CHAPTER 12

Climate Change

Climate Change

Climate change, itself, is not a natural hazard. Natural hazard mitigation planning does not typically include a plan for climate change. However, climate change can affect and amplify the impacts of many other natural hazards. Specifically, changes in climate will affect future risks to drought, flooding, severe weather, landslide, wildfire, avalanche and dam failure. In order to appropriately prepare for natural hazards, this plan will consider the impact of climate change on natural hazard risk. This section will give an overview of climate change by providing a historical context to changes in temperature and precipitation in Utah, future projections of temperature and precipitation and the impacts of climate change on key natural hazards.

Climate change can be defined as the warming of Earth and changing of weather patterns because of changes in the composition of the atmosphere. Climate change is occurring due to changes in the concentrations of greenhouse gases in the atmosphere. Greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxides (N_2O) trap radiation, or heat, near the earth's surface and cause air temperatures to warm. Greenhouse gases are an important part of our atmosphere; life would not exist on Earth without greenhouse gases. However, excess amounts of greenhouse gases in our atmosphere have caused rapid warming of air temperatures since the middle of the twentieth-century. Warming temperatures, alone, have a significant impact on life on Earth, but the rapid increase in greenhouse gases in the atmosphere can impact many other aspects of climate that affect the safety of Utah residents.

Warmer temperatures cause more rain to fall on Earth because warmer air holds more water vapor than colder air. Here in Utah, more rain could be a positive aspect of climate change. However, increased precipitation (rain or snow) from climate change does not occur uniformly in time or space. That means that climate change will make the world wetter overall, but that increase in rainfall may happen in some places but not others and rain will fall more intensely. So, some locations will get wetter, some locations will get drier and all locations will experience more intense, or extreme, precipitation. Climate change will cause precipitation to fall more intensely during some storms, but there will also be longer dry periods between storms.[1] This concept will likely be especially true in Utah, as Utah's climate is generally very dry and some areas of Utah are prone to strong thunderstorms that can cause flash floods. Climate change, caused by changes in the concentrations of greenhouse gases in the atmosphere, will cause temperatures to increase, but it will also cause changes in weather. The typical weather patterns of Utah may not be the weather patterns of the future. Climate change will certainly bring increased temperature to Utah, but it will also bring changes in precipitation. The change in precipitation will affect the type of precipitation that falls (rain or snow), how much falls, when it falls and how intensely it falls. Changes in precipitation amount, intensity and timing will greatly impact future natural hazard risk in Utah.

Global air temperatures have increased by approximately 1.8°F (degrees Fahrenheit) since 1850.[2] Temperatures have not warmed uniformly across the earth's surface; in general temperatures have warmed more over land and less over oceans. Continental regions, those far from the ocean, like Utah, have generally warmed more than the global average. However, even in Utah, there is variation in the amount of warming that has occurred. In northern Utah, temperatures have warmed by approximately 2°F since 1900.[3] Most warming in northern Utah, and throughout the state, has occurred since about 1960. There is a trend in rapid temperature warming in Utah since 1960. Many other parts of the country or world have seen temperatures consistently rise since 1900, but in Utah, the trend of rising temperatures is present since 1960. The southwestern United States is a region of great variability in temperature and precipitation. While temperatures have consistently risen in most Utah locations since 1960, no trends in precipitation have been observed. Precipitation in Utah is generally low and highly variable; there have been no long-term trends in precipitation. Thus far, it is not getting wetter or drier in Utah; precipitation remains extremely variable. Figure 1 shows historical temperature and precipitation for Logan and Duchesne, Utah. Since 1910, annual average temperatures in Logan have not significantly warmed. However, since 1960, temperatures have warmed slightly, at a rate of 0.25°F per decade. In Duchesne, temperatures have warmed sharply in the twentieth century; increasing from an average annual temperature of 43°F to nearly 48°F. Gaps in data for Duchesne make strong conclusions on temperature change impossible, but temperatures have generally warmed by 0.4°F per decade since 1910. Average annual precipitation for Logan was 18.2 inches in Logan and 9.4 inches in Duchesne; no

