

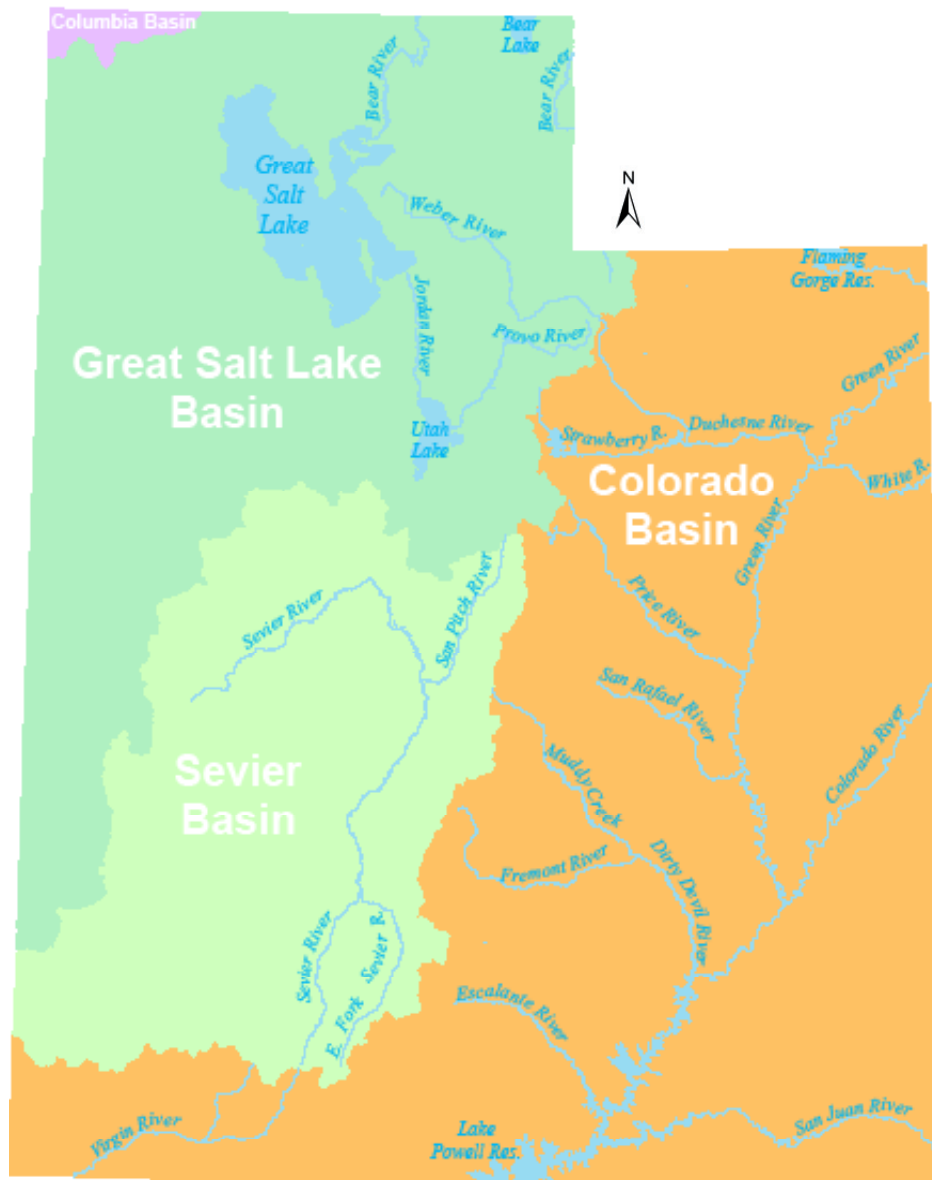
CROSSROADS UTAH



UTAH'S CLIMATE FUTURE

2012. 1st Edition

CROSSROADS UTAH



Contributors: Zachary Frankel, Gordon Rowe, Alex Schmidt, Nick Schou, John Weisheit, Michaeline Nelson, Andrew Myers, Kayla Weiser, Nicole Anderson, Ezra Nuttall and Matt Adolphson. Watershed Map by Gordon Rowe and the Utah Rivers Council. Landscape Illustrations by Parker Hinckley. Special Thanks to Jim Catlin, Kevin Mueller, Ray Bloxham, Heath Weaver, Tim Bardsley, Rob Gillies, Rob Davies, Ryan Pleune, Jamie Pleune for reviewing the report and offering material. Individual's appearance in this publication does not mean they support or approve of the editorial content of this report nor its recommendations.



Utah Rivers Council

1055 East 2100 South Suite 204
Salt Lake City, Utah 84106
801.486.4776
www.utahrivers.org

The Utah Rivers Council seeks to protect Utah's rivers and clean water sources for today's citizens, future generations, and wildlife.

Introduction: What is in Your Hands

Over the last 18 months, Utah Rivers Council staff and volunteers have been researching one simple question that has a myriad of complicated answers: What are the impacts of rising temperatures on Utah and what can we do to prepare ourselves for this future?

To answer this question we've digested scores of scientific papers, textbooks, agency publications and news articles. We've attended seminars, conferences and lectures to help us paint this picture in addition to having long conversations with prominent scientists, policy experts and academicians.

What you hold in your hands is the first edition of this answer and we intend to have many more editions. If you believe we missed something, let us know. We will update this report frequently because preparing for this challenging future requires asking and answering this same question again and again. Much of the purpose of this effort lies in getting your help in leading our State down the right path.

Everything in this report can be broken down into two concepts: information and corrective action. Understanding the impacts of warmer temperatures on Utah is as critical as knowing how our policies and behaviors make these impacts worse.

Yet we must do more than understand what's going to happen. We must act by engaging our fellow Utahns and their decision makers to be proactive and conservative. *Sections written in BLUE are action sections designed to translate what you hold in your hands into meaningful preparation to meet our challenging future.*

"I have been impressed with the urgency of doing. Knowing is not enough; we must apply. Being willing is not enough; we must do."
Leonardo da Vinci

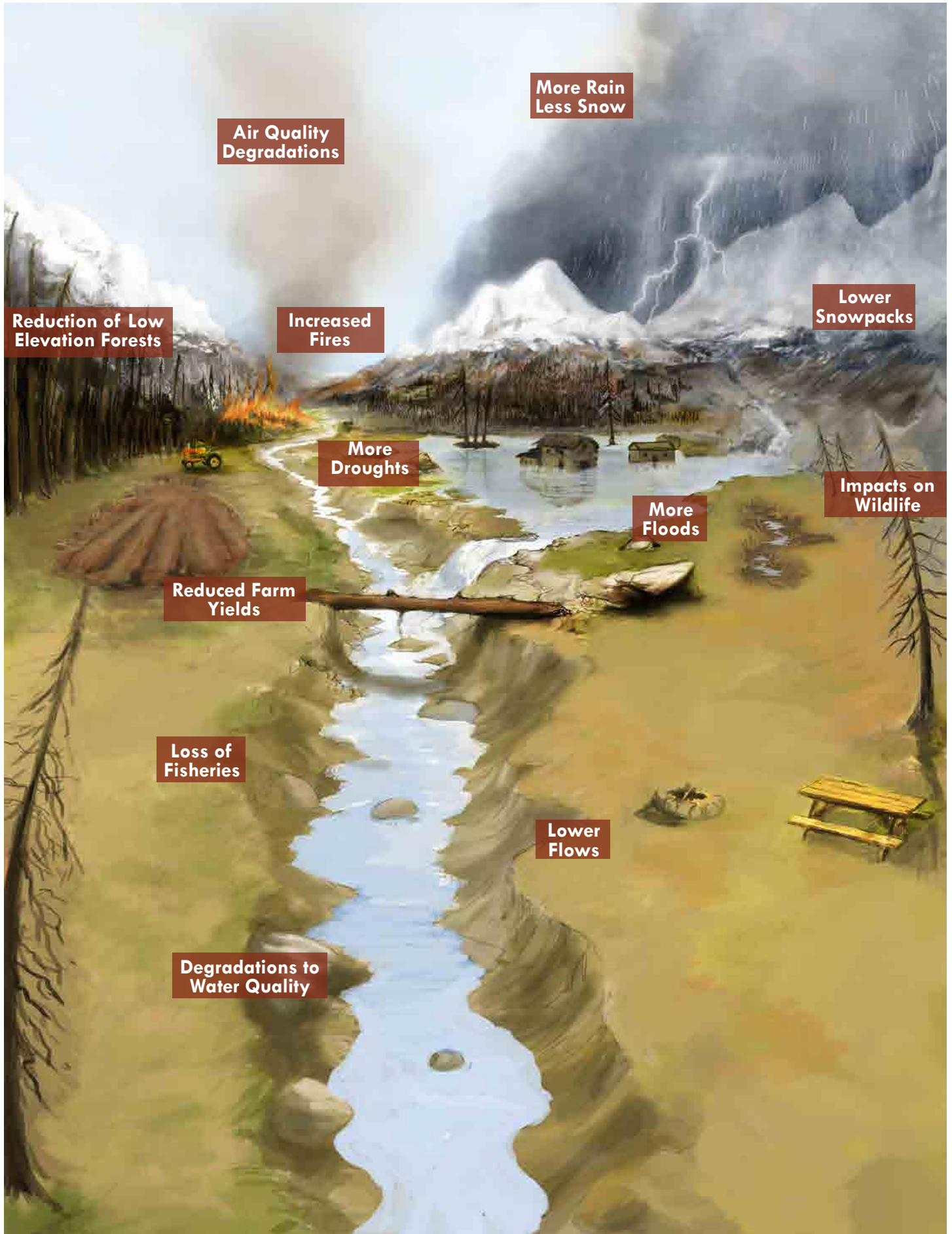
TABLE OF CONTENTS

Woefully Unprepared or Turning the Corner?	4
Rivers As Life Support Systems	6
Air Temperature Increases	8
Less Snow	10
Lower Rivers	14
3 Critical Water Problems in Utah	16
More Floods	20
Megadrought on the Colorado River	22
The Great Salt Lake & Bear River's Future	24
Utah Agriculture	26
Changing Forests	28
Water & Air Pollution Problems	29
Mining Bust for Utah?	30
References	32

Utah's Past



Utah's Future



Utah: Woefully Unprepared

Imagine you're in the back seat of a car speeding down a gravel road. As the car approaches a sharp corner above a cliff, the front seat passenger yells "Faster, faster!" leaving you with two choices: get the driver to slow down or take your chances by doing nothing. If the car goes off the cliff everyone will suffer, but slowing down will harm no one. This is the crossroads we find ourselves at today.

