities		
	Increase regulation of recreation		
	Faster agency response to emerging issues		
Building social capital	Increased communication & collaboration		



instance, an integrated approach might highlight challenges such as decreased habitat available for high altitude species such as pika and marmot and increased recreation in these areas due to displacement of recreation activities (hiking, mountain biking) from hotter and fire-prone lower elevations. It may also identify opportunities such as working with land managers to improve overall system health (restoring riparian areas, maintaining healthy elk populations), which can benefit both livelihoods and ecosystems.

Resilience and Vulnerability of Land-Based Livelihoods

Ranchers. The ranching community is used to dealing with variability on a variety of spatial and temporal scales. The Gunnison Basin is not an easy place to ranch given the short growing season, cold winters and low precipitation. Ranchers are experienced with dealing with adversity and this experience has cultivated traits of flexibility and tenacity. Ranchers demonstrate innovation and a variety of current adaptations to respond to variability. Innovations such as the local land conservation organization have helped the community adjust to pressures from increased land values and recreational interests. In addition, they have a long legacy in the region and have built up local knowledge about how to successfully ranch in the Basin. The ranching community, despite increased independence in daily operations, is united on large issues facing them and there remains a social network in which advice and information are circulated. Multiple generations of adaptation to severe climate give them both the innovations and perspective needed to deal with change.

Despite their personal and communal adaptive capacity, there are institutional and contextual limitations to ranchers' ability to adapt. Their dependence on public land makes them vulnerable to changes in forage and water resources, which may lead to further restrictions on grazing. Ranchers already describe how they feel like they are the easiest use to control, and worry that they will be further limited by climate change. Concern about public land access is connected with growing recreational pressure on public lands and the proposed listing of the Gunnison sage-grouse. This potential confluence of events would pose increased stress upon ranching livelihoods, and could potentially introduce a threshold in ranchers' ability to stay in business. While ranchers describe a close knit ranching community, many express a lowered level of social capital with the community as a whole. Tension with the broader community makes ranching livelihoods more vulnerable to climate change because it limits the ability to find creative and adaptive solutions.

Recreation-based Businesses. Many of the business owners have a diversity of income-generating activities that take advantage of multiple seasons and recreational activities. Those who are diversified may be more resilient to weather stressors at one time of the year. For instance, guides talked about years where the weather was good for fishing but not hunting and vice versa. Many businesses expressed their ability to make small adjustments to weather on a yearly basis. In addition, many recreation-based businesses described how climate change might actually improve both recreation opportunities and visitation as the winters become warmer and more people want to escape high temperatures at lower elevations.

Recreation-based businesses were worried about several climate-change related factors. As a destination resort, businesses were concerned about the ability of travelers to arrive given increased winter precipitation and the potential for extreme weather events. In addition, many expressed feeling vulnerable because of their dependence on the ski area. While projections suggest improved ski conditions at Crested Butte, people expressed concern about increased dust on snow events and the potential for rain on snow events. They also expressed concern about the ability of land management agencies to be flexible with recreation permits given potential changes in weather and timing of recreation activities. Finally, many rely on a short season to make most of their income (whether several months of skiing or 3 months of fishing). This dependence on a certain time of year may make them vulnerable if weather changes during this window of time.

Table 9. Primary ecosystem services that ranching and recreation-based livelihoods depend upon and the potential impact that climate change will have on them.

Ecosystem Service	Type	Livelihood dependent on ecosystem service		Description	Potential climate change impact
		Ranching	Recreation		
Forage & browse production	Provisioning	X		Food for livestock in spring/summer and fall	Depends on moisture. If projections are correct, may decrease production in spring/summer. If incorrect, may increase production in spring/summer by shifting growing season earlier in the year.
Hay production	Provisioning	X		Food for livestock during winter	Depends on moisture. If good snowpack and no downstream calls, may be stable or increase.
Fisheries	Provisioning		X	Fishing opportunities on rivers, streams and reservoirs	May decrease or shift to higher elevations if streams/rivers are warmer and habitat is not as suitable.
Wildlife	Provisioning		X	Hunting opportunities	Could increase or decrease. Could shift the hunting season.
Water	Provisioning	X	X	Water for recreation and ranching	The total amount of water is not predicted to decrease, but the timing and intensity of events may shift.
Climate regulation	Regulating	X	X	Year-round regulation of climate events	Predictability of weather events may decrease and variability may increase.
Water flow regulation	Regulating	X	X	Regulation of spring runoff for recreation and irrigation	Predictability may decrease with an increase in variability.
Natural hazards regulation	Regulating		X	Regulation of fire frequency	Natural hazards may increase and not fit within the normal range of variation.
Pest regulation	Regulating		X	Regulation of pests such as pine beetle	Pests may increase and new pests may enter the system.
Aesthetic	Cultural	X	X		Uncertain. Certain aesthetic values tied with ranching livelihoods may decrease. Increased recreation may decrease overall aesthetic experience.
Recreational	Cultural		X		Uncertain. Increased demand may decrease recreational experience and changed weather patterns may shift recreational use.

