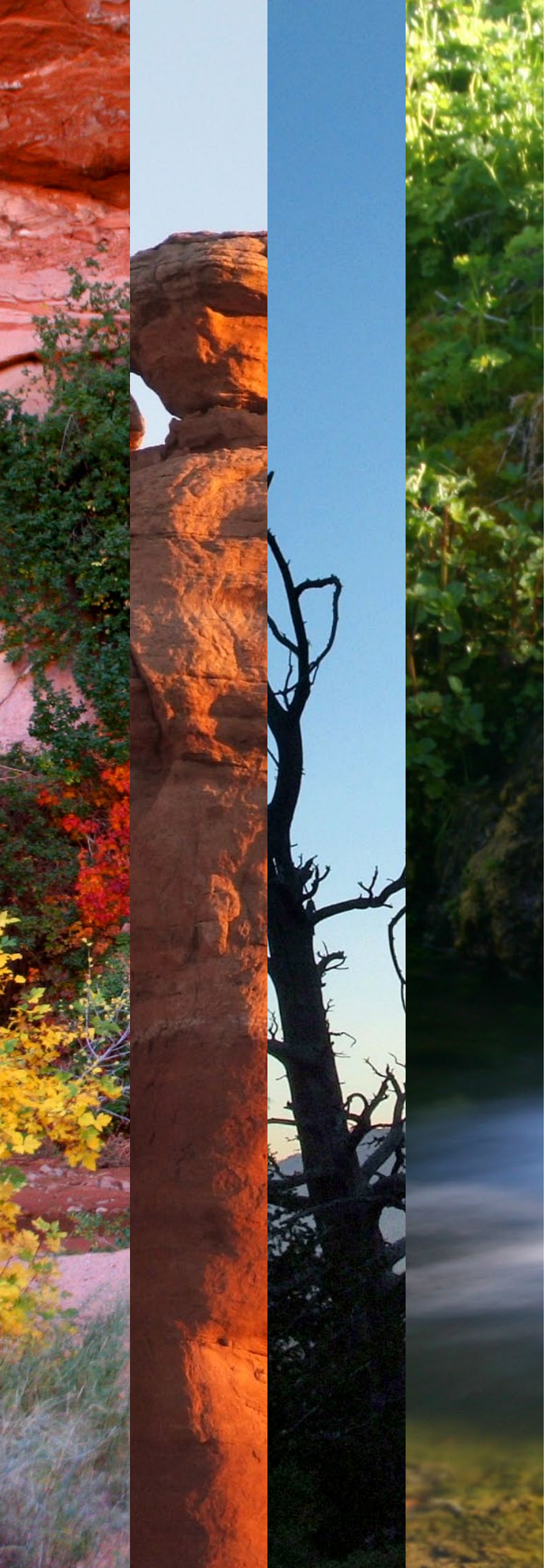

CLIMATE CHANGE and PUBLIC HEALTH in UTAH

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This report, Climate Change and Public Health in Utah, provides an accessible overview and description of the influence of environmental factors on climate change and health in Utah. Within its pages you will not only find a snapshot of climate change and environmental health, but also information we have provided about what you can personally do to protect health and reduce the risks of climate change.

We have created the sections of this report in a similar format to the indicator reports published on Utah's Indicator-Based Information System for Public Health (IBIS-PH). We hope that as you read this report, you will feel comfortable turning to IBIS-PH for additional information. I am confident that we at the Utah Department of Health will be able to answer any questions whose answers are not found on IBIS-PH.

This report was made possible by the efforts of several Utah agencies. A special thanks to the Environmental Epidemiology Program within the Division of Disease Control and Prevention for putting together this report. In addition, I would like to acknowledge the collaborative efforts of all those agencies within Utah who share data, maintain public information sources, and promote public and environmental health.

The environmental health of Utah can only be protected through the cooperative efforts of both the public and private sectors. This report marks just one step in evaluating how we are doing and measuring our progress. I urge you to read this report and use its contents to help promote a healthier environment for our state.

Robert T. Rolfs, MD, MPH
Division Director

VISION, GUIDANCE AND LEADERSHIP

The authors wish to thank Greg Williams, Manager, Utah Environmental Public Health Tracking Program, and Sam LeFevre, Manager, Environmental Epidemiology Program, for their vision, guidance, leadership and support for this work.

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FOREWORD

The Earth has experienced the slow processes of climate change for as long as the Earth has existed. There are many natural cycles, both cosmic and terrestrial, that influence the climate on the Earth. In recent years, concerns about the influence of human activities on climate change have increased in society. Regardless of the political and societal debates, changes in the climate have the potential to adversely affect the public's health.

Within the last 50 years, public health professionals have been successful in reducing and preventing various public health problems. With those successes, the role of public health has broadened from its initial focus on municipal sanitation and infectious disease control to providing public health guidance for urban design and the built environment, improving quality of life, health care cost reduction and a variety of other important issues. With this broader perspective, environmental factors other than sanitation management are increasingly important to the goals of public health.

Environmental health contributes to public expectations in four major needs: safe air, safe water, safe food and safe places (e.g., homes, work places, recreational places, etc.). Climate impacts each of these needs in an immediate way. The public is concerned about how local climates are impacting their need for clean air and water, safe food and safe places. The public is asking public health professionals to address these concerns through surveillance, assessment and policy implementation. The Utah Environmental Public Health Tracking Network helps by providing data to support these three functions. The Utah Environmental Public Health Tracking Network provides a way to fill the gaps between what we know about climate change and its impact on health by collecting and providing this data.

This booklet was compiled to provide a better understanding of how climate change can affect the health of Utah's citizens. The booklet presents climate-related public health indicators pertaining to disease outcomes, environmental pollution and weather to show trends that may be useful to support public discussion of the effects climate has on public health and policy. Indicators were selected based on existing literature and projections of the effects that climate change can have on health. The Utah Environmental Public Health Tracking Network will maintain and update these indicators and add more indicators in the future. The public and policy makers are invited to check our progress and more environmental health information and data at: http://ibis.health.utah.gov/.

It is the hope of the Environmental Epidemiology Program that this booklet will provide valuable information to policy makers, public health professionals, environmental professionals, local health care providers, educators and the general public. We hope that you will find this booklet engaging and thought provoking, and that we have contributed to the public discussion.

Authors: Melanie Spencer, Emily S.B. Stembridge, Lynn U. Phillips

ACKNOWLEDGEMENTS

The Utah Environmental Public Health Tracking Program would like to thank all the people who were so helpful in the creation of this book. Countless individuals within these agencies generously provided their time and expertise to ensure that this booklet contained the most accurate and pertinent information.

We are particularly grateful to the contributions of the following organizations:

Utah State University
- Utah Climate Center

University of Utah

National Oceanic and Atmospheric Administration

Eastern Great Basin Coordination Center

Salt Lake City Mosquito Abatement District

Utah Department of Environmental Quality
- Division of Air Quality

Utah Department of Health
- Asthma Program
- Bureau of Epidemiology
- Office of Health Care Statistics

United States Geological Survey
- Utah Geological Survey

U.S. Environmental Protection Agency

Centers for Disease Control and Prevention

Utah Department of Natural Resources

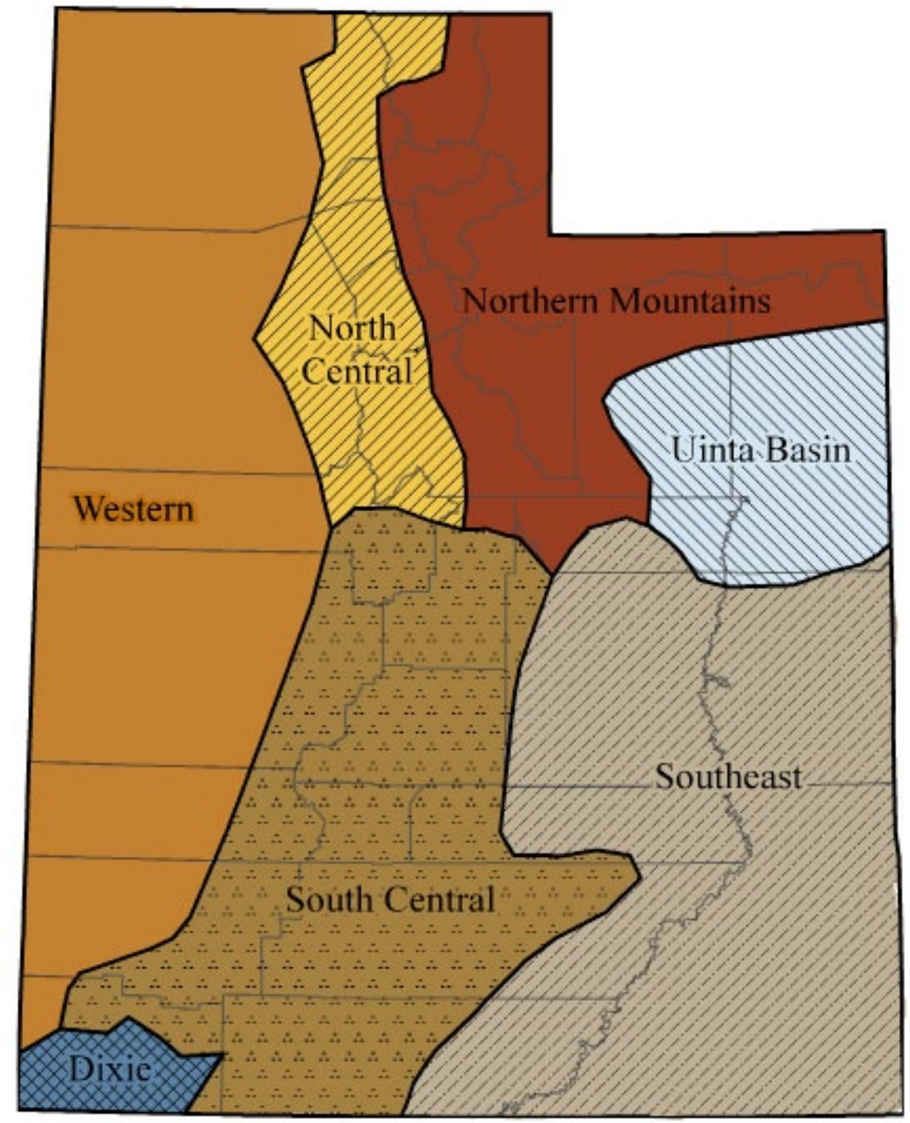
U.S. Global Research Program

METEOROLOGICAL INDICATORS

Meteorological indicators may be one of the most valuable methods of evaluating whether a climate is changing. Following trends for meteorological indicators allows the scientific community to determine if temperatures are increasing, precipitation events are being altered and if extreme weather events are occurring with increased frequency. Changes in temperature, precipitation and extreme weather events have the ability to negatively affect the health of populations throughout Utah. Utah's geographic diversity may allow for certain Utah communities to be disproportionately affected over others. This is why extensive study of meteorological indicators is necessary to establish which populations within Utah will be the most vulnerable to adverse health outcomes due to climate change. The following sections discuss in detail how climate change is affecting each indicator and why these indicators are important markers for health in Utah.

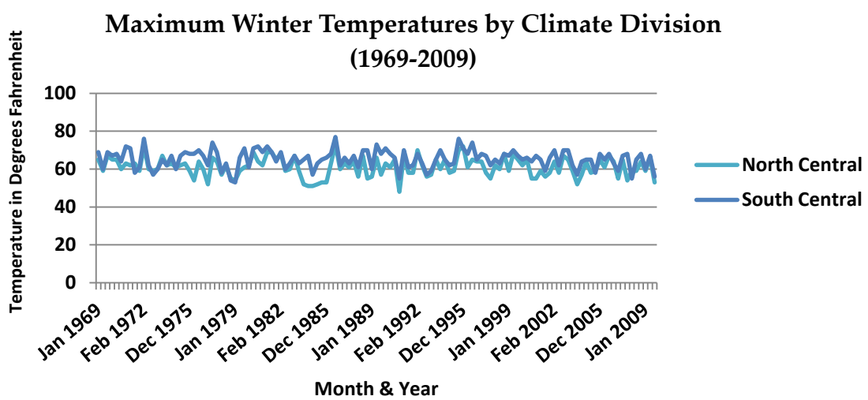
UTAH'S CLIMATE DIVISIONS

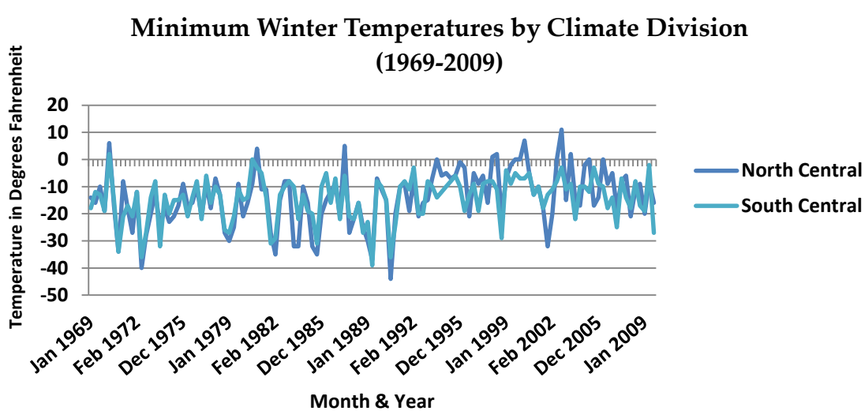
Due to its geographic and climatic diversity, Utah is divided into seven different climate divisions. Each division has a unique climate, which may suggest that different divisions throughout Utah will have diverse reactions to climate change. It is important to understand the climatic complexities of each division to determine how climate change will affect the health of various Utah communities. The meteorological section of this booklet displays temperature, precipitation and drought trends within each climate division that highlight the similarities and differences the seven climate divisions have regarding these indicators. Utah's climate divisions are displayed on the adjacent map.



TEMPERATURE

Temperature measurements over time have been the primary method of assessing the occurrence of climate change, with higher temperatures indicating warmth and lower temperatures indicating coolness. Over the past century, global surface temperatures have increased, yet the warming is not consistent across the globe. Areas such as the southeast United States have actually seen cooler temperatures. Yet, when looking at the eight hottest years on record, seven of those years have occurred since 2001 (NOAA, 2008). When looking at temperature change in the atmosphere, the troposphere (the level of atmosphere five to eight miles from the earth's surface) has shown an increase in temperature since the 1970s. Yet the stratosphere (the level of atmosphere 9 to 14 miles from the earth's surface) has cooled over this period of time (EPA, 2011). Utah's geography is incredibly diverse; therefore temperatures by region will be different. Utah is divided into seven different regions, all of which have various climates. From the deserts of the southeast region to the majestic Wasatch Mountain range in the northern region, each region within Utah has distinct characteristics.