1 Prein, A. F. et al. The future intensification of hourly precipitation extremes. Nat. Clim. Chang. 1, 1–6 (2016).
2 Masson-Delmotte, V. et al. Global warming of 1.5°C An IPCC Special Report: Summary for Policymakers. (2018). doi:10.1017/CBO9781107415324
3 Rice, J. et al. Assessment of Aspen Ecosystem Vulnerability to Climate Change for the Uinta-Wasatch-Cache and Ashley National Forests , Utah. General Technical Report RMRS-GTR-366 (2017). doi:10.1007/s00394-011-0203-6

Figure 1. Historical temperature (left panels) and precipitation (right panels) in Logan (top panels) and Duchesne (bottom panels). Temperatures and precipitation are annual averages. Gaps in data represent years where not enough data existed to calculate an annual average. Dashed orange line (left panel) shows trend in temperature; the dashed black line (right panel) shows average precipitation. Data was obtained from the NOAA weather service office in Salt Lake City, UT; NOWData; https://w2.weather.gov/climate/xmacis.php?wfo=slc

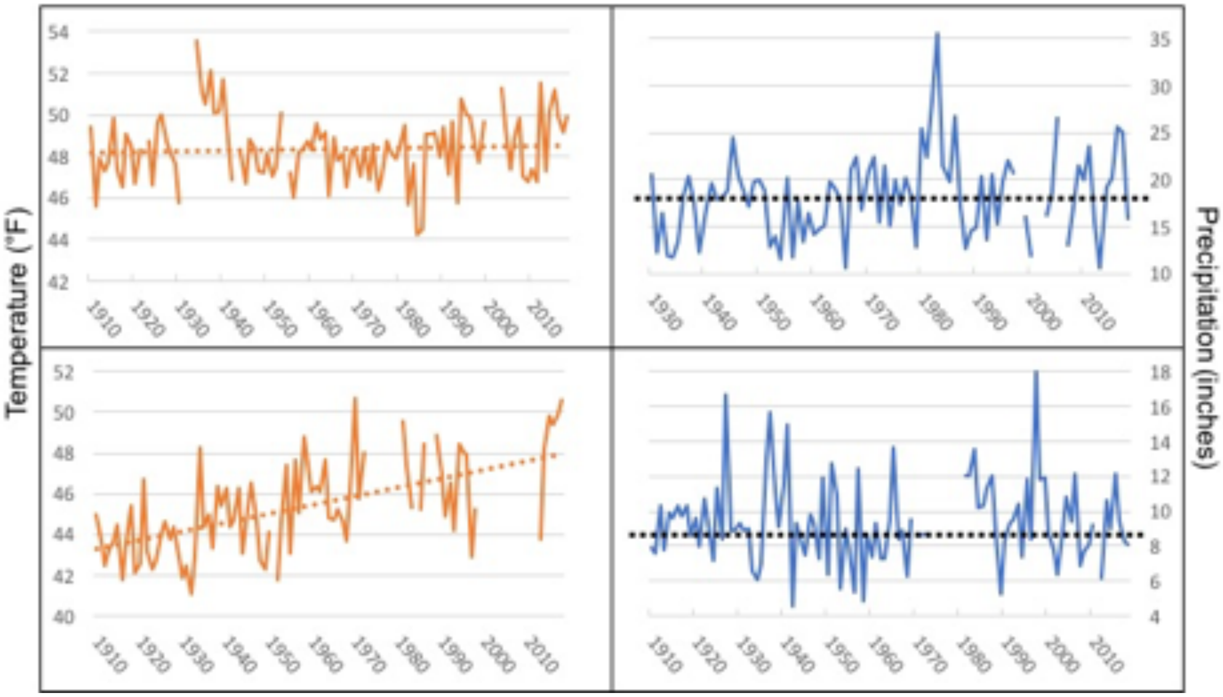
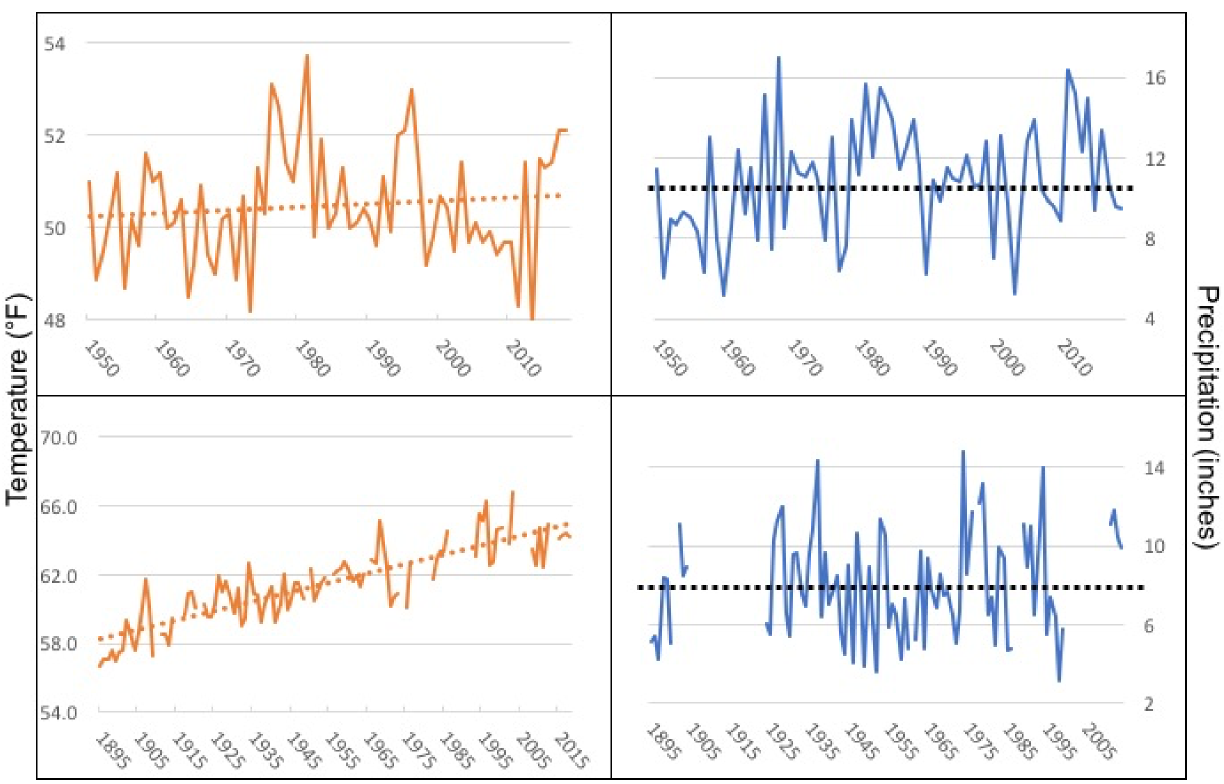


