CLIMATE ADAPTATION PLAN FOR PUBLIC HEALTH

A Framework to Prepare for the Health Impacts of Climate Change

SALT LAKE COUNTY
HEALTH DEPARTMENT

DIRECTOR'S STATEMENT

The release of greenhouse gases into the earth's atmosphere has set the climate on a course to change drastically in the near future, and these changes are having a significant impact on human health in Salt Lake County. There is broad scientific consensus that climate change is occurring at a rate faster than previously anticipated, and is causing warmer temperatures, droughts, and more frequent extreme weather events in the region. It is important that we take action now, both to mitigate the impacts of climate change and to develop adaptation strategies that enhance the region's resiliency to the inevitable changes it will experience.

Many responses to climate change could positively impact the region in multiple ways, simultaneously reducing the burden of disease, saving money, protecting the environment, developing community, and addressing inequality. Salt Lake County's Climate Change Adaptation Plan for Health will provide a plan for organizations in the Salt Lake region to respond to the health impacts of climate change, serving to build a healthier, more resilient community, and setting an example for other local health departments in Utah.

DR. ROYAL DELEGGE
Environmental Health Director

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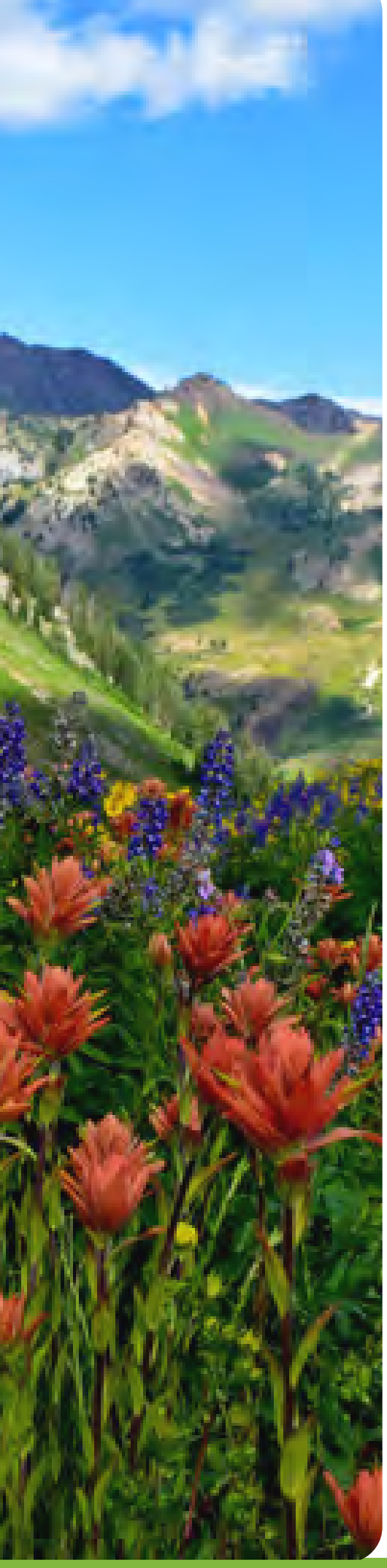
The goal of this document is to provide a framework for an adaptation plan, laying out the predicted climate-related health risks and the actions that can be taken to improve the county's resiliency.



Executive Summary

"Climate change represents an inevitable, massive threat to global health that will likely eclipse the major known pandemics as the leading cause of death and disease in the 21st century … The health of the world population must be elevated in this discussion from an afterthought to a central theme around which decision-makers construct rational, well informed action-orientated climate change strategies."

— Dr. Dana Hanson
President, World Medical Association

EXECUTIVE SUMMARY

The Climate in Utah is Changing

- Warming will continue, with longer and hotter heat waves in the summer, and a longer freeze free season, a higher average annual temperature, and fewer cold snaps
- Droughts will become hotter, more severe, and more frequent
- Late season snowpack will continue to decrease
- A decrease in soil moisture and river flow will occur
- Precipitation extremes in winter will become more frequent and more intense (i.e. more precipitation per hour)
- Flooding will become more frequent and intense in some seasons
- The distribution of plant and animal species in the region will change, as well as the timing of the regional life cycles of species
- There will be an increase in wildfires, outbreaks of forest pests and disease, and changes in land cover [1]
- Higher temperatures will accelerate the production of ground level ozone, and airborne particulates will be present at a higher rate as the Great Salt Lake dries up

Climate Change and Vulnerable Populations

- Low- income households will be more vulnerable as they are more exposed to hazards and have fewer resources that make them resilient
- Emergency responders, such as firefighters and first responders, are at a greater risk of injury and death
- Outdoor workers, such as construction workers and farmers, are more exposed to heat, vector-borne diseases, and extreme weather
- The elderly and the very young are most vulnerable to disease and extreme weather
- Communities of color and immigrants already experience higher rates of disease and poverty, making them disproportionately affected by climate change

Climate Change is a Threat to Public Health

Heat

- Extreme heat is associated with increased hospitalizations and deaths due to **heat stroke** and **heat exhaustion**

Water

- Harmful **algal blooms** and **parasites** such as cryptosporidiosis, cholera, campylobacter, and leptospirosis will be more common in warmer temperatures
- **Water shortages** associated with the drying climate will have a broad health impact in the region

Air

- Higher levels of ground level ozone, increased levels of airborne particulates, and longer freeze-free seasons may exacerbate the burden of **asthma, allergies**, and other **respiratory conditions**

Pathogens

- Changed temperatures and precipitation patterns will affect the range and prevalence of **disease vectors**, causing arthropod or rodent-borne pathogens to become a greater problem
- Higher temperatures and power outages may increase the prevalence of food and water borne pathogens

Infrastructure

- Damage to infrastructure during extreme weather can cause **injuries**, **fatalities**, and **stress**
- Historical data was used to predict the region's average and extreme weather and guide the development of infrastructure, but as flooding, wildfires, droughts, and heat become more severe infrastructure will need to be adapted

Disease

- Air pollution and heat stress exacerbate the symptoms of **chronic conditions** such as asthma, COPD, allergies, chronic renal disease, diabetes, and a wide range of **cardiovascular issues**
- Declining air quality, depletion of stratospheric ozone, and heavy rainfall and flooding will increase exposure to UV radiation and toxic chemicals, increasing the risk of some types of **cancer**
- Climate change will inevitably have an impact on **mental health**, causing an increase in post-traumatic stress, anxiety, depression, conflict, and grief

Introduction

"Widespread scientific consensus exists that the world's climate is changing. Some of these changes will likely include more variable weather, heat waves, heavy precipitation events, flooding, droughts, more intense storms, sea level rise, and air pollution. Each of these impacts could negatively affect public health."

– The U.S. Centers for Disease Control and Prevention

INTRODUCTION

Human health is being impacted by increased temperatures, changed precipitation patterns, and many other effects of climate disruption. Public health organizations around the world have recognized climate change as a threat, and are beginning to develop plans to minimize the harm climate change causes human health.

In 2015, Salt Lake County Health Department began taking steps to study and prepare for the health impacts of climate change. The SLCoHD Climate and Health Workgroup was formed to research how the region is vulnerable to climate change, to increase awareness of climate and health-related issues, and to plan strategies for adaptation. While SLCoHD is following the example of many other state and local health departments across the country working on the issue, it is a leader in climate adaptation planning among health departments in Utah.

Climate Adaptation Plan for Health

The purpose of this report is to provide a framework for the region's Climate Adaptation Plan for Health. It outlines the status of the region's climate, its likely changes and effects on health. The issues described in this report cannot be addressed by Salt Lake County Health Department alone; there are many stakeholders who have shared responsibilities in protecting the health of our population and many points of view that should be considered in ensuring that the region is adequately prepared. We hope that this report helps set direction for the Climate Adaptation Plan for Health, and provides a useful foundation of information to stakeholders interested in becoming involved.

Climate Adaptation Steps:

1) Forecast climate impacts

2) Project burden on public health

3) Foster collaborations and plan interventions

4) Develop and implement a climate adaptation plan for health

5) Evaluate impact of adaptation planning

ENVIRONMENTAL HEALTH AND CLIMATE CHANGE

The Salt Lake County Health Department's Environmental Health Division has a legacy of exercising the science and practice of preventing human injury and illness, promoting well-being. This is achieved by identifying and evaluating environmental sources and hazardous agents and limiting exposures to hazardous physical, chemical, and biological agents in air, water, soil, food, and other environmental media or settings that may adversely affect human health.

Environmental Health Specialists are trained to:

- investigate, sample, measure, and assess hazardous environmental agents in various environmental media and settings;
- recommend and apply protective interventions that control hazards to health;
- develop, promote, and enforce guidelines, policies, laws, and regulations;
- develop and provide health communications and educational materials;
- manage and lead environmental health units within organizations;
- perform systems analysis;
- engage community members to understand, address, and resolve problems;
- review construction and land use plans and make recommendations;
- interpret research utilizing science and evidence to understand the relationship between health and environment; and
- interpret data and prepare technical summaries and reports.

Decades of scientific investigations and studies have determined that climate systems worldwide are being disrupted by human activity and significantly affecting the most primary environmental resources that sustain human health. Water, air, soils for food production, ocean life systems, and human habitation are all susceptible to substantial instability. This is particularly important now as there is broad scientific consensus that climate change is occurring at a rate faster than previously anticipated, and is causing warmer temperatures, droughts, and more frequent extreme weather events in the region.

The future of environmental health practice will be influenced by disruptions inherent with climate change. Salt Lake County is taking a proactive approach and applying the practices of Environmental Health Science and is coordinating with additional entities to produce strategies to mitigate, adapt, prepare and respond to acute and chronic events spurred by the changing and altered climate.

Climate & Health Symposium

Since 2015, SLCoHD has hosted an annual Climate & Health Symposium to bring together academics, public health professionals, and the public to study and discuss the local health impacts of climate change. The Climate & Health Symposium is a great opportunity to network with others working on climate change issues locally, and to learn more about the health impacts of climate change and the steps that can be taken to build a more resilient community.

Over 150 people attended the April, 2017 event. Presenters emphasized that climate change is a human issue as much as an environmental issue, and explained how our health will be impacted by changing air quality, water availability and quality, the distribution of disease vectors, and other climate-related issues. Researchers presented on their projects studying the spatial distribution of air pollutants in Salt Lake County, and explained the co-benefits of reducing local emissions of greenhouse gases. Water issues such as decreased runoff, increased concentrations of pathogens and contaminants, and increased demand for water were discussed, and last year's unprecedented harmful algal bloom in Utah Lake was highlighted. An entomologist from the city's mosquito abatement district presented on the effect of climate change on the distribution of disease vectors, and what can be done to track and control the population of these vectors. Presentations explored how climate change issues could be best communicated to audiences of different ages and backgrounds in a way that is engaging and inspires action.

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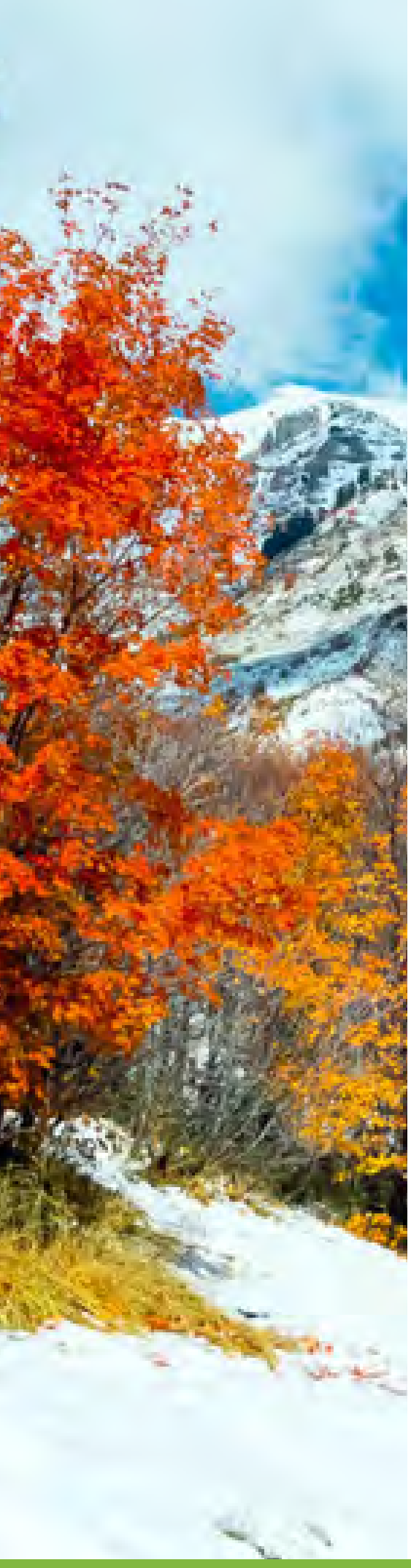


Observed and Projected Climate

"Scientific evidence for warming of the climate system is unequivocal."

- Intergovernmental Panel on Climate Change

GLOBAL CLIMATE TRENDS

Retrieved directly from NASA Global Climate Change Page:

The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 7,000 years ago marking the beginning of the modern climate era — and of human civilization. Most of these climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives.

The current warming trend is of particular significance because most of it is extremely likely (greater than 95 percent probability) to be the result of human activity since the mid-20th century and proceeding at a rate that is unprecedented over decades to millennia [1].

Measured Temperature Changes

The planet's average surface temperature has risen about 2.0 degrees Fahrenheit (1.1 degrees Celsius) since the late 19th century, a change driven largely by increased carbon dioxide and other human-made emissions into the atmosphere [2]. Most of the warming occurred in the past 35 years, with 16 of the 17 warmest years on record occurring since 2001. Not only was 2016 the warmest year on record, but eight of the 12 months that make up the year — from January through September, with the exception of June — were the warmest on record for those respective months [3].