Behind the wheel is the State of Utah and so far the driver is speeding up, claiming there is no cliff. Regardless of what you "believe" about our climate, it is undeniable that Utah's temperatures have risen dramatically over the last 30+ years. This temperature increase creates a cascade of impacts to Utah's watersheds that have major economic impacts to all of us. Make no mistake – it's a cliff.

While other states prepare for warmer temperatures, Utah insists on making risky choices out of hubris that threaten everyone's well-being. The catch is we can't just understand the problem, we must act to change the driver's behavior because knowledge without action is akin to ignorance. The time to debate has passed, the time to prepare has begun.

So far Utah is woefully unprepared for the impacts of warmer temperatures. A study by NRDC graded Utah as being one of the 7 least-prepared states for the challenges of the 21st Century. Rising temperatures impact all sectors of Utah including health care, agriculture, real estate, water supply and recreation. The economic costs of these impacts can be mitigated, but only if we respond appropriately.

Recently, the Utah Department of Health published a great study exploring the impacts warmer temperatures will have on Utahns' health. This excellent summary explores these impacts and offers actions people can take to protect themselves and their families. Health leaders are providing proactive leadership by choosing a conservative and intelligent response to an obvious problem.

By contrast, another State agency, the Division of Water Resources has chosen a risky behavior by refusing to consider the impacts of warmer temperatures on Utah. To understand how risky this denial is, consider that rising temperatures alter the fundamental source of our existence in Utah – our snowpack. Snowmelt provides over 80 percent of the Wasatch Front's water but there is less snow and it's melting earlier.



or Turning the Corner?

Do we prepare ourselves for rising temperatures or should we risk grave harm to ourselves by ignoring how we are aggravating this crisis?

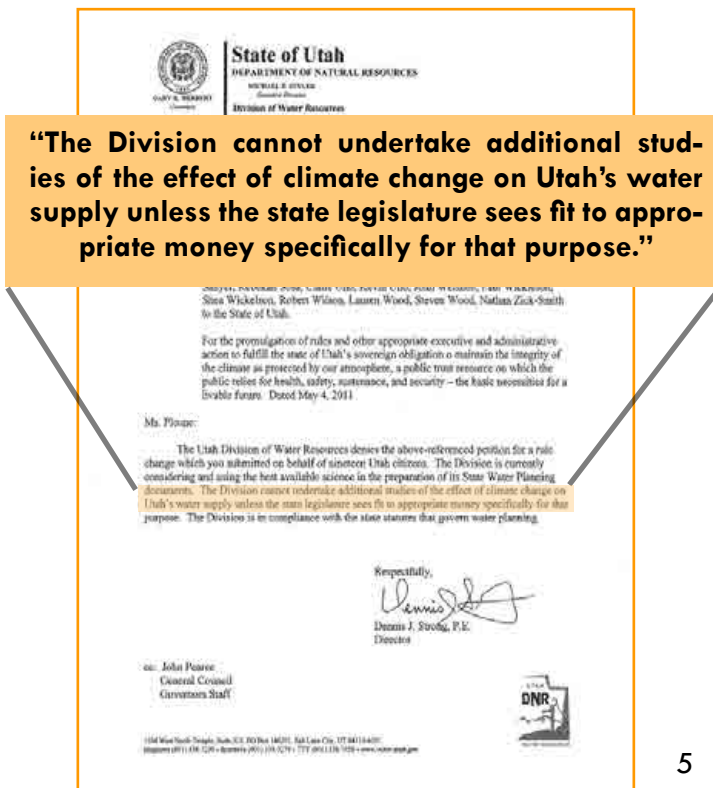
Although Utah is the second most arid state in the nation, the Division of Water Resources refuses to study how less snow will impact our water supply. Worse yet, Utah is America's most wasteful water user but this same agency encourages Utahns to waste water. This is done by the agency's advocacy of keeping Utah's water rates the cheapest in the U.S. Cheap rates seem like a good deal until one realizes Utahns pay hundreds of dollars in property taxes each year to lower the price of water, thereby encouraging waste.

As neighboring states eagerly push residents to reduce water waste with good rate structures, rebates and enforcement programs, Utah enables water waste by invoking "Strong's Law," named after the Director of Water Resources. This "law" is that 'Water conservation requires something to die.' Such a claim infers that all water used in Utah is done so with 100 percent efficiency, which is wishful given the abundance of neighborhood gutters gushing with water on any summer day.

These two agencies perfectly symbolize the crossroads we find ourselves at as a State and as individuals. Should we choose a path of great risk, or should we choose the safe, conservative path? This report is full of choices for you to make. Getting involved is the safest path for all of us.

Dangerous Behavior. *Division of Water Resources letter refusing to consider the impacts of an ~8°F temperature increase on Utah's water.*

Proactive Leadership. *2012 Utah Department of Health study exploring the impacts of rising temperatures on Utah's health.*



Rivers As Life Support Systems

Utah's rivers are more than just water sources and trout streams. Rivers are life-support systems that keep most fish and wildlife species alive in our state. Utah is America's 2nd most arid state and why 80 percent of our wildlife species depend on rivers for a portion of their life cycles. Saving life from extinction in Utah means saving our rivers from being dried up.



For fish and amphibians, rivers provide essential aquatic habitat for survival. Large mammals use rivers for migration corridors and as water sources which explains why elk in western Montana spend 80 percent of their time in summer within one-fourth a mile of permanent water. In mid-summer, Pronghorn antelope in Utah consume 1.2 gallons per day, often staying within 4 miles of a water source.

Utah's rivers are essential to life in part because of the corridor of diverse vegetation they support called a riparian zone. Although accounting for only 7 percent of Utah's landscape, more wildlife species use riparian areas than all other habitat types combined.

Riparian zones provide important nesting and prey habitat for avian species explaining why bird densities may be twice as high in riparian areas as in upland areas. In the arid Southwest, over 75 percent of all bird species nest primarily in riparian zones. Around 80 percent of neotropical migrant songbirds depend on riparian woodlands for nesting.

People are often shocked to learn Utah's rivers have no legal right to exist. Our rivers are someone's water rights headed downstream and why the majority of Utah's fisheries are dried up for agriculture, municipal use or waste. In Utah, municipal and agricultural diversions partially or totally dewater 53 percent of the State's 6,281 miles of fishery streams. As we divert, dam, and channel rivers, the future of aquatic species grows more and more uncertain. This is largely why almost half of all endangered species live in fresh water.



Good Conservation is Good Economics

“Sound conservation policies are essential to Utah’s quality of life and our economic future. Fishing alone generates over \$700 million annually in revenues to the state; revenues that eclipse hunting and often skiing. These watersheds also create additional recreational opportunities, jobs and combined billions to the state of Utah. Given the scarcity of water in Utah compared to many of our neighbors its critical that we put sustainable water resource policies in place to protect our quality of life, those related jobs and the revenues our water resources generate. Careful stewardship of our water resources isn’t a luxury, it’s essential to our states economic future.”



Steve Schmidt
Owner
Western Rivers Flyfisher

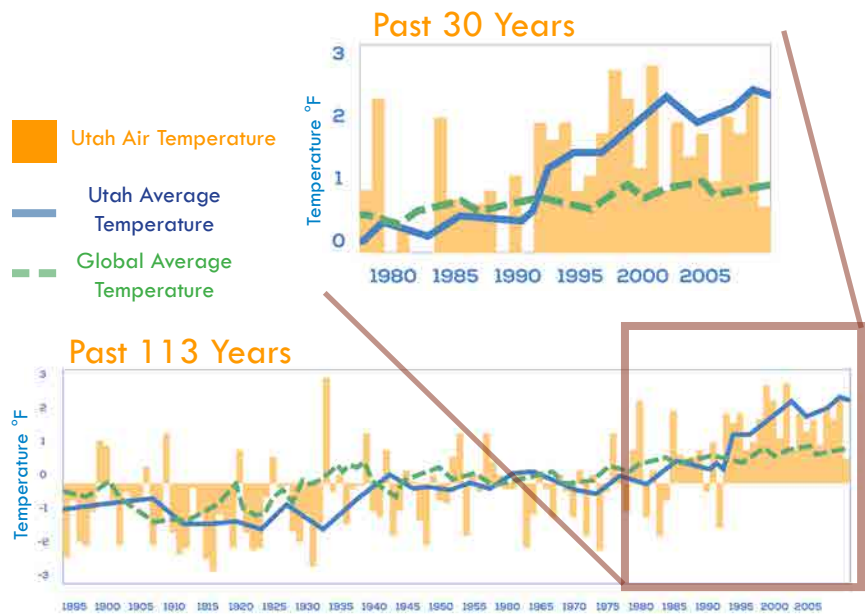
Utah has one of the worst records for river protection in the West. Many in the water development industry scare the public and decision makers into believing Utah must divert its rivers to survive through fear and misinformation. This is why in 2012 there were 850,000 acre-feet of proposed water diversions in Utah, enough for a city of 4 million people for a year. In the face of these threats, Utah can offer virtually no river protection – no permanent instream flows, no state river protection statutes, virtually no leadership to protect Utah’s aquatic ecosystems.

How Warm Will Utah Get?

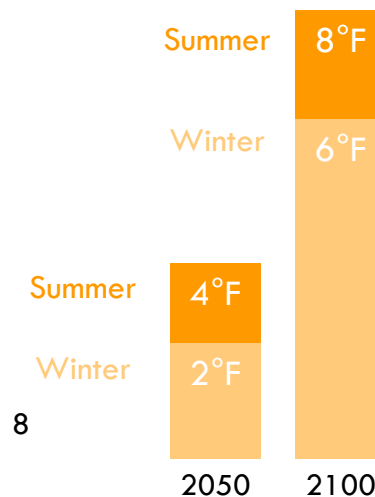
Over the past 100 years, the Earth's average temperature has increased 1.3°F. Utah's distance from the ocean's cooling effects makes for larger temperature increases than the global average. That's why Utah's average temperature has increased roughly twice as much as this global average increase over the same period, by about 2.7°F.

By 2050 it has been estimated temperatures in Utah will be ~2°F higher in winter and ~4°F higher in the summer compared to current temperatures. By 2100 average air temperatures in Utah may increase by ~6°F in winter and by ~8°F in summer from today's temperatures. This is an enormous temperature jump that will have serious impacts to Utah's watersheds. Warmer temperatures trigger a cascade of impacts our State must respond to both in how we manage our watersheds and in our land and water policies.