Thresholds and Tipping Points for Land-Based Livelihoods

Participants in land-based livelihoods are dependent on specific ecosystem services (Table 9) and desired weather events (Appendix 1B: Figure 2 and 3). Projected climate change may impact both in ways that challenge livelihoods and the ecosystems they rely upon. Interviews suggested four primary thresholds of concern to ranchers and recreation businesses.

Increase in drought conditions. Increase in the duration and frequency of drought events is the primary concern of the ranching community. Ranchers were concerned that several drought years in a row could make it challenging for them to stay in business. Drought has impacts that are felt throughout a single year (insufficient stock water, low rangeland production, low hay production, potential for curtailing of public lands leases) and across years (expenses for purchasing hay, sales of cattle). Ranchers are concerned that these impacts could be intensified if the Gunnison sage-grouse is listed and agencies are required to be more conservative during drought years. Recreation-based businesses were concerned that decreased precipitation in the spring and summer months may decrease wildflowers, decrease the quality of the fishing and biking experience and lead to hotter conditions and increased fire risk. If drought frequency and duration increases, this may represent a threshold for individual ranchers. Some ranchers may be forced out of business or move to less challenging environments. This could lead to fragmentation of rangelands into smaller ownership parcels and sales of water from agriculture to development.

Change in timing of runoff. Both recreation-based businesses and ranchers were concerned about a change in the timing of runoff. Earlier or faster runoff may also make it challenging for ranchers to irrigate, especially if federal agencies are inflexible with turnout dates. Ranchers rely on public lands to move their cattle off hay meadows during irrigation in the spring. Since ranchers rely on hay production for winter-feeding, changes in spring temperature and precipitation may impact their ability to overwinter cattle. Recreation-based business, especially rafting and fly-fishing guides, rely on stable and predictable runoff for recreation activities. They are concerned that changes in the timing of runoff may make it challenging to operate their businesses. By itself, this may not represent a threshold, but it could lead to increased pressure for development of water storage projects in order to regulate flow.

Increase in extreme weather events. Recreation-based businesses were also very concerned about increases in extreme weather events. The recreation economy depends on tourists traveling from other locations, and increases in extreme winter storms in the winter or fire risk during the summer may make it difficult for tourists to travel to the Gunnison area. Recreation business owners were also concerned about weather-related dangers including an increase in dangerous stream-crossings, avalanches and fire. These events may make Gunnison a less attractive place to recreate. Ranchers were also concerned about extreme winter events that make it challenging to feed cattle and create potential conflicts with wildlife. The impacts of increased extreme weather events are difficult to predict, but will likely make it more challenging for businesses to operate.

Increase in recreational pressure. Recreation businesses and ranchers also felt that climate change in other areas could lead to an increase in tourism in Gunnison, as people flee hotter temperatures elsewhere. Increased recreation pressure may make it more difficult for recreation businesses to continue to offer a quality experience. Ranchers were also concerned that an increase in recreation pressure would lead to further conflicts regarding multiple use landscapes. If recreation pressure increases, this could create a threshold for land-based livelihoods in which multiple land-use pressures increase and the quality of the recreational experience decreases.

Climate Smart Conservation: Integrating Livelihood Concerns into Conservation Planning

This analysis highlighted factors that increase the resilience and vulnerability of land based livelihoods, documented current perceptions of climate change and assessed the ways in which livelihoods currently cope with weather and propose to adapt to climate change in the future. These factors help to identify climate adaptation strategies that may serve to increase the resilience of the social-ecological system as a whole and spot potential challenges that degrade livelihoods, ecosystems or both (Table 10).