Response from Earth's Systems

In addition to measured changes in temperatures, evidence for climate change can be seen in the response from Earth's systems. As a result of the world's warming, ice caps, glaciers, ice sheets, and permafrost are melting. Arctic sea ice is now declining at a rate of 13.3% per decade relative to the 1981-2010 average. Glaciers are retreating almost everywhere around the world [4]. More frequent extreme weather events including heat waves, droughts, wildfires, and extreme precipitation events are being recorded. The U.S. National Climate Assessment reported that heat waves have become more frequent, with western regions setting records for heat events in the 2000s [5]. The U.S. has also recorded increasing numbers of intense rainfall events, consistent with climate projections [6]. These are just a few examples of signs that the climate is changing. Changes have also been recorded in studies showing sea level rise, ocean acidification, and many studies showing changes in ecology around the world.

Extreme Events

Retreating Glaciers

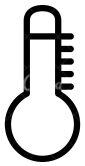
Sea Level Rise

Decreasing Snowpack

SOUTHWEST CLIMATE TRENDS

The Southwest U.S. climate has long been affected by natural fluctuations that have causing droughts, floods, heavy snow falls, heat waves, severe winds, intense storms, cold snaps, and poor air quality conditions in the region. It has also been affected by a rapid increase in population over the past few decades, causing significant alternations in land use, cover, and water supplies. These factors, combined with the effects of climate change, are the reason why the Southwest is considered to be one of the most "climate-challenged" regions of the continent [7].

There are many observed recent changes in the Southwest climate that have been attributed to human-caused emissions of greenhouse gases. These are just a few examples of changes seen in the Southwest; many other changes in the regions climate have occurred over the past century [8].



Temperature

- Of all decades from 1901-2010, the decade of 2001-2010 was the warmest and forth driest in the Southwest
- The average annual temperature increased 1.6 degrees Fahrenheit between 1901 and 2010
- More heat waves and fewer cold snaps occurred in the decade of 2001-2010 compared to the 1901-2010 average

Streamflow

- Streamflow and snowmelt in many snowmelt-fed streams of the Southwest trended towards earlier arrivals from 1950–1999, and climate science has attributed up to 60% of these trends to the influence of increasing greenhouse gases concentrations in the atmosphere. This trend of earlier snowmelt and streamflow has continued from 2001-2010, likely in response to warmer temperatures.
- Streamflow totals in the four major drainage basins of the Southwest were 5% to 37% lower during 2001–2010 than their average flows in the twentieth century

Growing Season

- The growing season for the Southwest increased about 7% (seventeen days) during 2001–2010 compared to the average season length for the twentieth century.

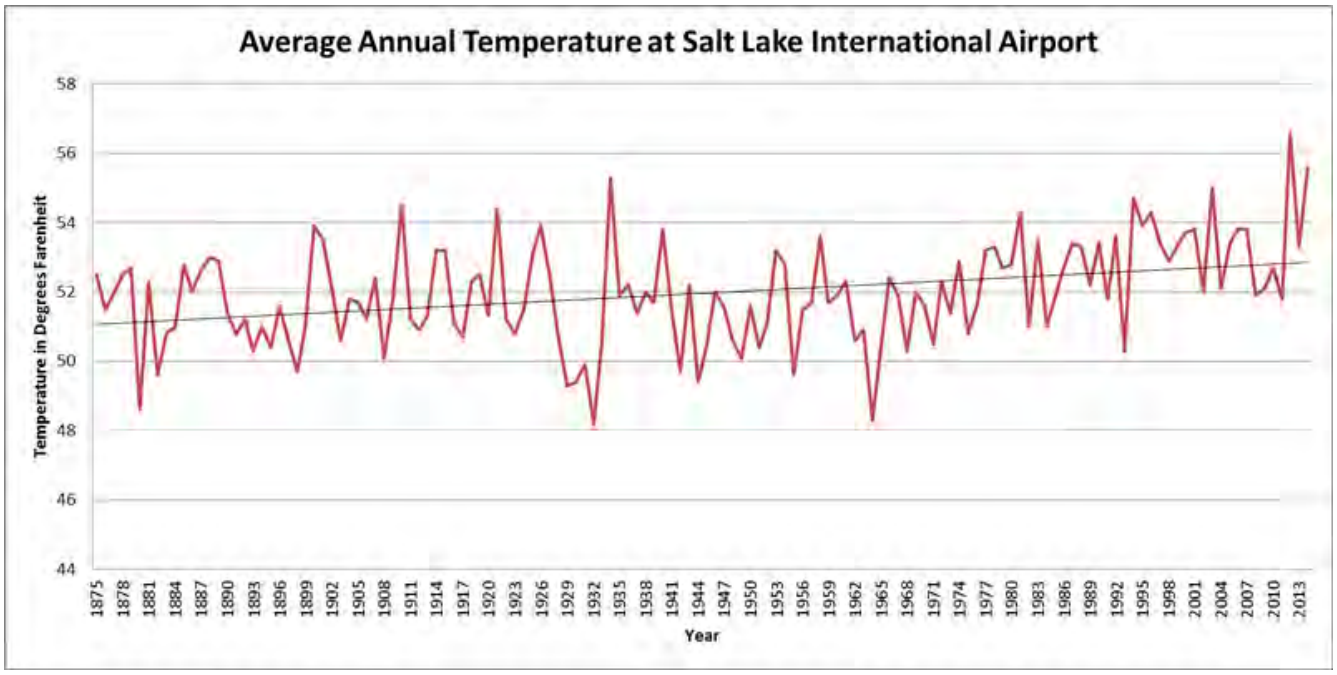
Drought

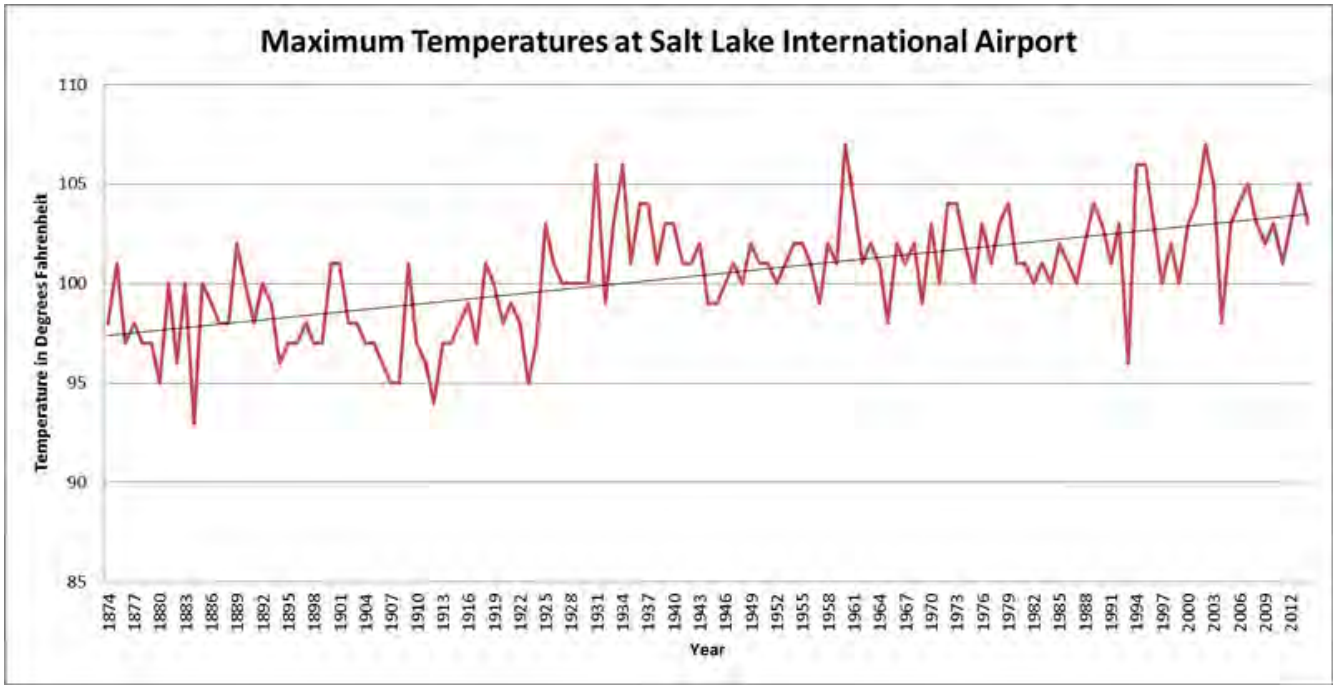
- The extent of drought over the Southwest during 2001–2010 was the second largest observed for any decade from 1901 to 2010.
- According to paleoclimatic reconstructions of past droughts, several droughts in the preceding 2,000 years exceeded the severity and duration of droughts during 1901-2010.

UTAH CLIMATE TRENDS

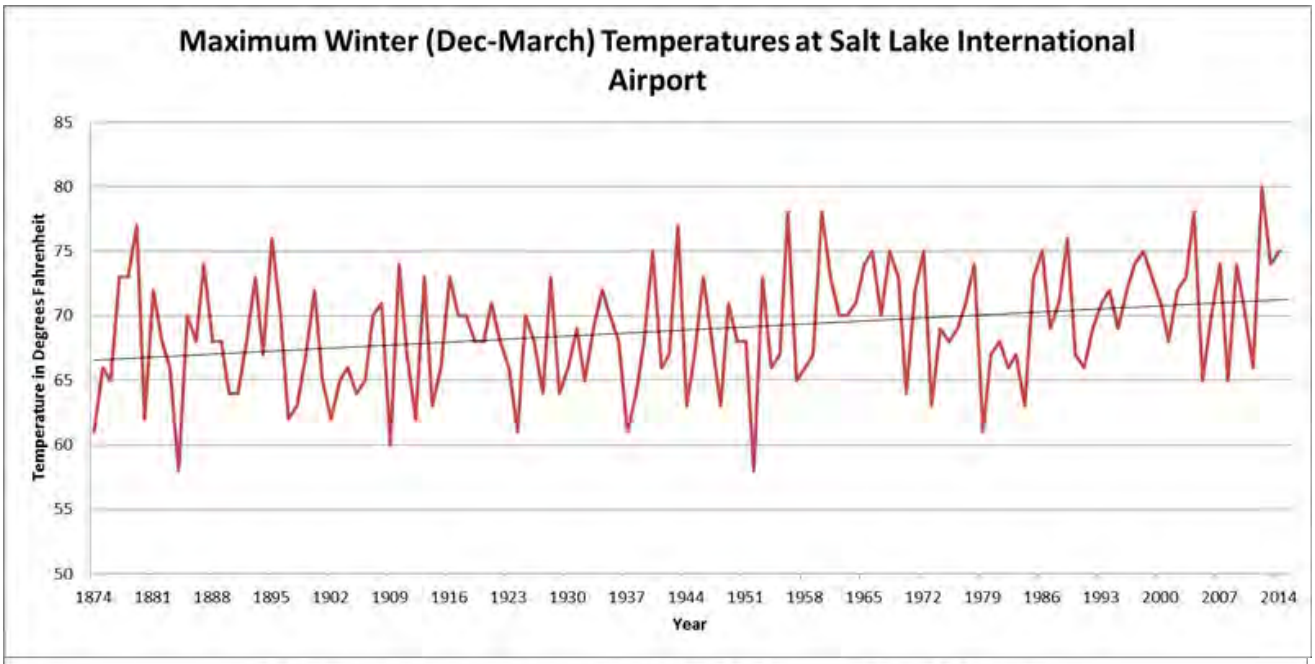
Temperature

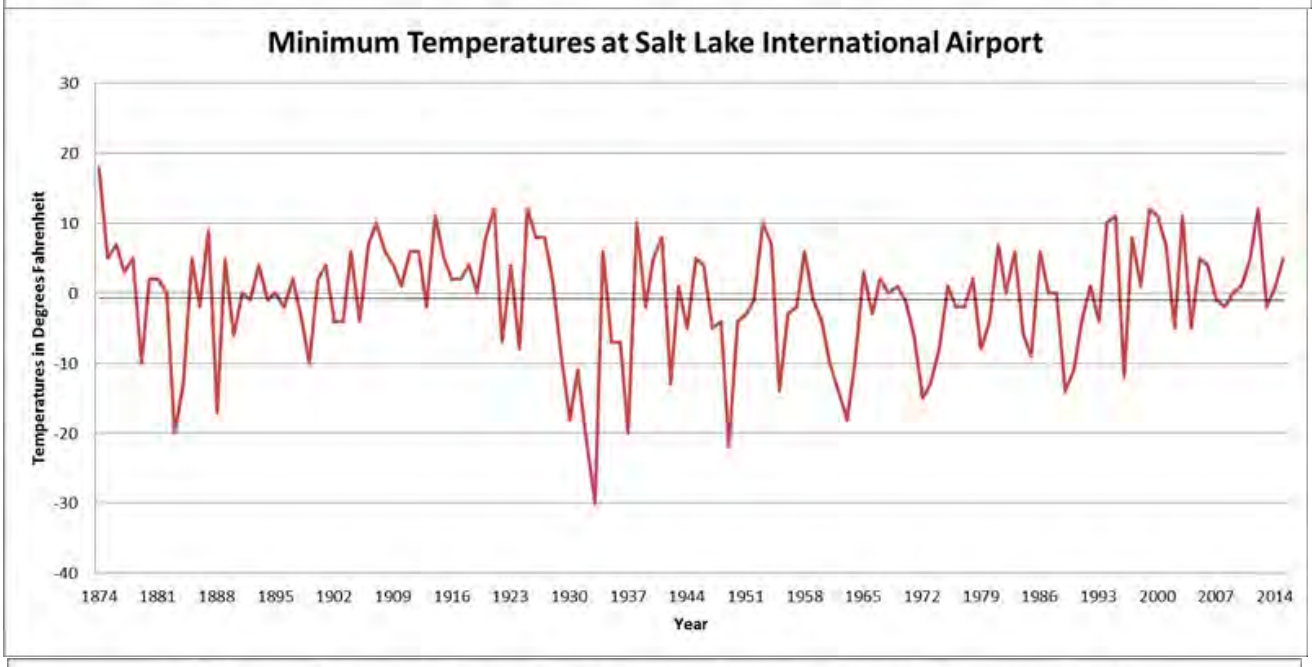
The climate trends affecting the Southwest have also been measured and observed in local meteorological indicators. The following graphs show temperature patterns measured at the Salt Lake City Airport dating back to 1884. Although this is rough data, trendlines show an increasing average annual temperature, increasing maximum annual temperatures, and increasing maximum temperatures in the winter. The minimum summer temperature graph also shows an increasing trend, indicating that summer temperatures are not dropping as much at night.