The Past:
*Utah is Warming
 Faster than the
 Global Average*



The Future:
*Temperatures Will
 Get Even Warmer*



A Few Degrees, What's the Big Deal?

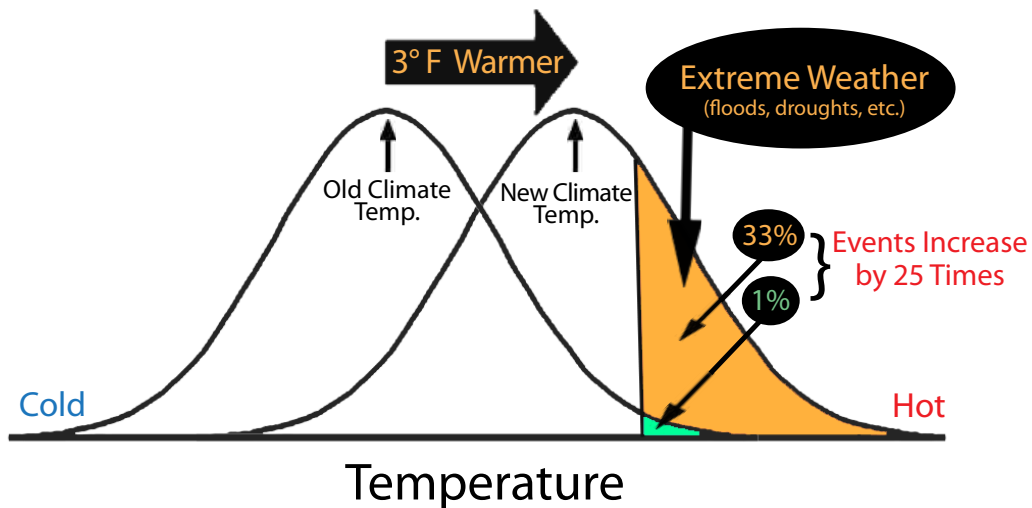
A few degrees warmer might seem like a small change, but it has big repercussions on Utah by increasing the chances of extreme weather events like floods, droughts and heat waves. The following example illustrates how a small shift in temperature can have big consequences. Suppose when the average temperature is 59°F there is only a 1 percent chance of experiencing an extreme event shown below in bright green at the bottom right of the bell curve, below. We could pick any extreme weather event, but let's use a drought that only occurs once in 100 years.

When we increase the average air temperature by just 3°F, our chance of having a drought is now 33 percent, or 1 in 3 years, as shown in the orange section of the bell curve. Simply by using the same distribution and shifting the average by "just a few degrees" a seemingly small temperature change caused a 25 fold increase to the frequency of an extreme drought. The severity of extreme weather events has also increased dramatically.

This concept applies to floods, heat waves and wildfires meaning we need to think carefully about how to prepare for more risk. Extreme climate events are already occurring in more intense and frequent intervals. According to NOAA, July 2012 was the hottest month ever recorded in the lower 48 states.

Below: Dramatic increase in extreme weather events caused by simply warming average temperatures by 3 degrees. This shift increases the frequency of such events from once every 100 years (green) to once every 3 years (orange).

Extreme Weather Events Increase 25 Times from a 3°F Increase



The Impact to Utah's Most Precious Resource:

Cities and towns across the American West owe much of their existence to snow and Utahns are no different. Over 80 percent of the Wasatch Front's water comes from snowmelt which is why one of the biggest impacts of rising air temperatures is the havoc it wreaks upon our snowpack. Warmer winter air temperatures create a cascade of problems with precipitation patterns that will reverberate across Utah's watersheds.

Warmer air means precipitation will come more frequently as rain and less as snow. Several studies have found that spring snowmelt is occurring earlier by 2 – 4 weeks. This reduces the number of calendar days in which snow accumulates. Recent Utah studies now document a reduction in total snow cover and snow depth. Increased air temperatures reduce the amount of snow in our watersheds in part because warming raises the rain/snowline. In other words, the elevation where freezing occurs is rising, thereby decreasing the total watershed area covered by snow.



Climate models indicate there will be a slight increase in winter precipitation levels with different projections between Southern and Northern Utah. Summers in both Southern and Northern Utah are likely to see less precipitation. During winter, Southern Utah may see the same

level of precipitation whereas Northern Utah is projected to see an increase in precipitation on the order of 10 – 15 percent. Unfortunately, it seems unlikely that this relatively small increase will compensate for the many other changes expected to our snowpack.

An analysis of snowpack between 1979 and 2008 in both the Ben Lomond watershed and in the Oquirrh Mountains made some startling estimations. Leigh Jones estimated there would be an 8 – 10 percent decrease in snow with each 1°C in warming of the air mass above the surface, called the troposphere.

Below: Research by Jones et al, estimating decreases in snow precipitation as a function of rising air temperatures in the atmosphere. Bottom right: predictive maps showing shift from snowfall to rain at different elevations in the Central Wasatch Mountains.

Loss in Snowfall anticipated by Temperature Increase

Temperature Increase in Troposphere	Decrease in Snowfall
+1°C = +1.8°F	8 – 10 % decrease in snow precipitation
+2°C = +3.6°F	16 – 20 % decrease in snow precipitation
+3°C = +5.4°F	24 – 30 % decrease in snow precipitation

Snow

Time to Face the Music

"Utah's climate is like music. Its driven by harmonics from different frequencies that can be broken out and reconstructed to form the whole just like instruments in a symphony. We're trying to put all the elements together to understand outcomes and make predictions about the next few movements we will experience. The climate symphony is definitely changing and we need to be ready for these changes. Observation records show the snow cover across Utah has decreased 35 percent over the past 50 years, alongside a declining snow depth and a 9 percent decline in the snow precipitation ratio. This new music may force us to reexamine some water policies in the West. For example, the laws around the Colorado River were based on a very wet period and states like Colorado, California and Nevada may not be able to take their "shares" because the water that is available will not be adequate."

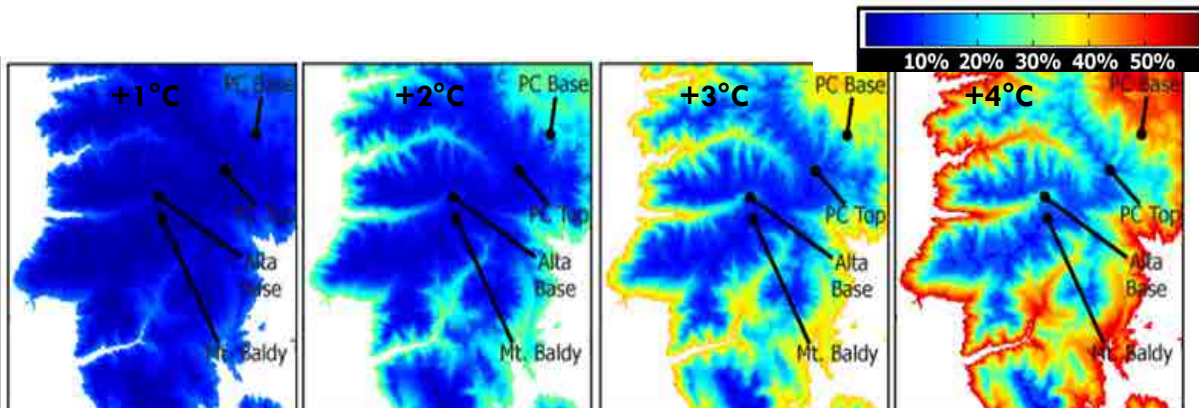
Robert Gillies
State Climatologist and Director,
Utah Climate Center



Photo Courtesy Utah Agricultural Experiment Station

Map of Snowfall Sensitivity as a function of Increased Temperature

Percent of snow that will instead
fall as rain with warming



Melting Park City's Economy

“We’re passionate about the mountains in which we live, work and play. Preserving and enhancing the active lifestyle and mountain experience for generations to come is part of everything we do. Snow is essential to not just our business model but in supporting all life in the mountains. The study Park City Mountain Resort and Powdr commissioned is an effort to increase awareness about global warming. By 2075, climate change could result in the sustainable snow level at Park City to be at 9,500 feet and by 2100 the level could be up to 10,200 feet. With the highest peak at Park City Mountain Resort at 10,000 feet, the impact to our economy will be hundreds of millions of dollars. If these effects become reality the loss of our ski industry is the least of our problems. Snow is water and water is life.”

Park City Mountain Resort’s 2009 study evaluated the impacts of warmer temperatures on their snowpack and the economy that depends on it. All scenarios point to serious snowpack loss over the next 65 years. The base area may not have a skiable snowpack for Thanksgiving and spring break. This shorter season excludes some of the winter’s most profitable weekends which will have a big impact on Summit County’s economy, as the table below shows.

Brent Giles
Chief Sustainability Officer
POWDR
Park City Mountain Resort

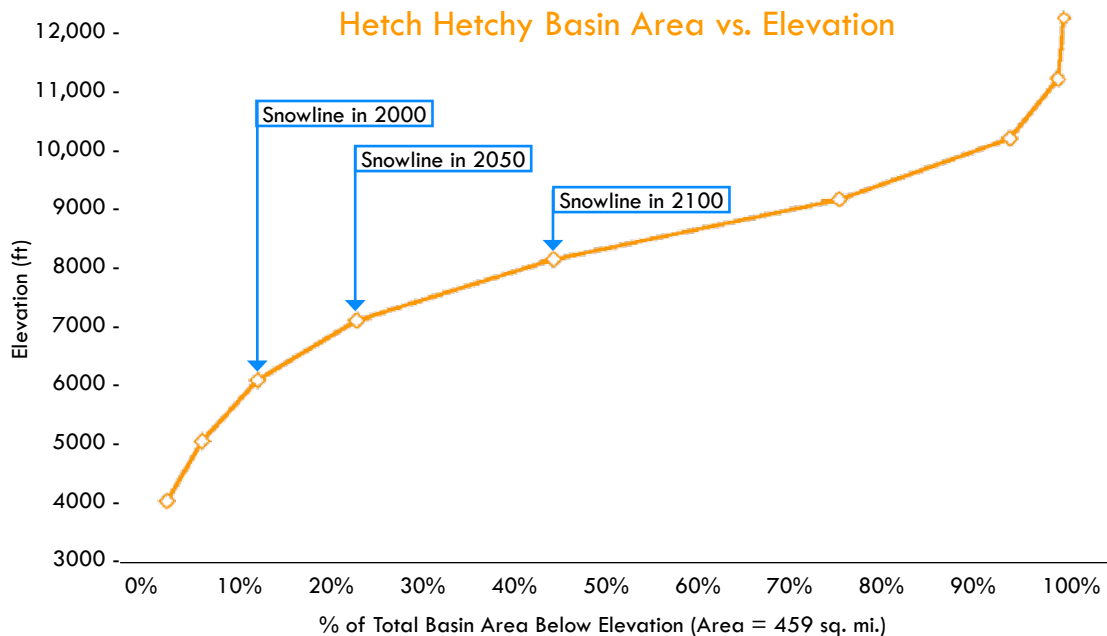
Economic Impacts of Snowpack Loss to Summit County

Climate Scenario	Snowpack Change	Lost Skier Days	Lost Labor Income (\$)	Lost Jobs
2030	-15%	152,453	20,361,574	1,137
2050 Low	-27%	203,800	27,219,466	1,520
2050 Middle	-34%	336,665	44,964,935	2,511
2050 High	-43%	498,353	66,560,052	3,717

What Should We Do About Less Snow?

