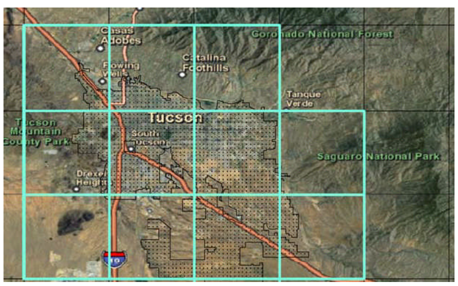


# Regional Climate Adaptation Planning Alliance

## Report on Climate Change and Planning Frameworks for the Intermountain West

**Prepared by ICLEI**

For

**Members of the Urban Sustainability Directors Network**

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## Executive Summary

Major cities in the arid and semi-arid areas of the Western US have developed a Regional Climate Adaptation Planning Alliance to develop a common regional approach to adaptation planning – including a collective vision of resilience, planning frameworks and information sharing opportunities. This Alliance is founded on its members' shared goal to make climate change adaptation a priority at the local level and the collective understanding that successful climate change adaptation requires regional collaboration. Subsequent sections of this report lay out a vision for resilience in the West; suggest common adaptation goals for municipalities in the region; describe the rationale for action on adaptation; establish common assumptions about climate change scenarios; and identify common focus areas and planning frameworks.

Sections 1 and 2 outline a collective vision for a region resilient to changing climate conditions. The vision describes a positive future in which Western communities identify the trends and hazards that threaten quality of life, and take the initiative to respond locally and regionally in building stronger communities, economies, and ecosystems. Section 2 outlines the principles that can guide Alliance members in achieving its vision of resilience.

Moving from the vision toward planning steps, Section 3 elaborates on the following six reasons to engage in climate change adaptation:

1. The climate has already changed and future changes are highly certain.
2. Climate change poses a threat to existing community priorities and commitments.
3. Today's decisions have long legacies, thereby shaping tomorrow's vulnerabilities.
4. Planning now can save money, while inaction now will lead to higher costs in the future.
5. Planning for uncertainty is not new, and can be integrated into current planning frameworks.
6. Adaptation has co-benefits for other community priorities.

Section 4 is a focused summary of current climate change science that is relevant to the broad region of the Intermountain West. It provides the scientific basis for planning and outlines the historic and projected shifts in two primary changing climate conditions – temperature and precipitation. Additionally, information on snowpack and streamflow, secondary climate change condisioins, is provided due to the significant role these factors play in the region. The report draws on existing academic literature and finds overwhelming evidence that the region will experience a trend toward higher temperatures with a projected rise in 2020 to between 1.9 and 3 °F above a 1960 – 1979 baseline.[1] The report also found significant evidence that the region will likely see declining snowpack and streamflow over the long term. While projections for temperature and snowpack are more certain, the variability of precipitation patterns currently prevents to scientists from discerning a definite trend for the region. The section concludes with key information for understanding climate change including shifting averages, increasing extremes, and the timing of change.

Although temperature, precipitation, and snowpack projections are important to understand in themselves, communities are often most concerned with the *impacts* of climate change to communities. Section 5 presents key climate change impacts for the region, covering five different sectors – Water

[1] Karl, 2009.

Resources; Agriculture and Food Security; The Built Environment and Extreme Events; Public Health; and Economic Impacts. The section also includes key information about the interdependencies of climate change impacts.

Water resources will be severely impacted by a number of key factors, but the ability to meet consumer demand in multiple sectors could be most threatened by increasing dryness. The built environment is most threatened by future increases in flooding, wildfire risk and energy disruptions. The report finds that the biggest concern for the public health sector is likely to be the increase in heat-related morbidity and mortality over the coming decades. Although the secondary impacts to the regional economy are not as clearly understood, the costs of inaction are likely to be very high. For water supply alone, the cost of climate impacts could be as high as nearly 1 trillion dollars annually by 2100.[2] .

The final three sections provide additional information to help the Alliance pursue its next steps. Section 6 uses ICLEI's Climate Resilient Communities™ (CRC) Five Milestones for Climate Adaptation planning framework to describe the general approach of climate adaptation planning. The section also outlines three different options for local governments to work through this framework: 1) Stand-alone adaptation planning 2) Integrated adaptation planning and 3) Sector-specific adaptation planning. Section 7 provides guidance and options for information-sharing among Alliance participants. Finally, Section 8 identifies the following near-term objectives for Alliance activities:

1. Establishing a regular dialogue by conference call or online meeting;
2. Creating a resolution articulating the group's intentions and goals;
3. Adoption of the resolution by local governing bodies; and
4. Developing an online platform for information-sharing.

[2] NRDC, 2008

## Section 1. Vision for a Resilient Region

Resilience is the ability to rebound from stress and change. The warming of the earth is unequivocal and in the face of this change, resilient cities and regions will be those that can continue to prosper economically, socially, and ecologically even as their surroundings change.

In the Intermountain West, communities have a long history of weathering adversity and emerging as stronger, more cohesive places. As climate and related extreme weather conditions change, Western communities are beginning to innovate in independent and original ways to prepare. While it remains unclear how state and federal agencies will involve themselves in climate adaptation, cities and counties in the West are starting to address the challenge head on at the local level, and are sharing their successes and lessons learned with their peers from other local jurisdictions. Their vision is of places where:

- A diverse and thriving economy can adapt to changing weather patterns.
- Natural resources are managed such that species can adapt as their habitats shift with the climate.
- Robust public health infrastructure, social networks and other social systems enable the region to minimize the health impacts of climate change.
- Lives, homes and infrastructure are protected from extreme weather events and related flooding, wildfires, landslide, and other hazards.
- Communities incorporate resiliency and adaptability to changing human migration patterns.

While this positive vision of resilience is attainable, it is by no means assured. With insufficient planning and action, the region could experience devastating effects. The threats from climate change cross many sectors in the region and will impact the area's economy, social systems, urban services, and environmental resources. *Economic* impacts could be quite severe. By 2030, the pending loss or major decline in the ski industry in Park City, Utah alone could result in $120 million in lost economic activity, with 1,137 lost jobs and $20.4 million in the form of lost earnings.[3] Tourism could also be affected by higher wildfire risk, while places threatened by flash floods may lose businesses to locations where they can operate more consistently. *Social* impacts are also a major concern. For example, intensifying heat waves will impact vulnerable populations, causing severe illnesses and possible fatalities if adaptation measures are not taken. Rising temperatures and increased wildfires impact air quality, resulting in additional human health impacts. *Environmental* impacts could also be staggering, including the potential threat to forests from fires and pine beetle infestations.[4]

Despite the severity of these dangers, the biggest threat to the region may be from water shortages. If actions are not taken to prepare for a more limited water supply, communities of every size and type could suffer.[5]

Realizing the positive vision of resilience and sustainability will be one of the most challenging endeavors the region has faced. Climate and weather do not respect the lines of states or political parties, and regional collaboration is key to achieving success in this effort, for some of the reasons described below:

[3] Stratus, 2009.
[4] Karl, 2009
[5] Ibid. p. 129.

- Many of the vulnerable systems and resources that communities rely on are essentially regional systems. Water resources management in the Colorado River Basin is a prime example of a vulnerable system that is regional in nature.
- Communities across the region may find that they have similar threats, such as heat health impacts, that could be addressed in similar ways through sharing of best practices.
- Collaborative planning can aggregate resources and leverage and attract funding that might not be available for smaller-scale projects. For example, a smaller city may not be able to obtain funding to run climate change models for their individual community, but would be more likely to succeed working with other cities to fund a regional-scale assessment.
- Equipment and resources could be shared or leveraged across the region. A contemporary example is collaborative purchasing power that cities and counties have started to use for solar panels, and which could be applied to other common needs. Another possibility in this area is the sharing of server space where climate and impacts data is stored.

These examples only begin to describe the opportunities that could arise from a regional approach to pursuing the vision of a resilient region.

## Section 2. Collaborative Planning Principles

There are a number of guiding principles that when applied collectively and collaboratively will help the region to achieve the vision set forth above. The nine principles described below can be divided into two categories. The first four principles focus on regional collaboration, while the latter five can be applied at the city or county level, but may still benefit from a regional component.

*Regional Collaboration*

- Recognize and utilize commonalities across the region
- Collaborate regionally when appropriate
- Embrace and understand regional differences
- Respect each other and leverage shared knowledge and collective skills

*Local Application*

- Plan locally, consistently applying shared regional understandings
- Utilize a multidisciplinary, integrated approach to solutions
- Plan for multiple time frames and impact scenarios
- Select strategies with multiple benefits and minimal detrimental impacts
- Apply a “degrees- of- risk” framework

The first step of regional collaboration is to recognize commonalities in terms of shared goals, shared resources, shared needs and shared threats that could be addressed collectively. Once these common areas are identified, they can then be used as leverage points as well as points for collaboration. For example, if a shared goal is to better understand the relationship between climate and stream flows, communities could work together to advance this scientific understanding. On the other hand, collaboration will also benefit from knowing what the differences are between the regions and how those differences should be respected during problem-solving and collaborative decision-making. Following these principles will enable the cities of the West to collectively advance their climate change adaptation efforts and achieve their long term vision of resilience.