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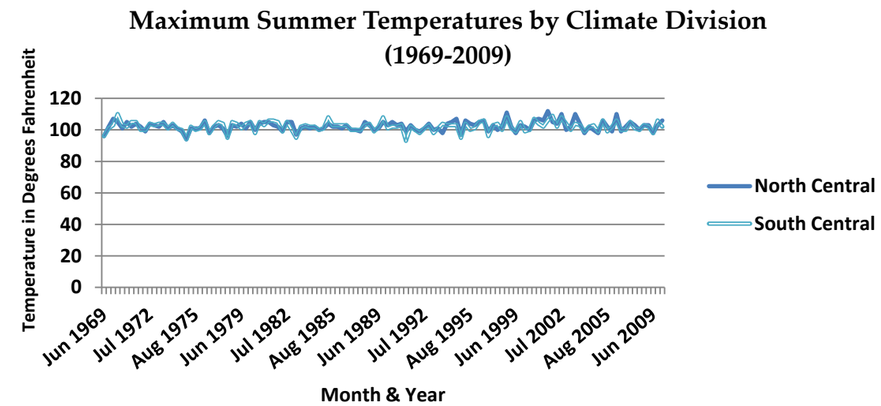

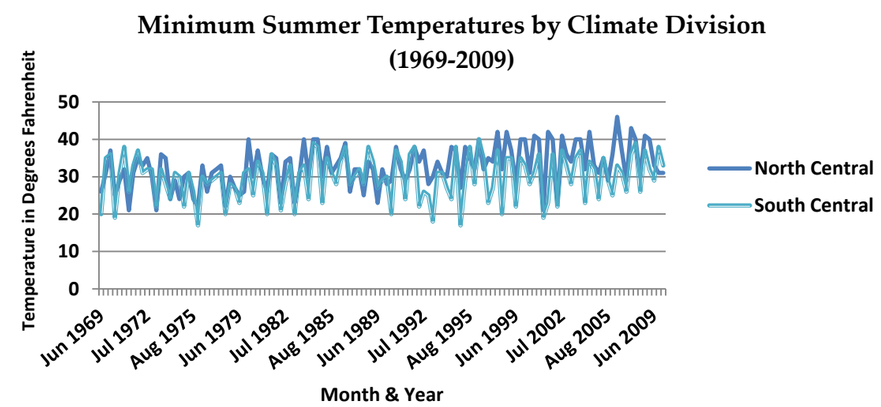

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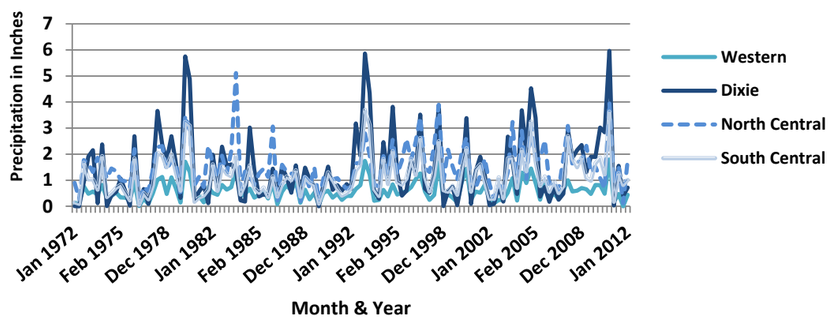
Climate experts have also studied whether temperature extremes are affected by climate change. The National Oceanic and Atmospheric Administration (2008) stated that differences between maximum temperatures and minimum temperatures, known as the diurnal temperature range, have been diminishing for most of the planet since the mid-20th century. Minimum temperatures have increased quicker than maximum temperatures, resulting in less extreme cold days and nights and a higher occurrence of extreme warm days and nights (NOAA, 2008).

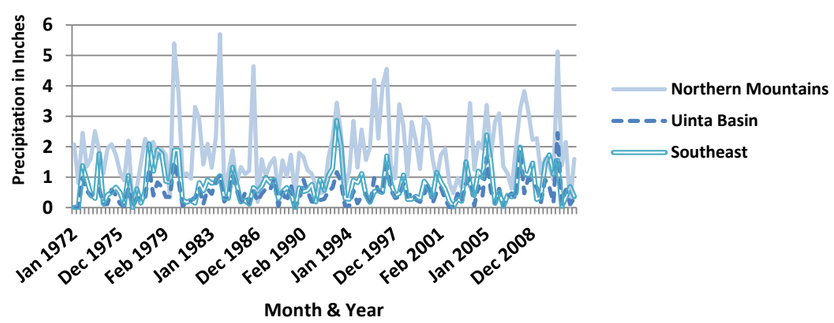
PRECIPITATION

Although it is more difficult to measure than temperature, precipitation patterns seem to be affected by climate change as well. The greatest effect is on the hydrological cycle rather than precipitation levels alone. As temperature continues to increase, there will be more evaporation and consequently a greater amount of water vapor in the atmosphere. This increase in water vapor will produce higher intensity precipitation events even if total precipitation levels in a specific area are decreasing (Trenberth, 2010). Intense precipitation events and the frequency at which they occur could also alter maximum and minimum levels of precipitation that are usually observed. Globally, regions such as South America, northern Australia and high latitudes within the Northern Hemisphere have experienced increased annual precipitation (NOAA, 2008). Consequently, southern Asia and tropical regions in Africa have seen decreased annual precipitation (NOAA, 2008). The graphs below display Utah's average precipitation trends by climate division.

Average Winter Precipitation Trend by Utah Climate Division (1972-2012)



Average Winter Precipitation Trend by Utah Climate Division (1972-2012)



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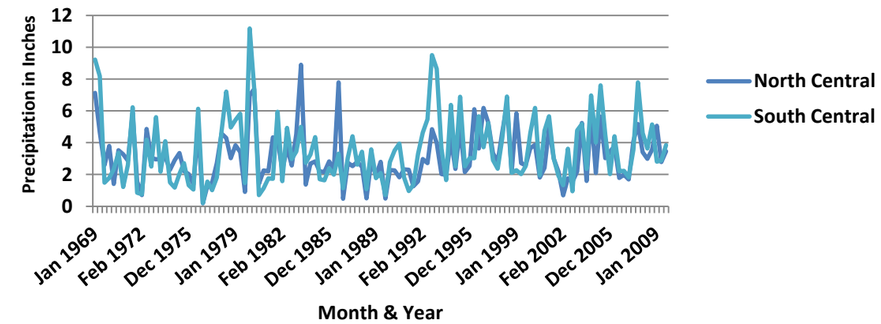
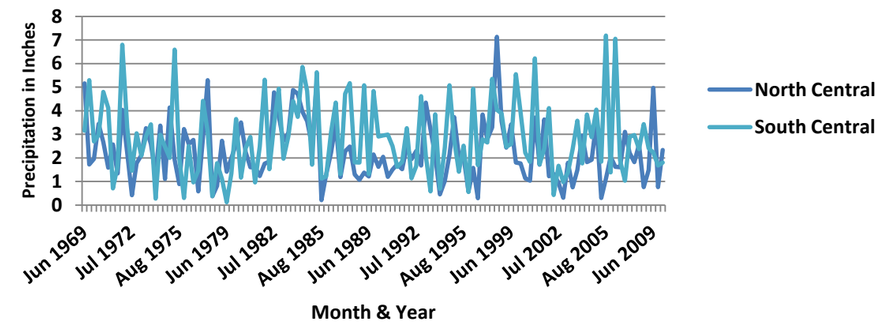
Maximum Winter Precipitation by Climate Division (1969-2009)



Maximum Summer Precipitation by Climate Division (1969-2009)



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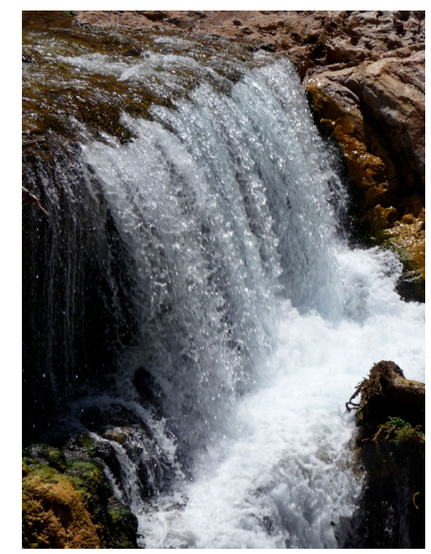
When discussing precipitation events, it is important to mention El Niño and La Niña cycles. El Niño occurs when trade winds weaken, allowing for warm water to pool in certain areas of the Pacific Ocean. The oscillation cycle that occurs between the warm water and the atmosphere during an El Niño causes increased precipitation events in the southern United States and South America. Consequently, higher frequencies of droughts are seen in Australia during an El Niño. La Niña has the opposite effect of an El Niño. During a La Niña cycle, ocean temperatures are colder near the equator in the Pacific Ocean due to strong trade winds. A La Niña cycle will usually create heavy precipitation events in areas like Australia and drought conditions in South America. It is important to note that El Niño and La Niña are not caused by climate change. These weather episodes have been present for thousands of years, yet the frequency at which El Niño and La Niña occur may be affected by climate change. Climate experts have observed over a 130 year period that El Niño cycles have been occurring more frequently than their cooler counterpart, La Niña (NOAA, 2008). Yet, more research is needed to discover if El Niño frequency is related to climate change.



EXTREME WEATHER EVENTS

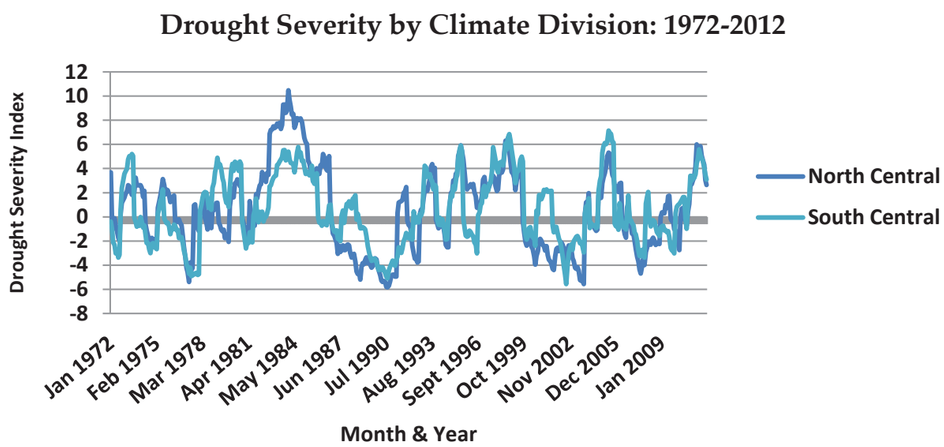
Climate experts project that as the climate continues to change, so will the frequency of extreme weather events. Such events have the potential to adversely affect human health and are therefore a public health concern. Droughts, floods and wildfires have been present in Utah, but the question is whether climate change will influence the frequency of these extreme weather events. The following delves further into the relationship between climate change and the frequency of droughts, floods and wildfires within the state of Utah and why these events are important to public health.

DROUGHTS

Why Droughts are Important to Public Health

Droughts are climate events in which normal levels of precipitation are not achieved over a defined period of time, resulting in a shortage of the water supply (King, 2008). The balance between precipitation and evaporation are integral in determining the occurrence and severity of a drought. Climate experts project that as climate changes, precipitation may decrease while evaporation will increase due to warmer temperatures, creating a higher frequency of drought occurrences (EPA, 2011). This is a concern to public health because droughts can create a shortage of clean water used for consumption. Furthermore, a decline in the water supply could put a strain on agriculture and the ability to grow and supply food to Utah's citizens.

If a drought is severe enough, it has the potential to adversely affect daily standards of living. Energy production, sanitation and even air quality are all affected by the availability of water (CDC, 2010). In general, Utah is already considered to be the second driest state in the nation, receiving approximately an average of 13 inches of precipitation a year (King, 2008). Like temperature, precipitation and drought severity can vary depending on what region of Utah is being affected. The following graph displays the drought severity for the most populated climate divisions, quantified by the Palmer Drought Severity Index. Drought trends seem to follow the same seasonal pattern, but variance from wet to dry spells are different depending on the climate region.



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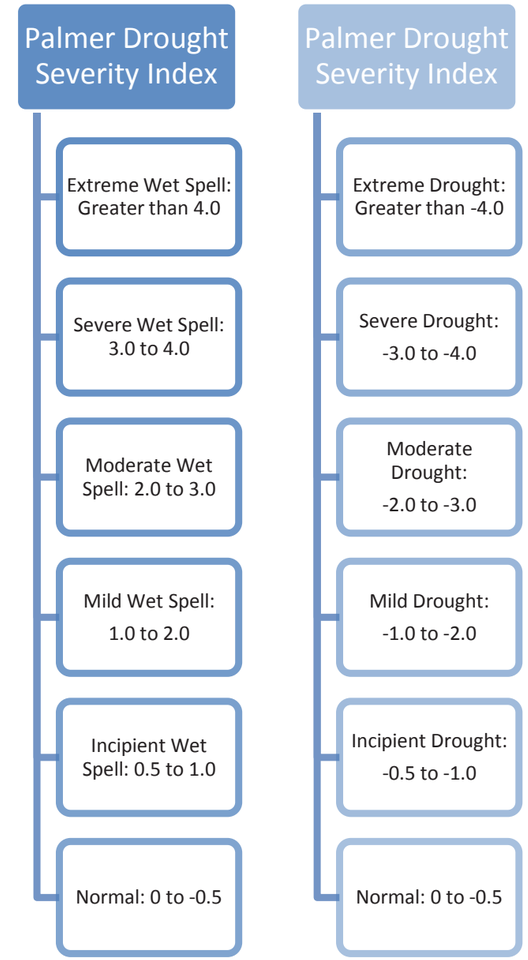


PUBLIC HEALTH'S ROLE

The Centers for Disease Control and Prevention (CDC) National Center for Environmental Health (NCEH) created a manual for public health professionals on how to protect the health of their citizens during a drought. With the assistance of the Environmental Protection Agency (EPA), NOAA and the American Water Works Association, the manual, "When Every Drop Counts," discusses how public health professionals should prepare for a drought, protect the public's health during a drought and how to evaluate drought response activities. The 54 page booklet is an excellent resource for public health professionals on proper responses to a drought at the local and state level. A copy of the manual can be found at www.cdc.gov/nceh/ehs/publications/drought.htm.

HOW PREPARED IS UTAH?

Be Ready Utah is an emergency preparedness campaign that educates the public on how to prepare for a variety of natural disasters. Created in April of 2005, Be Ready Utah focuses on individual responsibility in preparing for a disaster while providing the tools and education to properly plan for any event. Within the beready.utah.gov website is the Utah Natural Hazards Handbook, which is a manual that discusses how Utah has prepared for a variety of natural disasters. The drought section of the handbook details what the state will do in response to a drought. Activities include implementing water use restrictions, temporary redistribution of water to high need areas, conservation methods in agriculture and reuse of treated wastewater (King, 2008).
In addition to this handbook, the Utah Division of Water Resources created a drought management toolkit to aid public water suppliers as they prepare for future droughts. The toolkit contains a drought mitigation plan which assesses how vulnerable a water system is and what can be done to strengthen the system against future droughts. Additionally, the toolkit details a drought response plan, which includes how public water suppliers should respond to a drought and appropriate actions to conserve water (Water Resources, 2008).

FLOODS

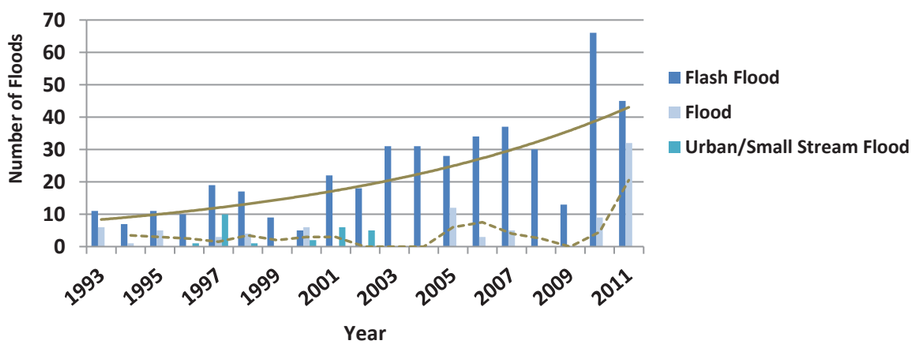
Why Floods are Important to Public Health

In Utah, long-term rainfall, rapid spring snowmelt, dam breaks and flash flooding are the four primary ways floods occur (Barjenbruch et al. 2008). All four causes of flooding can be extremely dangerous to the health of Utah citizens. In terms of climate change, the data regarding how climate change may affect flood frequency is minimal. The EPA reports that the number of heavy rainfall occurrences has increased and these occurrences lead to increased flooding events. Yet, the EPA recognizes that this is not happening in all areas (EPA, 2011). The graph below shows the number of flood events that have taken place from 1993-2011 in Utah and are broken down by flood type.