A 2008 study of the Hetch Hetchy drainage in Northern California is an excellent example of what every Utah water supplier should be asking themselves. This study examined the total reduction in snowpack within the watershed as a function of increased air temperatures.

Since Utah is the 2nd most arid state in the nation and we can expect less snow at the end of each winter, one wonders why every water supplier in Utah isn't studying their watersheds to determine how much less runoff they can expect in the future. Most Utah water suppliers are years behind in determining the impacts upon their watersheds and their customers. It is time for these agencies to estimate how much less water they will receive in coming years.



The 2008 study by Hetch Hetchy Water & Power shows the total reduction in snowpack in the Hetch Hetchy Basin of California as a function of rising snowlines and temperatures. To date no Utah water supplier has completed similar studies.

Ask Your Government Water Supplier for Some Accountability

Your water district is a government agency created to serve you. They collect your property taxes and are subject to oversight by the public and the Utah Legislature. Has your water district started preparing for rising temperatures and less water? Write them a letter and ask them why they have not studied the impacts of less snow in the coming years.

Less River to Go Around

Aquatic ecosystems in arid Utah will be heavily impacted during the driest of months by a cascade of problems caused by rising air temperatures. Several studies estimate a decline in trout habitat of anywhere from 40 to 50 percent around mid-century, depending upon how warm temperatures become.

Increased air temperatures mean increased water temperatures which makes it harder for fish and other aquatic species to breathe because warm water holds less dissolved oxygen than cold water. Further, since fish cannot regulate their body temperatures they contend with warmer waters by swimming upstream to cooler flows, spelling problems for fish encountering barriers upstream. It also means greater habitat competition in high-elevation streams, posing threats to native fish such as cutthroat trout residing in headwaters.

A 2006 study found that warmer flows also reduce the size of mayflies and the timing of their hatch. As mayflies are one of the food sources of choice for trout this is another pressure upon these fish. The increase in winter time flooding impacts fall-spawning species such as brown trout because they are susceptible to winter high flows. Finally, the increase in fires leads to an increase in sedimentation in streams and a reduction in riparian tree cover, which further increase stream temperatures.

These impacts combine to reduce the quantity and quality of fish habitat across much of the West. Since cutthroat trout have already seen dramatic reductions in range due to both habitat alteration and competition with nonnatives, their survival could be in jeopardy.

Given that warmer and drier summers lead to an increase in water demand, there will be a greater impact of human diversions on aquatic ecosystems when our rivers are at their lowest volumes of the year. Yet relatively little scientific research has examined flow changes to Utah's rivers as a function of rising air temperatures. Since Utah is the 2nd driest state in the country, this is one of the biggest needs facing the management of Utah's rivers and fisheries.

Right: Predictive study on habitat reduction to trout species from increased water temperatures, flooding and fires by Wenger et al. Protecting existing, high quality fishery habitats is an important strategy in managing the impacts of rising temperatures.

Fishery Impacts from Warmer Temperatures

Species	Habitat Reduction by 2040	Habitat Reduction by 2080
Brook Trout	-44%	-77%
Brown Trout	-16%	-48%
Cutthroat Trout	-28%	-58%
Rainbow Trout	-13%	-35%

Higher Temperatures Spread Whirling Disease

New studies indicate the fish parasite known as whirling disease may increase in distribution in the future because of rising stream temperatures. Whirling disease affects many wild fish species including salmon and trout. While the parasite is not transferable to humans, it slowly attacks the nervous system of the fish, eventually making feeding nearly impossible. Warmer temperatures force trout to migrate upstream to cooler habitats thus increasing the disease's distribution. Worse yet, studies have shown that fish are more susceptible to the disease in warmer waters.

Let the Market Protect Utah's Rivers with Instream Flows

Protecting Utah's rivers with permanent protection is critical to ensuring the survival of Utah's fish and wildlife and the economies that depend upon them. Unfortunately, Utah has created very few tools to protect rivers for future generations. One problem is that Utah water law does not recognize water in a stream needed by fish and wildlife as a 'legal' use of water. Other states recognize the legal value of such rights, called instream flows.

This means is that cities and farms conserving water cannot put surplus water into a stream running through their property or else they may lose this water to those who want to divert it. This is because some in State government believe the legal right to use water should only be granted to entities seeking to divert it, not leave it in the river.

The State is preventing the free market from allowing a willing seller to freely enter into a contract with a willing buyer.

Instream flow rights allow landowners, businesses and municipalities to ensure the existence of valued streams with a permanent water right. Such legal recognition is a market-driven, low cost means to ensure ecosystems exist without taxpayer investment. A market exists to buy this water, if the State would only get out of the way.

Despite support from landowners and a successful lobby effort by various groups including the URC, just two Utah agencies have the authority for instream flows and they have done so on only 7 stream segments. 'Trout fishing groups' are allowed to file a change application but only to benefit native trout species and only for a short period of time – it isn't permanent.



What does your legislator think about the State curtailing the free market? Ask them. Tell them you want to change Utah's instream flow law to let the market solve this problem. A minor change to state law would allow landowners to save streams that cross their lands for future generations.

3 Critical Water

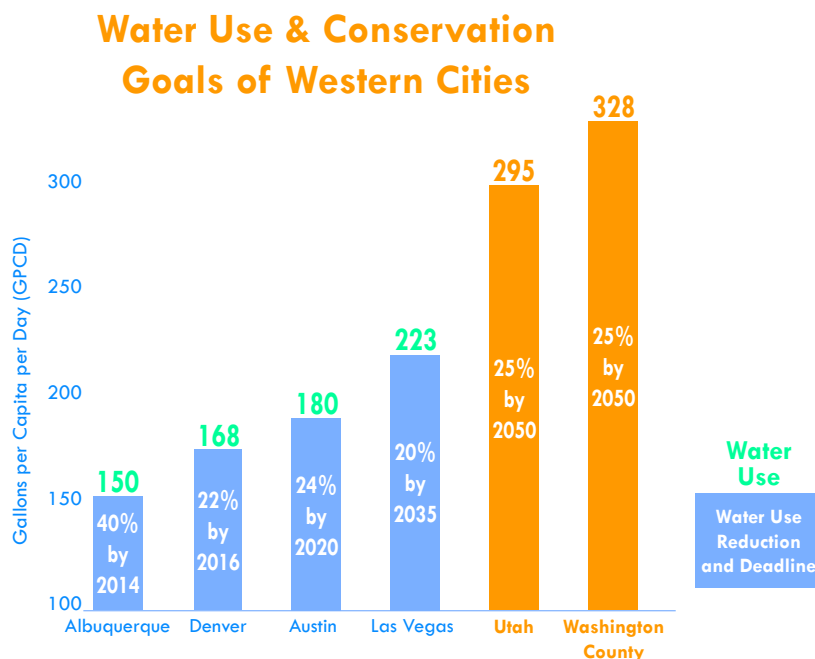
Utah is the most wasteful water user in the country with residents using nearly twice the U.S. average of water (per capita). Some Utah cities use three times this average and a whopping 70 percent of residential water use is for overwatering lawns each summer. Overreacting is a chronic problem in Utah.

This sky-high water use becomes the justification for the water development industry to propose billions in unnecessary water projects that have devastating impacts to Utah's desert watersheds and the species that depend on them. Although inexpensive water conservation efforts could easily eliminate the "need" for billion dollar diversions of the Bear and Colorado rivers, many water agencies scare the public into unnecessary spending with a campaign of fear and ignorance. There are 3 problems we must solve if we are to prepare for the impacts of a warmer world:

#1 Water Conservation Lip Service. As other states worked for decades to reduce water use, Utah has provided only lip service to water conservation. Utah runs an annual advertising campaign in print, radio and television to encourage the public to use less water. Although this is a good first step, this ad campaign is the only step Utah has taken in 30 years. Other states eliminated subsidies to encourage waste, created rebate programs, watering restrictions, enforcement efforts and amended their landscape ordinances, among many programs. Instead of following the lead of other states, state officials offer excuses and explanations to defend our waste, with some water leaders even criticizing the practice of water conservation itself (see 'Strong's Law' in introduction).

One of the biggest problems is that Utah has procrastinated the deadline for reducing water waste until 2050, which translates into reducing water waste by just one-half of one percent per year. How can water officials claim we are running out of water and not discourage water waste?

The Opportunity: Create a 10 year Water Conservation Deadline



Utah is not just America's highest water user, its water conservation deadlines are 30 years behind most other cities, demonstrating the State's apathy to reducing water waste.

Utah's goal is to reduce water waste by 0.5% per year. This is ridiculous compared to what other states are achieving.

Far Right: Cities embracing the free-market charge the full cost of water in bills and have lower water use. Phasing out property taxes could reduce water waste by billions of gallons.

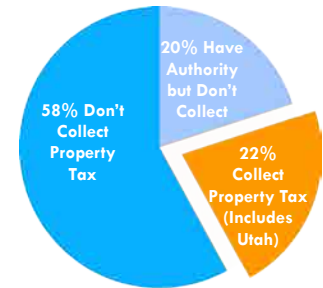
Problems to Solve

#2 Collecting Taxes to Encourage Water Waste. Utah stands alone in collecting property taxes from homeowners to lower the price of water by all of its water suppliers. These taxes are why Utah has America's cheapest water rates and is the country's most wasteful water user. One simply cannot escape the reality of market economics. Cheap water rates seem like a good deal until one considers the property taxes, sales taxes and income taxes paid to lower water prices making it clear this is no bargain. One wonders why a state claiming to support free-market principles would invest itself in a tax-based payment system for water.