Even if a regional approach does not materialize, communities can apply the last five principles individually to achieve future resilience. First, local and county governments should plan at the level for activities within their jurisdiction, establishing a vision for the community and developing the steps necessary along the way to achieve that vision. When creating solutions to existing problems or devising steps to achieve resilience, a multidisciplinary approach should be applied. Additionally, solutions that achieve multiple benefits should be pursued in order to most efficiently enhance a community's resilience while also addressing other community goals. In a similar vein, solutions should be considered for their negative external effects and only those that do not significantly disrupt or harm other systems should be applied. Finally, the security community recommends that a serious risk management approach be applied to climate change threats. As described in Box 1, the Three-Tier "ABC" Framework can and, when possible, should be applied at the national, regional and local levels. This risk framework can be used as a guide to local efforts.[6]

**Box 1: The Three-Tier "ABC" Framework**

**A:** Aim to stay below 2°C (3.6°F)* of global warming. This component is related to climate change mitigation efforts that focus on reducing world wide greenhouse gas emissions so as to avoid unmanageable climate change.
**Local Example:** Integrating climate change adaptation with climate mitigation work to ensure that adaption actions are not increasing greenhouse gas emissions.

**B:** Build and budget assuming 3-4°C (5.4-7.2°F)* of warming. This is related to understanding climate change impacts and planning to make changes to reduce the impacts of future threats.
**Local Example:** Focus adaptation efforts on the perfect storm of interdependent impacts that could result from this global average temperature change. Aiming on the higher end helps a community apply the precautionary principle.

**C:** Contingency plan for 5-7°C (9-12.6°F)* of warming. Currently, this component is related to monitoring for tipping points and creating contingency plans to respond to catastrophic impacts.
**Local Example:** Local monitoring programs can help enhance the understanding of how weather and climate relates to global extremes. Additionally, the creation of post disaster redevelopment plans can help a community plan for unpredictable extreme events

* The global temperature increases outlined here are only suggested and reflect the thinking of the majority of global political and scientific actors. Additionally these are global average temperature changes and not local average changes or daily weather conditions.

**Source:** Degrees of Risk: Defining a Risk Management Framework for Climate Security

## Section 3. Rationale for Adaptation

There are a number of general as well as place-specific reasons why climate change adaptation is a smart option for communities across the Unites States and in the Intermountain West in particular. Provided below are some of the most compelling reasons for Western communities to move forward with climate change adaptation:

1. ***The climate has already changed and future changes are highly certain*.**[7] In many parts of the world, the current climate is already noticeably different from the historical climate. Across the Intermountain West annual average temperature increases have been observed and future projections indicate a rising trend (Section 5). Climate change has serious direct and indirect impacts on communities (Section 6) and communities that engage in advanced planning can benefit.

[6] Mabey, 2011
[7] Hansen, 2005

2. ***Climate change poses a threat to existing community priorities and affects a local government's ability to deliver on its existing commitments***. For example, across the Intermountain West local governments are committed to providing their citizens with access to potable water for a variety of uses; however, if today's agreements and infrastructure projects do not account for future snowpack changes, local governments will not be able to achieve this established goal.

3. ***Local officials are making major development decisions today that will have long legacies; therefore, today's choices will shape tomorrow's vulnerabilities.*** Infrastructure designed and built today could last anywhere between 30 and 100 years depending on materials. Moreover, homes permitted and built today are often expected to last 50 to 80 years; however, if built in tomorrow's floodplain, these positive developments could become major disasters.

4. ***Planning now can save money, while inaction now will lead to higher costs in the future.*** Paying for prevention upfront can avoid more significant costs in the future. For example, it has been found that one dollar of hazard mitigation today can prevent the expenditure of four dollars of post-disaster reconstruction in the future.[8] This principle also extends to reducing the future costs of incremental climate change impacts.[9]

5. ***Planning for uncertainty and future variability is not a new process, and can be integrated into current planning frameworks.*** Many local governments create long-term plans such as comprehensive or master plans that establish a future vision for their communities while dealing with uncertainties in population growth and economic trends. While there will always be uncertainty about the precise ways in which climate change will impact specific communities, local governments can make informed decisions about how to adapt based on the best available information and integrate these choices into existing planning efforts.[10]

6. ***Adaptation can have co-benefits for climate change mitigation and local sustainability efforts that a local government already may have adopted***. Some actions can achieve greenhouse gas emissions reductions while at the same time helping cities adapt to expected climate change. Energy efficiency, for example, is a common strategy to reduce greenhouse gas (GHG) emissions; it can also increase a city's energy security – including the capacity to cope with future climate impacts to the energy sector – by decreasing electricity consumption and thereby reducing vulnerability to grid overload and outages.

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[8] GFDRR, 2010.
[9] Snover, 2007.
[10] Dessler, 2010.

## Section 4. Climate Change – Global and Regional Understanding

### 4.1. Global Climate Change Overview

Over the past century, numerous changes in climate—which refers to long term average trends in weather—have been documented globally. To date, the world has seen increases in annual average temperatures, altered precipitation patterns, and sea level rise. Globally, temperatures have increased an average of 1.3°F over the past century resulting in less snow accumulation in the winter and an earlier arrival of spring in many parts of the world. Sea level has been rising globally at a rate of 0.8 inches per decade or 0.67 feet over the century, another documented impact of the earth's changing climate. These global climate change trends – increasing temperatures, altered precipitation patterns, and rising sea level – are expected to continue into the future, and the rate of change is expected to increase.[11]

### 4.2. Creating Future Climate Change Projections

When determining future climate conditions globally, scientists rely on global circulations models (GCMs), which are mathematical models that include a wide variety of physical process such as wind motion, cloudiness, and ocean currents, as well as geographical features such as topography and vegetation. These models are tested by comparing their results with data of past climates. Finally, GHG emissions scenarios are introduced into the climate models to create future projections.

The Intergovernmental Panel on Climate Change (IPCC) has developed a suite of GHG emissions scenarios shown in Figure 1. The scenarios factor in variables including population growth, energy use, and societal choices in order to create potential GHG emissions over the coming century. The scenarios themselves are considered alternative images of how the future might unfold and are therefore not assigned probabilities or likelihoods of future occurrence.[12]

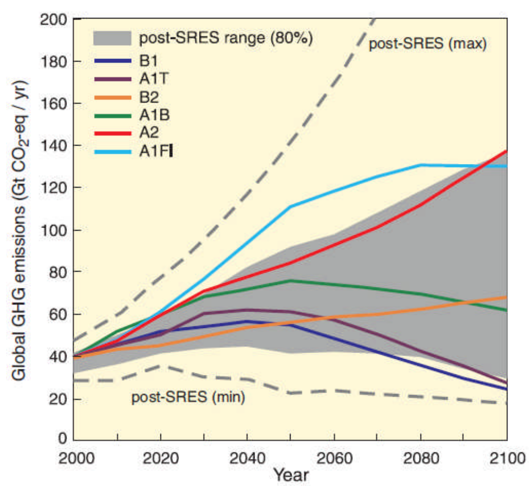


**Figure 1:** Emissions Scenarios used by the Intergovernmental Panel on Climate Change (IPCC, 2007, p.44).

Most analyses of changing climatic conditions and associated impacts include, at a minimum, a high-emissions scenario and a low-emissions scenario to create a range of possible future climates. One high emissions scenario shown is the A2 scenario (red), which is based upon a world with high population growth, slow economic development motivated by maximizing growth, and high fossil fuel use. The B1 scenario (dark blue), a low emissions scenario, envisions economic prosperity that is managed in a more sustainable way, with population projections that peaks in mid-century.[13]

Given that regional and local climate conditions can vary significantly from the world wide averages, it is necessary translate global results into regionally relevant information. In order to make these coarse resolution projections relevant at the regional scale, a general process called downscaling is used. This

[11] IPCC, 2007
[12] Ibid.
[13] Ibid.

general process comes in two different forms. Statistical downscaling works by creating a mathematical relationship between global model outputs and locally known climate conditions. Dynamic downscaling on the other hand creates regional climate models (RCMs) that simulate more local processes. For broad planning frameworks, both methods provide useful information; however there may be key local decisions that require a certain level or accuracy. In these specific cases local officials will have to consider the type of downscaling that was used.

Finally, it is important to recognize that due to a time lag in the climate system most models find similar projections for another 25 – 50 years regardless of the emissions scenarios used. In other words, key projections for the next 25 – 50 years will occur regardless of future global GHG emissions reductions. However, the results of the different scenarios diverge in the later half of the century.[14] Additionally, communities should be aware of the fact that a new set of emissions scenarios are being developed for the next IPCC assessment in order to reflect that fact that greenhouse gas emissions over the past decade have been at or above the upper range of the scenarios originally created.

### 4.3. Regional Changing Climate Conditions

The following sections describe existing regional climate change information and the expected range of changes for the broad collection of Intermountain West Cities. For the purposes of this scientific section, the larger Intermountain West region is divided into three distinct sub-regions, shown in Figure 2. The Intermountain-West[15] is the region between the Rocky Mountains in the east and the Sierra Nevadas to the west. Known for its dry but mild climate, this region typically includes Utah, Nevada, Arizona north of the Colorado River. The Front Range is the region just east of the Rockies in Wyoming and Colorado, which is protected by the mountains from extreme storm events. Finally, the Desert Southwest is an arid region centered around the four corners area and extending out to include southern Nevada. Although there are overlaps and no sub-regional definition can completely capture the intricacies of a specific place, these categories are useful in that they share essential landscape and climate characteristics. Table 1 provides a list of the cities that fall into each of the sub–regions.

| | Intermountain-West | Front Range | Desert Southwest |
|---|---|---|---|
| Cities | • Park City, UT<br>• Salt Lake City, UT | • Boulder County, CO<br>• Denver, CO<br>• Fort Collins, CO | • Flagstaff, AZ<br>• Las Vegas, NV<br>• Tucson, AZ |

**Table 1:** Planning Alliance cities in each sub-region.

The best available information was used to create these sub-regional summaries; however it should be noted that there remain gaps in the information available at this small a scale. These gaps, which are caused by lack of downscaled information and differing timeframes assessed, can be used to communicate with scientists, identifying places that their work can enhance local governments' ability to plan and adapt to climate change.