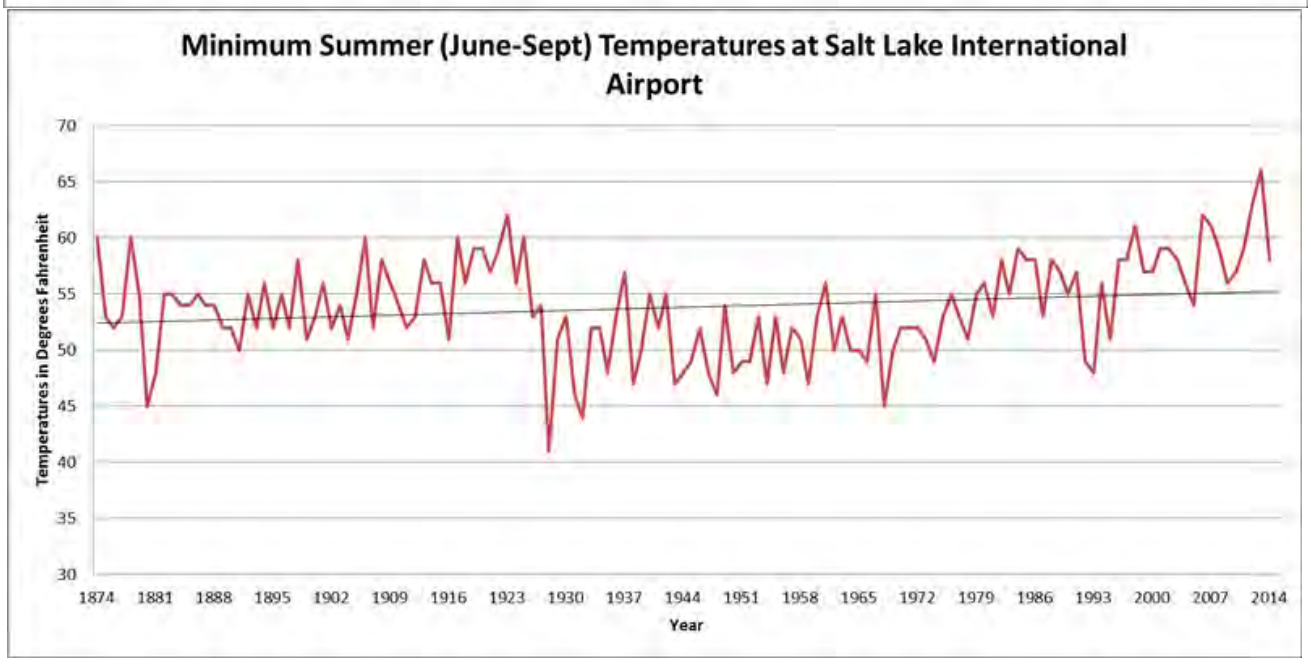




Information for both graphs obtained from the National Oceanic and Atmospheric Administration, National Climatic Data Center at http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp



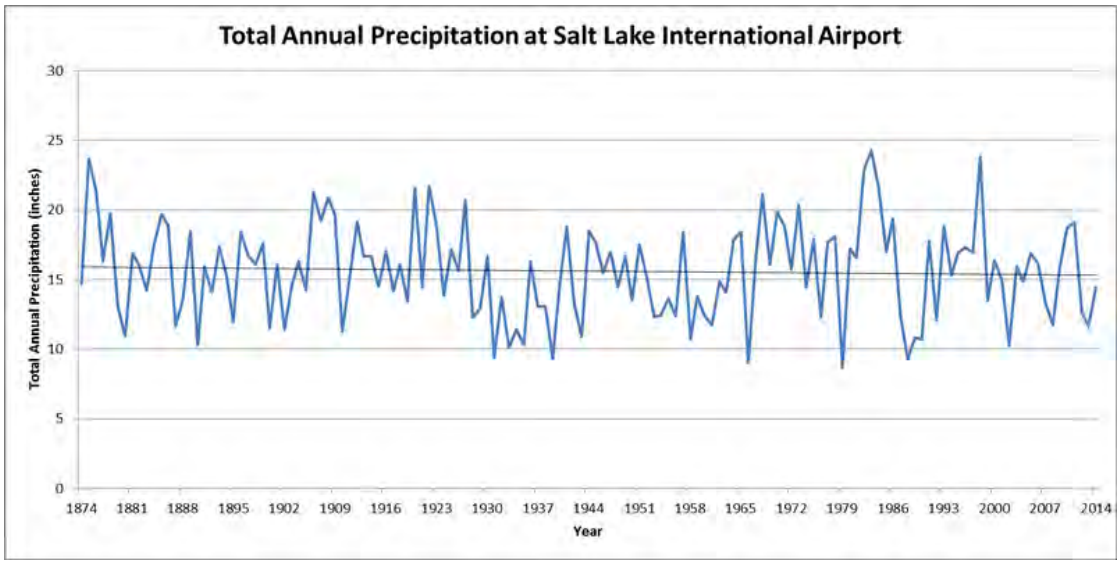


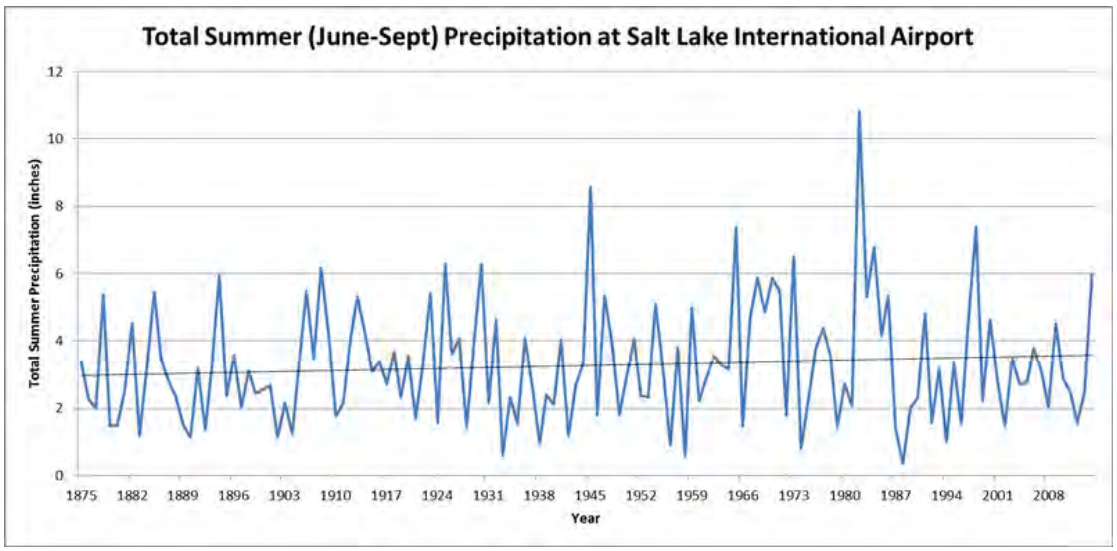


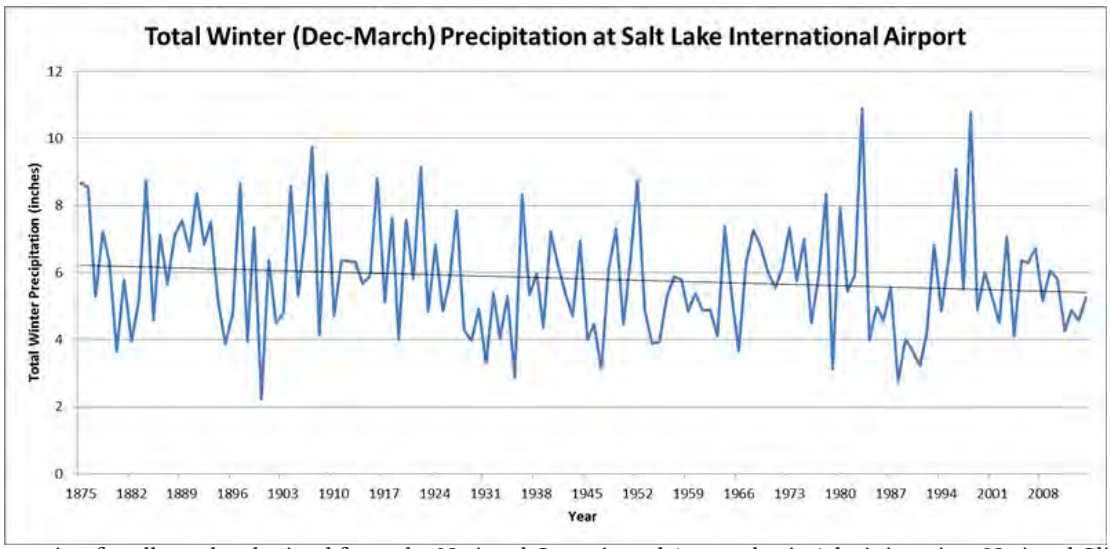
Information for all graphs obtained from the National Oceanic and Atmospheric Administration, National Climatic Data Center at http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp

Precipitation

Precipitation patterns are affected by climate change, although they are more difficult to measure or predict relative to temperature patterns. It is known that higher temperatures cause more evaporation, leading to more intense precipitation events. Annual mean precipitation is expected to become more variable [9]. The graphs below show precipitation trends at Salt Lake International Airport annually, during winter months, and during summer months.



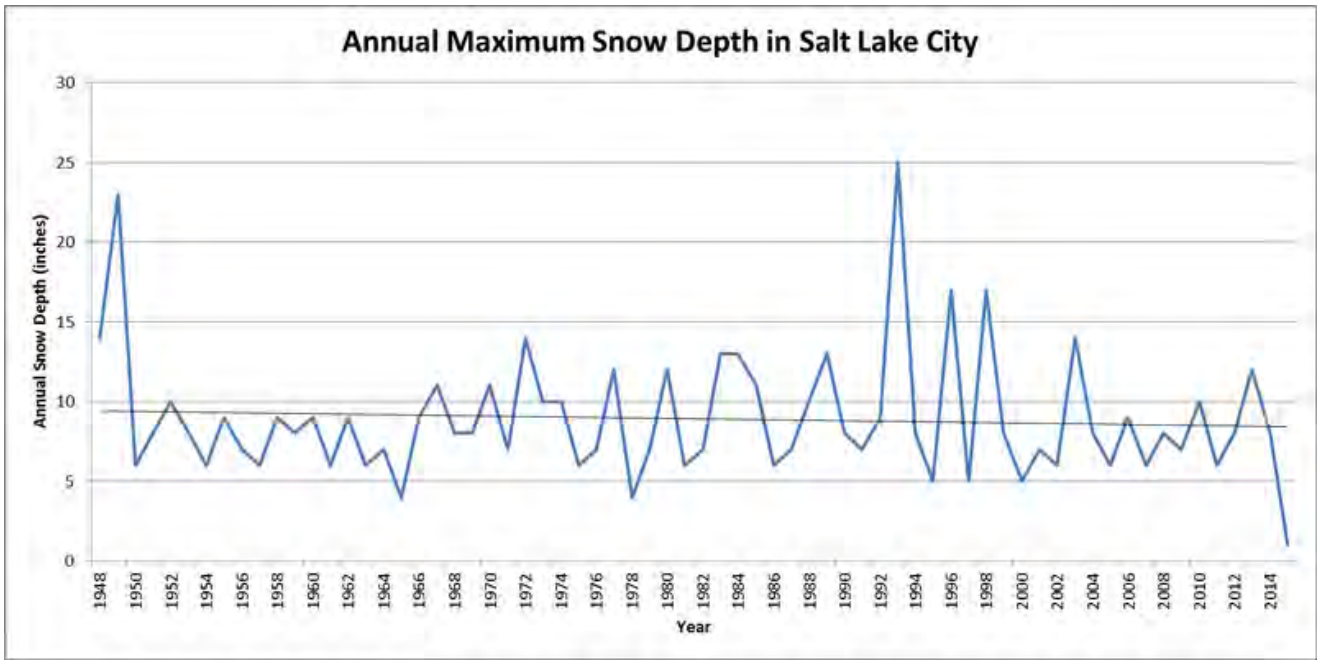




Information for all graphs obtained from the National Oceanic and Atmospheric Administration, National Climatic Data Center at http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp

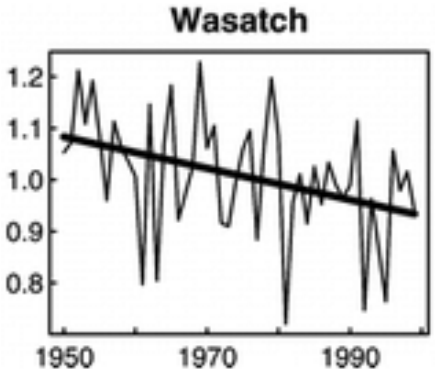
Snow

In the Salt Lake Valley, 80% of drinking water comes from reservoirs filled by runoff from the region's snowpack. Warmer temperatures cause more precipitation in winter months to fall as rain rather than snow, and also affect the timing and efficiency of spring runoff. As snowpack melts earlier in the spring, the volume of water that is in reservoirs decreases due to increased evaporation, sublimation, and transpiration [10]. The graph below shows the annual maximum snow depth varying from year to year.