The Opportunity: Phase Out Property Taxes for Water

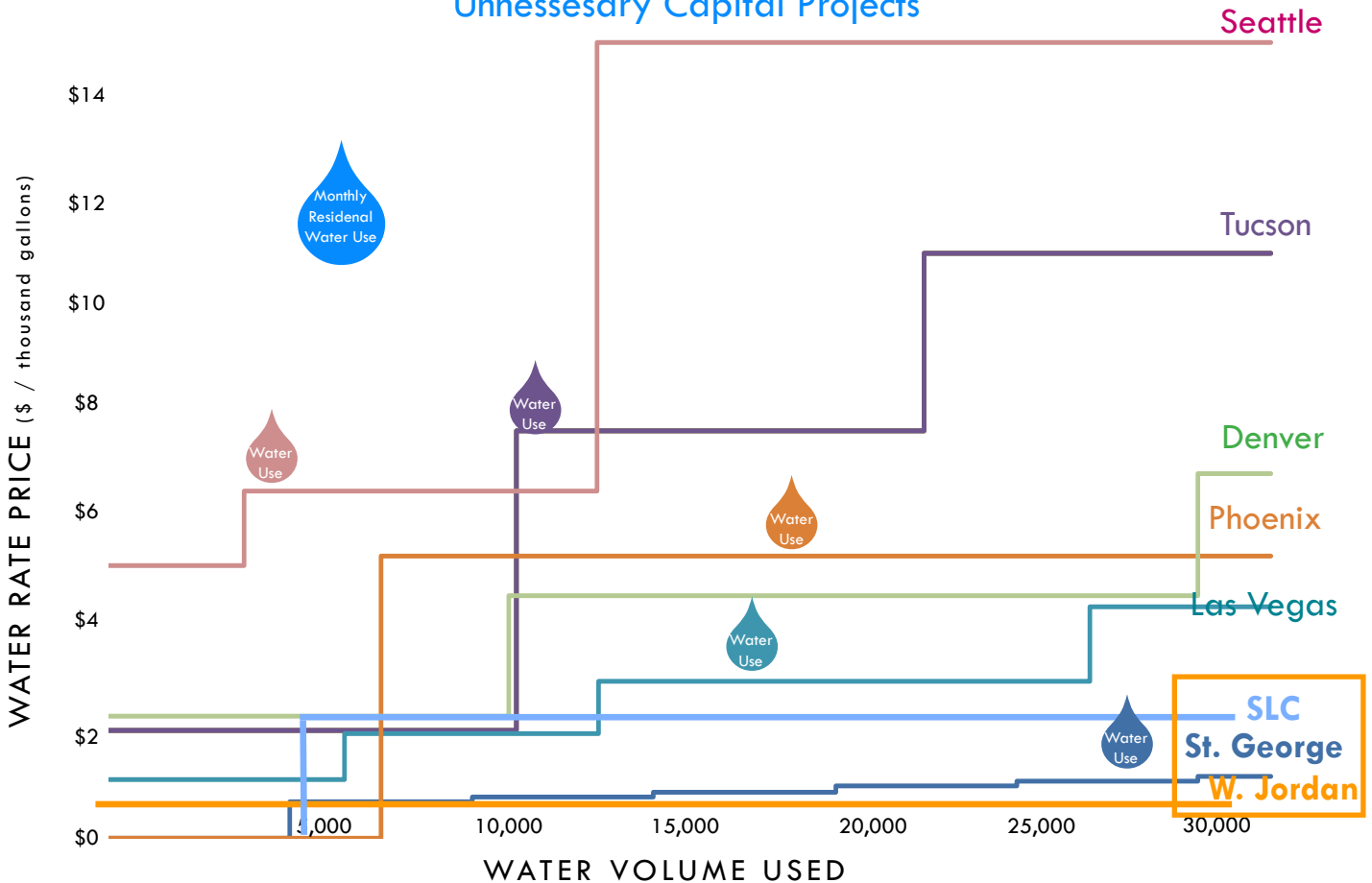
Western Water Districts Collecting Property Taxes

Right: 78% of Western water suppliers do not collect property taxes, based on a survey among the 58 major urban water delivery agencies.



Low Water Rates Encourage Waste:

Cheap Water Encourages Waste and Billions in Unnesesary Capital Projects



3 Critical Water Problems to Solve

#3 Ignoring Agricultural Water Conversions. A major portion of urban growth occurs on farmland, thus allowing the water previously used for crops to be freed up for urban uses. Instead of spending billions of dollars in new diversions, water suppliers could simply convert unused agricultural water into culinary grade water. Alas, many water leaders downplay this opportunity to use this water source in favor of receiving lucrative contracts totaling billions in new spending to divert Utah's rivers.

The Opportunity: Convert Unused Agricultural Water in the Salt Lake Valley instead of diverting the Bear River

Left: Holladay area farmer, circa 1880. Right: Homes have replaced the Salt Lake Valley's farmlands. Since agriculture uses far more water per acre than urban uses, converting farms to houses creates a surplus of water.



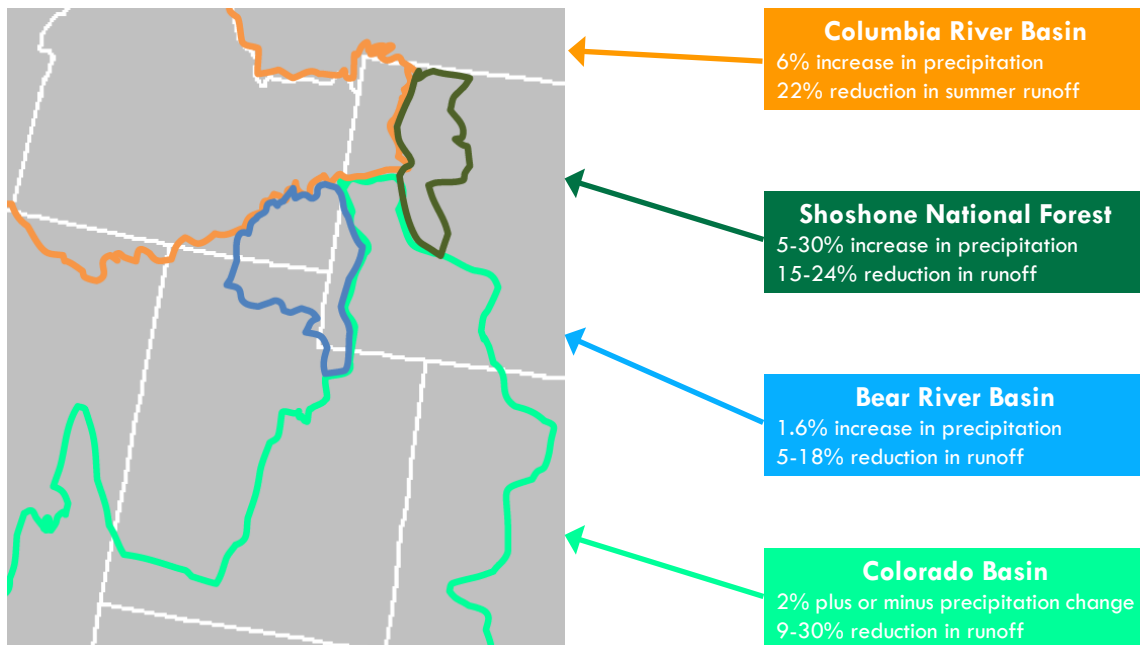
Left: One of scores of canals carrying surplus water across the Salt Lake Valley. Few realize these are irrigation canals or that they carry more surplus water than is being proposed to deliver to Salt Lake from Bear River development.

Ask Governor Herbert about this Surplus Water

You can help by asking Governor Herbert to study how much surplus irrigation water exists in the Salt Lake Valley. By simply publicizing the quantity of water diverted but unused by any purpose in Salt Lake, we can begin the process of converting this water instead of diverting the Bear River. It is estimated there are more than 100,000 acre-feet of surplus water in the Salt Lake Valley, according to records from the Division of Water Resources.

Governor Gary Herbert
350 North State Street, Suite 200
PO Box 142220
Salt Lake City, Utah 84114

Regional Flow Studies: Low Flows Ahead



Studies from different Western States indicate increased air temperatures are likely to trigger a cascade of changes which will reduce streamflows including: shifting snow to rain, an earlier spring runoff, raising the rain/snow line, drier soils and increased evapotranspiration. One study theorized that even in years of normal precipitation levels, low soil moisture may result in river flows at 75 percent of average. Neighboring states are devoting serious resources to understanding how much less water they can expect and how to prepare. Utah needs to get serious about preparing for the impacts of warmer temperatures.

Simple Supply Solution: Rainwater Harvesting

Neighboring states capture and store rain water where it lands in a simple method called rainwater harvesting. By storing the rain running off rooftops residents can reduce water demand, lower bills and potentially improve water quality by preventing runoff across roads which pollute waterways with oil and other toxics.

In 2010 the Utah Legislature passed a law allowing small scale rainwater collection and only by registering with the Division of Water Rights. The law comes with strict regulations: 2500 gallon underground containers or 200 gallon above ground containers. With per capita water use in Utah at the highest in the country, this law precludes residents from capturing enough water for their own usage. Other states encourage this practice with tax credits and some even require rainwater harvesting in certain new developments. Utah instead restricts this smart technology in part because the state does not understand its benefits.

Strict regulations arise in Utah because some believe every drop of rain is owned by a water right and collecting water from gutters and drains is "stealing." Since most water in streams comes from snowmelt, such claims are unfounded. Studies estimate an average of only 3 percent of urban rainfall makes its way into waterways and aquifers. Utilizing rainwater harvesting could actually increase the supply of water because we would not have to divert and treat as much from rivers and streams.

More Floods, More Often

Warmer temperatures cause the snow we rely on to come more often as rain. During winter, these rain-on-snow events are notorious for causing floods. Southern Utah has seen two big winter floods in the past 10 years. In January of 2005, the Santa Clara and the Virgin Rivers turned into raging torrents, bursting their banks and wiping out houses, roads and bridges. Some believe these rivers had not seen such high flows since the winter of 1862, when floods carried away several settlements. Others declared the floods of 2005 the '100 year' flood. Damages were estimated to be between \$150 and \$180 million.

Flood events could become more damaging due to the increased fire activity expected in Utah's future. Long after fires are extinguished, the risk of debris flows and floods rise because there is less vegetation to slow surface water runoff. Saratoga Springs experienced a damaging flood in September 2012 that sent mud into residents' basements after a fire scarred the landscape above. Utah can expect more destructive floods in the future and local municipalities should consider revising floodplain ordinances to avoid building in active floodplains.