Table 10. Potential climate adaptation strategies and their implications for livelihoods and ecosystems						
Management challenge arising from climate change scenarios	Climate change adaptation strategy	Ecosystem(s) impacted	Benefit		Potential tradeoffs	Type of adaptation
			Ecosystems	Livelihoods		
Increased need for responsiveness from federal land management agencies	Increased flexibility and responsiveness from land management agencies	All	Minimize use during stressful times.	Allow use to correspond with availability of resource and provide additional opportunities based on change in resource.	Relies on monitoring of resource and may require more time from agency personnel. There is also the potential for misuse and damage to resources.	Explicitly suggested by participants (Ranchers: 74%; Recreation:38%)
Unreliable river flow and loss of wetlands/water sources.	Development of small water storage	Mid-high elevation ecosystems	Provide year-round water for wildlife. Regulate runoff for habitat and ecosystem services.	Provide stock water and allow flexibility in use of pastures. Allow for more predictable runoff for recreational use.	Storage projects can be expensive and may disrupt ability of ecosystem to adapt to changed hydrograph.	Current and explicit (Ranchers: 38%)
	Additional water trading agreements	All	More flexibility for in-stream flow and habitat	More flexibility in use of water.	Flexibility in one location may mean more restrictions in another place.	Current (Ranchers: 26%) and implicit.
Potential listing of the Gunnison Sage-Grouse and impact on livelihoods	Funding for research to understand the role of grazing in decline of Gunnison Sage-Grouse	Low-mid elevation ecosystems	Better understanding of the threats and stressors to grouse populations.	Better understanding of how to manage for grouse.	Research may be difficult to design and implement. Potential conflicts with timeline of listing. Need for monitoring and synthesis.	Implicitly suggested by all ranchers.
	Funding/resources to attempt small-scale experiments to increase Gunnison Sage-Grouse populations.					
Increased stress on ecosystems and reduced ecosystem health	Restoration of streams	Riparian areas	Improved habitat for aquatic species.	Less erosion, improved aesthetics and improved fisheries.	May require restrictions on grazing use.	Explicitly suggested by participants (Ranchers: 11%; Recreation:13%).
	Grazing systems that increase cover and organic matter	All but tundra systems	Lower erosion, increased production and water-holding capacity.	More productive rangelands and increased health of overall system.	Some techniques may require expensive investments (fencing/water development) or change in regulation (larger cattle pools moving faster).	Current (Ranchers:16% and explicit (Ranchers: 11%).
	Control wildlife numbers	All	Lowered grazing pressure improves rangeland health for a multiple species.	Overall improvement in rangeland health, decreased competition.	Lowered elk numbers may be detrimental for hunting guides and may be politically challenging	Implicitly suggested by participants.
Increased recreation pressure	Increased regulation of recreation activities	All	Decreased fragmentation of wildlife habitat and lowered trail erosion.	Less stress on ranching livelihoods and potentially greater ability to provide a high quality recreational experience.	May be detrimental to recreation businesses if limits access.	Current (Recreation:7%) and explicit (Ranchers:37%, Recreation:13%).
Increased and interacting stressors on land-based livelihoods	Efforts to improve communication, collaboration and education across user groups (listening sessions, educational forums, participatory planning efforts, etc...)	All	Better coordination of activities may lead to lowered overall stress.	Identify positive solutions and create a vision for the future.	Requires time commitment from participants and may not lead to consensus.	Current and explicit (Ranchers:47%, Recreation:31%).

The climate adaptation strategy that was suggested most frequently by participants (74%: Ranchers, 38%: Recreation Businesses) was increased flexibility from land management agencies. Climate change projections suggest shifts in the timing and availability of natural resources including precipitation, runoff and forage production. Participants described how shifts in precipitation might necessitate shifts in grazing or recreation access to maintain livelihoods and protect the resource. As one participant stated, "If this global warming thing is really happening, which I think it is, we're going to have to adjust." Agencies are increasingly interested in managing from a resilience perspective, but often struggle with prior structures that limit their ability to be flexible (Benson and Garmestani 2011). From a conservation perspective, flexibility would allow grazing when it least impacts ecosystems and species of concern and allow ranchers to adjust for changes in annual weather patterns. The challenge of this strategy will be the additional workload it puts on agency personnel to monitor and adjust to changing weather. The GCWG and TNC could play a pivotal role in encouraging flexibility that protects resources and livelihoods. In regions such as Gunnison, where 80% of the land ownership is public, working with agencies to design more responsive and adaptive use of resources may be critical to maintaining the health of natural ecosystems and land-based livelihoods.