Figure 2. Historical temperature (left panels) and precipitation (right panels) in Cedar City (top panels) and St. George (bottom panels). Temperatures and precipitation are annual averages. Gaps in data represent years where not enough data existed to calculate an annual average. Dashed orange line (left panel) shows trend in temperature; the dashed black line (right panel) shows average precipitation. Data was obtained from the NOAA weather service office in Salt Lake City, UT; NOWData; https://w2.weather.gov/climate/xmacis.php?wfo=slc



long-term trends in precipitation were observed. In Logan the most significant droughts of record occurred in the 1930s, 1950-1965 and the early 2000s. Drought most significantly impacted Duchesne in the early 1930s and 1950-1965.

Figure 2 shows historical temperature and precipitation for Cedar City and St. George, Utah. Since 1950, annual average temperatures in Cedar City were variable and show only a slight warming trend. In St. George, annual average temperatures have steadily increased since 1895. Annual average temperatures in St. George have increased by 0.5°F per decade. No long-term trends in precipitation were observed. Precipitation was highly variable with a long-term average of 10.8 inches in Cedar City and 8 inches in St. George. The most significant periods of drought in the historical record were 1950-1965 and the early 2000s for Cedar City. In St. George, the most significant droughts occurred in the 1930s, 1950s and early 2000s.