2005 flood of the Santa Clara River



*The same spot before on a different day.
Photos courtesy Annette Taylor.*



Warming air temperatures lead to earlier and more intense run-offs and increase the likelihood of severe floods. As temperatures rise, we need to be more careful about building inside the floodplain or else prepare ourselves for significant loss of life and property.



We Need to Prepare

“There’s no question the earth is warming and as it does we need to be better prepared for extreme weather events. Droughts and heat waves cause more fatalities than any other weather-related phenomenon in the world. Floods in the U.S. cause scores of deaths and more than \$2 billion in damage each year. We need to start young in getting kids to understand these threats so we can be better prepared for these disasters in the future. We need to be prepared from day one about what is at stake with these extreme events.”

Jim Kosek
Chief Meteorologist
KTVX Channel 4



During and after photos of the 2005 flood of the Santa Clara River. Photos courtesy Annette Taylor.



Megadrought in the Colorado River Basin?

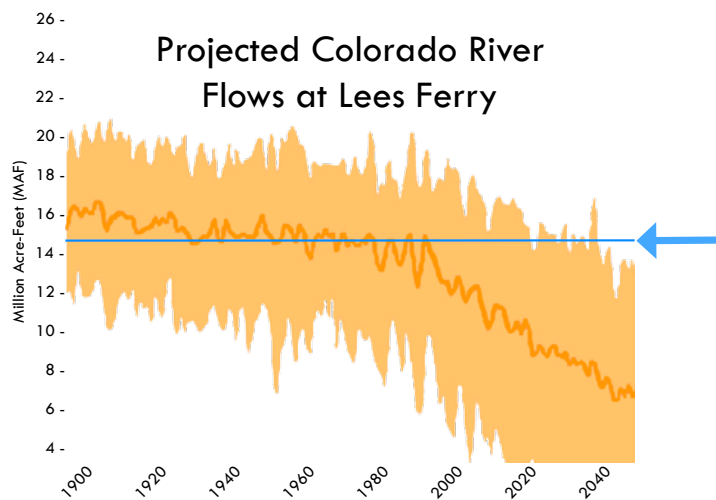
The Colorado River Basin provides water to 30 million people in 7 states. Over 80 percent of the Basin's flows come from snowmelt and mostly from the headwater states. These headwater states comprise just 1/7th of the watershed but produce 6/7th of the Basin's water and why Utah's snowpack is critical to Westerners from far outside our borders. Unfortunately, increased air temperatures are expected to lower Colorado River streamflows by 9-30 percent in coming decades.

Droughts like 2012 are more likely in the future as the American Southwest is likely to see a long-term drying period with lower precipitation levels. Many are calling this new era a megadrought which could be particularly difficult for Southern Utah, where streams are already under great duress during summer months.



Southern Utah's low elevation watersheds stand to suffer disproportionately from a megadrought because of the reduced volume of snowpacks expected at lower elevations. Watersheds like the Beaver Dam Wash, the Virgin River and the Santa Clara may have greater water deficits for native ecosystems as existing water diversions have greater impacts upon aquatic ecosystems.

These flow reductions are bad news for tens of millions of residents in the lower Basin and those wanting to see the Colorado River Delta restored. Where the mighty Colorado once entered the Sea of Cortez a productive estuary existed that provided habitat for 1,000 species of fish and wildlife, but today the river doesn't ever reach the ocean. If we are ever to try and restore this estuary, new diversions must be carefully scrutinized as to their real need.



Left: One of the more dire projections of Colorado River flows. The orange line is the average of simulations, the orange cloud shows the 10% to 90% range of simulations and the blue line is the water level of the 1922 Colorado River Compact.

Right: Table of how frequently water deliveries to the 7 Colorado River States will be missed as a function of reduced water flows.

Frequency of Missed Water Deliveries from Flow Reductions
based on SCRIPPS Institute Analysis

Reduction in River Flows	Frequency of Missed Water Deliveries
10% flow reduction	Missed 58% of time
20% flow reduction	Missed 88% of time

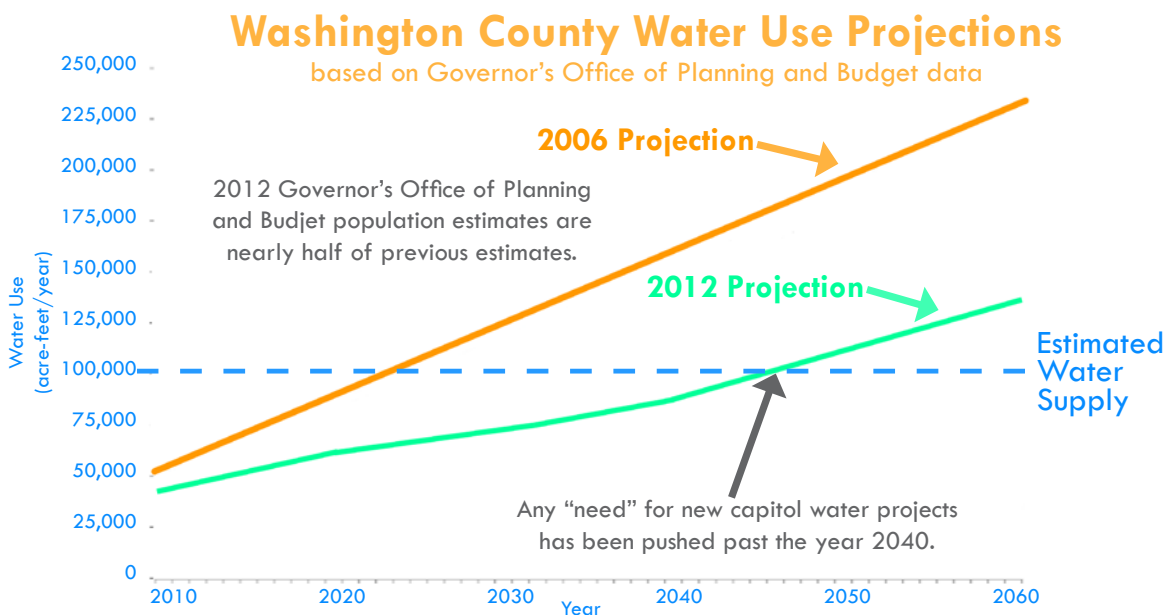
Utah's Response: Divert the Colorado River

Despite the expected decline in Colorado River flows, a group of unelected Utah water agencies propose to divert the river to America's most wasteful water user. The proposed \$2 billion Lake Powell Pipeline would deliver ~90,000 acre feet of water to Washington and Kane Counties for lawn water. As a measure of the pipeline's pork-barrel economics, one of the original counties slated to receive water from the pipeline – Iron County – backed out of the project in 2012 citing the extremely high price of project water compared to existing, cheaper water sources.

Washington County residents have the highest water use in the entire U.S., at more than twice the national average. Though water conservation could provide more water to Washington County for pennies on the dollar, spending advocates promote this expensive diversion by scaring the public into believing St. George is running out of water.

The Governor's Office of Planning and Budget recently released new population estimates for Washington County that show no need for more water for at least 30 years. Spending advocates argue water flowing out of Utah is "wasted" and should therefore be diverted so Utah can use its full share of Colorado River water. To pay for this project revenues will have to increase 370%, which will require massive increases in water rates.

Two Water Use Estimates for Washington County. The 2006 projection greatly over-estimated growth levels but is used to scare the public into believing there is a water crisis. The newer 2012 estimate from the Governor's office shows no need for more water until the year 2045 or later. In spite of this data, the Division of Water Resources is lobbying the State Legislature to spend \$1.5 billion on the Lake Powell Pipeline.



The Great Salt Lake's Future

West's Largest Wetland Ecosystem in Danger

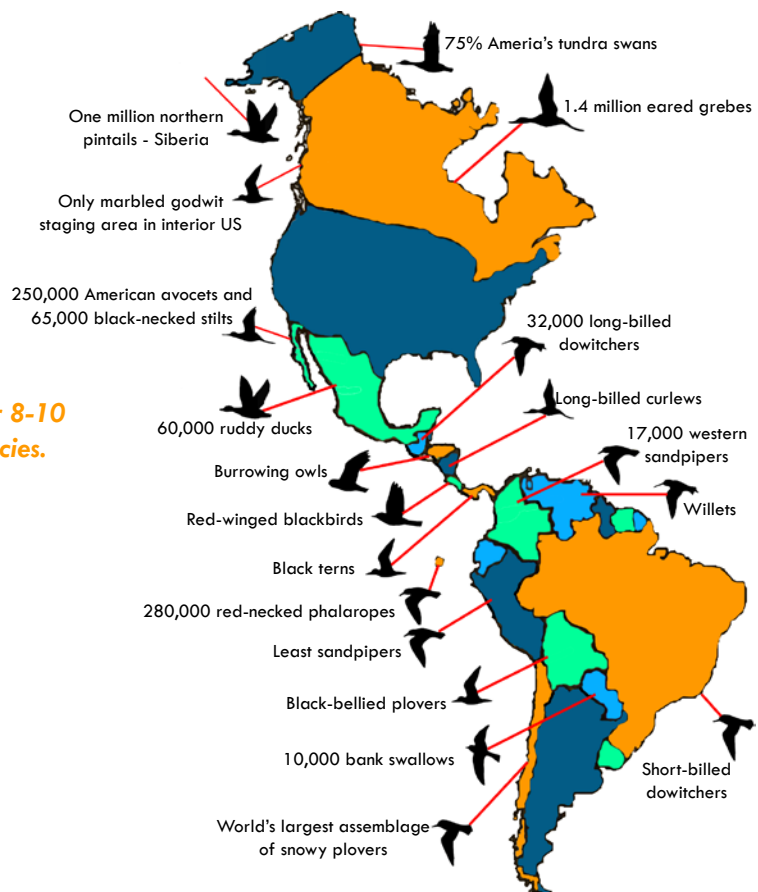
The Great Salt Lake is the largest wetland ecosystem in the American West. Its ~400,000 acres of shoreline wetlands create an amazing ecosystem supporting between 8 - 10 million migratory birds traveling across the Western Hemisphere from as far south as Chile, north to the Arctic Circle and as far west as Siberia. Over 230 migratory bird species depend upon the shoreline wetlands of the Great Salt Lake during their global migrations with some species gathering in greater numbers than anywhere else on the planet.