A second important strategy would be to foster collaboration between different stakeholders to jointly envision and plan for the future (Ranchers: 47%, Recreation Businesses: 31%). Participants talked about the interaction between different types of land use and the ecosystems and species in the Basin. Several talked explicitly about the need to collaborate in order to generate creative and viable solutions that would benefit ecosystems and communities. Potential strategies could include listening sessions, educational forums or participatory planning efforts. Participants spoke about the benefit of past efforts and their belief that viable solutions would only emerge from ongoing efforts. One potential strategy would be to foster ongoing dialogue and planning regarding climate change, impacts to livelihoods and potential solutions.

A third strategy, given the concerns of both ranching and recreation-based businesses about the potential listing of the Gunnison sage-grouse, would be to fund more systematic research on the primary factors influencing sage-grouse population decline. Ranchers admitted that grazing could have a negative impact on sage-grouse populations, but felt that there was not enough known about the interaction between grazing other potential threats to sage-grouse (predators, wildlife grazing, recreation and development). Several ranchers would like to design adaptive management experiments to better understand how to ranch successfully and sustainably with the Gunnison sage-grouse. Funding learning experiments that explore grazing, sage-grouse habitat and climate change could be a beneficial way to understand how to maintain ecosystems and livelihoods in a time of change.

The timing and availability of water is a critical resource for ecosystems, species and livelihoods. Ranchers would like to see increased water storage capacity (37%) in the upper watershed that could serve to regulate flow for irrigation and provide water sources cattle and they also were interested in maintaining stock water sources on public land allotments. These strategies may be in conflict with goals of the conservation community, who are concerned about the impacts of these strategies on ecosystems. It is important to highlight potentially controversial strategies so that stakeholders can be aware of potential conflict. An additional adaptation strategy that was in alignment with, but not explicitly mentioned by interviews, was developing new water trading agreements. New water trading agreements may be necessary for area water users to continue to negotiate trades in order to provide adequate water for a mix of livelihoods, species and ecosystems. Ranchers are interested in strategies that increase their access to and ability to regulate water flow. This could also be a benefit for ecosystems that rely on timing and quantity of water that are different from the new projected hydrograph, but tradeoffs must be taken into account.

Several ranchers and recreation businesses suggested the need to increase the resilience and health of the system to make it more able to cope with climate change. Suggested strategies included restoration of streams, use of grazing systems that increase cover and organic matter in soils and bringing wildlife numbers in line with the capacity of rangelands. Restoration of streams may improve habitat, increase production and improve aesthetic values for recreational experiences. A challenge might result from decreased access to riparian areas by cattle. Encouraging or providing incentives for ranching practices that increase soil organic matter and cover may benefit ecosystem health and range productivity, but they

may require expensive investments or change in regulations. Stream restoration and grazing practices are tractable at a local scale and could be implemented in a short time frame given adequate incentives and education. Several of the elk herds in the Gunnison Basin are twice the stated objectives (Gunnison Basin Habitat Partnership Committee, 2010). Changed policies that could lead to a decrease in elk may improve habitat for other species and help ranchers continue to run their allotted numbers without rangeland degradation. This strategy, however, may be detrimental to area hunting guides and may be politically challenging. These strategies suggest that by increasing health of the system you are increasing general resilience, which will make the systems more resilient to both climate change and other stressors.

Participants also felt that climate change projections may increase recreational pressure in Gunnison Basin as people shift recreational use from fire-prone and hotter areas to the higher elevations of the Gunnison Basin. This could add increased stress to ecosystems and species already at risk with a changing climate. This could mean that recreation pressure might intensify in popular areas and simultaneously spread to new areas, diffusing the overall pressure on resources. Recreation businesses were concerned about increased competition for use of public lands, a degraded recreational experience and crowding in specific areas. Ranchers were worried about the need to educate recreational users about cattle, increased grazing restrictions due to recreation pressure and the daily hassles of coping with open gates and tampered water developments. Several recreation businesses expressed satisfaction with recent recreation planning and hoped that restrictions would increase the quality of the recreation experience. One potential strategy could be proactive planning and development of regulations to deal with the potential for increased recreation pressure in the future.