[14] Ray, 2008

[15] The hyphenated version of the Intermountain-West refers to this geographically distinct sub-region; however the Intermountain West Alliance refers to all members of this group.

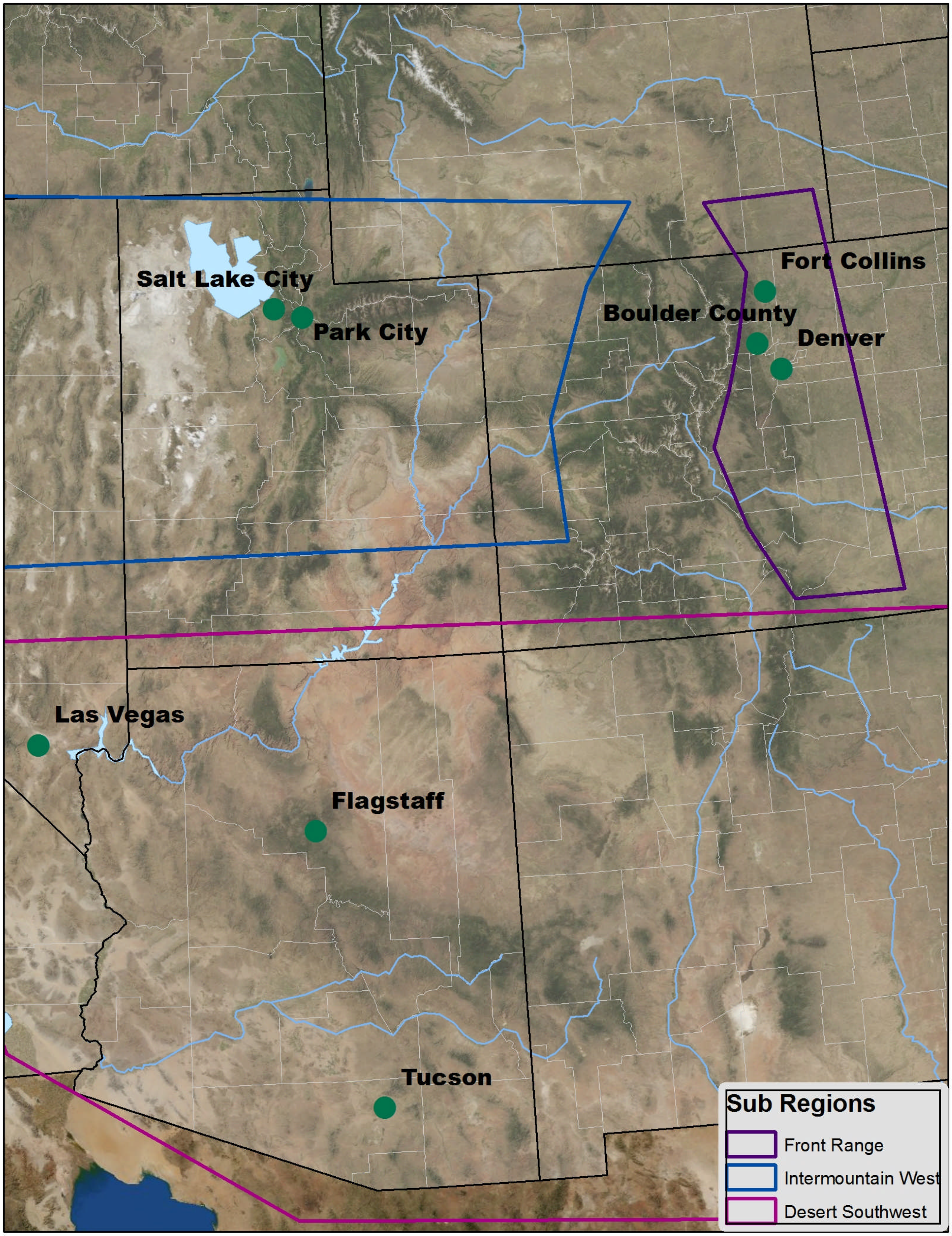


**Figure 2:** Map of the Western region with the 8 cities and counties collaborating in the Alliance, as well as the sub-regions of the Front Range, the Intermountain-West and the Desert Southwest.

### 4.3.1. Historical climate change information

Before addressing future predictions of changing climate conditions, it is important to understand historical trends in climate. These trends provide an understanding of the types of climates and variability that have affected a region over time and help to evaluate future climate scenarios. Table 2 provides a summary of historical climate trends for each sub- region. It presents information for two primary changing climate conditions – temperature and precipitation – and the secondary changing climate conditions of snowpack and streamflow.

| | Intermountain-West | Front Range | Desert Southwest |
|---|---|---|---|
| Temperature | Trend for 1907 - 2007:<br>+ ~2.0 °F in Utah | Trend for 1977 – 2006:<br>+ ~ 2.0 °F in Colorado<br>+ 2.5 °F in North<br>+ 1.1 °F in South* | Trend for 1976 – 2005:<br>+ 2.5 °F in Arizona |
| Precipitation | • No discernable trend for annual average precipitation. | • No discernable trend for annual average precipitation.<br>• Limited change of snow to rain occurring. | • No discernable trend for annual average precipitation. |
| Snowpack & streamflows | • No trend in snowpack over past 80 years.<br>• No streamflow trend over past 50 years. | • Small & insignificant reduction in snowpack.<br>• Peak streamflows have shifted two weeks earlier in spring. | • Small decline in snow cover.<br>• No observed streamflow trend for the region. |

**Table 2:** Sub-regional historical trends in temperature and precipitation (Intermountain West – BRAC 2007, Front Range – Ray 2008, Desert Southwest – Lenart 2007). * Note: The 39th parallel separates the northern and southern parts of the state.

**Temperature:** Although there have been regional and local variations, the historical record indicates that the trend across the western United States is of general warming (Figure 3). This finding comes from analysis on most recent studies that investigated temperature trends. The research looked at different types of temperature-related trends, including average winter temperatures, spring warm spells dates, and wet day minimums, which are amongst a large array of different temperatures analysis that can aid in planning processes in different ways (for more detail see section 6 below). Despite the variety in the studies, all four found warming across the western United States.[16]

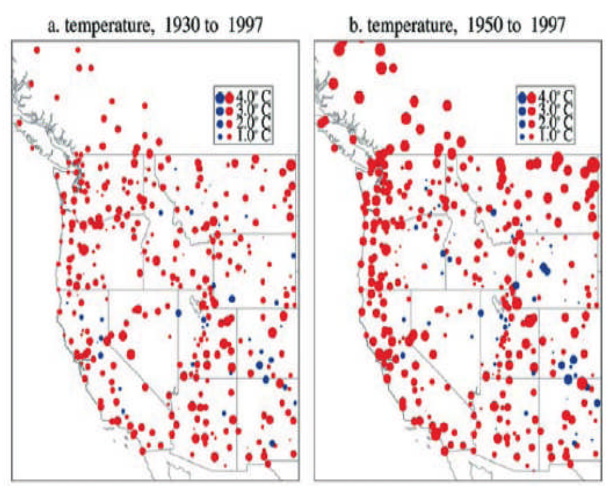


**Figure 3:** Winter temperature trends for the Western United States – Red is warming and blue is cooling (Mote et al. Figure 6).

In addition to studies that looked at this very broad region, some studies have conducted more granular regional assessments of temperature. Two reports, *Climate Change in Colorado – A Synthesis to Support Water Resource Management and Adaptation*; and *Colorado Climate Preparedness Project – Final Report*, provide significant information and analysis relevant to the State of Colorado. The first report found that the trend for

[16] Udall, 2007

1977 – 2006 was + 2.5 °F in the northern front range and + 1.1 °F in the southern front range as separated by the 39th parallel.[17] *Global Warming in the Southwest: An Overview*, prepared by Climate Assessment for the Southwest (CLIMAS), found that the trend for 1976 – 2005 was + 2.5 °F in Arizona.[18] In Utah, the Blue Ribbon Advisory Council on Climate Change (BRAC) commissioned a scientific assessment that indicated that the past decade's average temperature was higher than any observed during the past century. Additionally, there was an increase in approximately 2 °F over the 100-year average.[19]

Finally, at the local level, there are many factors that affect temperature trends. Among the key factors are elevation, proximity to water or mountains, and development patterns. Some local studies have been conducted looking at warming trends for a specific community. For example, a study, called An Assessment of Climate, Snowpack, and Economic Impacts performed for The Park City Foundation found that daily minimum average temperatures are warming at all regional weather stations, but that daily maximum temperatures displayed no consistent trend.[20]

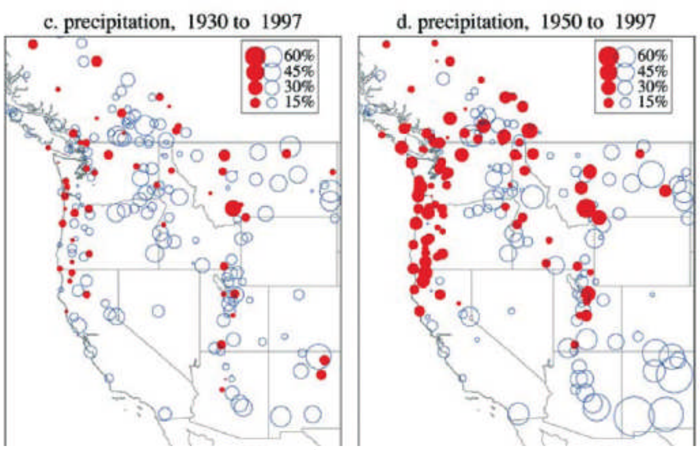

**Figure 4:** Winter precipitation trends for the Western United States – Red is a decrease and blue is an increase (Mote et al. Figure 6).