Great Salt Lake wetlands are heavily dependent on the Bear River, which provides nearly 60 percent of the Lake's surface water inflow each year. But the Bear River's freshwater inflows are now threatened by both climate change and proposed water development. A study performed as part of a Nature Conservancy effort in 2010 offers a glimpse at how warmer temperatures may impact this vital river. Their analysis examined several scenarios within the Bear River Basin, as shown in the table below. The preliminary projection makes a startling estimate of flow reductions on the Bear River.

	Precipitation Change	Temperature Increase	Change in River Volume
Scenario 1	1.6% Increase	3.5°C Increase	5-18% Decrease
Scenario 2	3% Decrease	2.7°C Increase	5-13% Decrease

Depending upon precipitation, the Great Salt Lake could be lowered several feet in elevation or more. Reducing the Lake's elevation means the total perimeter of wetlands would also be reduced. Although this is one of North America's most important bird habitats, very little science has been conducted to estimate how changes to lake elevations affect wetland acreages and impact individual bird species.

The Great Salt Lake is Critical Habitat for Birds Throughout the Western Hemisphere



The Great Salt Lake provides habitat for 8-10 million migratory birds across 225 species.



Proposed Bear River Diversion

Threatens to Lower the Great Salt Lake

The State of Utah and several local water suppliers are proposing to divert the Bear River upstream of its confluence with the Great Salt Lake. The proposed \$800 million water project would divert 20 percent of the Bear River's annual flow and lower the Great Salt Lake by 2 – 4 feet in elevation or more. This would effectively dry up tens of thousands of acres of shoreline wetlands, in addition to any losses incurred by flow reductions expected by rising air temperatures.

The purpose of the proposed diversion is ostensibly to provide additional lawn water for residents in Salt Lake, Davis and Weber Counties. Although some water suppliers would have us believe we are on the verge of a water crisis, the truth is that Utahns are America's most wasteful water users. Even Las Vegas residents use less water than most Wasatch Front residents, a dubious distinction to be sure.

The proposed Bear River diversion could easily be eliminated by reducing water demand. Although some Wasatch Front water suppliers have worked to lower water use, most ignore or campaign against using simple market economics to lower water use. Water rates along the Wasatch Front are some of the lowest in the country because water suppliers encourage waste by lowering the price of water. This is achieved by collecting property taxes to reduce or subsidize the price of water.

Residents of the Wasatch Front must ask themselves if they wish to dry up tens of thousands of acres of wetlands around the Great Salt Lake simply to grow grass. Many local cities still require developers to install grass landscapes with new homes, which is an absurd mandate.



Habitat for millions of migratory birds would dry up if the Bear River is diverted.



Hard Times Ahead for Utah Agriculture

In 2012, roughly half of America's counties made drought declarations as farmers and ranchers were forced to cease operations. Crops wilted, soils dried out and cattle were taken to slaughter earlier than normal because of drought. In Utah, 16 of 29 counties were declared a disaster allowing farmers to apply for federal relief. This declaration comes just three years after 19 Utah counties qualified for disaster relief in 2009.

Agriculture is vital to Utah's economy, employing over 66,000 people and producing \$16.3 billion in 2008, according to one source. Warmer temperatures are likely to increase the severity and frequency of droughts and new studies indicate the droughts over the last 25 years in the Southwest have been more severe and more frequent than normal. Although increased air temperatures increase the length of the growing season, warmer temperatures cause plants to draw soil moisture faster making it hard to keep soils moist, thereby increasing water demand. With agriculture using 80 percent of Utah's water, increasing water use in this sector has dire impacts upon Utah's fish and wildlife species.

Higher temperatures are believed to cause Utah's most common crop, alfalfa, to flower earlier thereby reducing the yield of usable hay. The 2012 drought inflated the price of alfalfa hay, requiring ranchers to buy more expensive hay to feed livestock. This only aggravated many livestock operations.

Warmer temperatures allow some pests to feed on crops earlier and remain active later into the year as well as allowing an expansion in range of some pests. Non-native weeds may also increase in abundance thereby competing with crops and native ecosystems. Weeds are most commonly mitigated by spraying glyphosate, also known as Roundup. Glyphosate is the most widely used herbicide in the country and some studies contend it loses efficiency with increased CO2 levels.

Open range cattle will have challenges since increased carbon dioxide levels cause grasslands to produce more foliage, but reduce the total protein content of the forage for cattle. The range will also see the spread of inedible invasive weeds like cheat grass, which may migrate into higher elevations as temperatures increase. Cheat grass is not nutritious for livestock, making open rangeland less productive. Dairy cows produce less milk and gain less weight during periods of high temperatures. This is more bad news for Utah's dairy industry, which is Utah's largest agricultural sector but has been declining by nearly 10 percent a year for much of the last decade.



Protecting the Nation's Food Supply

"It's been so dry out there this year, the trees are chasing the dogs. We're looking at one of the most severe droughts since the Dust Bowl days. I've been on our family farm and ranch for all my life and I've seen some big changes. Springs that have never dried up before are now dry and the soils are so dry even the rain isn't keeping them wet. This fall we had deer coming into our hay shacks to feed, which I've never seen before.

There's probably some merit to climate change and its impacts on our farms and ranches. One way we can prepare for the future is to create a strong safety net for agriculture to protect the nation's food supply. This means making sure our producers get a fair price for the commodities they grow and protecting our agricultural lands. We're just not making any more farmland. Being in the second driest state in the nation makes it even more important to protect our most productive farmlands."

Arthur Douglas
Executive Director
Utah Farm Service Agency

Utah Needs to Protect its Remaining Farmlands

In the face of the daunting list of impacts listed on the previous page, Utah's best farmlands have been rapidly replaced by urban development. Over the last 30 years, Utah has lost about 30 acres of farmland every day, for a total of 300,000 acres.

Although every Utah Governor gives lip service to protecting farmland, each Governor has reduced funding to protect farms. Today, no State funding is available for farmland preservation. Restoring funding for farmland preservation is a critical component of good agricultural policy.



Changing Forests

In recent years, hotter temperatures, reduced precipitation and earlier runoff has allowed wildfires to increase across the West, adding 78 days to the time of year that fires burn. Studies show that years with an earlier snowmelt had 5 times as many wildfires as years with a later runoff. Earlier runoff reduces soil moisture, leads to drier vegetation and provides fuel for fires that expands vulnerable areas into higher elevations.

Rising temperatures also limit the range of many coniferous trees, forcing them to constrict to higher, cooler elevation zones. Continued warming could lead to a rise in the altitude of vegetation belts at a rate of 8-10 meters per decade. This rise in vegetation belts reduces suitable habitat for high mountain species, such as the La Sal Pika which may be in danger of extinction if the unique alpine tundra habitat it depends on is reduced in range.



Burnt landscapes like this forest near Bryce Canyon National Park can be some of the most ecologically important and biodiverse parts of ecosystems. Photo courtesy of Jared Tarbell

Healthy forests depend on fires to build strong and diverse forests. Landscapes that have experienced intense fires are some of the most ecologically-important and biodiverse parts of Western forests. Forests have changed drastically in the mid 20th century due to fire

suppression. The summer of 2012 was an abnormally intense fire year but historical evidence shows fires were more intense and frequent prior to suppression. In trying to prevent fires from affecting forests, we undermine the health of the forest ecosystem.

Government agencies have a hard time balancing forest health and home safety. Houses are getting built further into forests, making “safe” fire areas smaller and harder to come by. Simple fire mitigation practices can be implemented by homeowners to reduce the chance of fire destroying their properties and help alleviate some of the costly fire suppression expenses.

The U.S. regularly spends over \$1 billion a year fighting and recovering from wildfires. Last year the Forest Service spent 45 percent of its annual budget on fire prevention and suppression, up 20 percent from 2000. With the coming increase in fires these costs can be expected to go up.

Warming Means More Pollution Problems

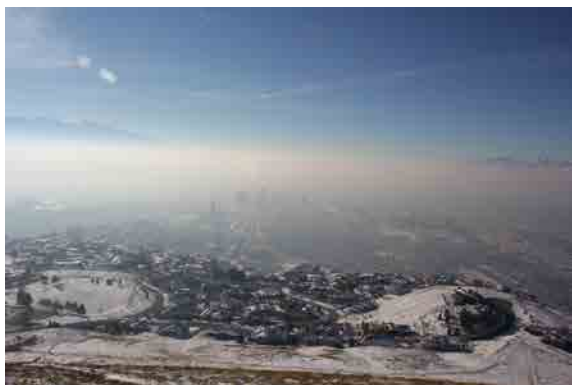
Water



As Utah experiences reduced streamflows from warmer temperatures we will also see water quality degradations in our streams and rivers. Existing contaminant loads will enter streams running at lower water volumes, particularly during late summer and fall, resulting in a higher concentration of contaminants. Continued expansion of the urban footprint will further increase pollutants as water runs across more roads and other impervious surfaces. Since higher contaminant loads increase water treatment costs we can expect these higher costs to be passed on to consumers and taxpayers.

One solution to help address this problem is for local municipalities to create more permeable surfaces in urban areas, instead of concrete and other hardscapes that don't absorb water. Watershed restoration activities also help retain and capture surface water runoff, thereby lowering treatment costs over the long run.

Air



Salt Lake City's inversions are the cause of some of the worst air quality days in the nation. Photo courtesy of Tim Brown

Northern Utah has some of America's most polluted airsheds during the winter months. On days with severe inversions fine particulate matter concentrations reach dangerously high levels, exceeding EPA thresholds for what is considered safe to breathe. In 2008 several counties also nearly exceeded EPA regulations on ozone concentrations. Ozone affects the respiratory system, among both old and young populations and the EPA compares the effects to getting a sunburn inside your lungs. Since ozone is produced on hot days, warmer summer temperatures makes this problem even more pronounced. Studies estimate that ozone concentrations will rise 5-10 percent by 2050, making bad air days more detrimental to Utahns' health.

The Utah Department of Health released a report on the effects of warmer temperatures and its toll on public health which showed certain particles, such as sulfur dioxides, may increase because warmer temperatures allow them to oxidize more quickly. Having some of America's dirtiest air is a detriment to attracting businesses to Utah and a health risk to many populations. Over half of Utah's air pollution originates from cars so the solution to cleaner air is in our hands. Limiting driving and using public transit on poor air quality days can significantly reduce the health dangers associated with air pollution.

Another Boom-Bust Mining Cycle for Utah?

Utah has large deposits of tar sands and oil shale that may usher in a new era of strip mining that would forever change our State. Most of the ore in eastern and central Utah is in high elevation watersheds important to fish and wildlife populations. These ecosystems are covered by grasses, forbs and trees and sustain large populations of wildlife, particularly big game. The mix of tree covers range from juniper and pine, to firs and aspens. The thin soils took thousands of years to develop and proposed strip mining would permanently denude these high plateaus. Strip mining is a one-use-only land practice, whereby other uses will not be available for thousands of years, if ever.