Whether it is an abundance of snowmelt runoff, a heavy thunderstorm or dam failure, floods can negatively affect the public's health in a number of ways. One of the primary concerns is contaminated drinking water.

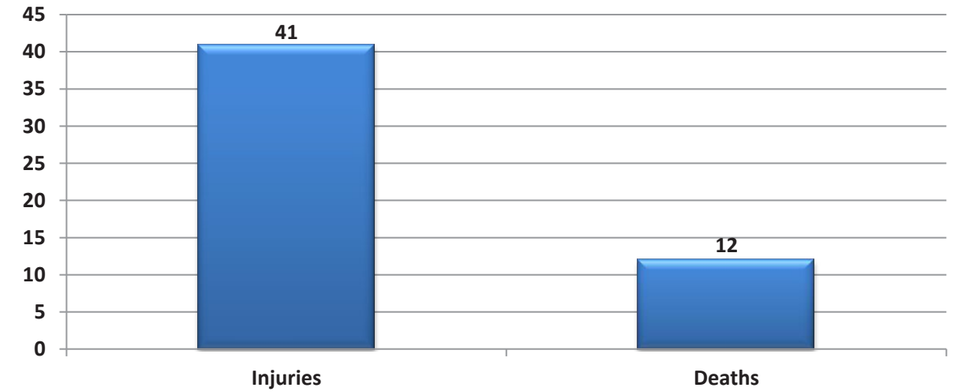
Floods can move massive amounts of debris and compromise sewage systems, which can contaminate the clean drinking water supply. Waterborne diseases, such as *Giardia* are transmitted through the consumption of contaminated water (contaminated with fecal matter) and can cause great debility and even death. Stagnant flood waters can become a breeding ground for vector-borne diseases, like West Nile virus, that could be detrimental to individuals who are displaced by a flood. Severe floods can knock over power lines and do extensive damage to homes, easily allowing for the release of hazardous chemicals into the community (CDC, 2011). Other health concerns include drowning and injuries directly related to flooding.

Number of Flood Events in Utah by Flood Type (1993-2011)



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

Deaths and Injuries from Utah Floods (1993-2011)



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

PUBLIC HEALTH'S ROLE

The Utah Department of Health (UDOH) Bureau of Emergency Medical Services and Preparedness is in operation to coordinate local, state and federal agencies in assisting health care systems with emergency preparedness and how to respond when a disaster strikes. If a flood or any other type of disaster were to occur, UDOH has implemented a 24-hour statewide support line to assist public health professionals and health care providers in supplying aid to the community. At the federal level, the CDC has a web page dedicated to educating the public on how to prepare for a flood and what should be done after a flood. Topics include water safety, sanitation and hygiene, mold, and precautions to follow after a flood occurs. Flood information from the CDC can be accessed at www.bt.cdc.gov/disasters/floods.

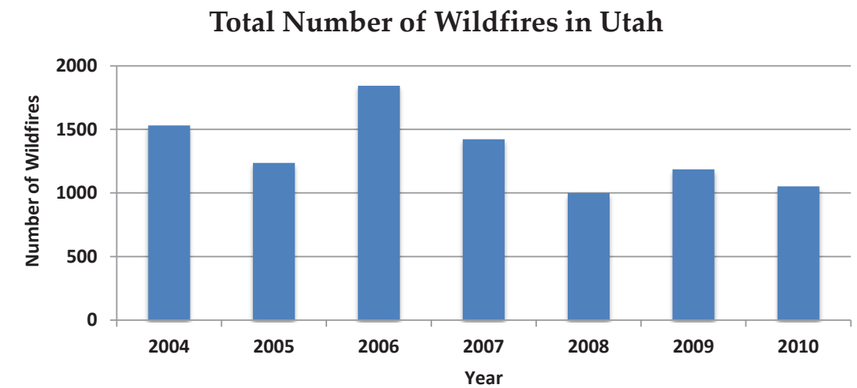
HOW PREPARED IS UTAH?

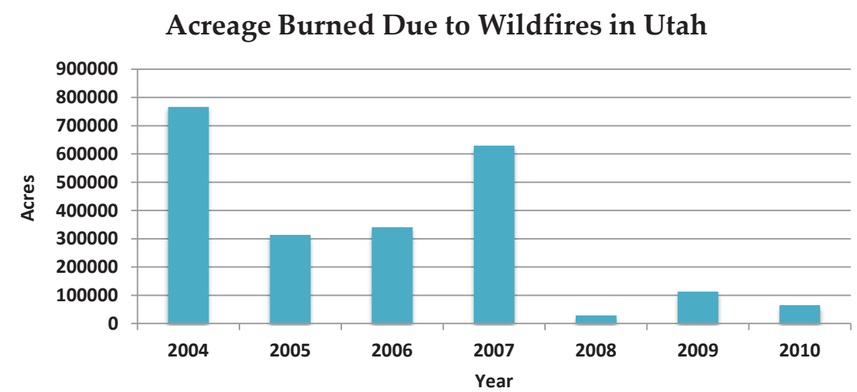
As with droughts, the Utah Natural Hazards Handbook has a section regarding Utah's response to floods and flood education. Most importantly, almost all areas in Utah participate in the National Flood Insurance Program, which provides coverage on any building. This ensures that if a flood were to strike, means would be available to cover property damage and other flood-related losses. In terms of assessing flood risk, local emergency officials are available to determine flood risk in your area. Additionally, flood insurance rate maps can also aid in evaluating flood risks (Barjenbruch et al. 2008). Maps can be found at www.floodsmart.gov. Assessing flood vulnerability of different regions is an important step in the flood mitigation process. Experts from organizations such as the State Flood Hazard Mitigation Team have determined flood vulnerability for each county in Utah. Identifying levels of vulnerability helps with future mitigation strategies. The manual also highlights mitigation strategies that can be implemented at home, for businesses and public works agencies.

WILDFIRES

Why Wildfires are Important to Public Health

Wildfire frequency is dependent on a delicate balance between precipitation, heat, abundance of fuel (ie. grass) and natural or human caused ignition. No one aspect specifically causes a wildfire, but the relationship between these different factors can determine a high or low frequency wildfire season. A heavy snowpack in the winter with a wet spring and a slow transition from cool to warm weather could result in a low wildfire season. Consequently, a dry winter, rapid heating in the spring and an abundance of dry grass could lead to a high-frequency fire season (G. Dingman, Predictive Services, February 15, 2012). Although the research is limited, it is suspected that climate change could interfere with this multi-factorial balance and potentially alter wildfire frequency. Climate change affects seasonal precipitation and temperature, so it is possible that less precipitation and higher temperatures due to changes in the climate could increase the frequency of Utah's wildfires. As of 2011, Utah was at 40% snowpack, which is considered low (G. Dingman, Predictive Services, February 15, 2012). Wildfires can adversely affect human health, primarily through exposure to smoke. Wildfire smoke negatively affects everyone, but individuals with pre-existing conditions may have worse symptoms. Common symptoms from smoke inhalation include shortness of breath, chest pain, headaches, coughing, irritated sinuses and stinging eyes. Vulnerable populations would include those with asthma, heart or lung disease and other pre-existing respiratory conditions. Individuals with respiratory problems may experience the inability to breathe properly, wheezing, cough and chest discomfort. Those with heart disease may experience fatigue, rapid heartbeat, chest pain and shortness of breath. If the wildfire is severe enough or if there is a high frequency of fires producing an abundance of smoke, healthy individuals may experience more severe manifestations of these symptoms (CDC, 2007).





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

PUBLIC HEALTH'S ROLE

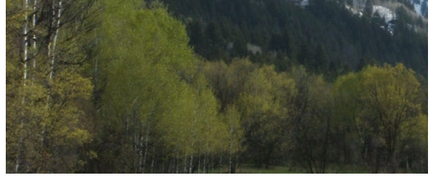
Since a variety of agencies handle wildfire response in Utah, public health's role is primarily educational. The CDC has a web page dedicated to how to protect yourself during a fire and what to do after a fire has occurred. How to limit smoke exposure, protecting your home and treatment of burn victims are some of the topics discussed. Access to wildfire education can be obtained at www.bt.cdc.gov/disasters/wildfires.

HOW PREPARED IS UTAH?

There are multiple agencies within Utah that aid in wildfire response and mitigation. The Utah Interagency Coordination Guide details what organizations are involved with wildfire occurrences. In addition, the guide's main purpose is to assist these government and non-governmental agencies in working together to assist Utahns before, during and after a wildfire occurs (Conservation & Development). The Utah Natural Hazards handbook also has a section pertaining to wildfires, which provides education on what is being done and what the public can do when faced with a wildfire. Education primarily includes how to mitigate wildfire hazard, such as maintaining clearance of vegetation, purchasing a home in a low-risk area and the importance of an adequate water supply. To help homeowners with these mitigation processes, the Interagency Fire Service is creating community wildfire protection plans (Dunford & Holfelts, 2008). These plans will help homeowners improve the chances of their home surviving a wildfire.

ENVIRONMENTAL INDICATORS

The environment plays a key role in the public health of Utah. From air and water quality to radon and lead, there are many environmental factors that can influence the health of our residents. While many environmental factors are naturally occurring, our behavior can influence and increase some of the negative affects that influence climate change factors, such as automobile emissions and air quality. We can help reduce our impact by implementing tools and guidelines provided by public health programs at the state and national levels.



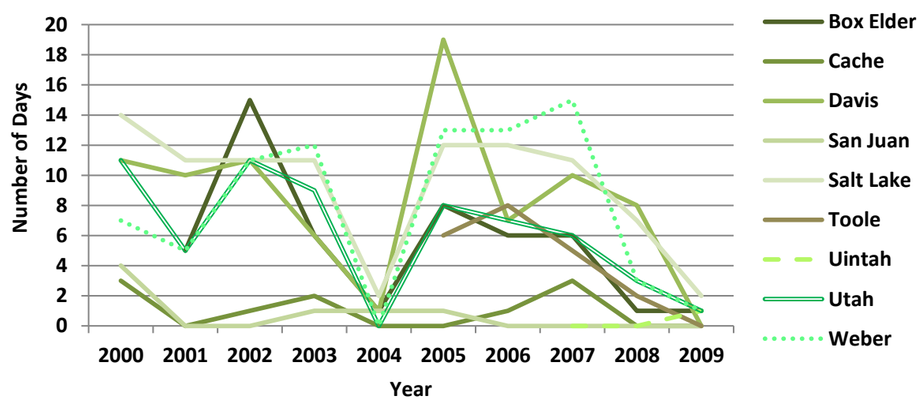
OZONE

Ozone is created when nitrogen oxides and volatile organic compounds chemically react in conjunction with the presence of warm temperatures and sunlight. Since warm temperatures and intense sunlight are required for ozone production, the highest levels of ozone are typically seen in the summer months between 2 p.m. and 8 p.m. (UDEQ, 2010). There are two types of ozone that influence human health. Stratospheric ozone is the level of ozone approximately 15 miles above the earth's surface that provides protection against extreme amounts of ultra violet radiation (NASA, 2004). This layer acts as a shield to protect against diseases like skin cancer and is therefore considered the good type of ozone. Conversely, the bad type of ozone is seen closer to earth and is referred to as ground-level ozone. The same chemical reaction is occurring, but this reaction is now trapped at the earth's surface and in turn generates pollution.

Roughly 50% of the ground-level ozone pollution in Utah is due to automobiles (UDEQ, 2010). Yet the question remains whether climate change plays a part in the creation of more ground-level ozone pollution. As temperatures increase, it is expected that the number of bad ozone days will increase, since heat accelerates the nitrogen oxide and volatile organic compound reaction (NASA, 2004). Researchers have found that a combination of higher temperatures, sunlight, emissions and air stagnation events (i.e., inversions) may result in an increase of ozone levels. Furthermore, ozone levels are predicted to increase by 5-10% in the United States between now and 2050 due to a changing climate (English et al. 2009). However, more research is needed to accurately gauge what portion of ozone is actually increasing solely due to climate change.

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. No one is immune to the negative effects ozone pollution can cause. The most susceptible populations include young children, the elderly and individuals with pre-existing respiratory conditions, such as asthma. Yet, healthy adults can experience harmful effects of ozone, particularly when exercising or participating in manual labor outside (UDEQ, 2010). Air Action alerts can be broadcast via electronic media to communities or individuals can sign up to receive Air Action alerts via email at: www.cleanair.utah.gov/youcando/aqAlerts.htm.

Number of Days Maximum 8-Hour Average Ozone Concentrations Exceeded National Ambient Air Quality Standard By County (2000-2009)



Infromation obtained from the UEPHTN IBIS-PH at http://ibis.health.utah.gov/indicator/view/AirQuaOzo.Cnty.html

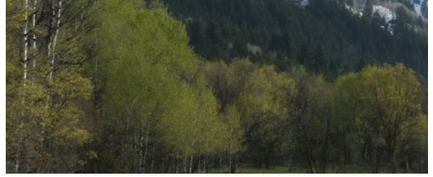
PUBLIC HEALTH'S ROLE

To ensure that ozone levels remain at a point that is not considered detrimental to the public's health, the Environmental Protection Agency (EPA) created the National Ambient Air Quality Standards, which apply to all regions within the United States. The National Ambient Air Quality Standards set acceptable levels for six principal pollutants including ozone. There are primary and secondary standards for each pollutant and ozone must meet both standards. Primary standards protect the public's health while secondary standards protect animals, vegetation and structures. The acceptable level for ozone is 0.075 parts per million (ppm) by volume within an eight hour period for both primary and secondary standards (EPA, 2011).

At the local level, the Utah Department of Health Asthma Program provides education to the public on how to protect against high ozone days. The website provides recommendations about engaging safely in outdoor activities during summer months, a symptom tracking sheet and a link to check current air quality. Information can be found at http://health.utah.gov/asthma/air%20quality/ozone_recommendations.html. Additionally, the Utah Department of Environmental Quality provides a "50 Summer Suggestions" fact sheet about what Utahns can do at home, work and while driving during the summer to help reduce ozone levels. The factsheet can be accessed at www.cleanair.utah.gov/summer/50summersuggestions.htm.

HOW PREPARED IS UTAH?

Since the early 1990s, Utah has remained under the designated levels for ozone required by the EPA. However, when ozone levels were restricted to 0.075 ppm in 2008, some counties in Utah were in danger of exceeding EPA ozone level requirements (UDEQ, 2012). Utahns play a crucial role in reducing harmful ozone. Regular vehicle maintenance and inspection, choosing alternative forms of transportation and utilizing eco-friendly technologies can help greatly reduce ground-level ozone. The Utah Department of Environmental Quality also announces an "Air Action" when high ground-level ozone is forecast (UDEQ, 2010). Paying attention to these announcements can help change behaviors during high-risk seasons that will aid in ground-level ozone reduction.