Figure 3. Historical temperature (left figures) and precipitation (right figures) in Salt Lake City (top panels) and Boulder (bottom panels). Temperatures and precipitation are annual averages. Gaps in data represent years where not enough data existed to calculate an annual average. Dashed orange line (left panel) shows trend in temperature; the dashed black line (right panel) shows average precipitation. Data was obtained from the NOAA weather service office in Salt Lake City, UT; NOWData; https://w2.weather.gov/climate/xmacis.php?wfo=slc

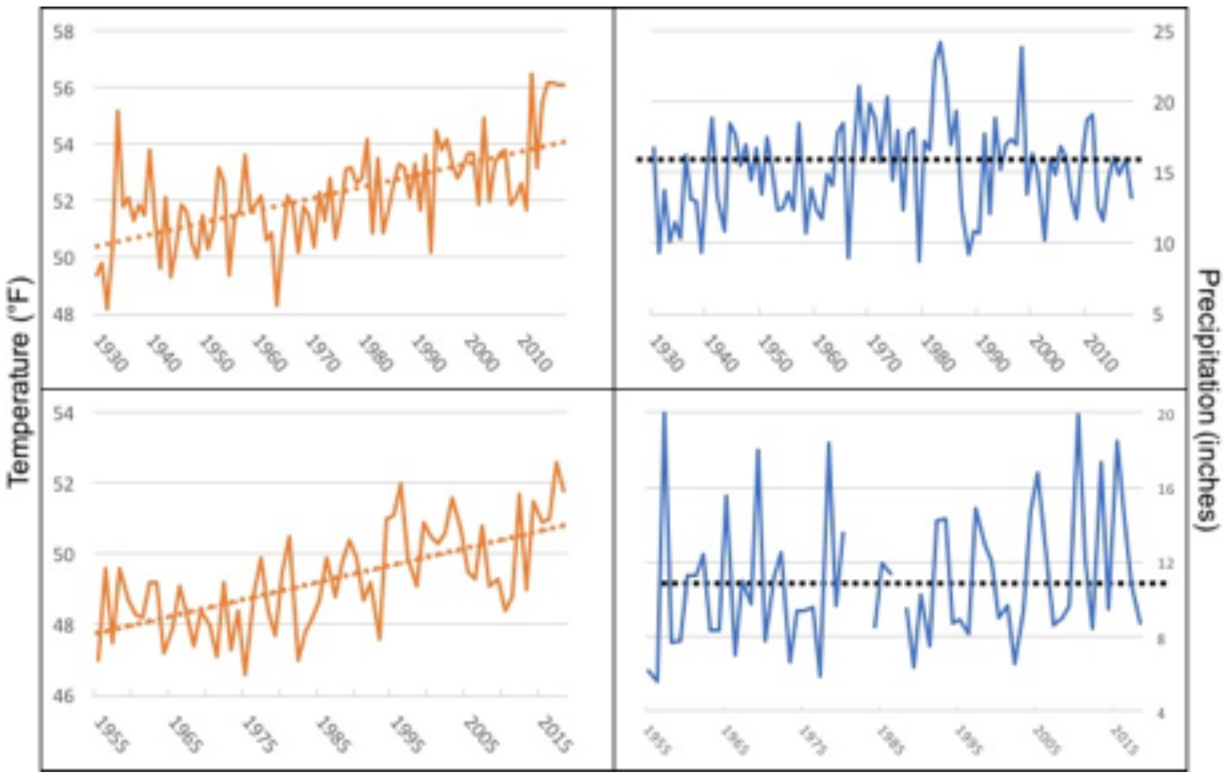
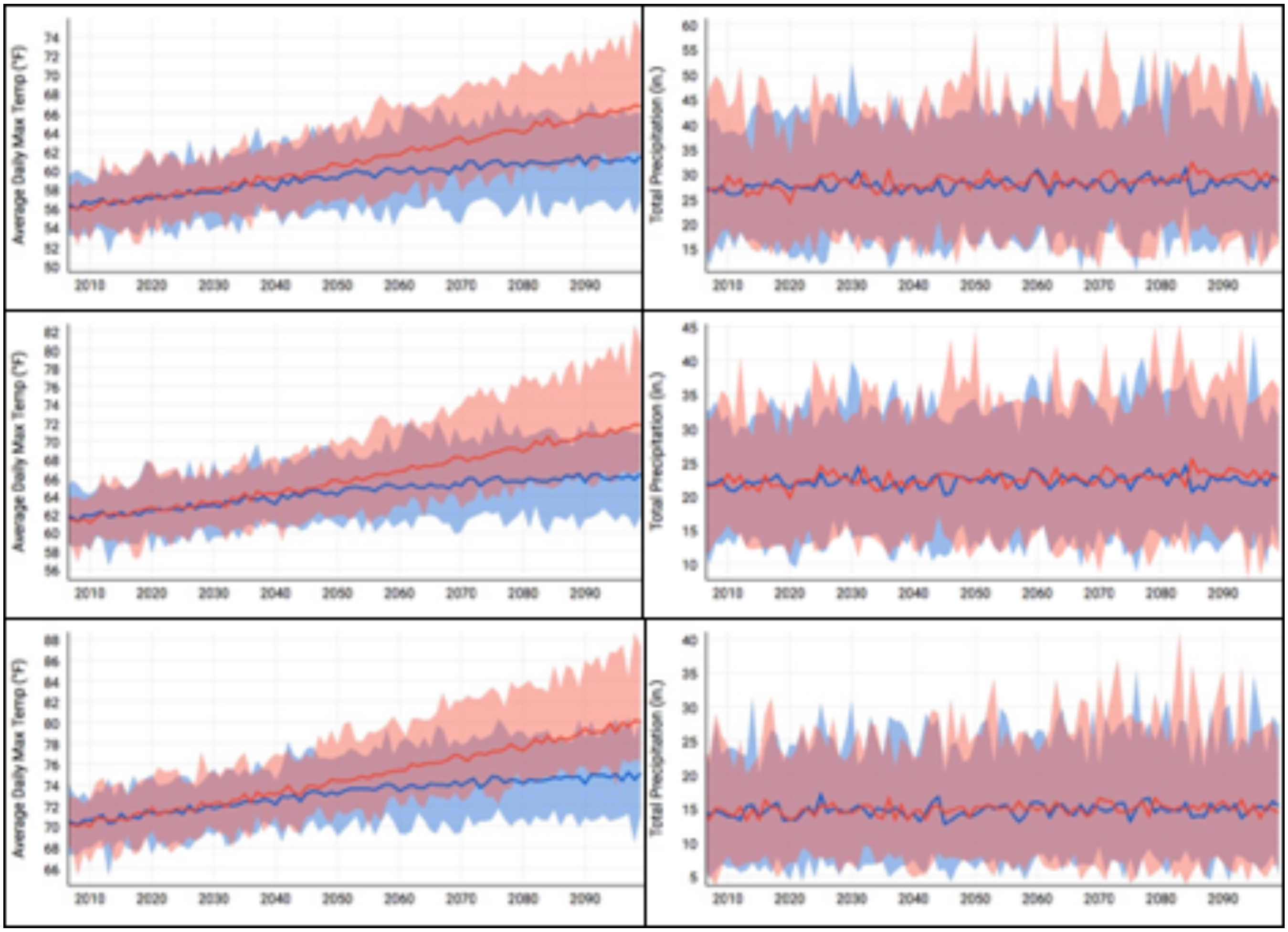