**Precipitation:** Unlike temperature, precipitation patterns are significantly more complicated and there are fewer consensuses around the western region's historical trend. Many processes and factors determine precipitation patterns. Among the key factors for the west are the jet stream and ocean circulation patterns, specifically the El Nino / Southern Oscillation (ENSO) pattern. These factors result in decadal shifts in precipitation patterns that make it exceptionally difficult to detect a long term pattern. The reports cited above for sub-regional temperature trends found that these factors have too great an influence to determine specific precipitation trends. However, *Climatic and Hydrologic Trends in the Western U.S.: A Review of Recent Peer-Reviewed Research* found that there was a "slight increase" in precipitation in the southern states of the West.[21] Figure 4 illustrates the paper's findings for historical precipitation trends in the region.

**Snowpack and Streamflow:** Although secondary climate change conditions, snowpack and streamflows are also significant contributors to water availability in the Intermountain West. Generally, the shift from snow to rain in the winter months, as well as the earlier arrivals of spring, have reduced the amount of snowpack as measured in snow water equivalents (SWE). These snowpack changes have been observed across the west between 1949 and 2004.[22] Although the trends have been observed throughout the west, there are sub-regional differences related to elevation and other local factors (Table 2). The key difference has been that most of the snowpack reductions in the West to date have occurred below 8200 ft; therefore, in states such as Colorado and places such as

[17] Ray, 2008
[18] Lenart, 2007.
[19] BRAC, 2007.
[20] Stratus, 2009.
[21] Udall, 2007.
[22] Knowles, 2006.

Park City, Utah where mountain elevations are higher, significant snowpack reductions have not been observed.[23] In addition to snowpack amounts, streamflow timing can influence water availability. Shifts toward an earlier peak streamflow have been observed throughout the west and are likely due to the fact that warming is occurring earlier.[24] In Colorado in particular, between 1978 and 2004, the spring pulse has shifted earlier by about two weeks.[25]

### 4.3.2. Future Projections

Historical trends provide an important backdrop to future projections and crucial information for calibrating models; however, in order to plan for climate change, future projected changes must be considered. The information below summarizes regional projections for the key climate conditions.

**Temperature:** According to the US Global Change Research Program's Third National Assessment, temperatures are projected to rise over the coming century across the entire Southwest – including Colorado, Utah, Nevada, New Mexico and Arizona. As shown in Figure 5, the rise above a 1960 – 1979 baseline projected for 2020 is between 1.9 and 3 °F regardless of the emissions scenario used. Looking out to 2090, the rise for a low emissions scenario is 3.8 – 6.5 °F while the high emissions scenario is 7 – 10.2 °F.[26]

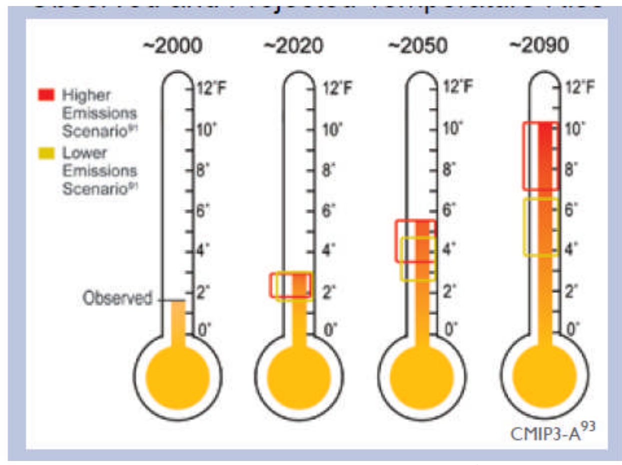


**Figure 5:** Observed and projected temperature rise from 1960 – 1979 baseline for the southwest. (USGCRP, 2009).

These averages provide information for the entire region, but studies have also looked more closely at a sub-regional scale. In Colorado the report, *Climate Change in Colorado – A Synthesis to Support Water Resource Management and Adaptation*, averaged 112 different model runs from 16 different global circulations models (GCMs) to create the relevant information for the state's water managers. Similar multi-model assessments were used for the BRAC report as well as the for CLIMAS report. Some of the results are illustrated in Table 3. At a local scale, scientists working with the City of Tucson projected the following temperature increases above the 1971 – 2000 average through the century, with the low end of the range associated with a low emissions scenario and the high end with a high emissions scenario. In most cases the greatest warming was seen in the summer and fall months.

- 2040 – Temperature rise between 1.9 and 2.3 °F
- 2070 – Temperature rise between 3.2 and 4.6 °F
- 2099 – Temperature rise between 4.3 – 6.2 °F[27]

[23] Regonda, 2005.
[24] Stewart, 2005 & Hamlet, 2005.
[25] Clow, 2007.
[26] Karl, 2009.
[27] Maurer, 2007.

| Timeframe | Annual Average Temperature Projections | Other factors | Anticipated Impacts |
|---|---|---|---|
| **Intermountain-West** | | | |
| 2100 | + 8 °F | | • Longer growing season<br>• Fewer frost days<br>• More heat waves<br>• More water shortages |
| **Front Range** | | | |
| 2025 | + 1.5 °F to + 3.5 °F | • Climate zones will shift upward in elevation; 7000 ft could feel more like 6000 ft in the future.<br>• Winters will include fewer extreme cold months and more have more warm months.<br>• Greater shifts in summer temperatures than winter temperatures. | • Longer growing season<br>• Fewer frost days<br>• More heat waves<br>• Increased forest fires<br>• More water shortages |
| 2050 | + 2.5 °F to + 5.5 °F | | |
| **Desert Southwest** | | | |
| 2100 | + 5 °F to + 8 °F | • Longer lasting heat waves ~ 2 weeks longer.<br>• Greater shifts in summer temperatures. | • Longer growing season<br>• Fewer frost days<br>• More heat waves<br>• Increased forest fires<br>• Greater water shortages |

**Table 3:** Sub-regional temperature projections (Intermountain West – BRAC 2007, Front Range – Ray 2008, Desert Southwest – Lenart 2007).

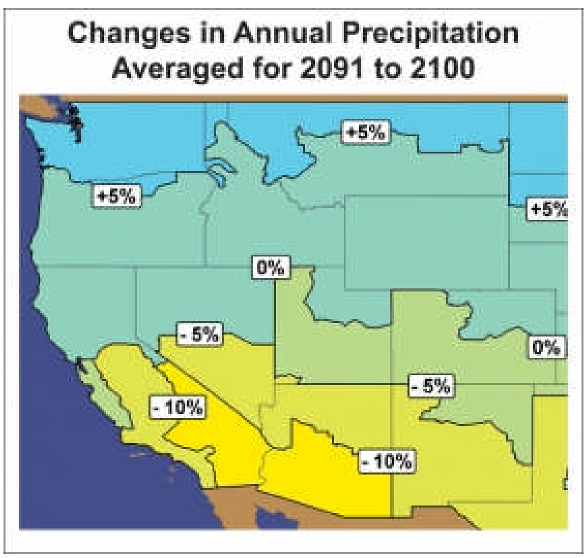


**Figure 6:** Projected annual average precipitation change above 1970 – 2000 average (Lenart, 2008).

**Precipitation:** Future precipitation patterns remain difficult to model, due to the complexity of factors affecting these patterns. Despite these difficulties, researchers at the NOAA Earth System Research Laboratory found 0 – 10 % reductions in annual average precipitation by the end of the century as compared to 1970 – 2000 average (Figure 6). This assessment used an ensemble of 18 global climate models and the moderate A1B emissions scenario[28]. However, despite these findings, most research indicates that annual changes are minimal when compared to interannual and decadal variability. Although there is uncertainty around annual averages, the sub-regional analyses report provided some key findings around precipitation pattern shifts, shown in Table 4. Generally, the reports agree that precipitation is likely to increase in winter months, and that there is likely to be a trend toward heavy rain events followed by dry spells.

[28] Lenart, 2008

| Intermountain West | |
|---|---|
| **Precipitation Projections** | **Anticipated Impacts** |
| • Potential decrease in annual precipitation in southern portion.<br>• Small increase in the northern portion.<br>• Shift in pattern to more frequent heavy precipitation events, separated by longer dry spells. | • Greater water shortages<br>• Increased flooding events<br>• Shifts in snow pack |
| **Front Range** | |
| • Little change in annual mean precipitation by 2050.<br>• More mid-winter precipitation throughout the state.<br>• Potentially a decrease in late spring and summer precipitation. | • Greater water shortages<br>• Increased flooding events<br>• Shifts in snow pack |
| **Desert Southwest** | |
| • 5 % decrease in annual average by 2100 compared to 1970 -2000 for Northern Arizona.<br>• 10 % decrease in annual average by 2100 compared to 1970 -2000 for Southern Arizona | • Greater water shortages<br>• Increased flooding events |

**Table 4:** Sub-regional precipitation projections. (Intermountain West – BRAC 2007, Front Range – Ray 2008, Desert Southwest – Lenart 2007).