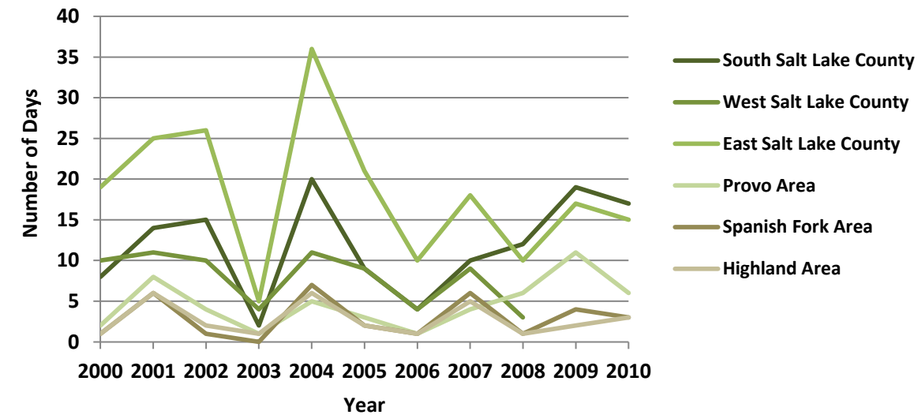
PARTICULATE MATTER

Among the two types of particulate matter that are present in our air, particulate matter 2.5 (PM 2.5) is of specific concern regarding human health. PM 2.5 measures 2.5 micrometers in diameter or less. When particulate matter 10 (PM 10) measures one-seventh the width of a strand of human hair, one can imagine just how small PM 2.5 really is. PM 2.5 is pollution made up of metals, allergens, nitrates, sulfates, organic chemicals, soil and dust particles that are emitted from sources such as combustion products, soot from fireplaces, blowing dust from construction sites and agricultural activities (UDEQ, 2011). The negative impact PM 2.5 can have on human health is substantial. Like most environmental exposures, PM 2.5 has the greatest impact on vulnerable populations. This includes young children, the elderly and people who suffer from heart or lung disease.

Some studies have shown that older adults are more likely to be hospitalized or die when particulate levels are high compared to the rest of the population. Those with heart and lung disease are in danger of these diseases being exacerbated. Individuals with lung disease may experience difficulty breathing, chest discomfort, coughing and fatigue. Additionally, some individuals may experience asthma attacks and a lowered ability to fight against respiratory infections (EPA, 2010). As for people with heart disease, PM 2.5 could increase the risk for heart attacks and arrhythmias, even if an individual is not experiencing any warning symptoms like chest tightness or palpitations. Yet even healthy individuals can succumb to the negative effects of PM 2.5 exposure. Common symptoms include coughing, shortness of breath, chest tightness and irritation of the eyes, nose and throat. Physical activity on days with high levels of PM 2.5 can also be problematic since faster and deeper breathing take more particles into the lungs (EPA, 2010). It is important to stay informed about poor air quality days to limit exposure.

The studies investigating climate change's effect on PM 2.5 are still fairly inconclusive. PM 2.5 is complex in its makeup and various components that compromise PM 2.5 interact differently with meteorological variables. For example, sulfates within the PM 2.5 mixture are expected to increase as temperature increases since sulfur dioxides will oxidize quicker in hotter temperatures. Consequently, organic chemicals are expected to decrease since higher temperatures will convert organics into gases (Tai et al. 2010). As temperature increases, PM 2.5 concentration has been shown to increase in the United States, but this is not the general consensus of the scientific community. However, researchers seem to agree that as precipitation increases, PM 2.5 levels will decrease since it "clears" the air (Jacob & Winner, 2009). If precipitation events are seen to increase with climate change, it is reasonable to conclude that PM 2.5 levels may decrease. Another agreed upon topic is the effect air stagnation events (i.e., inversions) will have on PM 2.5 levels. If air stagnation events increase in frequency with climate change, PM 2.5 levels are likely to rise because these events trap the pollution at the earth's surface (Jacob & Winner, 2009). More research is needed to accurately quantify to what extent PM 2.5 levels will be affected by a changing climate.

Number of Days PM 2.5 Levels Exceeded the National Ambient Air Quality Standard by Area (2000-2010)



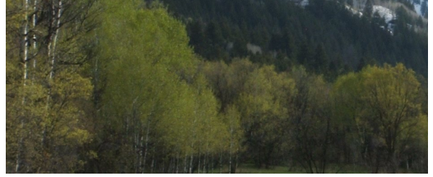
Infromation obtained from the UEPHTN IBIS-PH at http://ibis.health.utah.gov/indicator/view/AirQuaPM.Geo.html

PUBLIC HEALTH'S ROLE

Like ozone, the EPA set a National Ambient Air Quality Standard for PM 2.5, which is reported in micrograms per cubic meter (Âµg/m3). Prior to 2006, the allowable National Ambient Air Quality Standard for PM 2.5 was 65 Âµg/m3, but the EPA restricted that standard to 35 Âµg/m3 to ensure the public's health (UDEQ, 2011). In addition to decreasing the allowable levels of PM 2.5 in the environment, the EPA created the Air Quality Index for particulate pollution. The Air Quality Index is an application that state and local agencies utilize to disseminate information to the public about pollutants that may be in the air on any given day (EPA, 2010). Additionally, the public can go on to the EPA's website and gather daily information about air quality in a specific area. Air quality updates can be found at http://epa.gov/airnow.

HOW PREPARED IS UTAH?

The Utah Department of Environmental Quality, Division of Air Quality is responsible for operating and monitoring stations throughout the state to assess whether PM 2.5 is within the acceptable limits set by the EPA. The Division of Air Quality's surveillance allows for sufficient response time to implement mitigation strategies when PM 2.5 levels exceed the maximum requirements. If particulate matter exceeds the National Ambient Air Quality Standards, the state must submit a State Implementation Plan (SIP) to the EPA, which calls for mitigation strategies to reduce pollution. In the past, Utah has submitted SIPs that place control measures on power plants, wood burning restrictions and vehicle emission inspections (UDEQ, 2012). In addition to mitigation strategies, the Utah Department of Environmental Quality issues two types of advisories through local news media that alert the public to high pollution days. Air Action advisories warn that pollution levels are rising to unsafe amounts and encourage the public to engage in pollution reducing activities, like reducing the amount of driving. An Air Alert notifies the public that pollution levels have exceeded an allowable, safe standard and bans certain activities, particularly wood burning (UDEQ, 2011). Paying close attention to both alerts will allow Utahns to help reduce pollution across the state.



SURFACE WATER

There are two sources from which water is collected: surface water and groundwater. Surface water sources consist of lakes, rivers and reservoirs where groundwater primarily comes from wells and springs. Although 57.1% of Utah's drinking water comes from groundwater sources, surface water quality is important because it is more susceptible to contamination and is a significant water source for a variety of uses across the state (Utah Foundation, 2004). In Utah, the majority of surface water is used for irrigation rather than for public use (USGS, 2009). Yet as Utah's population continues to grow, the need for water will increase and clean surface water will be required to satisfy the growing demand for drinking water. As of 2000, Utahns used 4.76 billion gallons of water per day and with a growing population, that number will continue to increase (Utah Foundation, 2004).

Surface water contamination can occur in a variety of ways. Naturally occurring chemicals, such as arsenic, chemicals from agriculture (like pesticides) and sewer overflows are just some of the ways surface water can become contaminated. The health effects from these exposures can be severe and can include neurological deficits, gastrointestinal issues and problems with the reproductive system (CDC, 2010). Individuals who are most susceptible to the side effects of surface water contamination would be the elderly, young children, pregnant women and individuals who are immunocompromised, yet anyone can become sick when exposed to contaminants.

Since surface water is more exposed than groundwater, it is more susceptible to contamination from sediment runoff, runoff from agricultural chemicals and exposure from waste and miscellaneous debris. It is suspected that climate change may affect runoff flows and water temperature, which in turn affects the quality of surface water. Projections about climate change conclude that as the climate continues to change, precipitation events will become more intense. If precipitation events are heavier, it is possible that strong downpours will create greater sediment runoff into surface sources like lakes and rivers. This increase in sediment will include contaminants from agriculture, an overload of minerals and a variety of disease pathogens (USGCRP, 2009). Along with heavy precipitation, increasing temperatures will raise water temperatures. Warmer water temperatures could be detrimental to aquatic life living in lakes and rivers since increased water temperatures decrease oxygen availability. Additionally, lower oxygen concentrations in surface water, particularly rivers, will decrease the ability for rivers to self-purify (USGCRP, 2009).

Climate change also affects snowpack, which in turn affects runoff into Utah's reservoirs. As temperatures rise, what was once snow in the winter months becomes rain. Plus, increasing temperatures could aid in premature snowmelt. Many hydrologists conclude that as snowpacks melt prematurely, runoff into reservoirs will become more inefficient and ultimately decrease the water supply in the reservoirs. Climate models point to a decrease in the amount of snowfall in the Utah mountains with warming temperatures. As such, we can anticipate a more inefficient runoff due to increased evaporation, sublimation, and transpiration losses (McInerney, 2005). With the decline in runoff comes a decline in reservoirs, creating a deficit in Utah's surface water supply.

Information obtained from EPA: Protect Your Drinking Water for Life – What can you do to protect your drinking water?, http://water.epa.gov/action/protect/index.cfm#involve

PUBLIC HEALTH'S ROLE

To ensure that the nation's drinking water is safe for consumption, Congress implemented the Safe Drinking Water Act in 1974. This empowers the EPA to set maximum contaminant standards for more than 90 different contaminants. Primary standards protect the public's health by limiting dangerous contaminants in the water supply, while secondary standards are non-enforceable guidelines that attempt to regulate issues such as taste and color of the water (CDC, 2009). The EPA also has a list of contaminants that are currently unregulated but may become regulated in the future if found to negatively impact public health. Along with these standards, public water systems go through extensive processes to ensure that surface water is free of contaminants. As stated previously, surface water is usually more contaminated than groundwater, which is why it goes through a more intensive treatment process. With these regulations and processes in place, drinking water in Utah is safe for consumption. The EPA also provides education on how the public can help protect the water supply. Additional tips can be found at http://water.epa.gov/action/protect/index.cfm.

HOW PREPARED IS UTAH?

A significant component to keeping surface water clean and safe for consumption is diligent surveillance and repeated testing to ensure that the water remains clean. The U.S. Geological Survey monitors 140 sites in Utah that provide surface water quality data that is used by federal, state and local organizations to implement surface water regulations and water-related projects (USGS, 2011). The Utah Water Science Center, a division of the U.S. Geological Survey, also conducts its own projects that investigate the current water supply, how land use affects water quality and nutrient overload in rivers and streams (USGS, 2012). Projects and data analyses done through the Utah Water Science Center help evaluate Utah's current water supply along with demand and create water supply management techniques to ensure that clean water remains available to Utahns.

The Utah Department of Environmental Quality, Division of Drinking Water also plays a role in keeping Utah's water supply safe. The Division of Drinking Water is responsible for ensuring that Utah's water systems are in compliance with federal standards, through evaluating and monitoring water treatment plants and public drinking water systems. Additionally, the Division of Drinking Water provides assistance to public water systems to help them comply with federal and state water regulations.

HEALTH INDICATORS

Climate change can have an impact on many different aspects of health. In Utah, this includes respiratory systems, heat-related injuries, vector and foodborne diseases.

The increase in temperatures, more mild winters and less precipitation can foster the habitat, growth and abundance of allergens. This, in turn, can affect respiratory health especially for those who may already be susceptible to irritants.

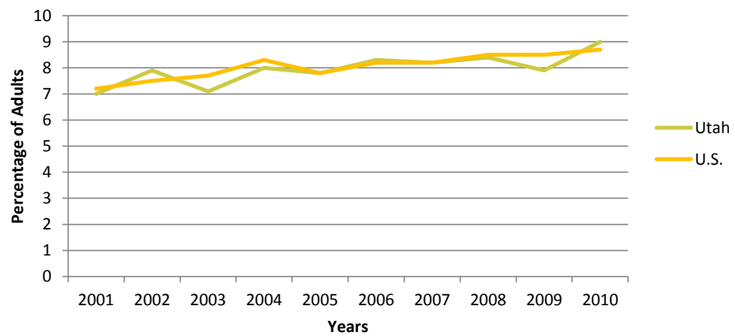
Increased temperatures can increase cases of heat-related disease, such as heat stroke and may affect those with existing heart conditions.

Vector and foodborne diseases, similar to respiratory illness, could increase with increasing temperatures and longer warm seasons that could create more hospitable habitat for such vectors. Remembering simple things like using sunscreen and sun protective clothing, tracking air quality and respiratory symptoms, staying hydrated and wearing bug spray can help us prevent possible negative health effects.

RESPIRATORY DISEASE

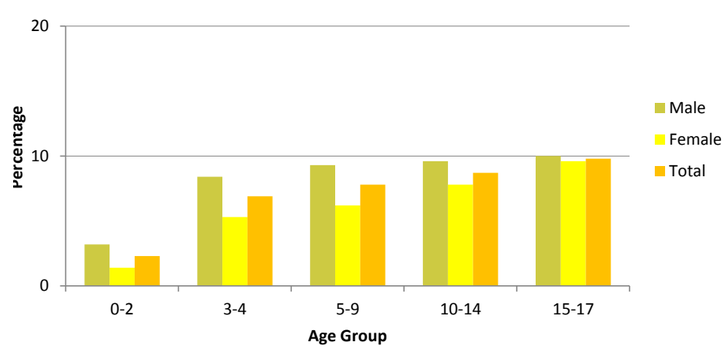
The two forms of respiratory illness that are cause for concern as it pertains to climate change are asthma and allergies. Asthma is a disease that affects the lungs where allergies occur due to the immune system's overreaction to certain environmental triggers. Individuals with asthma suffer from tightness in the chest, have trouble breathing and experience recurring episodes of wheezing. Unfortunately, asthma is one of the most common diseases among children, yet adults suffer with asthma as well (CDC, 2012). There are a variety of environmental exposures that could trigger an asthma attack. Common triggers include outdoor or indoor air pollution, allergens from pets or pollen, physical activity, cigarette smoke and viral infections, such as pneumonia (UDOH). These triggers can be avoided by limiting exposure and keeping a clean environment by washing objects that collect dust and regularly cleaning pets.

Asthma Prevalence Among Adults Aged 18 and Over, Utah and U.S., 2001-2010



Information obtained from UEPHTN IBIS-PH at http://ibis.health.utah.gov/indicator/view/AsthAdltPrev.UT_US.html

Child Asthma Prevalence by Age and Sex, Utah, 2007-2010



Information obtained from UEPHTN IBIS-PH at http://ibis.health.utah.gov/indicator/view/AsthChiPrev.Age_Sex.html

Allergic diseases occur when an individual is exposed to a substance in the environment that is considered an allergen. In terms of respiratory allergic diseases, allergens are usually inhaled through the nose and into the lungs. These allergens include pollen, mold spores, pet dander and dust within the house (AAFA, 2005). There are two forms of respiratory allergic diseases: allergic rhinitis and allergic asthma. When most individuals refer to suffering with allergies, they are primarily referring to allergic rhinitis, which is also known as hay fever or seasonal allergies. Symptoms of allergic rhinitis include sneezing, runny nose and watery, itchy eyes. Allergic asthma occurs when asthma symptoms are triggered by an allergen, causing an airway obstruction. The symptoms that occur during a typical asthma episode are similar to an allergic asthma attack and both types of asthma attacks can be mediated with medication (AAFA, 2005).

Pollen is of concern because it is the most common trigger for allergic reactions. Plant pollen has the ability to reach a variety of populations due to its ability to be carried by the wind and travel to different locations. Research shows that pollen distribution may also be affected by a changing climate. Studies have shown that increasing temperatures due to climate change allow plants to pollinate earlier, ultimately creating longer pollen seasons (Shea et al. 2008). Additionally, as climates change and become warmer in different regions, plants will have the ability to move into new areas, emitting pollen and exposing populations who were previously unexposed (Reid & Gamble, 2009). Carbon dioxide also contributes to the pollen production. Higher concentrations of carbon dioxide in the air aids in increased pollen production. As more carbon dioxide is emitted into the atmosphere, it is suspected that pollen production will increase and contribute to the exacerbation of asthma and allergic diseases (Shea et al. 2008).