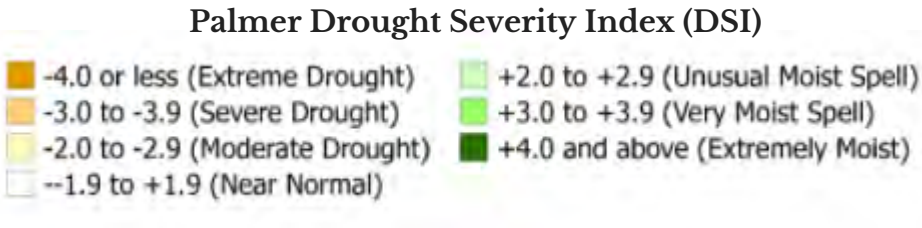
Information obtained from the National Oceanic and Atmospheric Administration, National Climatic Data Center at http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp

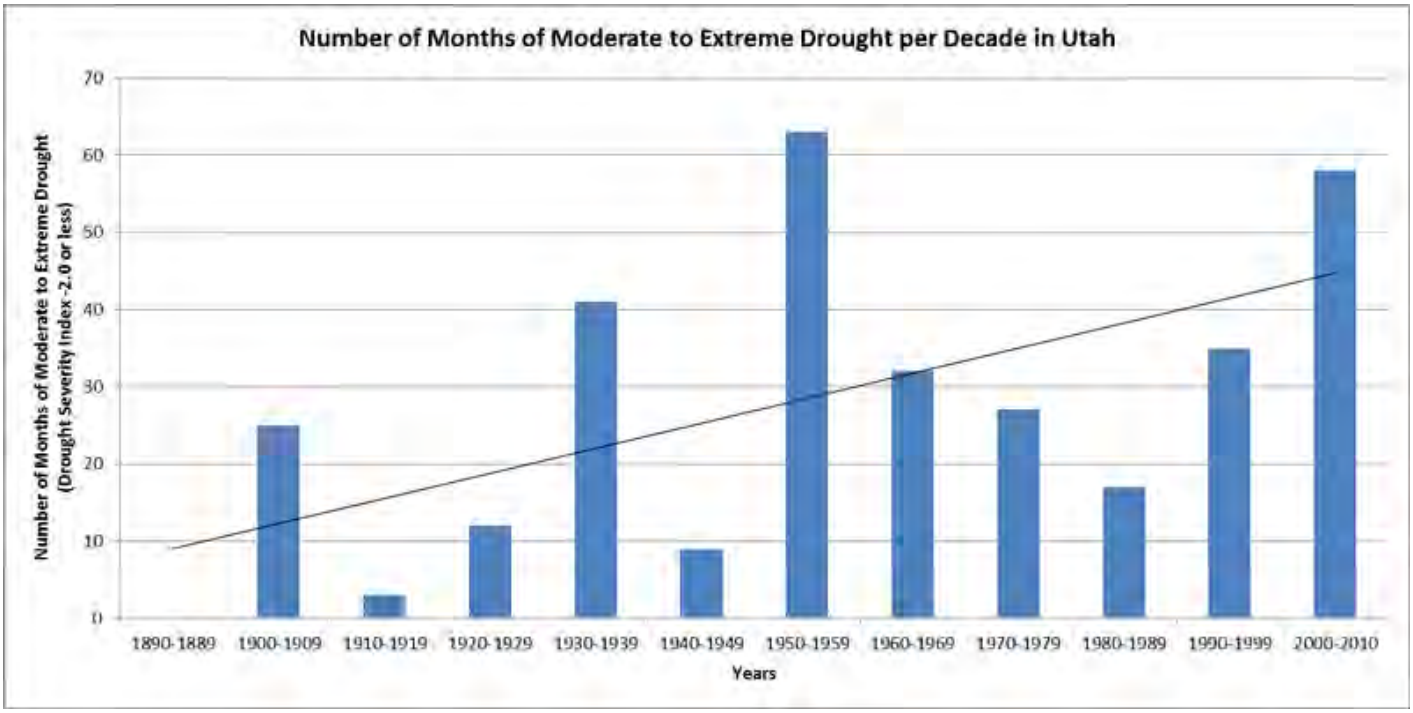
The graph on the right shows how the fraction of precipitation falling as snow vs. rain has declined over time in the Wasatch region [11]. The y-axis shows the April snow water equivalent (SWE) over water-year-to-date precipitation (P). Information obtained from Pierce et al (2008).



Drought

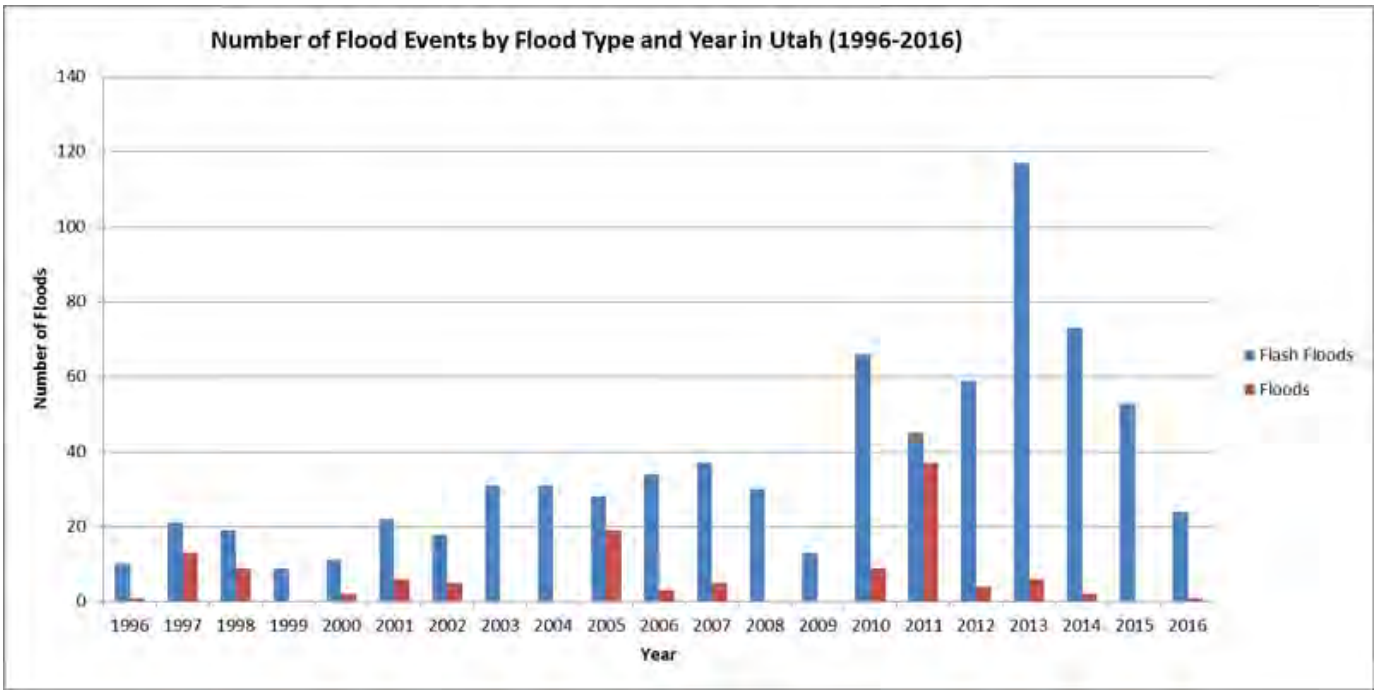
A drought is defined as a natural phenomenon in which rainfall is lower than average for an extended period of time, resulting in inadequate water supply [12]. The Palmer Drought Severity Index (DSI) is calculated to measure prolonged periods of abnormal dryness or wetness [13]. The following graph depicts the number of months each decade during which the DSI was higher than 2.0, indicating a moderate to extreme drought.





Flooding

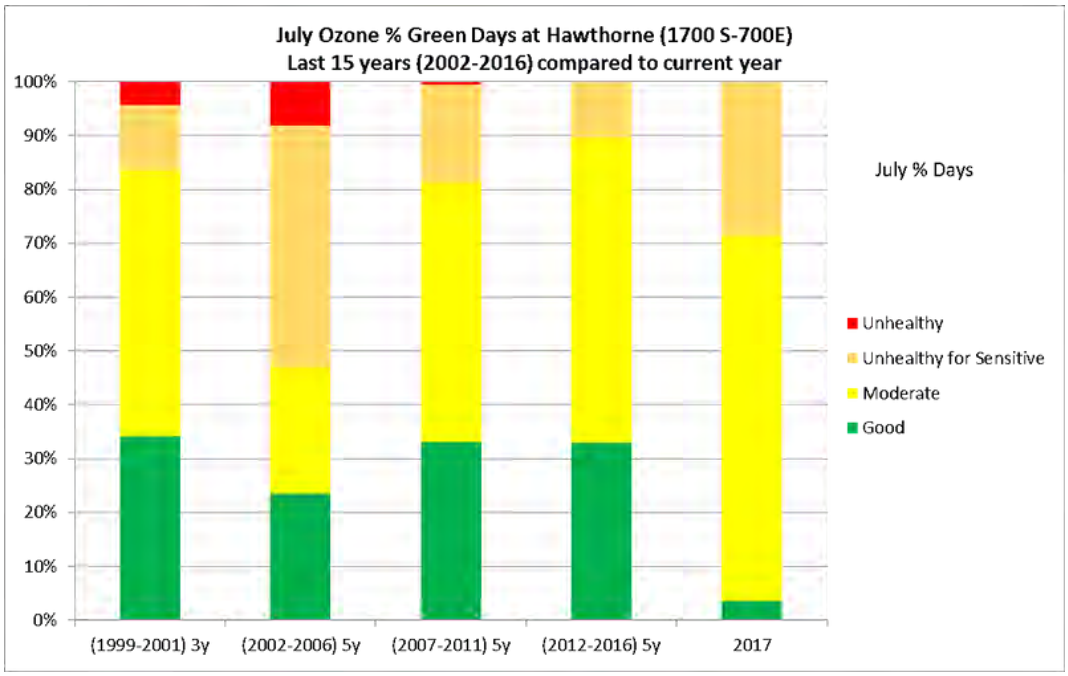
An increase in extreme events, including flooding, has been recorded in Utah in recent years.
Flash flood: A rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (e.g. intense rainfall, dam failure, ice jam). However, the actual time threshold may vary in different parts of the country. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters.
Flood: Any high flow, overflow, or inundation by water which causes or threatens damage.



Information obtained from Utah Department of Health's Environmental Health Tracking http://epht.health.utah.gov/epht-view/indicator/view/CliChaExtWea.FloNum.html

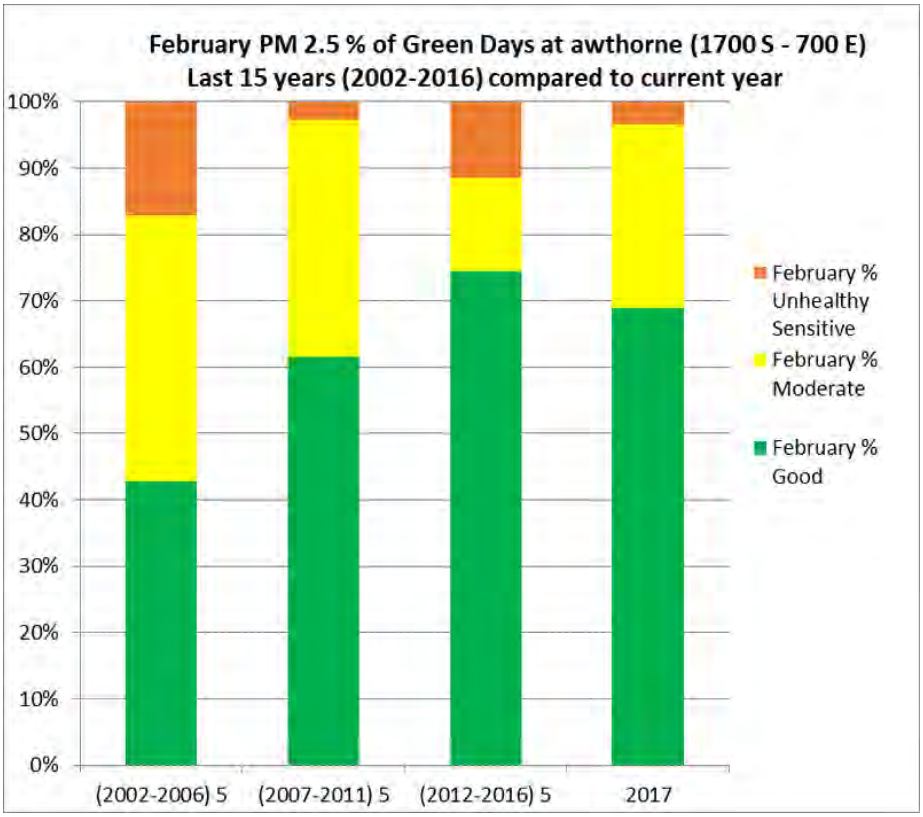
Ozone

This graph shows the ozone levels at Hawthorne for the last 16 years. During this period the levels of ozone precursors have declined, but July ozone levels have not improved. This year may have been particularly bad due to wildfires in other regions of the US, and due to many sunny, hot days this July.