**Snowpack and Streamflow:** Projections for snowpack across the west show a "precipitous decline in lower-elevation (below 8200 ft) snowpack."[29] This is likely caused by higher temperatures and snow falling as rain. Additionally, projections indicate that spring runoff timing will shift earlier in the season. The sub-regional projections are provided in Table 5. Additionally, a study conducted for Park City, Utah found that rising temperature will delay the start of snow accumulations by a full week by 2030 and up to five and a half weeks by 2075. In all the scenarios, the delayed accumulation resulted in maximum snow depths falling short of historical averages.[30]

| Intermountain-West | |
|---|---|
| **Snowpack and Streamflow Projections** | **Anticipated Impacts** |
| • Lower and mid elevation mountains will have a reduction in natural snowpack and snowfall in the early and late winter.<br>• An earlier and less intense average spring runoff. | • Greater water shortages<br>• Loss in winter recreation |
| **Front Range** | |
| • Major loss of lower elevation snowpack.<br>• Limited declines (10 – 20%) of higher elevation snowpack.<br>• Ongoing shift to earlier spring streamflows. | • Greater water shortages<br>• Loss in winter recreation |
| **Desert Southwest** | |
| • Snowpack declines likely due to a shift in the jet stream and El-Nino patterns driving precipitation falls northward. | • Greater water shortages |

**Table 5:** Sub-regional snowpack and streamflow projections (Intermountain West – BRAC 2007, Front Range – Ray 2008 Front Range – Ray 2008, Desert Southwest – Lenart 2007).

### 4.3.3. Additional factors

The changing climactic conditions summarized in section 5.4.2, though important in and of themselves, are primarily averages and do not fully address the subtlety necessary to capture climate change. There are two general additional factors that must be considered when understanding climate change.

[29] Christensen, 2006.
[30] Stratus, 2009.

### 1. The mathematics of changing averages

Averages provide a summary and therefore a simpler way of transferring information, but important details can be lost in presenting only averages. Figure 7 shows the details that are lost when simplifying climate change to average trends. The first detail is that when an average increases the entire curve associated with that average shifts. In other words, the extremes also move in the direction of the average. In the case of average temperature increases that means more extreme heat days. The second detail associated with averages is the variability the curve contains. In the case of climate change scientists also agree that variability will increase. The combined effect of these two changes (as shown in the bottom graphic) is more extreme heat days with less change in cold weather.[31]

This mathematical concept can and should be applied appropriately to all climate change averages that are presented, meaning that generally more extremes are to be expected with climate change.

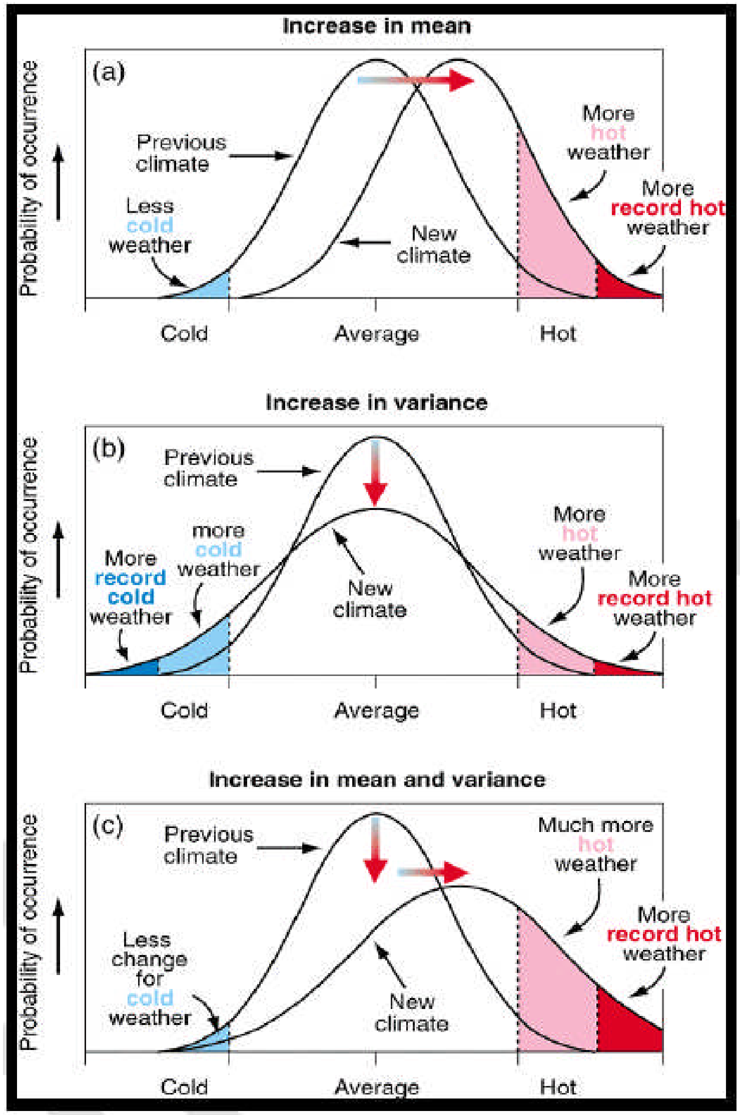


**Figure 7:** Explanation of shifting averages. Shaded colors are associated with labels on the horizontal axis – pink being hot and blue being cold. The arrows and text are showing the portion of temperatures that are within the changed climate but not within the previous climate. (State of California, 2009)

### 2. Timing matters

There are several timing components that are crucial to consider when understanding climate change. First, although sometimes thought of as a smooth transition from one steady state to another, climate change could happen very abruptly. Environmental systems are highly complex and dynamic, making them very resilient. However, there are tipping points that can cause changes to happen more rapidly than currently projected. Given this complexity, local governments would benefit from greater planning for more extreme contingencies as in the risk management framework presented in Section 3.

Another timing element that must be considered is when a specific changing condition might occur. For example, it is not simply that temperatures will be warmer year round; instead there is both a seasonality and daily component to this change. Several models have projected that summer warming will be greater than winter warming, meaning that the potential threats to snow and snow water equivalents is greater, while the heat wave threat may in fact be slightly less.[32]

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[31] State of California, 2009
[32] Ray, 2008

## Section 5. Climate Change Impacts

Climate impacts occur when climate change affects a specific natural or human system. From a planning perspective, impacts are often of greater interest than general changes in the climate. Although a 2 °F increase in temperature is interesting from a scientific perspective, a public health specialist is likely more concerned with how this change will alter the occurrence of heat waves and change urban air quality, for example. This section describes anticipated climate impacts on six major sectors. These sectors and impacts are highlighted because they are likely to present the greatest risk to a broad swath of communities across the arid and semi-arid Western US. Outside of these sectors there are other climate change impacts that ideally would be covered by a more complete localized assessment. The list below outlines some additional, or more narrowly focused, sectors that specific local governments may want to consider.

- Biodiversity
- Education
- Emergency Management
- Energy
- Forestry and Forest Services
- Insurance
- Recreation, Open Space and Parks
- Stormwater
- Transportation
- Wastewater

It is important to note that impacts described here are general, overarching impacts; however, impacts can vary based upon specific local, natural and manmade conditions. In order to move forward with local climate change adaptation decisions, a more detailed assessment of these impacts would be necessary.

### 5.1. Water Resources

Water resources, which are essential to all life, are influenced by variations in precipitation, storage, runoff and snow melt, evaporation, and water quality. For the purposes of the report, this analysis is limited to considerations of natural quantity and quality of water available, but a complete understanding would require a detailed local analysis of the water supply infrastructure as well as more localized water balance changes.

Climate change impacts on water resources can be broken down into five categories of changes:

- **Increased variability.** Although the models do not agree on projections for precipitation changes, scientists do agree that there will be increased variability in the future. This means that some years or seasons will see larger quantities of precipitation that may be followed by extended dry periods.[33] It is this shift in predictability that water managers are learning to address in order to best manage water resources.
- **Shifting runoff timing.** As the historical trend in Figure 8 indicates, snowmelt runoff timing across the west is getting earlier. The Variable Infiltration Capacity (VIC) hydrologic model indicates earlier snow melts result in higher streamflows early in the season, with significant drying later in the summer. Although model calibrations are still being refined, two different assessments that used multiple global circulations models (GCMs) showed decreased flow in

[33] Milly, 2005

the Colorado River ranging from a 6 % reduction between 2000 and 2070 and to a 20% reduction by midcentury.[34]

- **Droughts –** Long-term climate records of the Colorado River flows indicate the Southwest has a long history with drought and has "some of the longest documented 'megadroughts' on Earth."[35] Future drought projections remain uncertain; however, in regions such as the southwest where a drying trend is indicated, droughts more severe than those encountered in the instrumental record may become increasingly likely.[36]
- **Quality decreases –** Warming temperatures have and are likely to continue to cause water temperatures to rise. This rise in temperature will result in degraded stream quality for cold-water fish and as well as overall degraded lake water quality. There are additional water quality shifts that changes in run off composition and quantity can cause.[37]