PUBLIC HEALTH'S ROLE

Education is key in understanding how to avoid exposure to common triggers for allergies and asthma. The Utah Department of Health Asthma Program provides education to schools, health professionals and the general public on how to stay safe when exposure to environmental triggers is elevated. One example is the recess guidance for schools, which helps schools across Utah determine when air quality in their area is poor, and whether it would be beneficial to keep children indoors. Additionally, the Utah Inhaler Law now allows students to possess and administer an inhaler at school in case a child has an asthma attack. More information about asthma and allergies and what can be done to avoid exposure can be found at www.health.utah.gov/asthma.

HOW PREPARED IS UTAH?

Utah has a variety of programs and campaigns that work and advocate to keep Utah's air clean. The Utah Clean Air Partnership is an initiative to improve air quality that is overseen by Governor Herbert. This campaign seeks to reduce harmful emissions to improve air quality and educate the public on how to keep Utah's air clean. Current projects under the Utah Clean Air Partnership include the PM 2.5 State Implementation, the Clear the Air Challenge, Idle Free Utah, the Clean School Bus Project and Travelwise. More information about these projects and how you can participate can be found at http://ucair.utah.gov/partners/index.htm. The Utah Clean Air Partnership also provides education and links to a variety of topics such as air pollutant fact sheets, how to reduce emissions during different seasons and air quality alerts to see what air quality is like on any given day. Access to the Utah Clean Air Partnership Information Center can be found at http://ucair.utah.gov/infocenter/index.htm.

Through the collaboration between the Utah Department of Health Asthma Program, American Lung Association and the Utah Asthma Task Force, the Utah Asthma Plan was created. Implementation of the Utah Asthma Plan helps individuals with asthma manage their symptoms, assists health care systems in providing proper care to patients and identifies risk factors in order to implement appropriate intervention strategies to reduce asthma triggers in Utah. A copy of the Utah Asthma Plan (2007-2012) can be found at http://health.utah.gov/asthma/pdf_files/AsthmaStatePlan_2007.pdf.

HEAT-RELATED DISEASE

As climate change persists and temperatures continue to rise, it is likely that the frequency of heat waves across the globe will increase over time. An escalation in the frequency of extreme heat waves could affect the number of Utahns that will suffer from heat-related diseases. Currently, within the United States, heat waves are the most deadly weather event causing more deaths than tornadoes, earthquakes, hurricanes and floods combined (CDC, 2009). If climate projections are correct about increasing temperatures in the near future, heat waves will continue to rise in severity, frequency and duration. Intense and frequent heat waves will make it more difficult for individuals to properly cool themselves. Heat-related illnesses occur when the body is unable to cool itself, which can occur for several different reasons. Sweating is the body's way of regulating internal body temperature. When an area is hot and humid, sweat will not evaporate from the body, preventing the body from cooling down. Other risk factors that prevent the body from cooling include older age, sunburn, poor circulation and obesity (CDC, 2006).

When referencing heat-related diseases, the two most common illnesses are heat exhaustion and heat stroke. Heat exhaustion is the milder form of heat illness, which occurs when an individual is exposed to high temperatures for multiple days with an inadequate replacement of fluids. Those at an increased risk for heat exhaustion include people with high blood pressure and the elderly. Symptoms of heat exhaustion include muscle cramps, dizziness, paleness and extreme sweating (CDC, 2006). If left untreated, heat exhaustion can progress into heat stroke. Heat stroke is a serious condition that can cause permanent damage and death. Once an individual has developed heat stroke, the ability to cool the body has failed. Those at an increased risk for heat stroke are young children, individuals 65 years of age and older, people who are overweight or taking certain medications. Symptoms include a body temperature over 103 degrees Fahrenheit, dry skin, confusion and a rapid, strong pulse (CDC, 2006). A heat stroke requires immediate medical attention and can be life-threatening.

Cardiovascular diseases are associated with heat as well. Hotter temperatures cause the heart to beat faster and work harder as part of the body's cooling process. As previously mentioned with heat stroke, the body's ability to cool itself fails, which puts strain on the heart (SCAI). Individuals with pre-existing cardiovascular diseases are at a greater risk for developing heat stroke since the heart is unable to function at full capacity, lowering the ability for the body to regulate itself. Additionally, certain medications like diuretics and beta-blockers for individuals with cardiovascular disease decrease the amount of water in the blood stream. The reduced water content hinders an individual's ability to cool down, increasing the risk for heat stroke (SCAI). The Centers for Disease Control and Prevention (CDC) reported that hospital admissions for cardiovascular disease increase with heat along with a rise in the incidence of stroke (CDC, 2010). Scorching temperatures over longer periods of time may cause great disability and death among the large number of Utahns who suffer from cardiovascular diseases.

Information obtained from the Center for Disease Control and Prevention at http://www.bt.cdc.gov/disasters/extremeheat/heat_guide.

PUBLIC HEALTH'S ROLE

The CDC provides a wide array of information about how to recognize a heat-related illness and what to do if you or someone else is suffering from a heat-related disease. Access to CDC's complete prevention guide regarding extreme heat can be found at www.bt.cdc.gov/disasters/extremeheat_guide.asp.

Additionally, the Utah Department of Health, Heart Disease and Stroke Prevention Program provides information and resources to vulnerable individuals who suffer from cardiovascular diseases. The program educates health professionals and provides updates regarding learning opportunities through workshops and conferences. Information regarding the Heart Disease and Stroke Prevention Program can be obtained at www.hearthighway.org.

HOW PREPARED IS UTAH?

Carbon dioxide (CO_2) emissions are a great contributor to the change in climate and rising temperatures. Reducing emissions may help in decreasing the frequency and intensity of heat waves across the country. There are many programs that aim to reduce CO_2 emissions within the state of Utah. Campaigns such as the Climate Change Campaign through the Utah Clean Energy organization which seeks to influence policy on the local, state and federal level, is designed to reduce CO_2 emissions to try and avoid the negative effects that climate change may bring. To reach this goal, the Climate Change Campaign states that renewable energy and better energy efficiency are the best ways to reduce CO_2 emissions. The University of Utah is also playing a part in trying to reduce emissions by implementing renewable energy campaigns on campus and furthering research on how to make energy resources, like coal, cleaner to use. One of the more innovative programs in Utah was implemented by the Salt Lake City Convention and Visitors Bureau. The carbon offset calculator allows visitors to Salt Lake City to offset their CO_2 emissions due to travel, by purchasing trees to balance the CO_2 in the air. Users can calculate their carbon footprint due to vehicle or air travel and then decide how many trees they would like to purchase to offset the emissions. The calculator can be found at www.visitsaltlake.com.

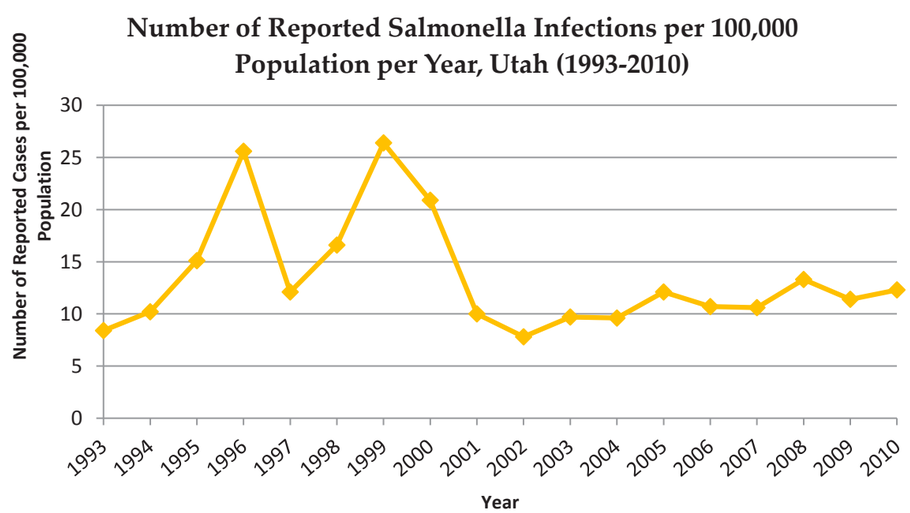
Preparing for extreme heat waves is the responsibility of all Utahns. It is imperative that Utahns become educated on how to avoid heat exposure and learn what to do when a heat-related illness occurs. The American Red Cross of Utah provides information on how Utahns can stay safe during the summer months. By following these instructions, Utah citizens can become prepared on how to stay safe in extreme heat conditions. Information provided by the American Red Cross can be found at www.utahredcross.org.

FOODBORNE ILLNESS

Foodborne illnesses are caused by consuming contaminated foods or beverages that contain a wide variety of bacteria, viruses or parasites. Approximately, 48 million Americans suffer from a foodborne illness every year, while 128,000 are hospitalized and 3,000 people die (CDC, 2011). The substantial number of Americans affected each year by foodborne illnesses creates cause for concern for public health. Currently, the top five pathogens that are causing foodborne illness among Americans are norovirus, *Salmonella*, *Clostridium perfringens*, *Campylobacter* and *Staphylococcus aureus* (CDC, 2011).

In terms of climate change, research suggests that rising temperatures may affect the frequency of infections from *Salmonella* and *Campylobacter*. *Salmonella* is a bacterium that is transmitted to humans by consuming foods that have been contaminated with animal feces. Foods that cause *Salmonella* infections usually include inadequately cooked ground beef and poultry, raw eggs and any type of produce that comes in contact with contaminated water. Symptoms from a *salmonella* infection may include fever, diarrhea and abdominal cramps that could last four to seven days (CDC, 2010). *Campylobacter* is also a bacterium and is the cause of most diarrheal illness in the United States. *Campylobacter* is primarily transmitted to humans through consumption of undercooked poultry or cross-contamination of other foods from poultry. Consumption of raw milk is also a common source for infection. Like *Salmonella*, symptoms include abdominal cramps, diarrhea and fever that may last two to five days (CDC, 2010).

Both *Campylobacter* and *Salmonella* display a pattern of increasing rates of infection during summer months. This rise of infections during the summer may be due to seasonal patterns, yet there may be a relationship between warmer temperatures and rates of illness. Increasing rates of infection during the summer may suggest that *Salmonella* and *Campylobacter* infections may increase with rising temperatures due to climate change (Greer et al. 2008). In fact, some research has shown that as temperatures increased, so did the number of *Salmonella* cases. Additionally, different types of *Salmonella* appeared to be more sensitive to temperature than others. However, studies regarding *Campylobacter* did not always follow the same pattern (Tirado et al. 2010). More research is needed to discover how climate change may affect *Campylobacter* and *Salmonella* infections.



Information obtained from UEPTHN IBIS-PH at http://ibis.health.utah.gov/indicator/view/FooPoiSalm.Ut_US.html

How climate change affects ocean temperatures is also a concern when discussing the incidence of foodborne diseases. *Vibrio vulnificus* is a bacterium found in warm ocean water and can be transmitted to humans through consumption of contaminated seafood or having an exposed, open wound. Symptoms from a *Vibrio vulnificus* infection include diarrhea, fever, abdominal cramps and can be life threatening among vulnerable populations (CDC, 2008). The U.S. Climate Change Science Program found an association between the temperature of the ocean's surface and the increase of *Vibrio vulnificus* within marine life. If sea surface temperatures continue to increase, which aids in the proliferation of *Vibrio vulnificus*, it is suggested that the rate of seafood-borne illness will increase (CDC, 2010). Along with increased ocean temperatures, a change in ocean salinity may also have an impact on *Vibrio vulnificus* and the possibility of contaminated seafood (Tirado et al. 2010).

PUBLIC HEALTH'S ROLE

Local and state health departments within the United States participate in diligent surveillance for a variety of foodborne illnesses. Surveillance allows public health practitioners to monitor the number of foodborne illness cases and intervene if an outbreak situation were to occur. Foodborne illness surveillance also allows public health practitioners to study trends to see what patterns foodborne illnesses follow over time. There are a variety of networks that are utilized locally and nationally to conduct foodborne illness surveillance. Foodborne Diseases Active Surveillance Network (FoodNet) is the primary mode of data collection for the CDC, which receives foodborne illness information from ten participating states. The National Molecular Subtyping Network for Foodborne Disease Surveillance or PulseNet allows states to communicate and connect cases to outbreaks that may affect multiple locations across the country. There are a variety of other networks that focus on different aspects of foodborne disease to ensure the health of all Americans. Utah has 12 local health districts that participate in foodborne disease surveillance in conjunction with the Utah Department of Health. The work of these public health practitioners is what continues to help Utahns stay safe from foodborne diseases.

HOW PREPARED IS UTAH?

Aside from the surveillance conducted at the health department, Utah also complies with state and federal regulations that are implemented to keep the food supply in Utah safe. The Utah Department of Agriculture created the Food Compliance Program, which monitors the food supply within Utah to ensure that all food products are safe for consumption. Through the program, the Utah Department of Agriculture regularly inspects establishments such as grocery stores, farmers markets and food processing plants to ensure that safe food standards are being met. Through Utah State University, the Utah Food Safety Coalition works to reduce the incidence of foodborne illness by providing education to the public in the hope of changing behaviors that promote illness. With the combined efforts of Utah's food industry, government, the public and Utah State University, the coalition aims to reduce the number of foodborne illnesses through education.

Utah also complies with federal regulations regarding food safety. The United States Department of Agriculture (USDA) provides food safety education to the public, including information regarding food recalls. Additionally, the USDA plays a part in implementing food safety regulations across the country. Other organizations such as FoodSafety.gov supply an abundant amount of education regarding proper food handling and foodborne diseases, to help the public avoid an illness from a foodborne pathogen. Education regarding food safety can be found at www.foodsafety.gov.

VECTOR-BORNE DISEASE

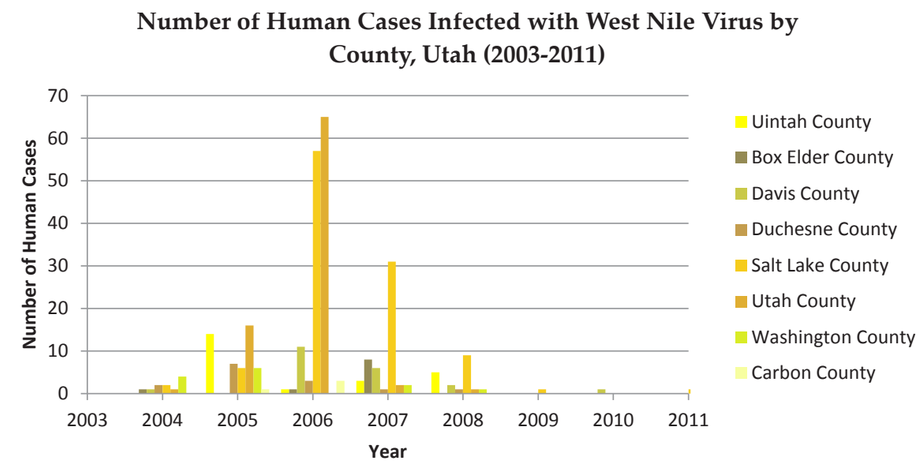
Climate change and its effect on vector-borne diseases could potentially be a concern for public health, yet more research is needed to identify whether rising temperatures will stimulate an increase in vector-borne diseases in the United States. A vector is any organism that is a carrier of disease that transfers the bacteria or virus to another organism. Animals and particularly arthropods, such as a mosquito, are the usual vectors that cause vector-borne diseases among humans. Vectors of concern in terms of climate change and increased frequency of disease would include mosquitoes and ticks. These vectors have the potential to spread malaria, West Nile virus, dengue fever and Lyme disease; all of which have negative health effects if introduced or spread within the United States.