PM 2.5

The graph below shows preliminary data collected at Hawthorne Elementry School in Salt Lake City, Utah. For the past 15 years, levels of PM 2.5 have been measured at this location to record how often levels of PM 2.5 reach moderate to unhealthy levels. Over the time frame depicted below, levels of PM 2.5 and it precursors have declined. It is possible that the increase nighttime low temperatures has led to a decrease the strength of winter inversions, reducing levels of PM 2.5. These improvements can also be partially attributed to a transition to cleaner vehicles, and a decrease in emissions.



PROJECTIONS OF FUTURE WARMING

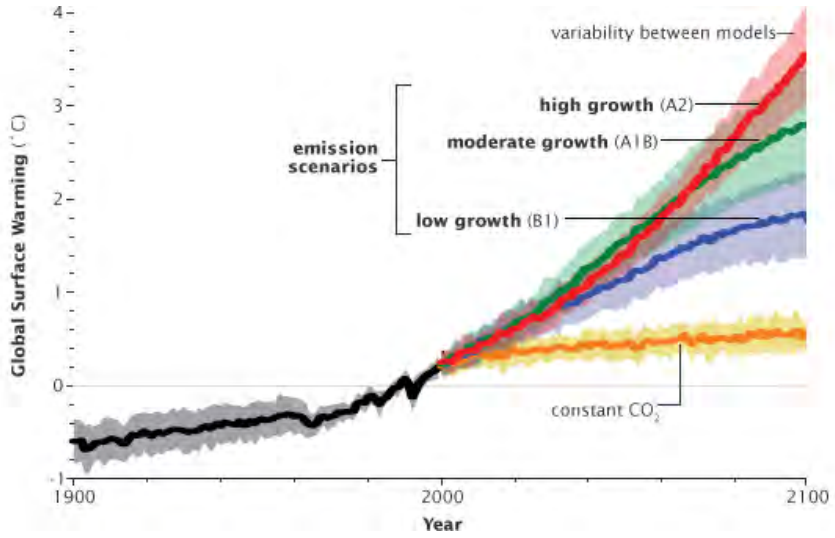
Temperature Projections and Emissions Scenarios

It is not certain how Utah will change in the future, and how quickly these changes will occur, and much of this uncertainty is due to the fact that it is difficult to predict how humans will choose to move forward. Climate scientists have developed a series of models based on different emissions scenarios, and the projections vary drastically between low emission and high emission scenarios.

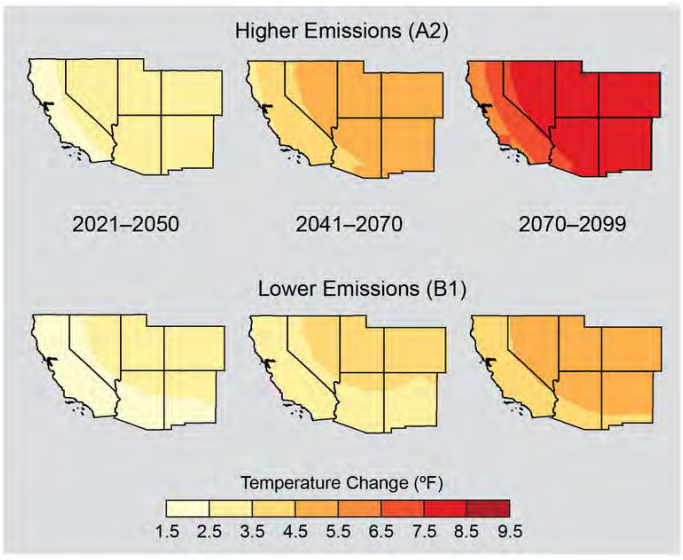
A2: High emissions scenario; a very heterogeneous world with continuously increasing global population and regionally oriented economic growth that is more fragmented and slower than in other storylines. In this scenario, annual average temperatures in the Southwest are projected to rise by 2.5˚F to 5.5˚F by 2041-2070 and by 5.5˚F to 9.5˚F by 2070-2099 with the greatest increases in the summer and fall.

A1B: Medium emissions scenario; rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies

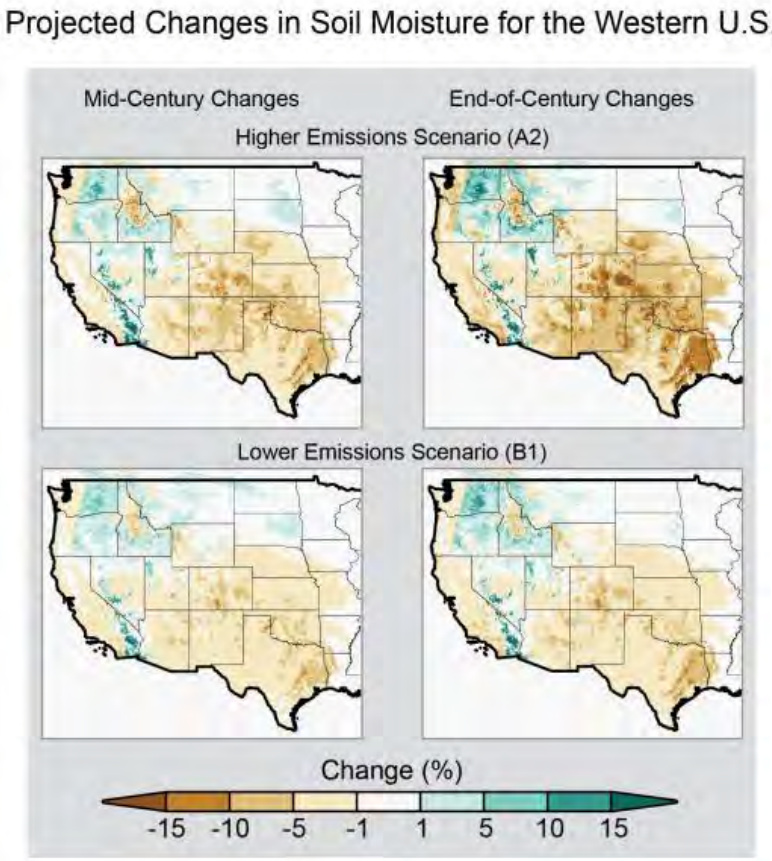
B1:Low emissions scenario; a convergent world with the same global population as in the A1 storyline but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. [14] In this more optimistic scenario, projected temperature increases in the Southwest are 2.5˚F to 4.5˚F (2041-2070), and 3.5˚F to 5.5˚F (2070-2099).



Projected Temperature Increases

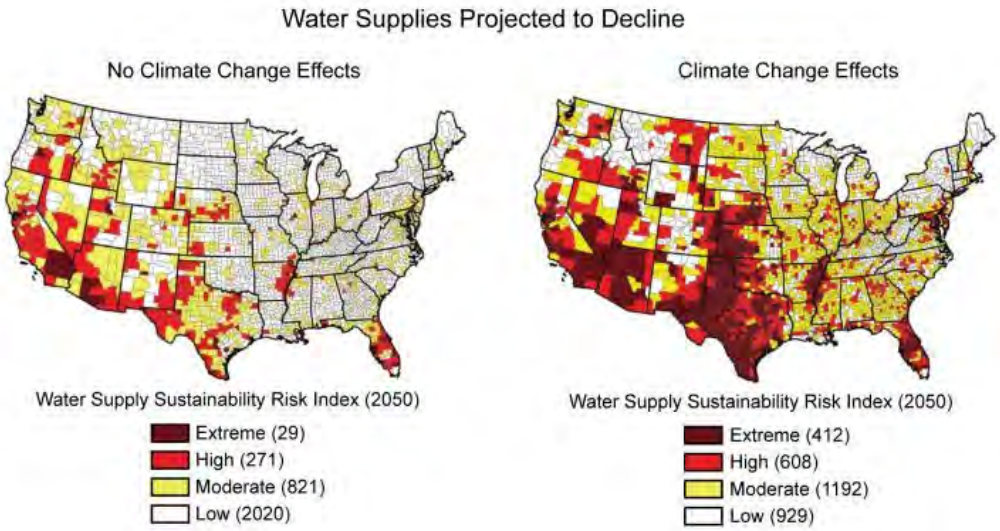


Evaporation and Drought



Increased potential for evaporation due to global warming is causing an increase in the duration of dry spells in the Southwest. Under each emission scenario the region will become dryer towards the end of the century, and there is evidence that short term (seasonal or shorter) droughts will intensify.

Municipal Water Supply



Climate change is projected to reduce water supplies in the Southwest, even in some areas where precipitation is expected to increase. Projections show that the quality of water will also decline due to floods, which can cause an increase in the amount of sediments and pollutants in water. Droughts can also lead to an increased concentration on contaminants in water [15].

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Health Impacts

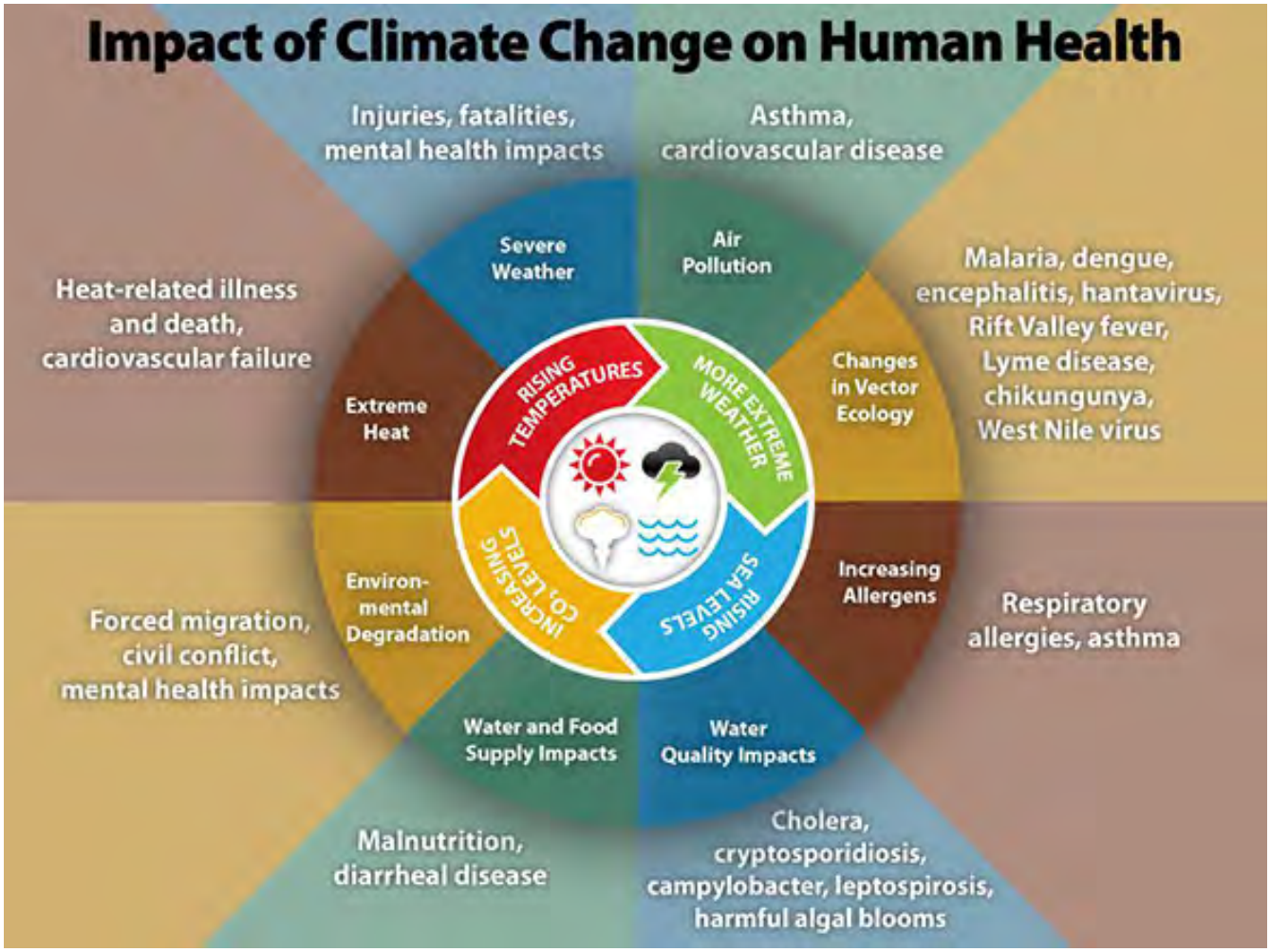
"I came to climate change not as a scientist or an environmental lawyer, and I wasn't really impressed by the images of polar bears or melting glaciers. It was because of the impact on people, and the impact on their rights -- their rights to food and safe water, health, education and shelter."