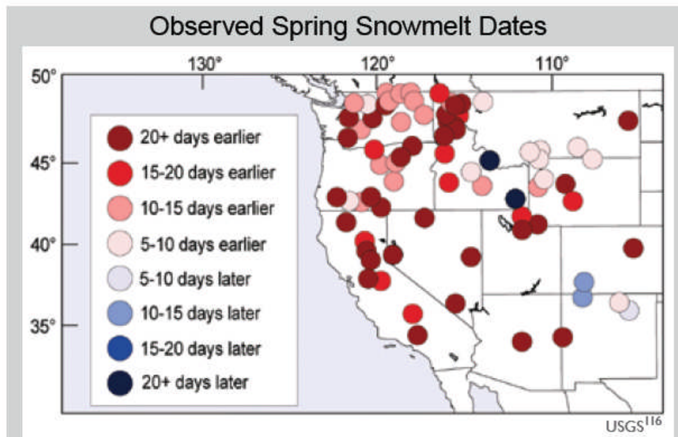


**Figure 8:** Changes in observed spring snowmelt dates for the western United States. Observations cover 1948 – 2002. (Karl, et. al., 2009)

As a primary consumer of water resources and maker of policy related to water resources, local governments and communities can have a meaningful impact on future water quality and quantity; however, power generation and agriculture are the largest consumers of water and therefore successful water management plans must consider these users as well.[38] Local governments can and have successfully created a variety of water conservation programs that reduce consumer water demands. For example, Flagstaff, Tucson and Las Vegas all have strong water conservation programs, enabling citizens and the city to reduce their water demand. Water managers also have developed sophisticated methods to design and operate the water infrastructure in order to maintain sufficient supplies. Resource management systems account for significant variability because water resources have always been influenced by irregular weather events. However, current models are based on some probability distributions that assume a steady state. Given that climate change will alter this assumption the future success of water management on the supply side will depend on managers' ability to account for change in predictability.[39]

## 5.2. Agriculture and Food Security

Generally, there are thought to be three different ways climate change could impact agriculture. First, agriculture could be threatened by the ***diminishing water supply***. Agriculture, which accounts for 31% of water used in the United State, is the second largest user of water in the Southwest.[40] With future projections for a drier regional climate and increased incidences of drought, the agricultural sector may be at risk from limited water supplies. Second, climate change may impact agriculture through the ***increased occurrence of extreme events***. Exposed to all weather events, agriculture could be

[34] CCSP, 4.3 2008
[35] Karl, 2009
[36] Seager, 2007
[37] CCSP, 4.3 2008
[38] Kenny, 2009
[39] Milly, 2005
[40] Kenny, 2009

negatively impacted by extreme heat, flooding, winter storms as well as invasive pests and pathogens.[41] Finally, average annual ***temperature increases*** are also thought to have negative effects on both crops and livestock. According to the US Global Change Research Programs Synthesis and Assessment report, "*The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity,*" a 1.2ºC rise in temperature over the next 30 years is projected to decrease major crop production (i.e. maize & wheat) by 4.0 and 6.7 percent, respectively, in their major productive regions. Moreover, the report concludes that "increases in air temperature reduce livestock production during the summer season with partial offsets during the winter season."[42]

Despite these potential negative impacts, the agricultural sector in the United States is often considered to have a high adaptive capacity. The sector has always been based around weather and has learned to deal with variability. Additionally, there is significant research and technological potential to help this sector adapt. On the other hand, negative impacts in other regions could affect food consumers in the Intermountain West. Disruptions in production around the globe could drive prices up locally, thereby making some foods unaffordable for certain socioeconomic groups. Moreover, these negative effects could be exacerbated by other shocks in the broader supply chain. For example, price inflation related to use of finite resources such as oil, could result in higher food prices.

At the local government level, agriculture is difficult to influence as there is limited jurisdiction directly over farms and the farm industry, but impacts can be partially offset by strengthening local food systems. Local governments can work with citizens and businesses to encourage local food production and improved access to local food.

### 5.3. The Built Environment and Extreme Events

The built environment is a broad system that includes the residential and commercial building stock and infrastructure such as transportation, water and energy facilities. This section describes the impacts of climate-related extreme events on the built environment.

Climate change is anticipated to have the following three major impacts on the built environment in the Intermountain West:

1. **Floods –** Projections of an intensified water cycle entail not only a greater likelihood of drought (Section 6.2) for the Southwest, but also an increased risk of flooding. In fact, winter precipitation in Arizona, for example, has already become more variable and the state has seen a trend toward both more frequent extremely dry and extremely wet winters.[43] This intensification can cause two primary changes in flooding impacts on the built environment. First, flooding may occur in places that are not currently designated as flood zones. Second, the flooding that occurs in flood zones could be significantly more severe, reaching greater heights and velocities.
2. **Wildfires –** Recent record setting wildfires are being driven by rising temperatures and reductions in soil moisture.[44] Given that climate change projections indicate ongoing rising temperatures and reductions in soil moisture, this trend of major wildfires is highly likely to continue. Fires can cause dramatic damage and ultimately complete devastation to the built environment, particularly to individual homes.

[41] Karl, 2009
[42] CCSP, 4.3 2008
[43] Goodrich, 2008.
[44] Westerling

3. **Extreme heat and energy disruption –** Rising temperature in the Southwest will result in decreases in demand in heating energy and increases in demand for cooling energy.[45] In the Southwest, where air conditioning use is high and populations are growing, increased demand could result in the region being unable to meet its demand, causing black outs.[46]

The built environment is a system where local governments can have significant influence over future outcomes. As the primary regulator of development through zoning and building codes, local governments can greatly influence both the location and design of buildings. Done properly, these activities can reduce the negative impacts of flooding, wildfire and energy disruption. For example, some local governments in home rule states[47] can institute a freeboard ordinance, which is a requirement that buildings in designated flood zones be built above the current minimum FEMA requirements. Moreover, local governments also are often the first responders in emergency situations. Cities and counties can adjust their hazard mitigation and emergency response to account for greater reach and frequency of extreme events under changing climate conditions.

### 5.4. Public Health

Public health is the practice of preventing disease, prolonging life and promoting wellbeing through policies and programs informed by science. In local communities, public health activities are centered around protecting residents from illnesses and helping them to develop healthy lifestyles.

According to the 2009 National Assessment, "*Global Climate Change Impacts in the United States,*" the number-one climate change impact on public health in the Southwest is temperature increases resulting in heat waves—prolonged periods of excessively high heat with little or no break overnight. This threat is particularly high in urban areas that experience the urban heat island effect due to high quantities of heat-absorbing asphalt.[48] Moreover, the Human Health Synthesis Assessment, "*Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems*" states that "it is very likely that heat-related morbidity and mortality will increase over the coming decades."[49]

In addition to heat waves, there are four other primary public health and climate change concerns in the region. The first is increased air temperatures causing *decreased air quality*. Particularly when combined with the increased wildfire threat noted in section 6.1, decreased air quality can cause a number of public health threats. Second, *extreme events*, such as flash floods and wildfires, can cause direct public health risks. Changes in *water supply and quality* described in section 6.2 will also have negative health consequences for the US in general and the region in particular. Finally, the full range of many *disease vectors* is likely to expand both northward and to higher elevations causing increased health threats in many parts of the US including the Southwest.[50]

In addition to understanding these public health impacts on the public at large, a particular focus should be placed on targeting vulnerable populations, as they will likely be impacted most severely. For example, although heat waves cause discomfort for all members of society, it is the elderly and those without the financial means for cooling systems that suffer the most and are at more risk of dying from heat waves.

There are many opportunities for local governments to limit the negative impacts of climate change on public health. For heat waves, a few primary action areas that a local government should focus on are:

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[45] Karl, 2009
[46] Wilbanks, 2007
[47] These are states that allow cities, municipalities, and/or counties the ability to pass laws to govern themselves. In the alliance, Arizona and Colorado have home rule. Utah is considered to have limited home rule; while Nevada does not have home rule.
[48] Karl, 2009.
[49] CCSP, 4.6 2008.
[50] Ibid.

1. **Provide Sound Home-Based Prevention Advice** – clearly communicating to citizens how they should act and take care of themselves during a heat wave can save lives.
2. **Reduce the Urban Heat Island Effect and Poor Air Quality –** local governments can identify urban heat hot spots and through targeted tree plantings and cool roof or green installations they can change a location's microclimate.
3. **Develop a Heat-Health Warning System –** Having a detailed plan that includes the best ways to inform and provide for all members the public is crucial in the event of a heat wave.

## 5.5. Economic Impacts

The economic impacts of climate change can be considered through two different lenses described and further explored below.

### 1. Cost of inaction

The first is the **cost of specific climate change impacts**, which is often described as the "cost of inaction." These costs are typically estimated through a combination of assessing past costs associated with extreme events and by modeling the future impacts of climate change. For example, the National Climatic Data Center (NCDC) found that the 1988 drought and heat wave that heat the central and eastern United States caused $69 billion of damages (in 2006 dollars).[51] This assessment was used to further support the U.S. Global Change Research Program (USGCRP)'s 1999-2000 study that estimated the costs of future changes in water supply for the contiguous 48 states, with and without climate change.[52]

Most climate change cost estimates to date have broadly assessed the costs of climate change globally. Recently, however, there have been a growing number of economic estimates that look at very specific costs associated with potential impacts or policy decisions. Some of the most significant findings for the Intermountain West were presented in a report prepared by Natural Resources Defense Council (NRDC) that compared the costs of 4 different climate change impacts – hurricanes, sea level rise, energy demand and water resources. The report – *The Cost of Climate Change: What We'll Pay if Global Warming Continues Unchecked* – found that the region was most at risk from rising energy sector costs and increasing water costs. It estimated that the water supply could reach almost $1 trillion per year by 2100 (Figure 9).[53]

**The Global Warming Price Tag in Four Impact Areas, 2025 through 2100**

| | In billions of 2006 dollars | | | | As a percentage of GDP | | | | U.S. Regions Most at Risk |
|---|---|---|---|---|---|---|---|---|---|
| | 2025 | 2050 | 2075 | 2100 | 2025 | 2050 | 2075 | 2100 | |
| Hurricane Damages | $10 | $43 | $142 | $422 | 0.05% | 0.12% | 0.24% | 0.41% | Atlantic and Gulf Coast states |
| Real Estate Losses | $34 | $80 | $173 | $360 | 0.17% | 0.23% | 0.29% | 0.35% | Atlantic and Gulf Coast states |
| Energy-Sector Costs | $28 | $47 | $82 | $141 | 0.14% | 0.14% | 0.14% | 0.14% | Southeast and Southwest |
| Water Costs | $200 | $336 | $565 | $950 | 1.00% | 0.98% | 0.95% | 0.93% | Western states |
| **SUBTOTAL FOR FOUR IMPACT*** | **$271** | **$506** | **$961** | **$1,873** | **1.36%** | **1.47%** | **1.62%** | **1.84%** | |

*Note: Totals may not add up exactly due to rounding.