Vectors and the diseases they incubate are complicated and complex. Therefore, predictions about how climate change will affect these diseases are difficult to make. Mills et al. (2010) indicated that climate change may affect the incidence of vector-borne diseases in a variety of ways. It is suspected that as temperatures continue to rise, mosquitoes, ticks and other animals will move into new geographic areas, exposing previously unexposed populations to disease (Mills et al. 2010). Dengue fever is a concern since the vector, the Aedes mosquito, has now been found within the United States. Outbreaks have occurred in Florida, Texas and Hawaii, but national reporting of the disease did not begin until July 2009. United States territories such as Puerto Rico and the U.S. Virgin Islands are endemic for dengue fever (USGS, 2011). Rising temperatures and stronger precipitation events across the United States may create additional habitats for the Aedes mosquito to survive in and allow for the spread of dengue fever. Furthermore, higher temperatures allow the Aedes mosquito to replicate the virus more quickly, permitting the mosquito to infect a greater number of hosts before it dies (CDC, 2010). Yet, transmission of the disease currently within the United States is rare and increased transmission will require more than changes in climate.

Warmer temperatures also have an effect on the proliferation of vector populations by decreasing the time for a vector to develop, which creates larger vector populations. Specifically, the mosquito has been studied in different parts of the globe and has demonstrated this type of development (Mills et al. 2010). Greater vector populations have the capacity to infect more human hosts, creating a larger burden from vector-borne diseases. As stated previously with dengue fever, temperature can affect the development of a pathogen within a vector. Pathogens like malaria and the plague are known to develop within specific temperature ranges (Mills et al. 2010). It is possible then that a change in temperature could change the development of a pathogen within a vector. Yet, more research is needed to determine if there is a relationship between warmer temperatures and increasing rates of disease.

Other vector-borne diseases that are a concern for public health include Lyme disease, malaria and West Nile virus. These diseases have a seasonal pattern and are sensitive to any deviations in climate (Frumkin, 2008). This sensitivity to climate may impact the incidence of these vector-borne diseases. Malaria, a disease found in warm climates, could potentially move into the United States from Mexico as temperatures increase. Lyme disease is also anticipated to travel into other states as the deer tick is able to survive in new areas due to climate change (CDC, 2009). West Nile virus has been present in the United States roughly for a decade; however it is unknown as to why West Nile was introduced and able to survive in the United States. Existing research does not provide any conclusive relationships between West Nile virus and climate change.

Climate is just one factor that influences the transmission of disease. The availability of adequate housing, proper sanitation and vector control programs also affect the incidence of vector-borne diseases. Extensive and long-term research is needed to discover exactly how climate change will affect the occurrence of these complex diseases.



Information obtained from USGS Disease Maps 2003-2011 at http://diseasemaps.usgs.gov

PUBLIC HEALTH'S ROLE

Surveillance of vector-borne diseases allows public health professionals to identify where diseases are occurring and implement interventions to stop the spread of the pathogen. Local, state and federal health agencies participate in surveying a variety of vector-borne diseases. Most of these agencies use ArboNet, an electronic surveillance system that tracks arboviral diseases (viruses transmitted by mosquitoes, ticks and other arthropods) within the United States. ArboNet monitors the incidence of arboviruses, which provides information to public health practitioners to implement control measures and stop the spread of disease. Surveillance through ArboNet identifies human cases, yet it also notifies public health about infected mosquitoes and birds.

Tracking vector-borne diseases at the local level of public health can also be accomplished by reporting from local hospitals and laboratories. Local health departments within Utah are notified when an individual tests positive for a reportable vector-borne disease in its jurisdiction. Plague and tularemia must be reported immediately to public health, where diseases like West Nile virus, dengue, malaria and Lyme disease must be reported within three days of a positive lab result. Reporting permits local public health practitioners to understand geographically where certain vector-borne diseases exist and implement prevention measures accordingly.

HOW PREPARED IS UTAH

There are 23 mosquito abatement districts throughout Utah. Each district is responsible for inspecting and treating mosquito breeding areas within their jurisdiction. In addition to treating highly populated mosquito areas, districts also monitor and test adult mosquitoes for diseases like West Nile virus and St. Louis Encephalitis. Once a mosquito tests positive for a disease, mosquito abatement can notify public health and the community about taking precautions to avoid exposure.

Academia within Utah is also involved in the study of emerging vector-borne diseases. Utah State University, in conjunction with the Utah Department of Health, Bureau of Epidemiology, is continuing to conduct the Utah Tick Survey. The purpose of the survey is to discover if Lyme disease can be acquired in Utah, by collecting and testing ticks for the bacteria that causes Lyme. If ticks within Utah do test positive, it will allow health care professionals to make more accurate diagnoses and permit public health professionals to intervene and implement tick control programs, as well as provide tick safety education. The Utah Tick Survey is an important study in identifying the presence of Lyme disease in Utah and determining what future directions Utah must take to protect the public's health.

COMMUNITY DESIGN

The design and layout of Utah's cities and neighborhoods has a substantial effect on the health of all Utahns. Urban sprawl, inadequate public transportation and energy inefficient buildings not only affect human health but also have a distinct impact on climate change through the generation of greenhouse gas emissions. Greenhouse gases include water vapor, carbon dioxide (CO2), methane and nitrous oxide, all of which play an important role in regulating the Earth's temperature. These gases help create the greenhouse effect, a process in which greenhouse gases absorb infrared radiation from the sun and contain the heat in the atmosphere. When the amount of energy radiated from the sun to the Earth's surface and the amount of energy emitted into the atmosphere are equal, the Earth's surface temperature remains constant (EIA, 2004). However, in the last 150 years, roughly since the start of the industrial revolution, greenhouse gases such as carbon dioxide have rapidly increased in concentration in the atmosphere.

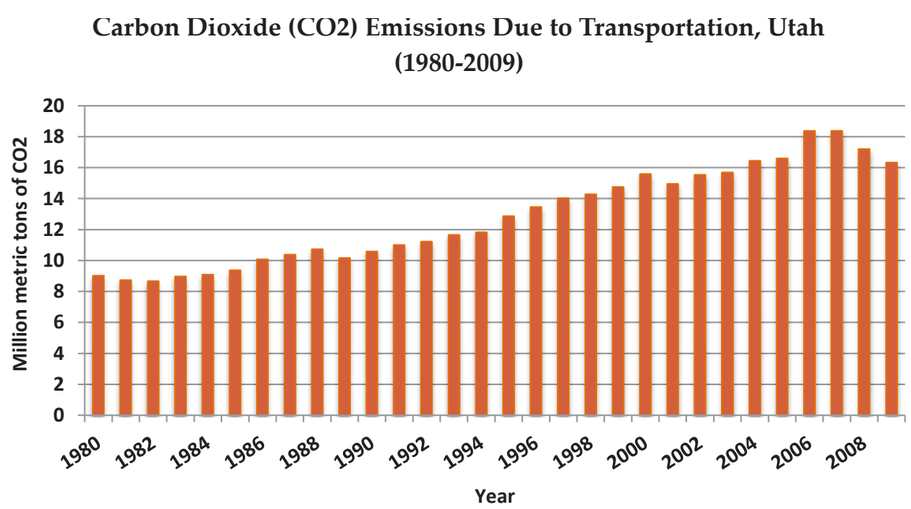
More greenhouse gases in the atmosphere, particularly carbon dioxide, will disrupt the balance between energy absorbed and energy emitted, causing greater amounts of heat to be trapped at the Earth's surface and ultimately increasing surface temperatures. Excess carbon dioxide emissions is strongly linked to human activities, primarily through the burning of fossil fuels. In fact, most greenhouse gas emissions in the United States come from energy use. Within the United States, carbon dioxide emissions from petroleum and natural gas represent 82% of the total man-made greenhouse gas emissions (EIA, 2004).

Increasing concentrations of carbon dioxide is a global concern. Globally, carbon dioxide emissions have increased by 1.3% per year from 1990 to 1999 and 3.3% per year from 2000-2006. Rising concentrations of carbon dioxide in the atmosphere has been the driving force for climate change and warming temperatures over the past 50 years (USGCRP, 2009). The following sections will discuss how different aspects of community design, such as transportation and buildings; influence the increase of carbon dioxide and other greenhouse gases and ultimately the overall effect on climate change.

GREENHOUSE GASES

GREENHOUSE GASES AND TRANSPORTATION

The location and interaction between highways, public transit and roads effect driving behaviors, which effects the amount of carbon dioxide emitted into the atmosphere. As of 2006, 28% of total greenhouse gas emissions in the United States came from transportation, while 94% of those emissions were from carbon dioxide (Younger et al. 2008). Commuting long distances to work, school, the grocery store and other destinations require Utahns to rely on vehicles, which contributes to the generation of carbon dioxide emissions. Mixed-use neighborhoods (communities that integrate businesses and residential buildings), biking or walking and utilizing public transportation are excellent strategies to reduce vehicle emissions. Yet, if community layouts do not promote alternative forms of transportation, technological advances for vehicles may help in reducing emissions. Strategies include the creation of low carbon fuels and improved vehicle design and technology (EPA, 2012). A reduction in carbon dioxide emissions due to technological advances or decreased vehicle usage has an affect on human health. Alternative modes of transportation, such as walking or biking provide needed physical activity and can reduce the risk for a variety of diseases. Furthermore, reduced carbon dioxide emissions can help prevent air pollutants from becoming trapped at the Earth's surface and causing respiratory infections and exacerbating asthma. Any reduction in vehicle induced carbon dioxide emissions can help mitigate climate change and improve human health.

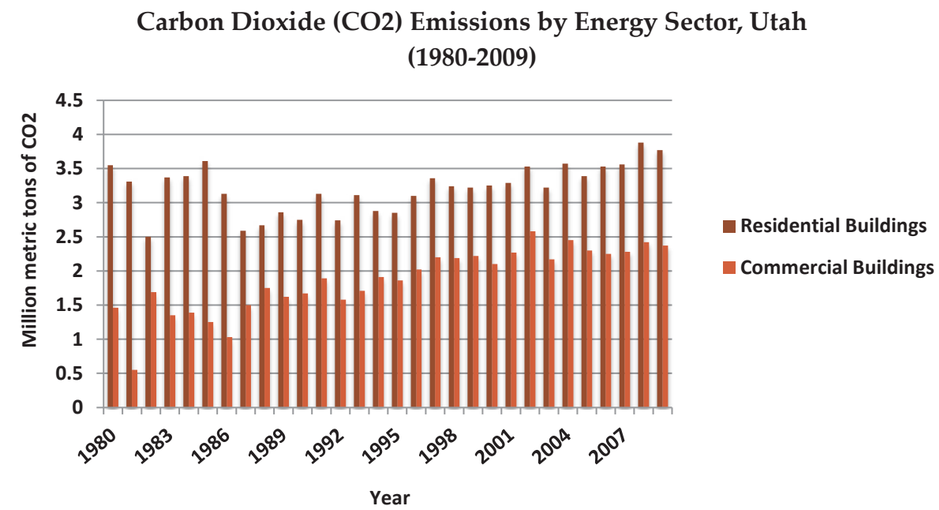


Information obtained from the Utah Geological Survey, Greenhouse Gas Inventories at geology.utah.gov/emp/energydata/ghgdata.htm

GREENHOUSE GASES AND BUILDINGS

Commercial and residential buildings use an abundance of energy and emit a large amount of carbon dioxide. In the United States, commercial and residential buildings (known as the building sector) use more energy than the transportation and industrial sectors and emit more carbon dioxide than both sectors. As of 1998, the building sector in the United States consumed 36% of the nation's energy and consequently, contributed to 35% of the carbon dioxide emissions (Battles & Burns, 2000). Within the building sector, electricity is a large source of energy consumption, which is fueled primarily by coal. By 2006, 83% of carbon dioxide emissions in the United States were generated by the electric power sector (Younger et al. 2008).

Not only does the use of electric power and other energy sources contribute to greenhouse gas emissions, the material used to construct the building, design and location of the building all have implications in terms of greenhouse gas emissions. Sustainable building materials and architectural designs that promote energy efficiency help reduce greenhouse gas emissions in the building sector. Additionally, electricity used for water, heating, cooling and lighting produce substantial amounts of carbon dioxide emissions. Engaging in efficient practices when using electricity for these purposes as well as utilizing energy efficient appliances can also help reduce carbon dioxide emissions among the building sector.



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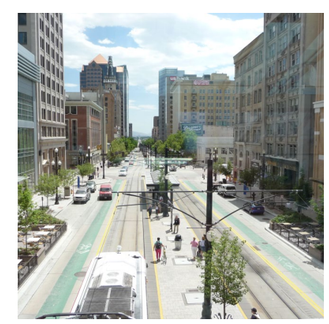
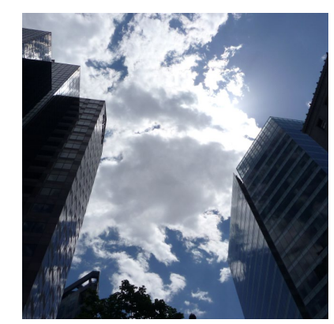




GREENHOUSE GASES FROM OTHER SOURCES

Although the transportation and building sectors emit the majority of greenhouse gases, there are a variety of other sources that contribute to the emissions problem. Deforestation and agriculture have been shown to play a part in the accumulation of carbon dioxide. Trees have the ability to absorb carbon dioxide, helping reduce total levels of greenhouse gas emissions. As of 2005, 85% of carbon dioxide absorption came from forests (Younger et al. 2008). Consequently, deforestation reduces the number of trees available to sequester excess carbon dioxide, increasing the levels of carbon dioxide in the atmosphere. Land use for agriculture plays a role in deforestation, but agriculture primarily contributes to greenhouse gas emissions from methane. In 2005, agriculture accounted for roughly 12% of total greenhouse gas emissions in the United States. Furthermore, as of 2006, 30% of methane emissions across the nation were attributed to agriculture (Younger et al. 2008). Reducing consumption and demand for meat could help reduce deforestation and methane emissions, ultimately leading to the reduction of excess greenhouse gases.

Other sources of greenhouse gas emissions come from manufactured chemicals that are released into the atmosphere. One chemical in particular, chlorofluorocarbons (CFCs), was used in the 1950s and 1960s in refrigerators, bug sprays, paints and a variety of other products. CFCs were inexpensive and effective to use, however it was discovered in the 1970s that CFCs were creating a hole in the ozone. Ozone is responsible for absorbing ultraviolet radiation and the depletion of the ozone allowed more ultraviolet radiation to reach the Earth's surface. In addition to the harmful health effect ultraviolet radiation can have, such as skin cancer, the depletion of ozone affects the temperature on the Earth's surface, contributing to climate change. Once the hole in the ozone was discovered, measures were taken across the globe to reduce CFCs, allowing the ozone to repair itself (NOAA, 1999). Many CFCs are now banned, diminishing the amount of CFCs emitted into the atmosphere. As CFCs continue to be phased out, the influence CFCs have on climate change will be minimal.

PUBLIC HEALTH'S ROLE

The Environmental Protection Agency (EPA) plays an important role in mandating regulations to reduce greenhouse gas emissions. The EPA is involved in many regulations such as improving fuel efficiency, reducing emissions from refineries and power plants and the creation of renewable energy programs. Aside from regulations, the EPA provides an abundance of information to the public regarding how to reduce carbon dioxide emissions at home, work, school and on the road. Furthermore, the EPA provides access to a greenhouse gas emissions calculator, which allows the public to calculate their household emissions and identify strategies to reduce emissions. The calculator and information on what you can do to reduce carbon dioxide emissions can be found at http://www.epa.gov/climatechange/wycd/index.html.