- Mary Robinson, former president of Ireland, UN High Commissioner for Human Rights

CLIMATE IMPACTS HEALTH

Until recently, most climate change research and discussions have centered on the environmental effects rather than the costs in human lives and suffering. The issue is often paired with images of polar bears, melting ice caps, or drying deserts, but its human impact is rarely mentioned. It is clear that climate change has the potential to harm human economic, social, physical, and mental well-being through many complex pathways. Although there are still many gaps in the understanding of climate and health, but this chapter aims to highlight health impacts that may result from Utah's projected change in climate. These impacts have been divided into six main categories: heat, air, water, pathogens, disease, and infrastructure.

Overview



The environmental consequences of our emission of greenhouse gases such as rising sea levels, increased carbon dioxide levels, rising temperatures, and extreme weather events are leading to a broad range of health impacts. While these will predominantly affect people in the developing world, the developed world still must be prepared for climate-related disease and damage. Diseases migrate across international boundaries, and climate change may accelerate this migration. In addition, much of the infrastructure in developed countries is not prepared to withstand the impacts of climate change, and must be improved to protect human health [1]. The remainder of this section will focus on climate related health risks to Utahns specifically, and will suggest potential interventions to increase the region's resiliency to these threats.

Heat

In the United States, the loss of human life during summer heat waves exceeds that caused by all other weather events combined [2]. Climate change will contribute to an increase in heat-related illness and deaths in the region, particularly among the elderly, infants, low-income communities, and outdoor workers. Almost all of the negative health outcomes of heat waves are preventable if the public is kept cool and hydrated.

Impacts of Heat on Human Health

- Extreme heat can lead to a range of illnesses including heat exhaustion, heat cramps, heat rash, heat syncope (fainting), and heat stroke [3].
- Heat stroke, which is defined by a body temperature above 104˚F is a serious condition that can cause disorientation, convulsions, loss of consciousness, and in some cases death.
- Extreme heat also worsens chronic conditions such as cardiovascular disease, respiratory disease, cerebrovascular disease, and diabetes, putting a strain on medical facilities handling increased admissions [4].
- There is an association between heat and violence and injury. A study of murder and temperature estimates an increase of 9 murders or assaults per 100,000 people for every 2˚ F increase in average temperature [5].

Potential Interventions to Mitigate or Adapt to Extreme Heat

- Minimize the effect of the urban heat island by planting trees, protecting parks, preserving open space around the city, and encouraging white roofs and sidewalks.
- Collect and analyze data from extreme heat events to better understand the temperatures and local impact on health, and to better prepare medical facilities to manage the increased burden.
- Improve warning systems and distribution of information to help the public, especially vulnerable populations.
- Improve communication between public health, medical facilities, the weather service, and the media.
- Establish public water stations and cooling centers during heat waves, and organize transportation to these cooling centers.
- Suspend utilities shut-offs during extreme heat events.
- Increase air conditioning capacity of nursing homes and adult care facilities.

Climate change is projected to impact the level of air pollutants including particulate matter (PM2.5), ozone formation, and allergens. PM2.5 are fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller [6]. Climate change may lead to a decrease in PM2.5 in winter months, as higher temperatures and decreased snow cover could weaken the strength of Salt Lake Valley's winter inversions. Still, an increase in P2.5 could result from the greater frequency and severity of summer wildfires in the Southwest. These wildfires may also cause an increase in volatile organic compounds (VOC) and NOx, which are ozone precursors. There is also an association between higher temperatures and ground level ozone , likely due to UV's effect on accelerating the reaction forming ozone. It is also possible that the receding of the Great Salt Lake may increase levels of particulates and release heavy metals previously sequestered in the playa into the air. The lake's history as a dumping ground has led many to suspect that a host of toxic metals, including lead and arsenic, will become airborne during wind events, and would be harmful if it blows into Utah's cities. Levels of allergens may increase due to the extended freeze-free season.

Impacts of Air Quality on Human Health

- PM2.5, ground-level ozone, and allergens exacerbate respiratory conditions including asthma, chronic obstructive pulmonary disorder (COPD), lung cancer, and acute respiratory illness, such as bronchitis [7].
- Air pollutants such as PM2.5 are considered a leading cause of cancer deaths by the World Health Organization.
- In addition to triggering respiratory conditions and causing symptoms such as chest pain, coughing, and throat irritation, air pollutants can exacerbate cardiopulmonary conditions, and in some cases lead to death [8].

Potential Interventions to Mitigate or Adapt to Air Pollution

- The most important step that can be taken to improve air quality is to reduce emissions of carbon dioxide, carbon monoxide, hydrocarbons, oxides of nitrogen and other products of combustion.
- There are many organizations and individuals that are making efforts to reduce emissions, taking initiatives that both improve air quality and mitigate climate change. Salt Lake City has set a good example by committing to have zero emissions from mobile sources by 2030 and zero emissions from all sources by 2040.
- Coordinate outdoor air quality and pollen count tracking systems.
- Develop an early-warning system for poor air-quality days that notifies asthmatics and other people who suffer from respiratory related illness.
- Develop strategies to address asthma rates

Water

With increasing temperatures, water, especially in the Southwest will become scarcer. Models suggest that the region is shifting from a snow to a rain hydrology, with less precipitation falling as snow. This shift, along with trends towards a more rapid and earlier snowmelt is causing less water to be stored as snow and then captured as runoff in the spring. Coupled with the projected increased population and cheap water prices, the availability of water will decrease even more. The combination of decreasing water bodies and increasing water temperatures is leading to more frequent and severe blooms of harmful cyanobacteria, known as "algal blooms" [9]. Warmer water temperatures will also increase the rate of reproduction of other species of bacteria, including cryptosporidium, giardia, and cholera, which are expected to be a greater issue as a result of climate change. Drought in the southwest will lower water levels, increasing the density of these pathogens and contaminants in the water supply. Heavy rain events and flooding will also occur more frequently, increasing the spread of contaminants [10]. This decrease of water availability and quality will cause a multitude of issues that will affect Salt Lake County residents.

Impacts of Water Scarcity and Quality on Human Health

- Many cyanobacteria can produce neurotoxic, hepatotoxic, dermatotoxic or other bioactive compounds that pose a threat if they occur in drinking water sources. The presence of high levels of cyanotoxins in drinking water can cause gastrointestinal complications, liver damage, neurological symptoms, and potentially but rarely, death.
- Waterborne pathogens such as cryptoporidium, giardia, and cholera can cause serious gastrointestinal complications.
- Water shortages can lead to food insecurity and malnutrition, and can lead to poor hygiene and improper washing of fruits and vegetables.
- Dehydration, especially during heat events, can have serious health effects.

Potential Interventions to Mitigate or Adapt to Water Issues

- Create strategies to decrease quantity of nutrients entering waterways to prevent harmful algal blooms.
- Due to the decrease in water supply, there will be a need for more monitoring to safeguard the valley's drinking water supply.
- Promote wastewater system emergency plans.
- Plan strategies to use less water, and to discourage wasteful water practices.

Pathogens

Climate change will have a significant impact on the prevalence and geographic range of pathogens and their vectors, leading to outbreaks of diseases that previously did not affect Utah. These pathogens could cause a wide range of illnesses and in severe cases, death. Climate change will impact the emergence of food-borne, water-borne, and vector-borne pathogens. Warmer temperatures will cause bacteria in food to grow more rapidly, and may lead to an increase in cases of salmonella and other bacteria-related food poisoning [12]. Flooding and heavy rainfall could cause overflows from sewage treatment plants into fresh water sources, contaminating crops. Power outages associated with extreme heat or storms may cause poor food storage. Flooding as well as drought can cause an emergency of pathogens in the water supply. Daily, seasonal, or year-to-year climate variability can result in vector/pathogen adaptation and shifts or expansions in the geographic ranges of insect, bird, and rodent vectors. Changes in landscapes is bringing wildlife in closer contact with humans, providing opportunities for diseases to emerge.

The Emergence of New Pathogens and Human Health

- Food-borne: Salmonella, E.Coli, and other bacteria
- Water-borne: Cryptosporidium, Giardia, and Cholera
- Rodent-borne: Hanta virus, Plague, Tularemia
- Arhropod-borne: Babesiosis, Chikungunya, Dengue Fever, Ehrlichiosis, Lyme Disease, Rocky Mountain Spotted Fever, West Nile Virus, Yellow Fever, Zika Virus
- Other wildlife: Ebola, Bird Flu, Cholera, new strains of Tuberculosis [13]
- Influenza season in North America is expected to be extended, and cases are expected to occur year-round.

Potential Interventions to Mitigate or Adapt to Pathogens

- Improve surveillance systems and preparation to detect new pathogens in our community, and prevent further spread of the diseases.
- Conduct finer-scale, long-term studies to help quantify: (1) the relationships among weather variables, vector range, and vector-borne pathogen occurrence, (2) the consequences of shifting distributions of vectors and pathogens, and (3) the impacts on human health.
- Enhance vector surveillance and human disease tracking.
- Identify populations and places vulnerable to pathogens and provide assistance and education.
- Collaborate on initiatives to eliminate stagnant water
- Work with zoning authorities to require new developments in at risk areas to design features that decrease vector habitats.

Infrastructure

Infrastructure in Salt Lake County was designed to withstand a hundred-year flood, but using historical data to predict averages and extremes is no longer applicable. The mechanical and physical infrastructure must be improved to withstand extreme weather events. Public health infrastructure must be developed and expanded to prepare staff for the health impacts of climate change.

Poor Infrastructure and Human Health

- Extreme weather could cause breakdowns in water, electrical, and sewer infrastructure.
- Heat, drought, and extreme weather could lead to more frequent urban fires.
- There is a risk of carbon monoxide poisoning related to power outages as a result of climate change induced disasters.
- Disruptions in services such as cell phone communication, transportation, and waste management are expected to increase.
- Loss of income for businesses during natural disasters can be a cause of stress and can cause food insecurity [15].

Preparing Infrastructure for Climate Change

- Conduct Health Impact Assessments on major developments and public investments.
- Incorporate emergency evacuation routes into active transportation designs.
- Education and job training programs for vulnerable communities to take advantage of adaptation and green economy growth.
- Prepare for post-event assessments of affected households to evaluate needs.
- Identify health hazards (toxic sites, etc) and prioritize improvements to mitigate exposures during hazard emergencies.
- Increase employer and worker training.
- Increase the number of community members involved in all hazards planning.
- Integrate climate change considerations with hazard vulnerability assessments and public health preparedness planning.

Although it's impact is not as direct, climate change is projected to greatly increase the burden of a wide range of chronic diseases. Nutrition and food safety can be affected because climate change can lower crop yields, reduce the nutritional quality of food, interrupt distribution chains, and reduce access to food because families lose income. Some crops, including rice, wheat, and potatoes, grown in higher levels of CO2 concentrations have lower concentrations of essential minerals and protein. Increased temperatures and decreased air quality may decrease opportunities of outdoor activity. Many interventions which help to decrease the burden of chronic disease have the co-benefit of also reducing greenhouse gas emissions and improving air quality.

Chronic Disease and Climate Change

- Mental health issues, including trauma, shock, post-traumatic stress disorder (PTSD), compounded stress, anxiety, substance abuse, and depression are all major acute mental health impacts that could result from extreme weather, pollution, and limited food and water resources [16].
- Profound changes in a person's home, as well as the feeling of lack of control over one's life can have major mental health impacts, including higher rates of aggression and violence, and a sense of helplessness and hopelessness.
- Scientific research shows that children and developing fetuses are at particular risk from air pollution, heat, malnutrition, infectious diseases, allergies, and mental illnesses, which have detrimental impacts on development [17].
- Heat and air pollution can trigger respiratory and cardiovascular disease, leading to strokes, heart attacks, asthma attacks, and increased hospital admissions.
- Climate change can increase exposure pathways for chemicals and toxins leading to cancer. Increased duration and intensity of ultraviolet (UV) radiation increases cancer risk.

Climate Change and Disease Interventions

- Support active transportation.
- Promote a plant-based diet.
- Building and growing community gardens.
- Strengthening educational campaigns on chronic disease prevention and management.
- Expanding the capacity of emergency rooms and access to health care, especially during extreme heat events and bad air days.