**Figure 9:** Cost estimates for climate change impacts 2025 – 2100. (NRDC, 2008)

51 NCDC, 2007
52 NRDC, 2008
53 NRDC, 2008

General future cost estimates such as the ones presented here, can be used by local governments to make a strong case for climate change adaptation planning. Alternatively, when looking to make more specific capital investments – creating a new water reservoir or changing the materials used in local roads, for example – communities may look to refine these cost estimates to apply in cost-benefit analyses at the local level.

### 2. Regional Economy

In contrast to the cost of inaction, the **health of the broader economy**, which consists of many variables across a wide range of sectors, is very difficult to evaluate with precision. Economists even disagree today on the health of the economy due to the use of different measurement tools. Some prefer to emphasize the Gross Domestic Product while others prefer unemployment statistics, for example. Given this complexity, there is no way to be sure how climate change will affect the Intermountain West's regional economy; however, each of the sectors described above has an economic component and the impacts on each sector will cause indirect effects on the economy. Described below are some of the indirect economic impacts that could result from the sector impacts above. In is important to recognize that these impacts can be both positive and negative.

The four shifts in water resources are likely to negatively affect many sectors of the economy. The shifting runoff timing and increase in drought are likely to have negative effects on water dependent industries such as agriculture. The region's ability to attract both new businesses and tourists could also be negatively affected by decreased water availability. Specifically, many people visit for both winter and summer water recreation opportunities, and these assets could be affected by changes in water resources (see Section 6.1).

The potential decline in global agricultural productivity could result in higher food prices, which would force many citizens to spend less on non-essential goods. Additionally, it could also result in residents dining out less, therefore impacting the local food service industry. However, rising food prices may lead residents to be more engaged in local agricultural economies.

The impact of extreme events on the built environment will also affect the economy, but the severity of this impact will depend on the choices made by local governments. Major destructive events such as floods that decimate entire cities can have a highly negative effect on a local economy. On the other hand, regular building and infrastructure upgrades that keep buildings up to the latest set of code requirements can provide regular employment to the building sector.

Impacts on public health will likely have a mixed effect on the economy. Generally, declines in public health may adversely affect consumer activity and labor productivity. However, in cases where local governments implement specific actions to improve public health, these actions could bolster the health care sector and the public sector.

## 5.6. Interdependencies of Climate Impacts

As the above description of impacts indicates, there are many interdependencies between impacts and vulnerable sectors. Ultimately, while the sectors operate independently to some degree, they also interact with one another collectively. Although complex, a complete picture of climate change impacts relies on a detailed understanding of the different intersections and interactions between impacts and sectors. The intention of such an analysis is to avoid maladaption, meaning a climate change adaptation measure that is ultimately more harmful than helpful.

One place to begin this more detailed assessment is by looking through the lens of existing local concerns. It is often thought that climate change could have compounding effects on existing problems. For example, a community that currently struggles with forest fire risks may be even more threatened in the future as these threats increase. Similarly, a community that lacks a flood evacuation plan will find that increased flooding only makes the need for this plan even greater. Using this lens of existing problems and concerns will also help communities identify win-win actions that not only benefit the community in the future, but also benefit the community today. Though a great lens to start with, communities should also consider the full suite of climate change impacts as some may be new to a community. For example, although public health officials currently watch for certain disease vectors, without a climate change lens they may not know to look for new ones to their region.

In addition to understanding how vulnerable sectors relate to one another and how climate change can compound existing problems, thorough understanding of climate change impacts requires an analysis of how first-order impacts directly related to climate—such as flooding—can lead to secondary impacts such as erosion or landslides. Table 6 highlights some of the extreme events and related impacts and vulnerable sectors that are of concern to the Western region.

| Primary Impact | Secondary Impacts | Vulnerable Sectors |
|---|---|---|
| **More widespread and severe flooding** | Erosion; Sedimentation; Scouring; Landslides; Water quality degradation | Agriculture; Built environment; Ecosystems; Public health; Public safety; Recreation; Water supply; Economy |
| **Increased incidence of wildfires** | Erosion; Landslides; Water quality degradation; Air quality degradation | Built environment; Ecosystems; Public health; Public safety; Water supply; Economy |
| **Drought events** | Wildfires; Infestation of beetles and other pests; Dust storms; Water quality degradation; Land subsidence | Agriculture; Ecosystems; Water supply; Economy |
| **Extreme Heat Events** | Wildfires | Public health; Public safety; Water supply; Agriculture; Energy management; Economy; |

**Table 6:** Climate-related Impacts of Concern, Secondary Impacts, and Vulnerable Sectors (from group workshop 2)

## Section 6. Planning for Climate Change Impacts

Planning for climate change, like other planning efforts is an iterative process that is modeled by ICLEI's Climate Resilient Communities™ (CRC) Five Milestones for Climate Adaptation planning framework (Figure 10). The Five Milestone framework is a guide that can be utilized by local governments to make their communities more resilient in a systematic, transparent way. Milestone 1 begins the process with a vulnerability assessment to help communities understand the threats they face from climate change. Milestones 2 and 3 involve setting goals and developing a plan to achieve those goals. Once the plan is established communities work in Milestone 4 to implement the strategies and actions laid out in the plan. Finally, ICLEI recommends re-evaluating the climate change preparedness plan over time


**Figure 10:** Five Milestones for Climate Adaptation planning framework (from ICLEI-USA's Climate Resilient Communities™ Program)

and incorporating lessons learned into a new iteration of the Five Milestone process.

This framework can be applied at the local government scale through the following three specific processes:

1. **Creating a stand-alone climate change adaptation plan.** Although perhaps the most time consuming and costly of the three options, a stand-alone climate change adaptation helps ensure that a community covers all the intricacies of climate change and its impacts on a community. This process also helps to ensure that the actions selected will benefit a community collectively and not one specific sector at the detriment of another sector. As examples, both Chicago, Illinois and Chula Vista, California have developed stand-alone climate change adaptation plans, which they are leveraging to integrate adaptation into plans and programs across City departments. Additionally, some members of this Planning Alliance – Boulder County, Colorado, Tucson, Arizona and Flagstaff, Arizona – are currently developing stand-alone adaptation plans.

2. **Integrating climate change adaptation into other local plans.** Many planning efforts that cities and counties already undertake could include climate change adaptation thereby mainstreaming this concept. One advantage to this approach is that it reduces the cost and burden to the local government of another planning initiative and leverages the funding and resources for the existing effort. However, this approach can result in local governments missing a key component of climate change. For example, when integrating with hazard mitigation plans, a local government may overlook slow onset climate change and shifting climate zones that can have major impacts that would be categorized as natural disasters.

   Keene, New Hampshire and Lewes Delaware can serves as examples of this approach. Keene has included climate change adaptation into its sustainability plan and Lewes created a joint hazard mitigation, climate change adaptation plan. Two communities in this Planning Alliance – Flagstaff and Tucson, Arizona – that are also ICLEI Climate Resilient Cities Inaugural Communities are also working to integrate climate adaptation planning into local plans.

   Planning activities that lend themselves to the introduction of adaptation generally address either sectors that are vulnerable to impacts or programs that reduce the risk of disasters; these include:
   - Comprehensive plans (land use and transportation)
   - Long-term development master plans
   - Climate mitigation or sustainability plans
   - Hazard mitigation plans
   - Emergency response or public safety plans

3. **Developing a sector-specific climate change adaptation plan.** Some local governments are developing climate change adaptation plans for a single sector or division within their government that is most threatened by climate change. Some coastal communities have focused on sea level rise and the flooding threat they face, while others, such as Tucson, are beginning to create water-specific climate change adaptation plans. The benefit of such an initiative is that it can focus resources on the local government's greatest vulnerability; however, this can also lead to a community to miss the linkages between many divisions of their government.

The climate change adaptation planning frameworks described above can also apply at a larger regional scale (i.e. multi-city or multi-county). There are three primary advantages to this kind of regional approach:

1. A group of local governments **share a specific system or resource** impacted by climate change. For example, a group of local governments that are in the same watershed could collaboratively address future changes to land use and water resource management so as to create optimal outcomes for their shared river system. Similarly, a group of communities using the same regional transportation system could engage in a collaborative climate change adaptation planning effort centered on this shared identity. Four Florida counties – Broward, Miami-Dade, Palm Beach, and Monroe –signed the Southeast Florida Regional Climate Change Compact in 2009 to ensure that climate change adaptation and mitigation efforts were conducted across county lines. A major uniting fact for these counties is their shared coastal aquifer, which is their primary drinking water source.