Conclusions

Climate change will impact both livelihoods and ecosystems in complex and interconnected ways. In order to understand the best strategies for climate adaptation planning, it is critical that we understand how ecosystems and livelihoods might respond to changes and what types of opportunities and challenges arise from these changing dynamics. The ranching community is overall very resilient. They have adaptive strategies for dealing with the extreme and variable climate, a strong community and a long history in the region. The ranching community is vulnerable to climate change because they depend on public lands, feel decreased support from other community members and have multiple stressors that challenge their ability to survive. Recreation businesses have mixed levels of resilience. Some have diverse livelihood strategies, while others are dependent on a single, short time period for income generation. Recreation businesses are vulnerable due to their dependence on the economic climate and the ski area. Climate change projections suggest both benefits and challenges for land-based livelihoods. While the increased duration and intensity of droughts may place additional stress on area ranches, climate and weather impacts to other locations may make Gunnison more attractive to tourists and increase recreation pressure in the Basin. Potential adaptation strategies suggested by the community include increased flexibility with land management agencies, increased collaboration and planning for the future and increased water development and coordination. This project has begun the process of documenting potential adaptation strategies that may benefit both livelihoods and the ecosystems they rely upon (Table 10). Conservation in a changing environment will require more attention to interactions between social and ecological systems.

Lessons Learned: Process

- It is difficult to engage people in thinking about the future. It is important to develop creative processes for empowering community members to consider what climate change projections might mean for them. This project demonstrated one way to engage community members. Other methods may include “futures” storytelling between youth and elders, scenario analysis, or focus group discussions.
- Community members need interpretation between climate change projections and the resources and ecosystem services that they depend upon. This project began a dialogue with community members about potential climate change impacts. Ongoing dialogue between climate scientists and community

members may hold potential for making climate change projections more tangible and meaningful to community members. In this way local knowledge and science together might better communicate the potential impacts of climate change projections. In order for climate change communication to be effective, it is important that we move beyond communication of “facts” to helping people envision what those facts will mean to them. Scientists and local community members may both learn from this process.

Lessons Learned: Gaps in Research

- I was unable to interview rafting guides in the Gunnison Basin. Several other recreation businesses spoke about the potential impact of climate projections on rafting, but I received no direct feedback from this community. Follow-up conversations with rafting businesses in the area would be useful.
- This study focused on the impacts of climate change on ranching and recreation-based businesses. Other important local economies such as real-estate/development were not included. Future work could expand this research into other economic sectors.

Next Steps and Recommendations to the Gunnison Climate Working Group

- For climate change adaptation strategies to be effective and sustained over time, they need support from the community where they are implemented. It is important to consider strategies that will be supported and perceived as needed by local communities.
- Climate change is shifting the way that conservation is defined and practiced. It is important that conservation groups begin to take seriously the interconnections between livelihoods and ecosystems. The strategies suggested by this report include strategies that fit well within the existing conservation model and others that challenge the boundaries and roles of conservation organizations. It is critical to begin to consider both types of strategies in order to adapt to a changing climate.
- The ability of agencies to be flexible and responsive to climate change impacts is of critical importance to regions where the majority of land ownership is public. This is an issue larger than this single project or Basin, but that will be a growing concern as climate change impacts increase. The Nature Conservancy has the opportunity to play an important role in facilitating dialogue and strategic thinking around how policies and practices might change in a way that are beneficial to both ecosystems and livelihoods.
- Participants were interested in collaborative efforts for envisioning and strategizing about how to adapt to climate change. The Gunnison Climate Working Group may want to consider including some form of dialogue about climate change as one of its strategies.

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APPENDIX 1A

Gunnison Basin Social Resilience & Vulnerability Assessment

Questions: June 29, 2011

- 1. Could you describe for me your [business/operation]?**
 - a. How long has this [business/ operation] been in operation?
 - b. What are primary income-generating activities of this [business/ operation]?
 - c. What are the primary reasons you are in this business?
 - d. What are the primary stressors or challenges that this [business/ operation] has faced in the past 20 years? How did you respond to them?
 - e. What percentage of your total income comes from this [business/ operation]? / Do your employees have any other sources of income?
 - f. Does your [business/ operation] interact or coordinate with similar organizations in your region? Please explain.

- 2. Community context**
 - a. How do you define your community? Are there several communities that you are a part of? Please describe them.
 - i. How well does your community work together to solve collective problems? Please explain.
 - ii. How often do you share information/insights with others in your community? Please explain.
 - b. Think of some of the primary leaders in your community/communities.
 - i. Do you think they are effective?
 - ii. Do they help to organize your community around issues important to you?
 - iii. Do they listen responsively to the needs of community members?
 - c. Think of the primary agencies or government institutions that regulate the use of natural resources that you rely on.
 - i. Do you think they are effective?
 - ii. Do they listen responsively to the needs of community members?
 - iii. Do they integrate your knowledge and insights into management of resources?