Figure 3 shows the historical record of annual average temperatures and annual precipitation for Boulder and Salt Lake City. Temperatures in both Salt Lake City and Boulder have warmed significantly throughout the historical record. Salt Lake City temperatures have warmed at a rate of 0.4°F per decade since 1930; annual average temperatures in Boulder have warmed at a rate of nearly 0.5°F per decade since 1955. As with other locations in Utah, precipitation was highly variable and no long-term trends were observed. Long-term average precipitation in Salt Lake City was 15.2 inches and 11 inches in Boulder.

Four of six locations in Utah described in Figures 1-3 showed strong warming trends over the historical period. The warming trend that is clear in the historical record is projected to continue throughout the twenty-first century. Figure 4 shows future projected changes in temperature and precipitation in Logan, Salt Lake City and St. George. For all three locations, temperatures are projected to warm by 3-4°F by 2050 depending on emissions scenario. By 2100, temperatures are projected to warm by 5°F under a moderate emissions scenario and 10°F under a high emissions scenario. There is a high level of certainty that temperatures will continue to increase in the twenty-first century; the only question is how much temperatures will increase. Global climate models used to project future changes in temperature all agree that temperature will increase for all regions of Utah. These global climate models do not agree about changes in precipitation. In general, precipitation will increase in the northwestern United States and

Figure 4. Projected changes in average daily maximum temperature (left figures) and projected changes in precipitation (right figures) for Logan (top figures), Salt Lake City (middle figures) and St. George (bottom figures). The blue line represents average projected temperature for a moderate emission scenario, blue area represents the range of climate models, the red line represents the average projected temperature for a high emission scenario, and red area represents the range of climate models. The moderate emissions scenario is the Representative Concentration Pathway, or RCP4.5, and the high emissions scenario is RCP8.5.5



it will decrease in the southwestern United States.[4] The geographical location of Utah sits in between these two continental-scale changes. Consequently, it is likely that northern Utah will see a slight increase in precipitation and southern Utah will see a slight decrease in precipitation. However, global climate models do not give a clear projection of how precipitation will change in Utah.

It is certain that temperatures will increase through much of the twenty-first century. Increasing temperatures, alone, will have several important impacts to natural hazards in Utah. Higher temperatures will increase the incidence of drought. In the future, years with "normal" precipitation will act like drought years when temperatures are hotter than historical average temperatures. Higher temperatures will increase the risk of wildfire. Higher temperatures in the shoulder season lengthen the fire season, dry soils, increase the dryness of dead wood and increase transpiration from plants; all of these factors lead to an increased risk of wildfire. Severe weather is likely to increase because climate change will cause an increase in extreme weather patterns; these extreme weather patterns can be related to both drought and floods. Extreme precipitation and warming temperatures will likely cause a greater incidence of floods. Warmer temperatures will likely cause a greater incidence of rain-on-snow events that cause mid-winter flooding. In general, climate change will increase the incidence of extreme precipitation. Increases in extreme precipitation associated with monsoonal rainfall will increase the risk to flooding in much of Utah. Overall, climate change will impact weather and climate hazards such as drought, flood and extreme weather and also impact other hazards such as wildfire, landslide, avalanche and dam failure.

4 US National Climate Assessment. Climate Change Impacts in the United States Climate Change Impacts in the United States. (2014). doi:10.7930/j0z31WJ2

IMPACTS TO UTAHN'S HEALTH

The serious health impacts from a changing climate and how it impacts Utahns have been documented in the Utah Department of Health "Climate Change and Public Health in Utah" plan. This plan addresses environmental and health indicators and the affects climate change is having on them and how our community design is compacting climate change effects.

Some of the health impacts include higher rates of respiratory disease, increased asthma prevalence, and increased heat related disease. From the Health Plan "*Ozone can have negative effects on human health. Increased levels of ozone can irritate the respiratory system and cause coughing, sore throat and chest discomfort. Additionally, if ozone pollution gets deeper into the lungs, it has the ability to damage the lining of the lungs. Other health effects include lower resistance to infectious diseases and allergen sensitivity*".

IMPACTS TO UTAH'S ECONOMY

Park City Green completed a study in 2017 to assess how climate change will impact the city as well as the skiing industry. The Ski industry employees 20,000 jobs and brings in $1.3 billion into Utah. The study suggests that Utah will no longer be the world skiing destination it is now, due to decreasing snow levels. "As a result, total snowpack and snow coverage will be reduced, the ski season will be shorter, and less of Park City Mountain Resort will be skiable." The immediate impact to the economy is a loss of $120 million as soon as 2030.

Climate change will impact Utah's agricultural economy as well. The livestock industry in Utah relies on open grazing, which is predicted to be reduced in capacity producing less feed supply while increased heat will have stress impacts on livestock. Hotter summers and less reliable water will affect what can be grown in arid Utah as will increase in wildfires that pollute water supplies. A 2011 paper "Ranching and Multi-year Droughts in Utah" found that "75% of Utah ranch operations reported major reductions in water supply, forage, and cattle productivity." According to a Utah State report, Agriculture is 15% of Utah's economy, accounting for $21 Billion a year.