2. Similarly, a group of local governments may be **collectively impacted by a single changing climate condition** such as temperature or sea level rise. This unifying climate change condition can vary; in a recent example, sea level rise was used to bring together five local governments (San Diego, National City, Chula Vista, Imperial Beach and Coronado), the Port of San Diego and the regional Airport Authority to collaborate on a sea level rise strategy for San Diego Bay.

3. Another benefit of a regional climate change adaptation approach is that much of the **science and data related to climate change exists at the regional scale**. Due to downscaling limitations addressed in section 5.3, climate change information is currently best understood at the regional level. Therefore, local governments can benefit from a collaborative effort that reduces redundancies in summarizing this large body of data.

Although the framework can be applied at a regional scale, there are several factors that may hinder such efforts. Local governments are on different planning cycles and timeframes that are often mandated by state and federal government. Therefore, regional decisions and commitments may not be actionable at the local level. Additionally, each local government has its own unique political considerations and regulatory environment that could complicate rather than enhance collaborative efforts. Although climate change data is regional, the impacts may vary significantly from one place to another due to geologic factors. These geologic differences can limit local government’s ability to collaborate on gathering scientific information on specific climate change impacts. Finally, the fact that funding allocations are often not typically available at regional scales could complicate collaborative planning.

No matter the scale or the approach, understanding the considerations listed below will help to ensure that a climate change adaptation planning effort is a success:

- **Engage stakeholders early and often**. Many of the actions local governments identify to achieve a resilient community require the cooperation and approval of the community. Engaged stakeholders can help ensure successful implementation of the plan.

- **All planning and decision-making involves uncertainty**. By its nature, planning involves taking action today to prepare for a future that is uncertain. Even traditional planning processes utilize population and economic forecasts that are imbued with uncertainty.

Although there is also uncertainty about the exact timing and detailed effects of climate change, communities can still take actions to address the threats climate change poses. In the face of uncertainty, communities may wish to begin with "no-regrets" or "low-regrets" actions that have co-benefits and do not entail significant incremental cost, and then progress to more costly measures as the precision and confidence of scientific models continues to increase.

Risk management and scenario planning are two frameworks for ensuring that new policies and actions incorporate consideration of uncertainty. Risk management ties decisions to an estimate of the probability of a particular outcome occurring. Scenario planning identifies multiple possible futures and identifies flexible actions that are appropriate to multiple scenarios and that preserve options should a particular scenario arise. While these approaches are effective in addressing uncertainties, they can also be expensive, requiring highly detailed analysis.

- **Institutionalize climate change adaptation**. Work to ensure that all decisions that have long term impacts include consideration of changing future climate conditions. Making climate change adaptation part of normal municipal operations will reduce the burden on the local government and enhance long-term resilience. In addition to the integration of adaptation into existing plans and work programs described earlier in this section, local government staff should be provided with training and resources to better understand adaptation. Building staff capacity will help the local government in integrating climate change into its traditional functions.

- **Take a holistic view.** There are many things that affect the future viability of a community and the types of impacts that climate change can have. Among these additional factors are population growth, economic shifts, migration patterns, food security, and energy systems. Careful consideration of these and other factors will make for a more successful climate change adaptation plan.

## Section 7. Collaboration and Sharing of Information

The Regional Climate Adaptation Planning Alliance has identified information-sharing as a key activity for the group in the near-term. Beyond increasing the effectiveness of technical planning activities, information-sharing can help to create a shared vision and common language around climate change adaptation. This will help locally as planners and other officials look to communicate with the broader audience of the general public and elected officials. Being able to identify other places taking similar actions can help to make a case for local action.

### Communications and Transparency

All successful collaborations hinge on a group's ability to listen to and speak freely with one another. This Planning Alliance has already established important working relationships through in-person and over-the-phone meetings. The next step will be formalizing the process, thus ensuring an ongoing dialogue and maintenance of collaboration. The group may choose to manage these communications on their own through informal means. Alternatively, the group may opt to create a more formal network through the development of a charter and assigned roles and responsibilities for members. The group is committed to open and honest communication, and will establish methods for keeping its information-sharing and decision-making transparent and accessible.

**Information Repository**
Given the amount of shared scientific and planning data that the group has in common, finding a way to meaningfully share this information would be of great benefit to its members. Similar to the communications area, this function could be achieved through informal means that to some extent already exist. However, to truly harness the power of information-sharing, a more formal mechanism may be desirable. One option would be to build an independent data sharing platform through free online venues or to build off existing climate change adaptation platforms. For example, several of NOAA's Regional Integrated Science and Assessments (RISAs) have created spaces for data sharing. In particular, the Western Water Assessment created a searchable, linked compilation of organizations, people, projects and products related to the State of Colorado's adaptation efforts (http://www.coloadaptationprofile.org/). Alternatively, Climate Assessment for the Southwest (CLIMAS) has a network site featuring climate change science and adaptation practices (http://www.southwestclimatechange.org/). The group could look to leverage these existing sites to create a more local government focused section or area. Moreover, there may be other online venues, such as USDN, ICLEI, or CAKE, where the group could locate its information-sharing platform.

## Section 8. Group Process and Next Steps

The Alliance is a novel solution to a common challenge for local governments in the US. The group is committed to building on its momentum and serving as a model that could be adapted to the needs and nuances of other regions. To this end, this section describes the group's process to this point and its short-term and longer-term objectives.

Over the past nine months, the local governments in the Alliance came together and accomplished the following steps:

1. Conceptualized the need for collaboration;
2. Articulated that need and secured funding from USDN;
3. Held a workshop to flesh out a collective vision for the process;
4. Contracted with ICLEI to produce this planning tool to enhance the process;
5. Held a second workshop to review scientific and planning assumptions and to further establish the vision and objectives of the group.

Going forward, the group has identified the following short- to medium-term objectives for furthering its collaborative adaptation planning process:

1. Finalizing this report, to be used as a tool for local and regional planning;
2. Establishing a regular dialogue by conference call or online meeting;
3. Creating a resolution articulating the group's intentions and goals;
4. Adoption of the resolution by local governing bodies;
5. Developing an online platform for information-sharing;
6. Identifying opportunities for collaborative planning projects.

The Alliance may wish to establish common indicators and evaluation timeframes to monitor their progress towards adaptation goals. The group should consider re-evaluating and assessing the completion of their near-term goals in one to three years. At that point, the group could consider establishing an ongoing assessment of the chosen indicators every three to five years. The metrics listed below could be used to gauge the success of this initiative for current members:

- On-going existence of a working relationship among member local governments;
- Number of other local governments that look to, turn to, or refer to this collective group for climate change adaptation planning expertise;
- Number of members with locally adopted climate change adaptation plans or integrated climate change adaptation efforts;
- Number of members that have mainstreamed climate change adaptation, taking future projections into account when siting development and designing infrastructure;
- Communication with scientists to create better downscaled regional data; and
- Number of shared events, co-created documents or other collaborative work products.

The eight local governments of the Regional Climate Adaptation Planning Alliance are taking concrete steps toward understanding and preparing for climate change impacts. In a multitude of ways, they all benefit from enhanced communication, information-sharing, and common approaches as they pursue their goals. The framework taking shape through the Alliance offers great promise in helping these cities and counties realize a vision of climate resilience in the American West.

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## Appendix A: Glossary of Key Terms

The following key terms are used throughout this report

**Adaptive Capacity** – The degree of built, natural or human systems to accommodate changes in climate (including climate variability and climate extremes) with minimal potential damage or cost, or to take advantage of opportunities presented by climate change.

**Climate Adaptation** – Any measure or action that reduces vulnerability against actual or expected climate change effects.

**Climate Mitigation** – Any measure or activity taken to reduce greenhouse gas emissions.

**Climate Resilient Community -** One that takes proactive steps to prepare for (i.e., reduce the vulnerabilities and risks associated with) climate change impacts.

**Exposure –** An exposure unit is an activity, group, region or resource exposed to significant climatic variations.

**Goal** – What a local government wants to accomplish through preparedness actions.

**Impact** – The effects of existing or forecasted changes in climate on built, natural and human systems.

**Maladaptation** – Adjustment to climate conditions in a manner that is ultimately more harmful than helpful.

**Preparedness Action -** The activity or activities that your government undertakes to achieve its preparedness goals.

**Preparedness Goal -** What you want to accomplish in your priority planning areas through preparedness action.

**Resilience** – The ability of a system to absorb disturbances while retaining the same basic structure and ways of functioning; the capacity to self-organize, rebound and/or evolve from stress and change.

**Risk** – The likelihood of an impact occurring (probability) and the consequence should that impact occur.

**Sensitivity** – The degree to which a built, natural or human system is directly or indirectly affected by changes in climate conditions or specific climate change impacts. If a system is likely to be affected as a result of projected climate change, it should be considered sensitive to climate change.

**Sustainability** – Long-term environmental, social and economic vitality in communities; the capacity to meet current needs without compromising the needs of future generations.

**Systems** – Built, natural and human networks, organisms, resources, services, assets, and infrastructure that benefit a community or region and could potentially be affected by climate change.

**Vulnerability** – Susceptibility of a system to harm from climate change impacts. Vulnerability is a function of a system’s sensitivity to climate and the capacity of that system to adapt to climate changes. Systems that are sensitive to climate and less able to adapt to changes are generally considered to be vulnerable to climate change impacts.