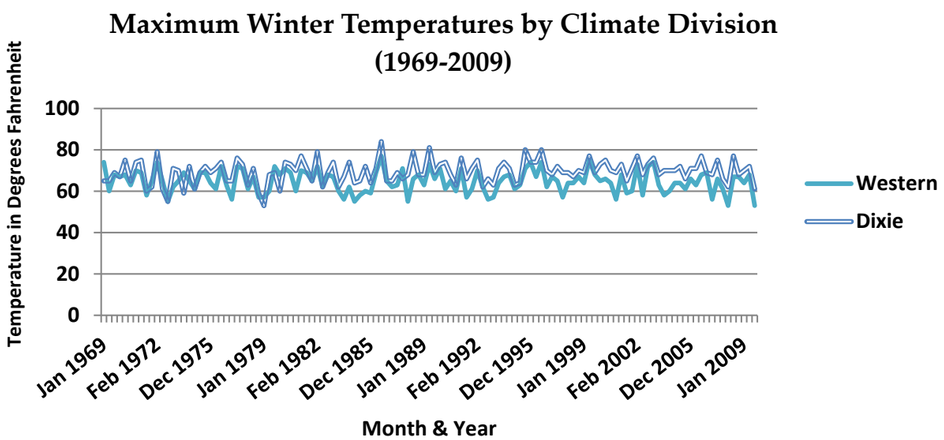
HOW PREPARED IS UTAH?

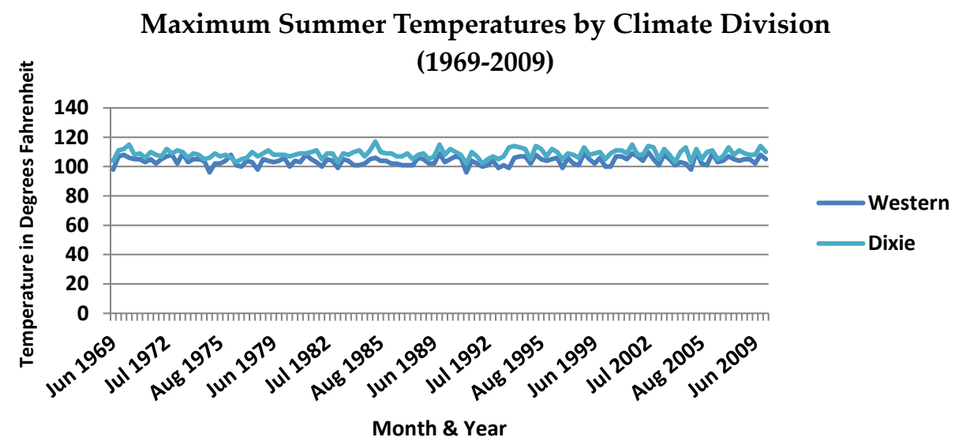
The EPA's State and Local Climate Energy Program provides analytical tools and other forms of assistance to identify and mitigate greenhouse gas emissions in Utah. Utah actively participates in many of the plans set by the program to reduce greenhouse gas emissions in the state. One plan, The Utah Energy Efficiency Strategy, was proposed in 2007 with a goal to support policies that reduce gasoline, electricity and natural gas consumption by increasing energy efficiency across the state by 2015. Another plan proposed through the Climate Energy Program was a greenhouse gas registry. The registry would require different sectors in Utah (i.e. industry) to report their greenhouse gas emissions to see if these sectors are emitting excess amounts of greenhouse gases. Utah is still in considering the registry. Additional information about all of the plans Utah participates in can be found at www.epa.gov/statelocalclimate/state/tracking/individual/ut.html#a04-a.

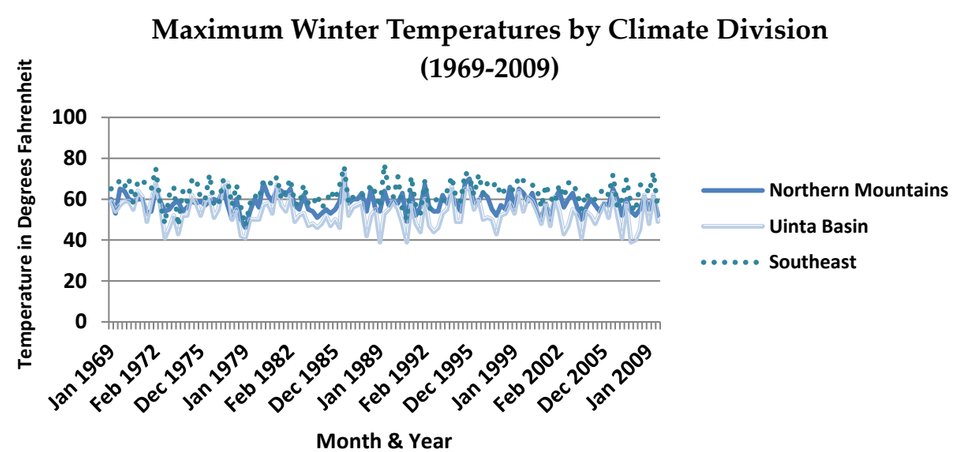
Work is also being done to reduce greenhouse gas emissions at the local level. The Utah Energy Conservation Coalition is a non-profit organization that provides training and education to builders and the public about how to create an energy efficient home. The goal of the organization is to provide tools to the public to make homes across Utah more energy efficient. The work done through the Utah Energy Conservation Coalition will help in reducing greenhouse gas emissions created by the building sector in Utah. Further information about the Utah Energy Conservation Coalition and how the organization can help your home become more energy efficient can be found at http://utahenergy.org.

APPENDICES

METEOROLOGICAL GRAPHS







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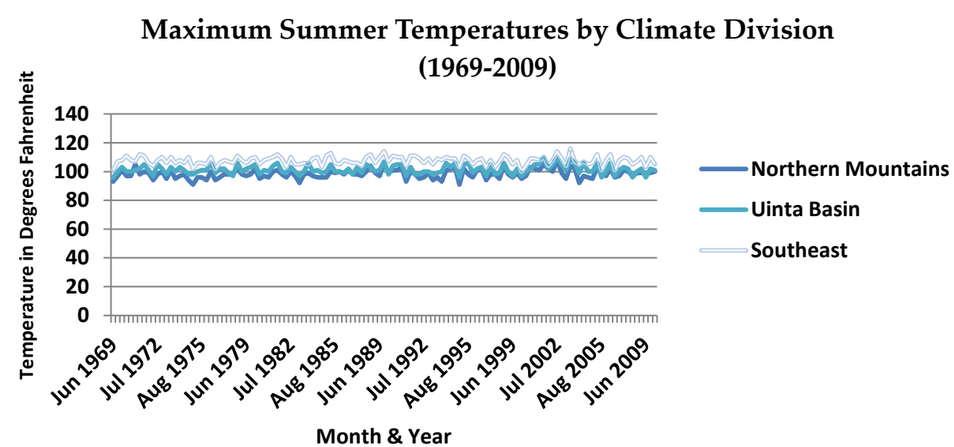

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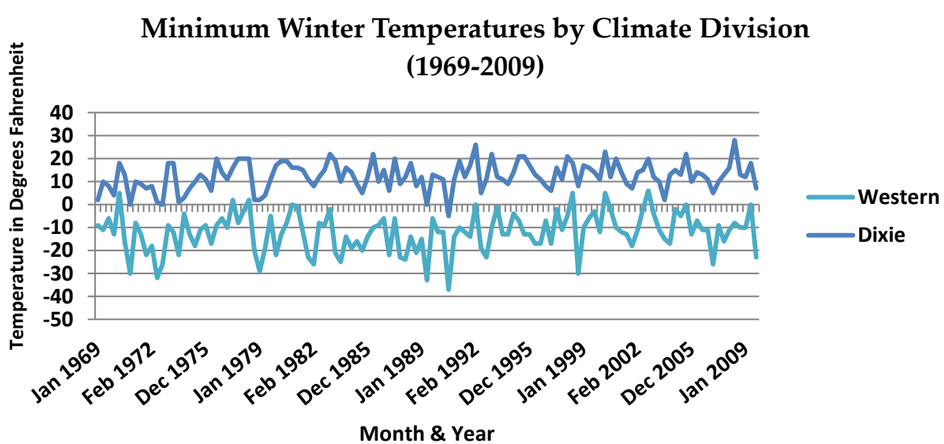

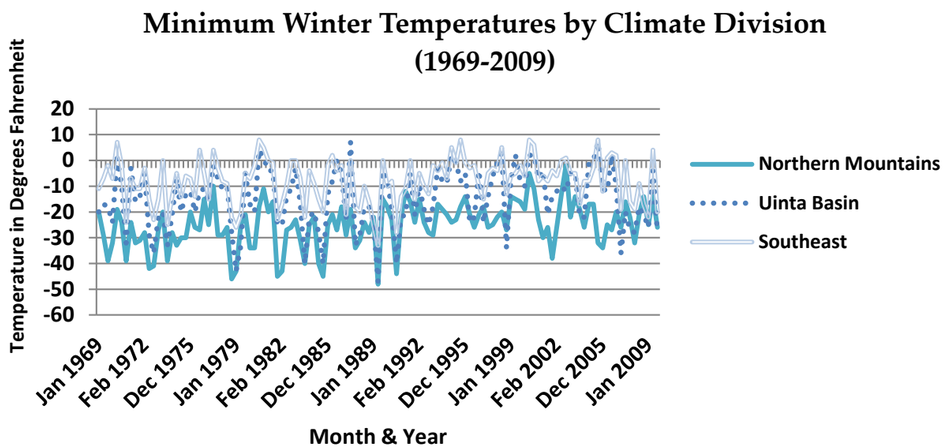

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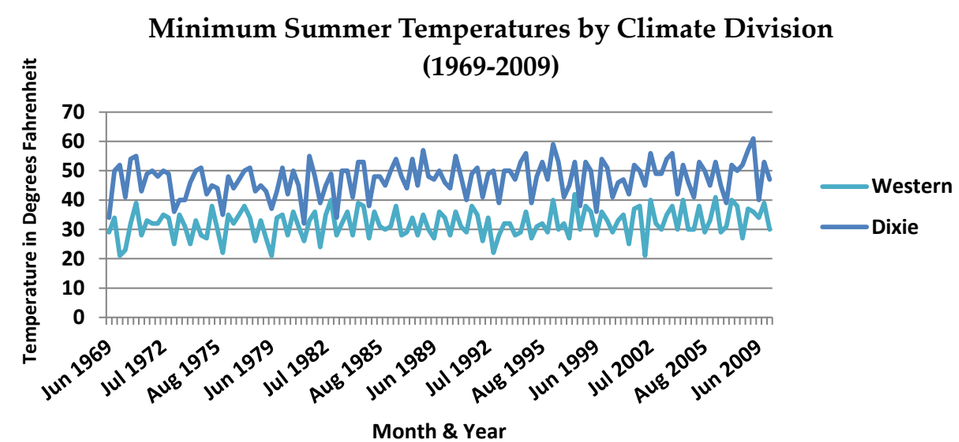

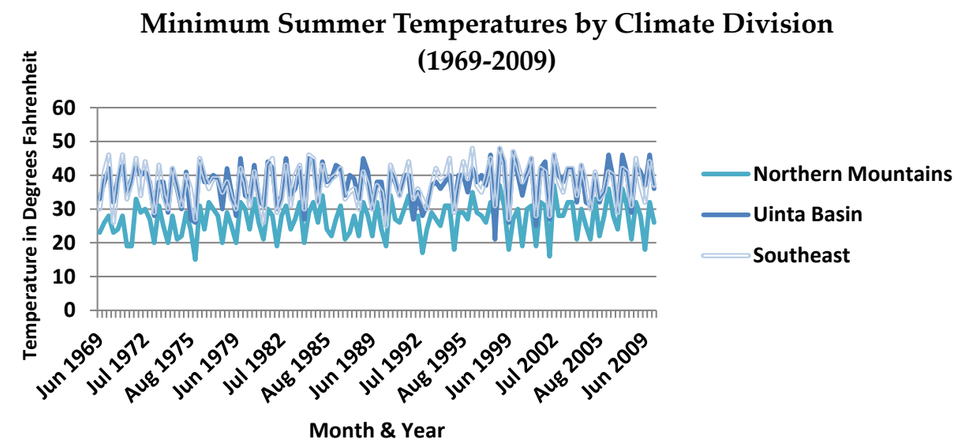

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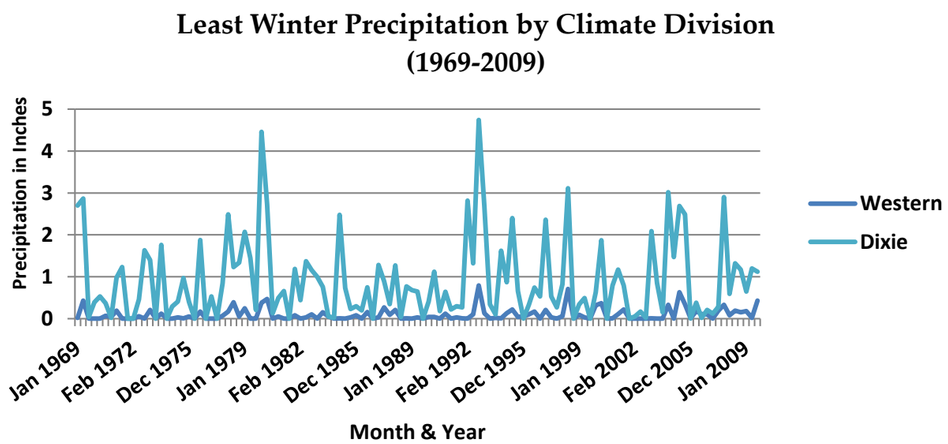

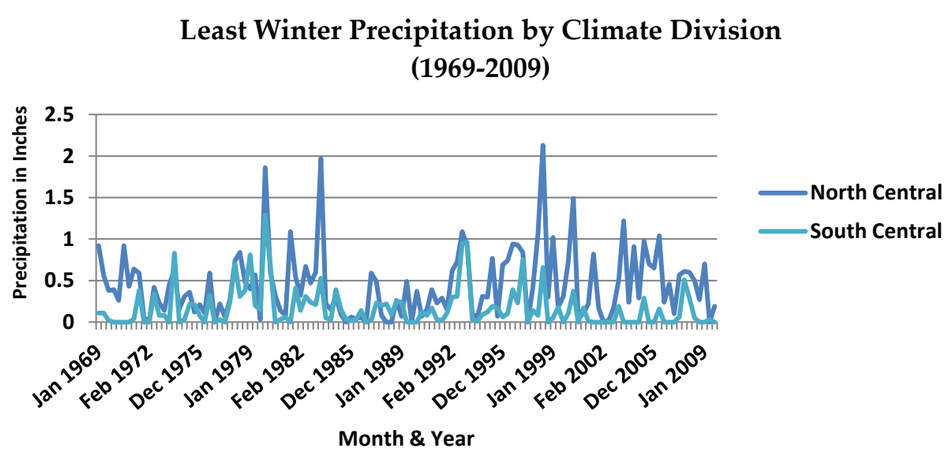

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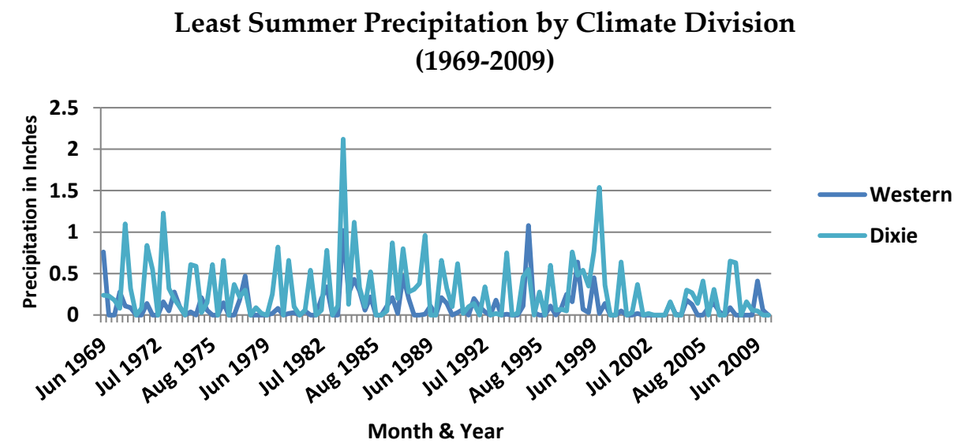