- 3. Dependence on the environment**
 - a. What natural forces can make your [business/ operation] successful/not successful? Can you explain why?
 - i. What are the most critical natural resources that you rely on?
 - ii. Are there natural events whose timing is critical to your operation (runoff times, warm/cool season grasses, etc...)?
 - b. Do you rely on access to public land for your operation?
 - i. Do you feel like decisions regarding access to natural resources in this area are fair and equitable? Please explain.
 - ii. Do you face any constraints in your use of these resources? Please explain.
 - c. Are there any factors that currently concern you about the future availability of these resources?

- 4. Has your [business/operation] been impacted negatively by weather events or year-to-year variations?**
 - a. What type of event/s or variations?
 - b. How frequent are these occurrences?
 - c. Could you describe the impact they had on your [business/ operation]?
 - d. How did you respond to these events?
 - e. Did you participate in any collective responses to these events?
 - f. Have you seen any trends (increase/decrease) or do you have any concerns about events like these in the future? Please explain.

- 5. Climate projections for the Gunnison Basin suggest temperature increases from 3-5 degrees and a shift in precipitation (more in winter, less in summer & spring). This could mean drier soils, earlier runoff, higher peaks in runoff, more drought and greater variability.**
 - a. If these projections are correct, how would your [business/ operation] respond to these changes?
 - i. How would you change your business/management practices?
 - ii. How would you change your interactions with similar organizations?
 - iii. What potential opportunities can you see?
 - iv. What potential challenges would it pose?
 - b. Can you see a potential transformation that your [business/ operation] could make to adapt to these projections?
 - i. Are there other potential income streams that you [business/operation] might consider in the future?
 - ii. If your primary income generating activities were no longer viable, would you [your employees] have other local opportunities for employment?

- 6. Do you have any suggestions about things that you, your neighbors, your community or land management agencies could do now to help the natural resources and economy of the Gunnison Basin to be more resilient in the future?**

- 7. Do you have anything else to add?**

Appendix1B: Explanation for Figures 2 and 3

Explanation of Figure 2

Ideal Weather Conditions for Ranching Businesses, Climate Change Projections and Areas of Concern

For ranchers, the times when climate change impacts will be most stressful are in the spring and summer (see hatched areas, Figure 2). In interviews, ranchers described how the spring was already the most challenging time for their operations. Ranchers currently rely on limited spring range, primarily on public lands, in order to get cattle off private lands and begin irrigating hay meadows. Increased temperatures and drying stock water on rangelands may further limit this critical resource, especially if the Gunnison sage-grouse is listed. Earlier or faster runoff may also make it challenging for ranchers to irrigate, especially if federal agencies are inflexible with turnout dates. Since ranchers rely on hay production for winter-feeding, changes in spring temperature and precipitation may impact their ability to overwinter cattle. Reduced moisture during the summer will also impact production on rangelands, impacting cattle weight and potentially leading to curtailing of leases due to drought.