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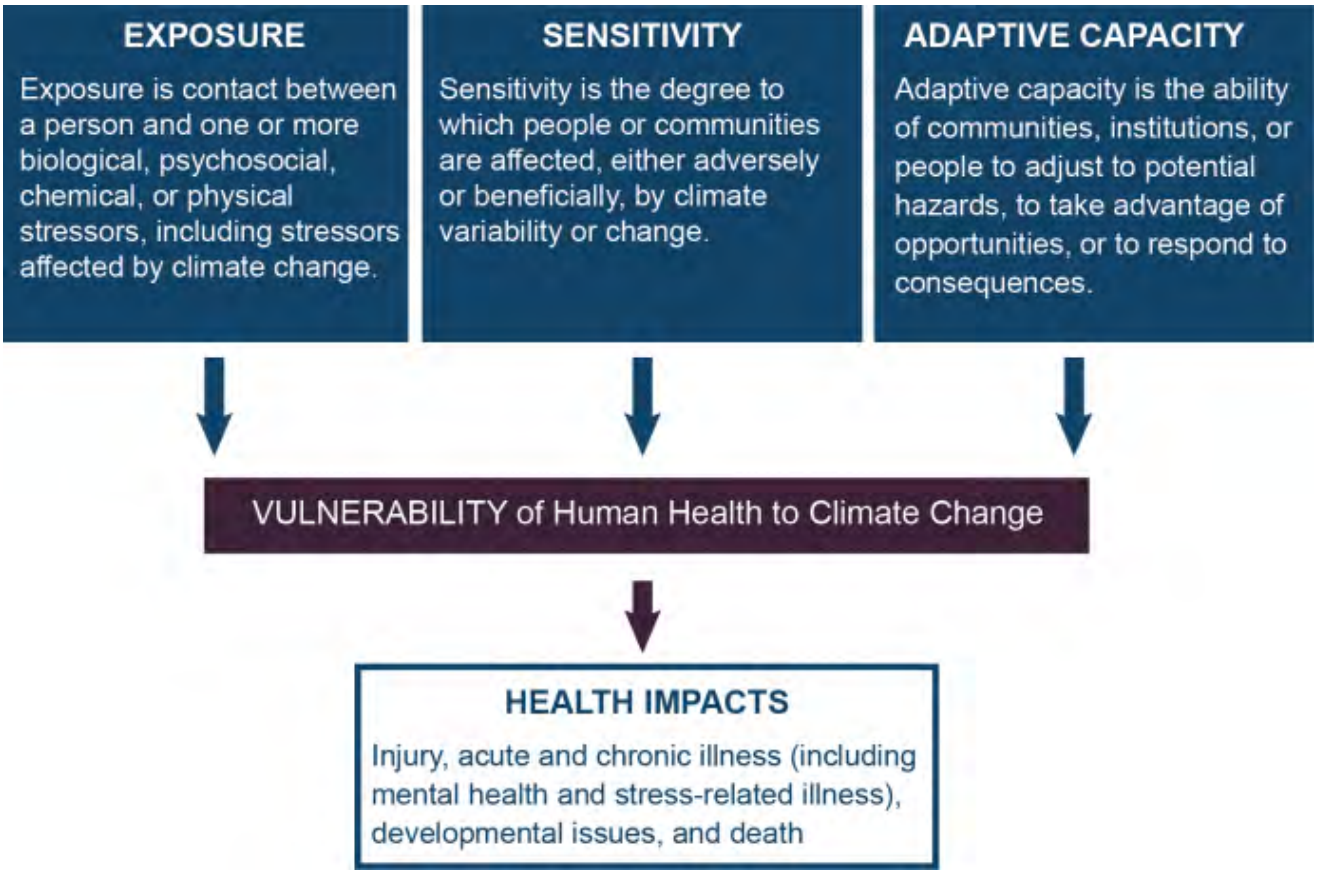
Vulnerable Populations

"Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities are generally greatest in countries at all levels of development."

- Intergovernmental Panel on Climate Change

VULNERABLE POPULATIONS

Climate change is having a disproportionate impact on the health of certain populations both locally and internationally. The vulnerability of any given group is a function of its sensitivity to climate change related health risks, its exposure to those risks, and its capacity for responding to or coping with the risks. Vulnerable populations include low income communities, some communities of color, immigrant groups (including those with limited English proficiency), Indigenous peoples, children and pregnant women, older adults, vulnerable occupational groups (such as outdoor workers), persons with disabilities, and persons with preexisting or chronic medical conditions.

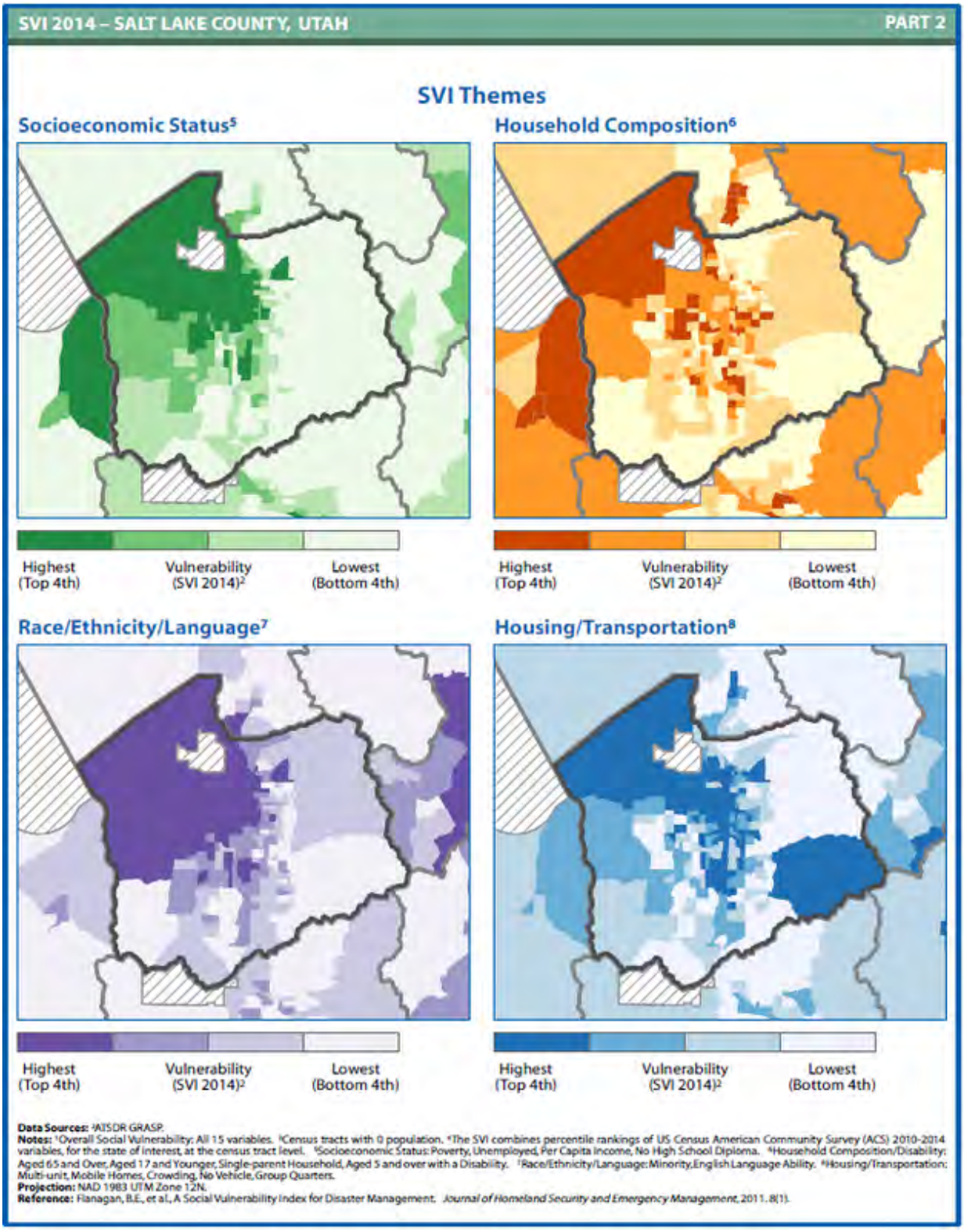


Defining the determinants of vulnerability to health impacts associated with climate change, including exposure, sensitivity, and adaptive capacity. (Figure source: National Climate Assessment)

A person's exposure to climate-related health risks is determined by their occupation, time spent in risk-prone locations, access to emergency assistance, socioeconomic status, infrastructure condition, mobility, and mental health or behavioral factors. Biological sensitivity can be determined by age and health status. Socioeconomic status is also associated with biological sensitivity, as social and economic factors cause disparities in the prevalence of chronic disease and health status. Adaptive capacity is also determined by socioeconomic status, access to infrastructure, access to health care, and health status, as well as by the skills, knowlege, and social cohesion a community has. Adaptive capacity is also determined by how institutions in the community have prepared for climate change.

Social Vulnerability in Utah

The Social Vulnerability Index (SVI) is a tool developed by CDC to aggregate US census data to estimate the social vulnerability by location. Social vulnerability is defined as a community's capacity to prepare for and respond to the stress of hazards or events ranging from natural disasters or disease outbreaks to human-caused threats such as toxic chemical spills [2]. Maps displaying socioeconomic status, household composition, race or ethnicity, native language, age, and infrastructure conditions have been created for each census tract. Currently a similar tool is being developed to assess a region's vulnerability to climate-sensitive health outcomes. This new tool will incorporate geographical vulnerabilities (such as proximity to flood zones, highways, or densely paved areas) [3].



As climate change increases the probability of more frequent or more severe extreme weather events, vulnerability mapping is an important tool for preparing for and responding to health threats. Vulnerability mapping is an important tool in allowing public health departments to target vulnerable communities for emergency preparedness, response, recovery, and mitigation. Visualizing vulnerable areas on a map allows public health responders to position emergency medical and social response resources where the need is greatest [1].

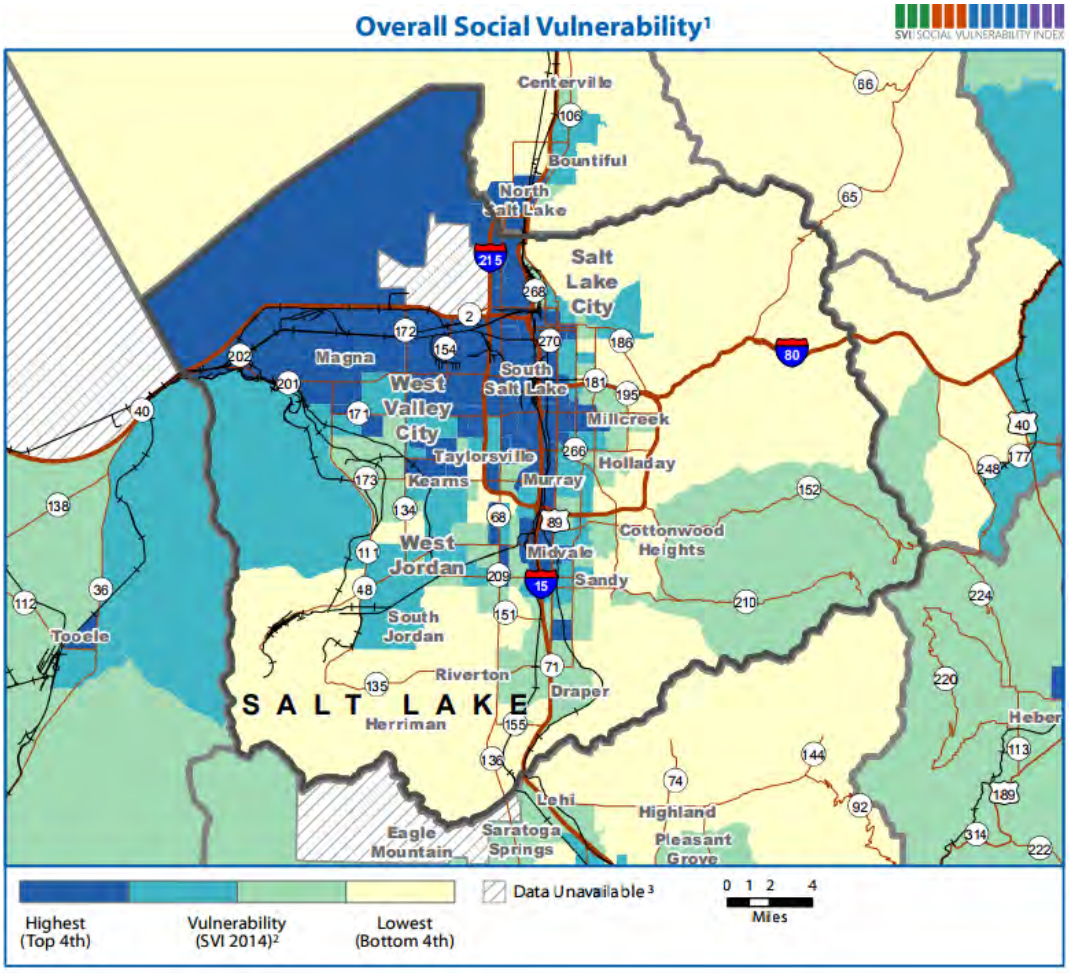
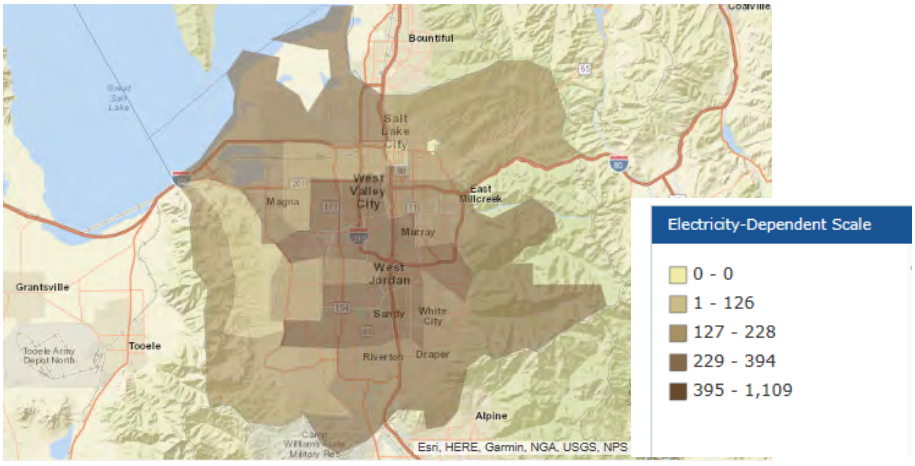


Figure depicts regions of Salt Lake County with highest overall social vulnerability in blue, and lowest in yellow. Retrieved from ASTDR page.



The Office of the Assistant Secretary for Preparedness and Response (ASPR) developed an interactive map that breaks down counties by the number of Medicaid recipients as well as the number of electric assistive device claims in a given area [4].