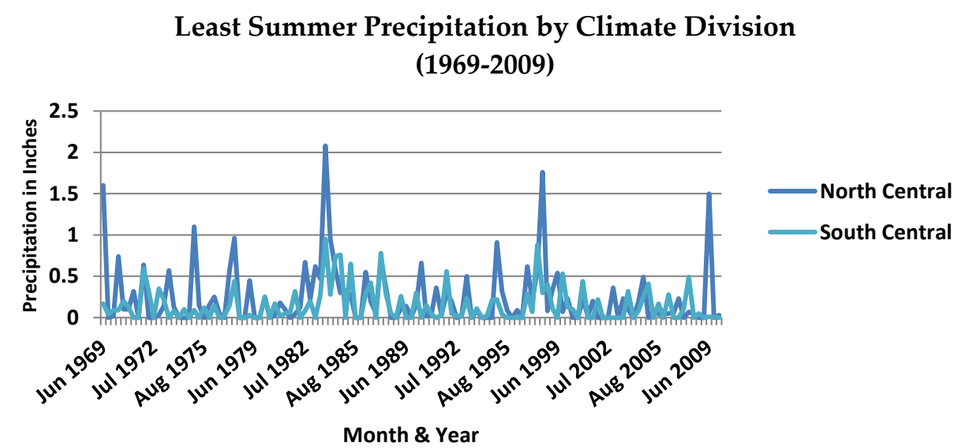

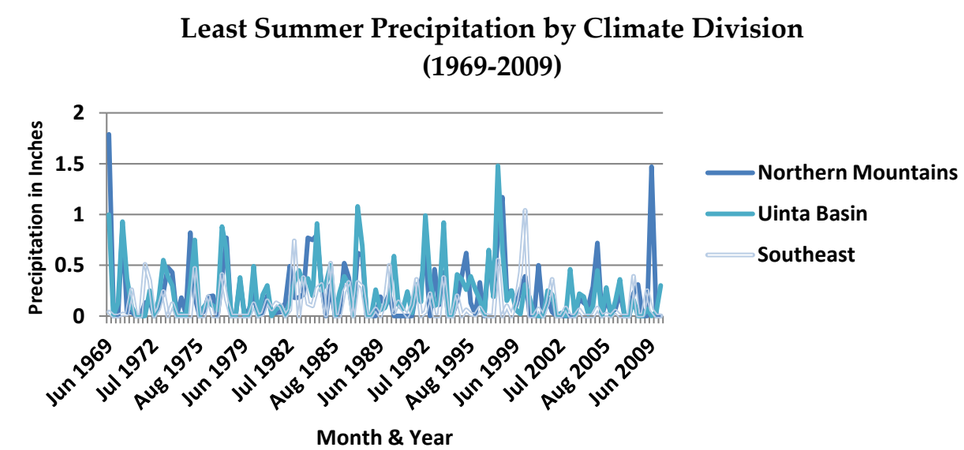

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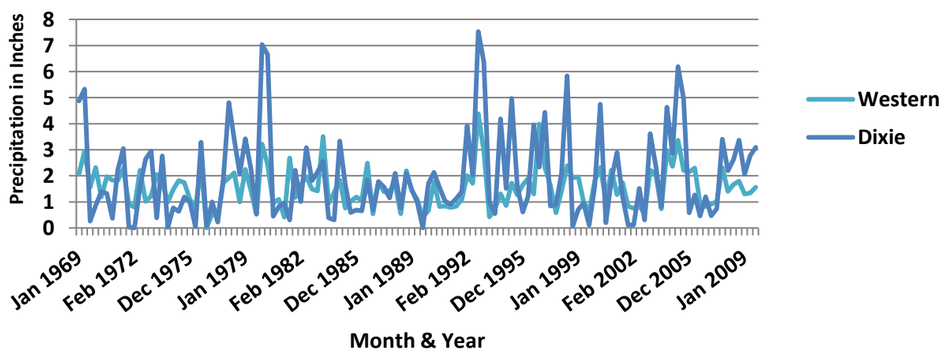
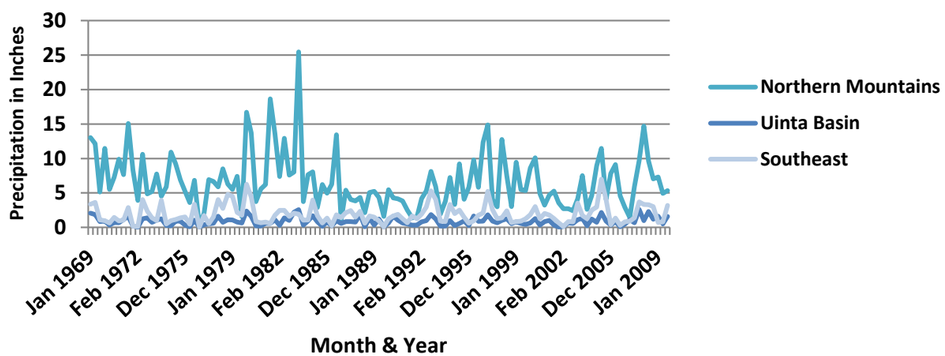
Maximum Winter Precipitation by Climate Division (1969-2009)



Maximum Winter Precipitation by Climate Division (1969-2009)



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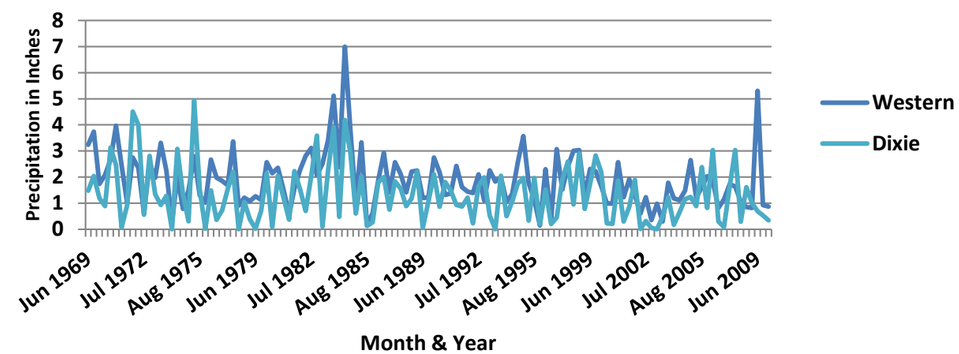
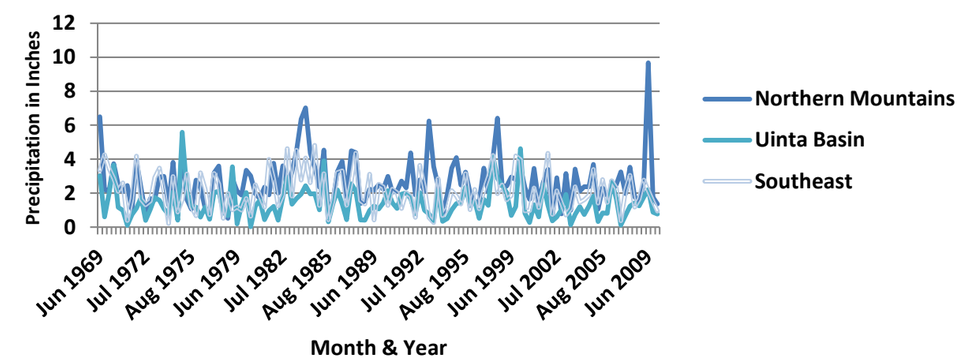
Maximum Summer Precipitation by Climate Division (1969-2009)



Maximum Summer Precipitation by Climate Division (1969-2009)



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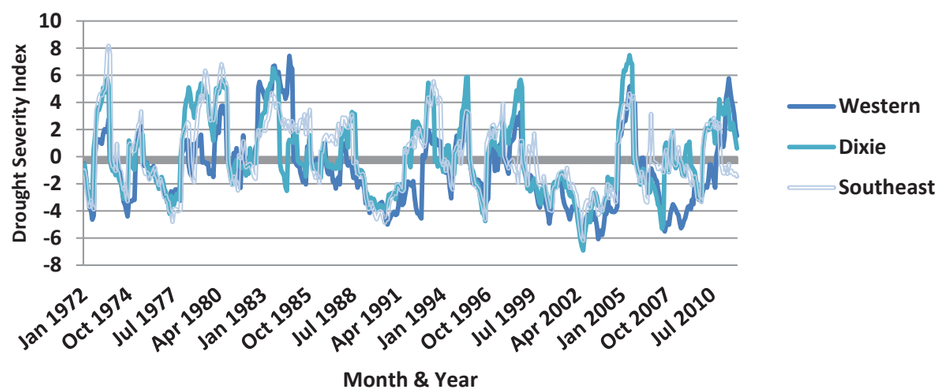
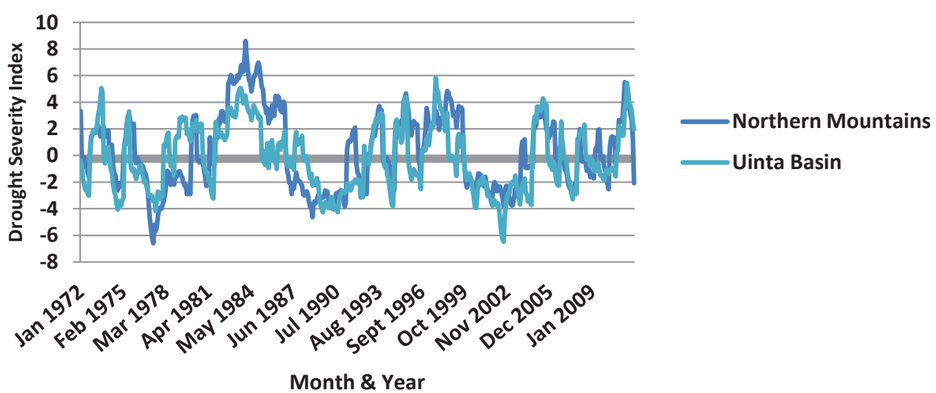
Drought Severity by Climate Division: 1972-2012



Drought Severity by Climate Division: 1972-2012



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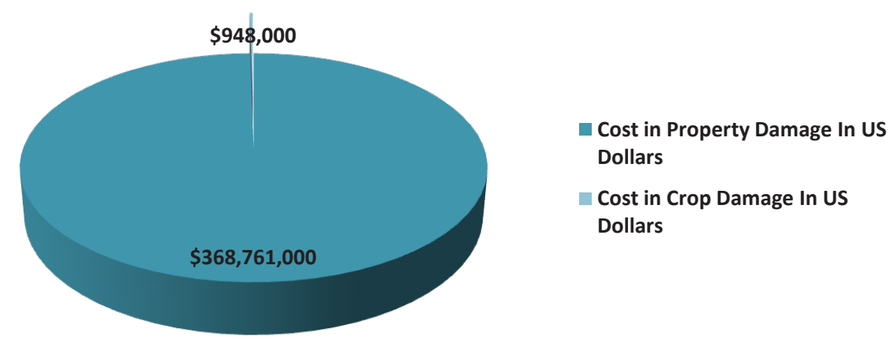
Cost Due to Flood Damage: Utah 1993-2011



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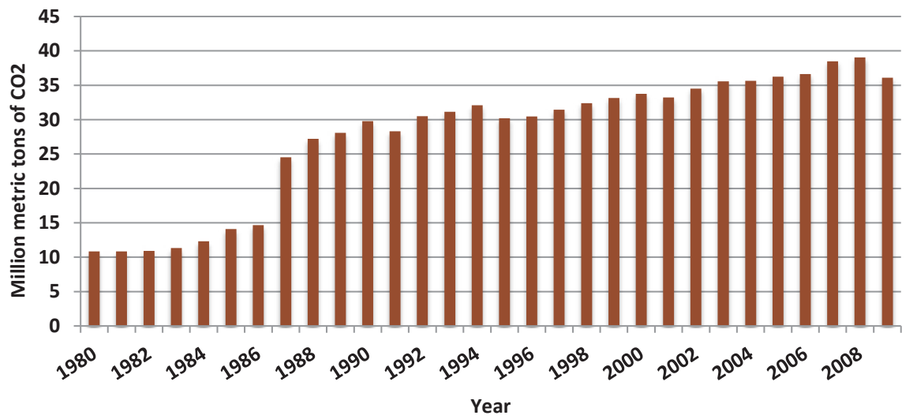
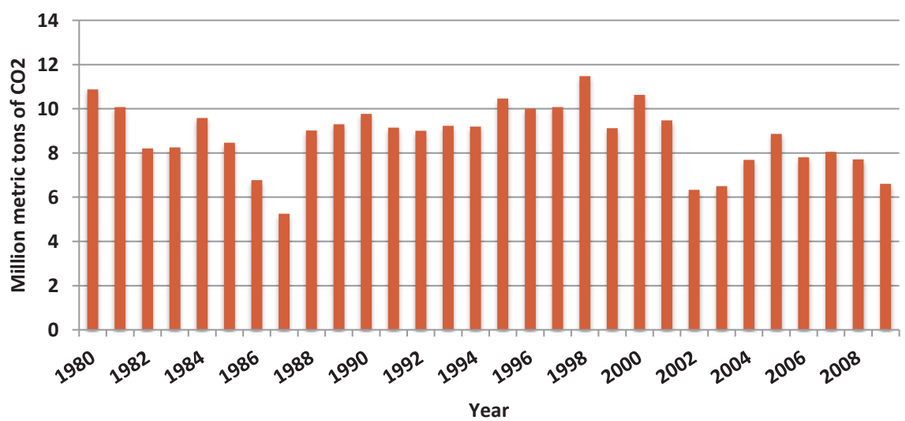
COMMUNITY DESIGN GRAPHS

Carbon Dioxide (CO2) Emissions Due to Electric Power, Utah (1980-2009)



Carbon Dioxide (CO2) Emissions From the Industrial Sector, Utah (1980-2009)



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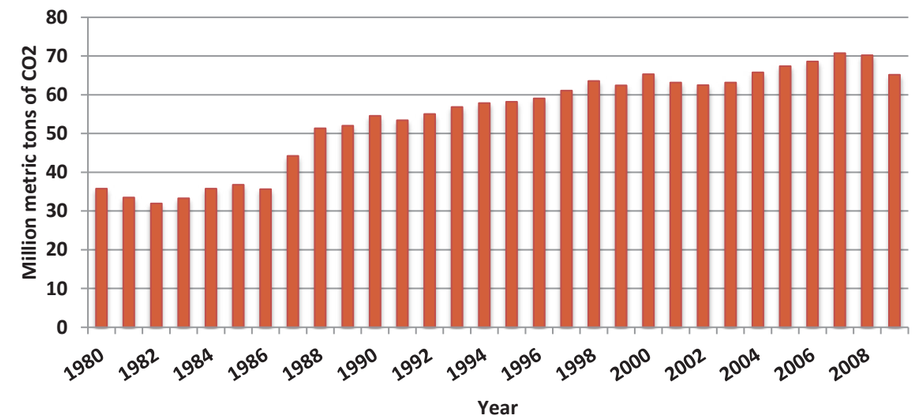
Total Carbon Dioxide (CO2) Emissions From All Energy Sectors in Utah, 1980-2009



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