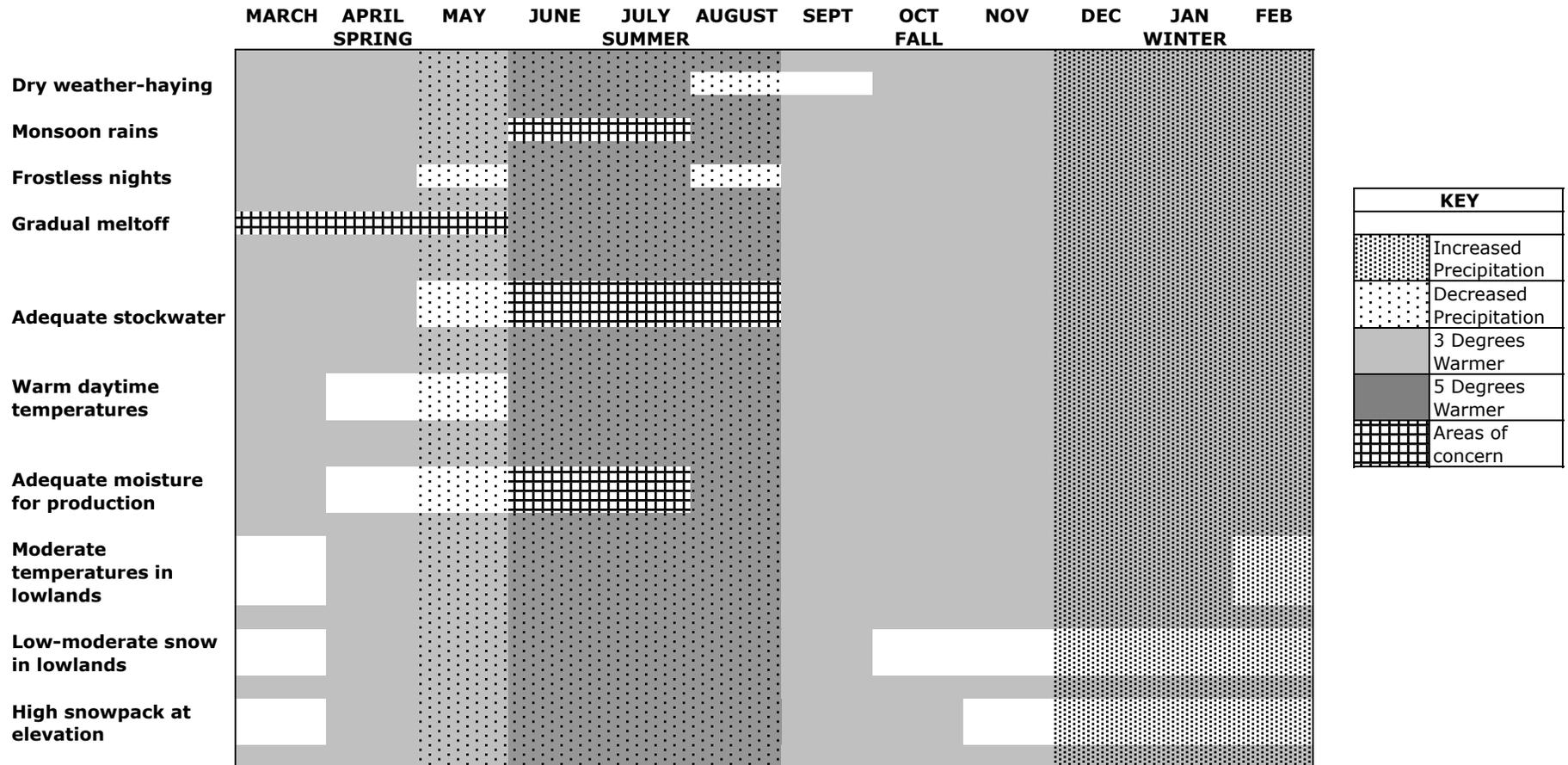
Explanation of Figure 3

Ideal Weather Conditions for Recreation-Based Businesses, Climate Change Projections and Areas of Concern

The potential negative climate impacts for recreation-based businesses are clustered in the summer and winter. Although recreation businesses felt that increased winter precipitation may help them, they were also concerned about increased extreme weather events and the impact of drought on the recreation experience (see hatched areas, Figure 3). Extreme weather events may make it difficult for tourists to travel to the Gunnison area and may increase danger related to avalanches and flooding. Decreased precipitation in the spring and summer months may decrease wildflowers, lower the quality of the fishing and biking experience and lead to hotter conditions and increased fire risk.