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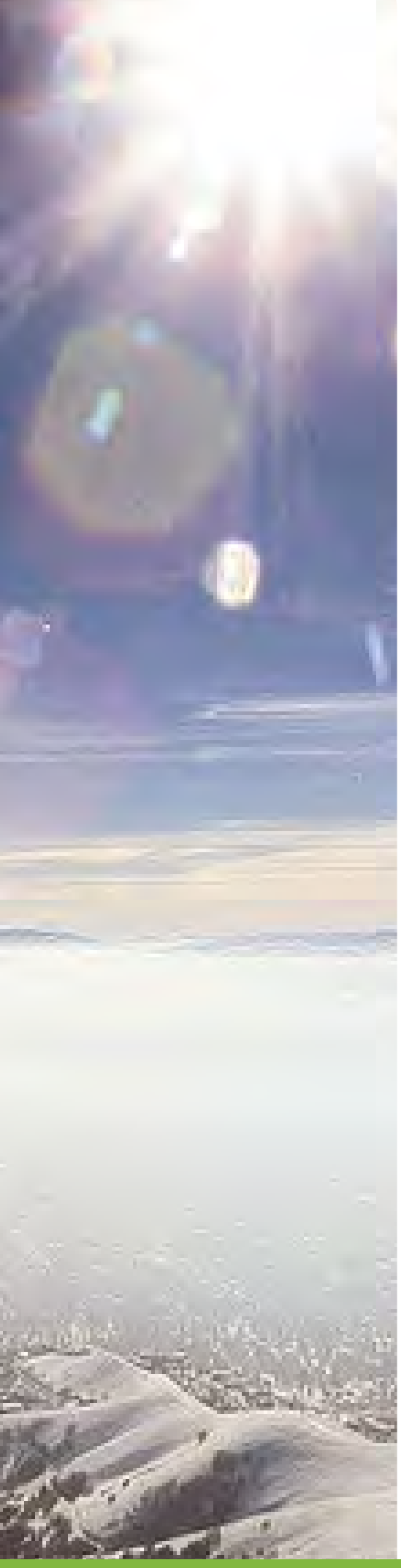


Next Steps

"The relationship between climate change and global health is unmistakable. This is a critical time for public health advocates to demand that political leaders safeguard the health of the world's population, with particular attention to the survival needs of the most disadvantaged."

- The International Response to Climate Change, An Agenda for Global Health

Working Within the BRACE Framework

Anticipating Climate Impacts and Assessing Vulnerabilities

Identify the probabilities of specific events that will take place in our region due to the effects of the changing climate.

Identify what specific vulnerabilities need to be addressed to meet the need of the population to mitigate the adverse effects predicted to occur

Projecting the Disease Burden

Working with weather, climate variability, and climate change data sources to identify climate sensitive health outcomes

Identifying vulnerable populations

Assessing Public Health Interventions

Identifying specific plans and actions to implement when conditions present themselves

Developing and Implementing a Climate and Health Adaptation Plan

Change Adaptation Planning includes various elements that this adaptation plan document provides a foundation for examining by participant organizations, including:

- Community profile which includes background information
- Most appropriate" regional/municipal climate change scenario
- Scoped local climate change impacts
- Prioritized consequences/prospects of risks and opportunities
- Maps showing priorities
- Adaptation planning principles
- Table of recommended adaptation policies and actions indicating priority, lead responsibility and fit with existing program (if applicable)
- Action plan for tasks to be accomplished in the community
- Community engagement process
- List of key stakeholders
- Inventory of risks and opportunities
- Inventory of consequences and prospects
- Gap analysis of programs useful for adaptation actions

Evaluating Impact and Improving Quality of Activities

While each agency will have different evaluation resources, the agency should be able to answer some basic questions after its evaluation activities:

- Does the public health agency have a reasonable estimate of the health impacts of climate change in its jurisdiction?
- Has the process allowed the public health agency to prioritize health impacts of greatest concern and the most suitable interventions?
- Has the public health agency prepared an adaptation plan for the public health sector within the jurisdiction?
- Are climate change considerations accommodated in public health planning and implementation activities?
- Are public health considerations accommodated in climate change planning and implementation activities?
- Are indicators in place that will evaluate the interventions implemented?

CURRENT COLLABORATIONS

HeatRisk Initiative

An initiative to warn of heat stress events and notification of how to take action when they occur has been launched by the National Weather Service in collaboration with the Salt Lake County Surveyor and the Salt Lake County Health Department. The National Weather Service has launched a heat risk assessment chart pilot project in four states for the next year. The Salt Lake County Health Department is providing health-related information for heat events to this package. The Salt Lake County Surveyor's Office has developed an online mapping application for residents of the county to identify cooling centers available to the public.

Heat is responsible for more deaths in the United States annually than any other weather phenomenon. Given this situation, and the prediction of more heat events on average in the future, people need to be aware of the dangers associated with extreme heat and to be prepared to take steps to protect themselves and to promote community safety and health during heat events.

Individuals can take specific actions that will help to mitigate the effects of heat and lower the risk of heat stress or even heat stroke. The first thing to remember is to drink plenty of water, even if you do not feel thirsty. In a very dry climate such as Utah's, individuals may not always recognize that they are becoming dehydrated. When very high temperatures occur, individuals should take care to never leave children or pets alone in closed vehicles, even for a few minutes. They may want to stay indoors, in cooler conditions, as much as possible and limit exposure to the sun. They should also check on family, friends, and neighbors who do not have air conditioning and who spend much of their time alone to assure that they are keeping safe. If people lack access to a cool environment, or lose power during periods of extreme heat, they should go to a cooling center or shelter. The Salt Lake County Surveyor's online mapping for cooling centers is found at https://slco.org/surveyor/cf/cool-zones/map.html.

Specific Actions Recommended to Individuals:
- Check on pets frequently to ensure that they are not suffering from the heat.
- Dress in loose-fitting, lightweight, and light-colored clothes that cover as much skin as possible. Also, avoid dark colors because they absorb more of the sun's energy.
- Protect your face and head by wearing sunblock and a wide-brimmed hat.
- Active individuals should postpone outdoor games and activities until cooler periods of the day.
- For those who work outside, avoid strenuous work during the warmest part of the day. Outdoor workers should use a buddy system to monitor coworkers when working in extreme heat, and take frequent breaks.

Up to date is available by checking weather reports for heat-related information from the National Weather Service. The National Weather Service HeatRisk information is available at http://www.wrh.noaa.gov/wrh/heatrisk/?fo=slc.

Utah Climate Action Network

The Utah Climate Action Network is a nonprofit organization with the mission of fostering diverse conversation, leadership on climate issues, and coordinating action to ensure a collaborative response to climate change and its impacts on the people, economies, and prosperity of Utah. The conveners of the group include Salt Lake City Sustainability division, Salt Lake County Health Department, University of Utah, Park City, Alta Ski Resorts, Utah clean Energy, & Brendle Group.

The Network was established to support the creation of new relationships and connections between governments, research institutions, non-profits/foundations, faith-based organizations, and the organizations in the private sector. The purpose is for exploration of climate change issues and solutions through inclusive dialogue, identification of climate-related actions of regional significance, including individual actions and opportunities to collaborate, and advancement of regional climate action and long-term resiliency.

The initial focus of the Network is to drive action and impacts in land, water, economy, health, transportation, and energy. These will be incorporated in approaches for the following:

- **Public Engagement –** Developing and delivering a clear and consistent climate message that informs Utah citizens of science-based climate realities, and compels them to engage in individual or group climate solutions.

- **Leadership and Policies –** Building support for local leaders and decision-makers, both in the public and private sector, to recognize climate risks and take actions to reduce impacts and enhance adaptability.

- **Enhanced System-Level Response –** Supporting the inclusion of carbon mitigation and climate adaptation priorities in existing organizational, partner, and regional efforts. Incorporate sector-based best practices and opportunities to reduce emissions and prepare for climate impacts.

The work of the network is taking place through four sub-groups that are focused on action steps to address climate issues.

- Public Health
- Greenhouse Gases
- Electric Vehicles
- Water

Wasatch Clean Air Network

The Wasatch Clean Air Network is a developing nonprofit organization created to foster discussion and collaboration between organizations in the region that have air quality issues as part of their missions and objectives.

A combination of factors, including a unique geographical setting, combined with weather patterns, and emissions, gives rise to extended periods when the Wasatch Front experiences some of the nation's poorest quality air. We must all recognize that, as there is no single cause, neither is there a single solution. All those who care about the future of Utah must recognize and embrace the complexity of the air quality problem. In one or more ways, we are all part of the problem and, therefore, we must all be part of the solution.

In recent years, several bipartisan, diverse groups of government, business, and individual stakeholders have met to propose recommendations to improve our air quality. Those bodies have articulated a variety of steps that can help address the problem. Various stakeholders have worked since then to implement these recommendations, focusing on modifying individual behavior and on pushing regulatory and legislative actions.

The vision of the network is to have healthy, clean air along the Wasatch Front throughout the year, but starting with healthy, clean air in the Salt Lake Valley. To achieve these goals, the network will work to create and maintain an online repository for current Utah Air Quality information, including

- A "toolkit" of successful initiatives that entities such as local governments and area businesses have achieved, to serve as a model and template for others seeking to implement similar programs;
- A compilation of relevant studies and reports about northern Utah air quality; an
- Information about critical government documents, such as State Implementation Plans and relevant regulation.
- Organize and convene Working Group formation and meetings
- Identify strategic opportunities for coordinated action to advance air quality solutions

Utah Clean Cities Coalition

The Utah Clean Cities Coalition is a long-standing nonprofit organization working to advance Utah's energy, economic, and environmental security by supporting local actions to cut petroleum use in the transportation sector with alternative fuels & alternative fuel vehicle technologies in order to improve air quality.

Clean Cities helps vehicle fleets and consumers reduce their petroleum use by building partnerships with local and statewide organizations in the public and private sectors to adopt:

- Alternative and renewable fuels
- Idle-reduction measures
- Fuel economy improvement
- New transportation technologies, as they emerge

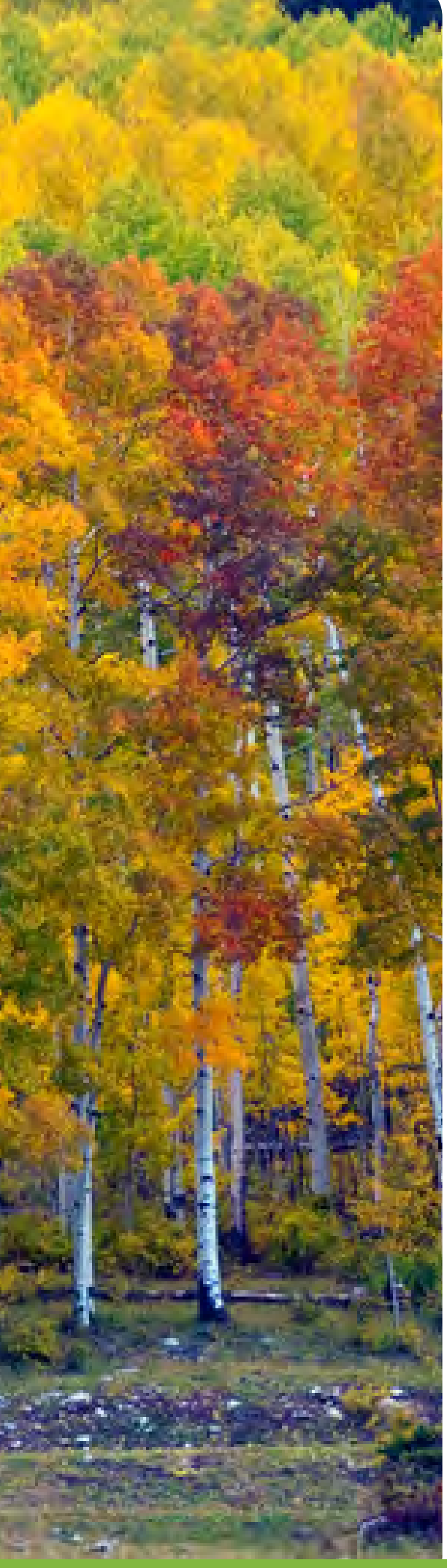
Clean Cities works to reduce U.S. reliance on petroleum in transportation by:

- Establishing local coalitions of public-sector and private-sector stakeholders committed to reducing petroleum use.
- Identifying funding and financial opportunities to support Clean Cities projects.
- Developing information resources that educate transportation decision makers about the benefits of using alternative fuels, advanced vehicles, and other measures that reduce petroleum consumption.
- Reaching out to managers of large fleets that operate in multiple states.
- Providing technical assistance to managers of fleets deploying alternative fuels, advanced vehicles, and idle reduction.
- Analyzing data from industry partners and fleets to develop tools and information for the Alternative Fuels Data Center that help stakeholders reduce petroleum consumption.
- Working with industry partners and fleets to identify and address technology barriers to reducing petroleum use.

Through the promotion of alternative fuels, alternative fuel vehicles, and fuel economy strategies, the Utah Clean Cities Coalition has worked to ease concerns about fluctuating gas prices and rising public and environmental health issues. Working closely with the federal and state government, as well as its stakeholders, The Utah Clean Cities Coalition leverages its resources to bring funding into Utah to support the development and deployment of alternative fuel infrastructure and vehicles.

The Utah Clean Cities Coalition also works with local partners, such as the Salt Lake County Health Department, the Utah Department of Health, and also the general public to promote smart transportation and fuel economy practices through the Idle Free Utah and the Clear the Air Challenge initiatives. Since their implementation, these campaigns have demonstrated significant behavioral change impacts including the adoption of Idle Free Resolutions and Ordinances in several cities across the state.

As a non-profit organization, the Utah Clean Cities Coalition utilizes its unique position in the community to provide a forum for local businesses, government and the public to influence the use of resources, create joint projects and collaborate on public policy for reduced petroleum use in Utah's transportation sector.



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