IMPACTS TO HAZARDS

Climate change exacerbates hazards Utah already experiences. An increase in variability of climate translates and extreme events which are shown in severity, frequently, and location. We will and have already seen extreme rainfall, wind, wildfire, extreme heat and extended drought. For example, Utah declared a State of Emergency due to severe drought in 2018, while also experiencing flooding caused by intense rainfall over recently burnt areas. For the hazards that are impacted by climate change, we address those changes in each of the hazards sections throughout the plan.

CLIMATE CHANGE AND THE SHMP

The state defines climate change mitigation and climate change adaptation as follows:

- **Climate Change Mitigation:** A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

- **Climate Change Adaptation:** Adjustment or preparation of natural or human systems to a new or changing environment which moderates harm or exploits beneficial opportunities.

This plan does not address any specific climate change mitigation or adaptation actions. There are however, mitigation actions for specific hazards that also address climate change. An example would be, to provide power after an earthquake, communities and citizens should look into the use of solar power. While this action would allow residents to maintain power after a large earthquake, it will also reduce carbon being released into the atmosphere, addressing elements causing the climate to change.
Other mitigation actions can be seen as climate change adaptation. Some of these would include actions taken to reduce wildfire, most drought actions, and some severe weather actions. An action to address drought, would be to change the way we are building communities, changing from sprawling infrastructure to more dense centers. While this will conserve water, it will also change the way we travel, driving less, using more public transportation and contributing less carbon into the atmosphere.
Before meaningful mitigation or adaptation for is presented, a comprehensive climate change assessment for the state in needed. This assessment would be the primary point of presenting specific mitigation and/or adaptation actions that are needed to be taken

statewide to reduce the impacts and reduce the nature of current hazards.

Our recommendation is for the state to follow other states and the federal government in requiring a comprehensive climate change assessment to be completed.

CLIMATE CHANGE PLANS AND LEGISLATION ADDRESSING IMPACTS IN UTAH

Two plans were mentioned previously, The Utah Department of Health's "*Climate Change and Public Health in Utah*" and Park City Green *completed a study in 2017*. In this section we will discuss other plans and Legislation that has passed.

In 2018, the Utah Legislature passed and Governor Herbert signed *H.C.R. 7* Concurrent Resolution on Environmental and Economic Stewardship. H.C.R. 7 recognizes the impacts of changing climate and encourages resilient ecosystems that can better adapt and the reduction of emissions through incentives and the support of growth in technologies and services that enlarge the economy.

The *Utah Climate Action Network* works to build partnerships between 20 public and private organizations, including Salt Lake City, Salt Lake County, Park City, Alta Ski Area, West Valley City and the University of Utah to address climate change in Utah. The Climate Network holds quarterly meetings and is working to bring these groups together to fully address climate change and its impacts on Utah.

Salt Lake City completed the *Climate Positive Plan 2040* in 2016. The plan establishes a baseline of where the city is and outlines transformational steps to reach their long-term climate and energy goals. Salt Lake City is a leader in addressing climate issues and innovative in their solutions and goals. Those goals include:

- **100 x 2032:** 100% Renewable Energy for Community Electricity Supply by 2032
- **80 x 2014:** 80% Reduction in Community Greenhouse Gas Emissions by 2040

They have implemented city operations solutions such as Net Zero construction that requires all new city buildings over 10,000 square feet must meet Net Zero Energy standards, and Clean Vehicle Fleet, replacing old vehicles with clean hybrid or electric vehicles.

The U.S. Forest Service rolled out their *Climate Change Vulnerability & Adaptation in the Intermountain Region* plan in the spring of 2018. The nearly 1000 page document address climate change for the intermountain West, that includes all of Nevada, Utah and southern Idaho. While the plan focuses on USFS lands, climate does not heed to invisible boundaries and much of what the plan addresses.

The U.S Global Change Research Program (USGCRP) delivered the fourth report of *The National Climate Assessment in 2018*. The report is mandated to be delivered to Congress and the President every four years and must integrate, evaluate, and interpret findings of USGCRP, and analyze the effects of the global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity and analyze global climate change, projecting trends for the next 25 to 100 years.

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