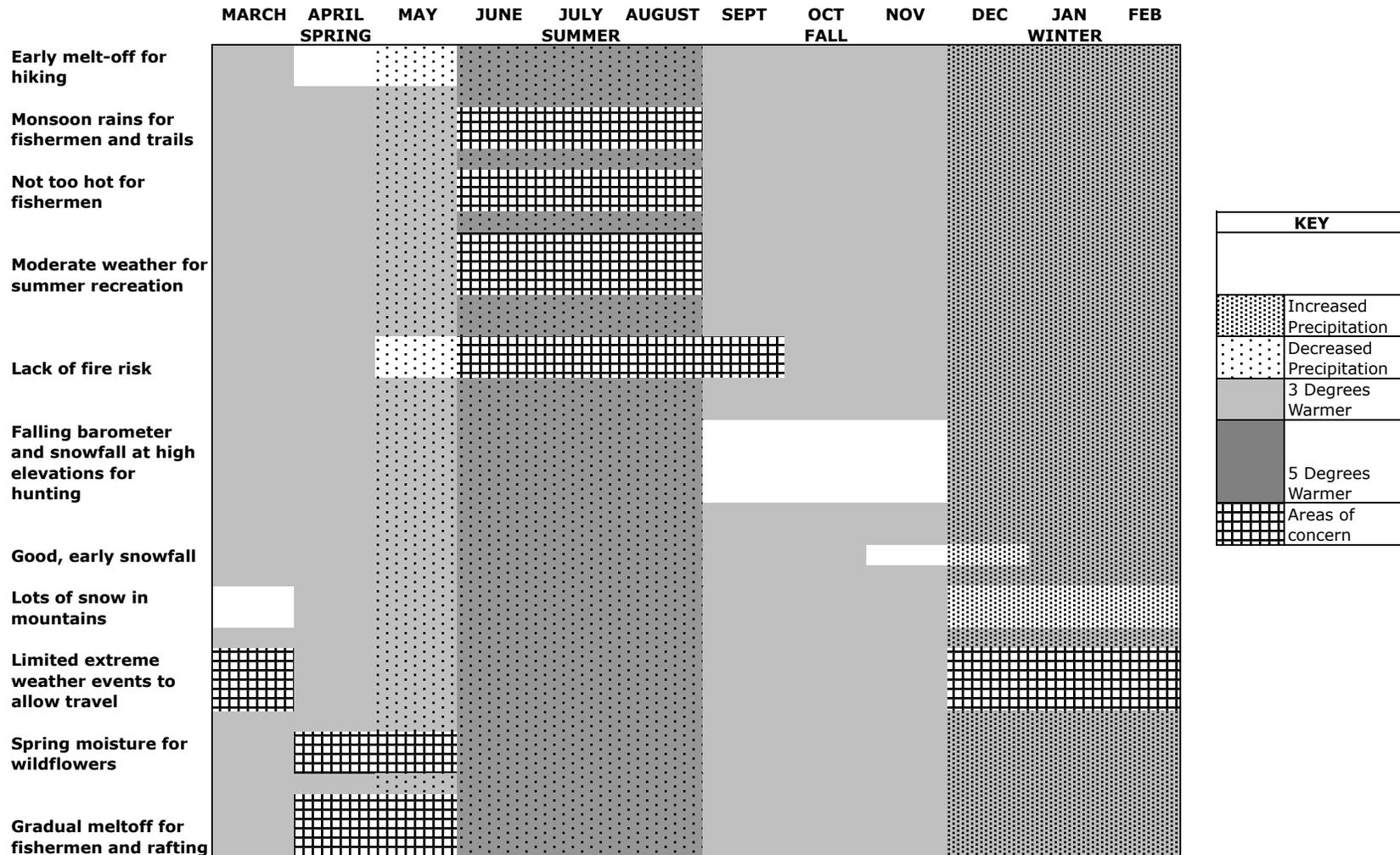
Appendix 1B

Figure 2. Ideal Weather Conditions for Ranching Businesses, Climate Change Projections and Areas of Concern. Each row depicts a weather event that ranching businesses described as part of an ideal year. Each column represents the time of year and the white horizontal bars show the timing of each weather event. The colors represent the warming projections for summer (rdark grey: 5 degrees warmer) and the rest of the year (light grey: 3 degrees warmer). The dots represent the precipitation projections for the spring and summer (decreased precipitation in wide dots) and winter (increased precipitation in dense dots). This helps to identify areas of concern in which projected changes impact ideal weather conditions (wide vertical bars).



Appendix 1B

Figure 3. Ideal Weather Conditions for Recreation Based Businesses, Climate Change Projections and Areas of Concern. Each row depicts a weather event that recreation-based businesses described as part of an ideal year. Each column represents the time of year and the white horizontal bars show the timing of each weather event. The colors represent the warming projections for summer (rdark grey: 5 degrees warmer) and the rest of the year (light grey: 3 degrees warmer). The dots represent the precipitation projections for the spring and summer (decreased precipitation in wide dots) and winter (increased precipitation in dense dots). This helps to identify areas of concern in which projected changes impact ideal weather conditions (wide vertical bars).



KEY	
White bar	Timing of weather event
Dense dots	Increased Precipitation
Wide dots	Decreased Precipitation
Light grey	3 Degrees Warmer
Dark grey	5 Degrees Warmer
Grid pattern	Areas of concern