Staggering quantities of water are required to extract these hydrocarbons, depending upon how much is mined. To develop all 321 billion barrels of oil shale in Utah would require 20 million acre feet of water, equivalent to 80 million American's annual water use. Developing all 19 billion barrels of tar sands hydrocarbons in Utah would require 5 million acre-feet of water, equivalent to 20 million people's annual water use. The proposal intends to use groundwater making it likely that much of this fossil water would be mined. Sediment, hydrocarbons and solvents would pollute streams and aquifers, polluting the Colorado River and the drinking water for 30 million people.

Thirty years of oil and gas production in the Uinta Basin has generated foul-smelling fugitive gases, dust, ozone, sulfur dioxide, and nitrogen oxides for rural populations. The four Wasatch Front oil refineries are likely to increase their processing loads, further degrading one of the Nation's dirtiest winter airsheds.

This kind of energy development is plagued with diminishing returns. The hydrocarbons extracted from these mining operations have never been introduced to the market because of the marginal yield and energy-intensive processing requirements. It takes about two tons of ore to yield a single barrel of crude and vast amounts of diesel fuel are required to extract the ore. Natural gas is also needed to both heat the rock and upgrade the hydrocarbons at the refinery. These inefficiencies will not reduce the cost of fuel at the gas station, nor will this mining improve our diminishing air quality or provide a good use of our limited water supplies.

John Weisheit, Conservation Director of Living Rivers, wrote this section and is working to protect Utah from frivolous strip mining from tar sands and oil shale development.



Left: Main Canyon, area proposed for tar sands development in Eastern Utah. Below: strip mining from tar sands site showing impacts to watershed.



Protecting Utah's Lands

Preparing for the impacts of rising air temperatures means ensuring protection for fish and wildlife species, particularly on land areas that are highly biodiverse. Utah has relatively few tools in our toolbox to protect these precious lands for both ecosystems and the many tourist and recreational economies that depend on them, even where these activities are the largest economic drivers in parts of rural Utah.

Some of Utah's most biologically productive lands are clustered around the Green River as it makes its way through the Book Cliffs. This rugged wild area is critical to a large diversity of plants and animals, including some of Utah's best big game habitat. Yet this region lies almost completely unprotected from destructive single-use industries, like the oil shale and tar sands described on the opposite page.

One of the few means of protecting key ecosystems and recreational economies in Utah is through wilderness designation. But Utah has consistently ranked last among the 11 Western States in total acreage of protected wilderness, a fact that is often ignored. Even Florida has more wilderness than Utah. Although some point to the existence of Utah's national parks to counter this lack of protection, all of Utah's national parks fit into an area smaller than Yellowstone National Park, which is located in a State with three times as much wilderness as Utah.

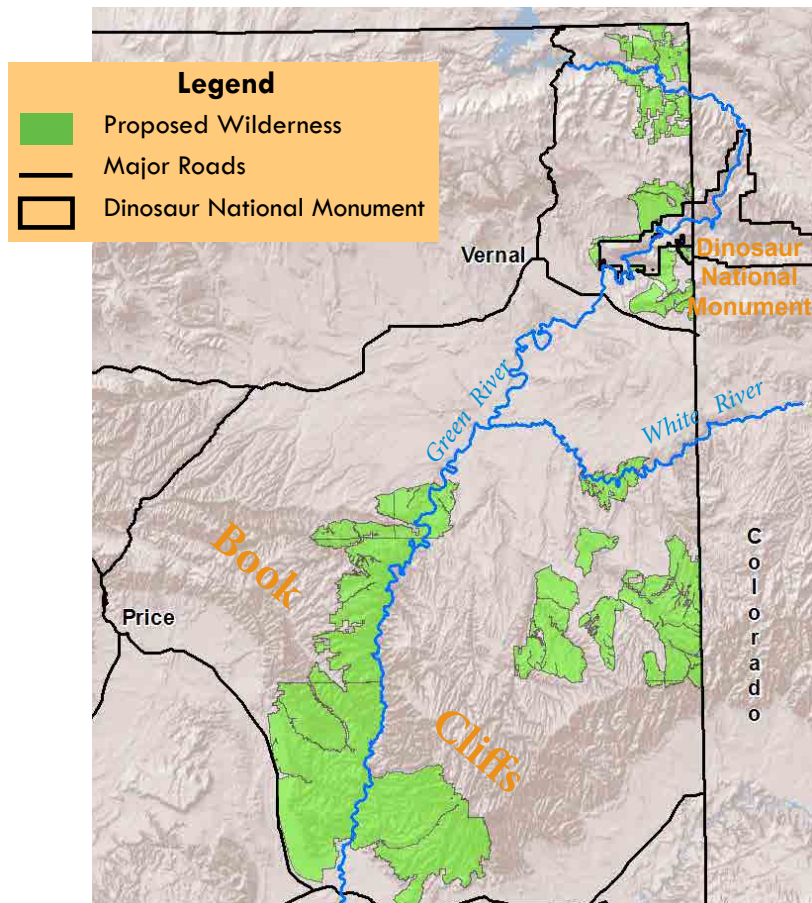
The roughly 1 million acres of public lands around the world-renown Green River are truly worthy of wilderness designation and should be set aside by Congress for the economic sustainability of future Utahns. Setting aside this critical area as wilderness will also help maintain the water supplies for the 30 million people of the Colorado River Basin, as these areas are critical watershed recharge areas for the Green, White and Colorado rivers.

At some point, Utahns must ask themselves why our State has the least amount of designated wilderness in the West. Don't Utahns love wide open spaces?

Right: Proposed wilderness areas (shown in Green) around the Green River corridor.

State	Acres of Wilderness
California	14,982,645
Idaho	4,523,135
Arizona	4,517,898
Washington	4,462,271
Colorado	3,700,148
Montana	3,443,407
Nevada	3,371,425
Wyoming	3,111,232
Oregon	2,474,435
New Mexico	1,650,596
Florida	1,422,247
Utah	1,160,300

Source: University of Montana



Sources

- Air Temperature:** Governor's Blue Ribbon Advisory Council on Climate Change. "Climate Change and Utah: The Scientific Consensus." Utah Department of Environmental Quality, September 2007.
- IPCC and Thomas Reichler, Department of Atmospheric Sciences, University of Utah. National Oceanic and Atmospheric Administration.
- Snow:** Clow, David W. "Changes in the Timing of Snowmelt and Streamflow in Colorado: A Response to Recent Warming." *Journal of Climate* 23: 2293-2306
- Mote, Philip W., et al. "Declining Mountain Snowpack in Western North America." American Meteorological Society, January 2005.
- McGurk, Bruce J. "Global Warming Effects on Hetch Hetchy Hydrology." Society of American Foresters Water Resources Working Group Newsletter, December 2008.
- Jones, Leigh P. and John D. Horel. "Assessing the Sensitivity of Wasatch Mountain Winter Precipitation to Climate Temperature Variations." University of Utah Department of Atmospheric Sciences, Western Snow Conference, 2009.
- Marks, Danny, et al. "Simulating Snowmelt Processes During Rain-on-Snow Over a Semi-Arid Mountain Basin." *Annals of Glaciology* 32: 195-202, 2001.
- Gillies, Robert R., et al. "Observational and Synoptic Analyses of the Winter Precipitation Regime Change over Utah." *Journal of Climate* 25: 4679-4698, July 2012.
- Park City Snowpack:** Stratus Consulting. "Climate Change in Park City: An Assessment of Climate, Snowpack, and Economic Impacts." The Park City Foundation, September 2009.
- Regional Flow Studies:** Western Water Assessment, CIRES, University of Colorado.
- Rice, Janine, et al. "Climate Change on the Shoshone National Forest, Wyoming: A Synthesis of Past Climate, Climate Projections, and Ecosystem Implications." USDA and Forest Service Rocky Mountain Research Station, January 2012.
- Degiorgio, Joan, et al. "Bear River Climate Change Adaptation Workshop Summary." Southwest Climate Change Initiative, May 2010.
- Mote, Philip W., et al. "Preparing for Climate Change: The Water, Salmon, and Forests of the Pacific Northwest" *Climatic Change* 61: 45-88, Kluwer Academic Publishers, 2003.
- National Research Council, Committee on the Scientific Bases of Colorado River Basin Water Management. "Colorado River Basin Water Management: Evaluating and Adjusting to Hydroclimatic Variability." National Academies Press, 2007.
- River Flows and Fish:** Clow, D.W., "Changes in the timing and magnitude of snowmelt and streamflow in Colorado- A response to recent warming." *Journal of Climate* 23: 2293-2306, 2010.
- Christensen, N.S., and Lettenmaier, D.P. "A multimodel ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River Basin." *Hydrology and Earth System Science* 11: 1417-1434, 2007.
- Payne, J.T., et al. "Mitigating the effects of climate change on the water resources of the Columbia River Basin." *Climate Change* 62: 233-256, 2004.
- Gleick, P.H. and E.L. Chalecki. "The impacts of climate changes for water resources of the Colorado and Sacramento-San Joaquin River Basins." *Journal of the American Water Resources Association* 35.6: 1429-1440, 1999.
- Wenger, Seth J., et al. "Flow regime, temperature, and biotic interactions drive differential declines of trout species under climate change." *Proceedings of the National Academy of Sciences*, 2011.
- "Healing Troubled Waters: Preparing Trout and Salmon Habitat for a Changing Climate." Trout Unlimited, October 2007.
- Whirling Disease:** De la Hoz Franco, Ernesto, et al. "Linking Environmental Heterogeneity to the Distribution and Prevalence of *Myxobolus cerebralis*: A Comparison across Sites in a Northern Utah Watershed." *Transactions of the American Fisheries Society* 133: 1176-1189, 2004.
- Flooding:** Cavaretta, J. "Portraits of Loss." *Stories of hope*. N.p., 2012.
- Wilkowske, C.D., et al. "Flooding and Streamflow in Utah during Water Year 2005." United States Geological Survey, May 2006.
- Bear River and Great Salt Lake:** Degiorgio, Joan, et al. "Bear River Climate Change Adaptation Workshop Summary." Southwest Climate Change Initiative, May 2010.
- Mearns, Linda O. "Overview of Regional Climate Change: The Known, the Unknown, and the Uncertain." National Center for Atmospheric Research, May 2010.
- Bedford Daniel and Andrea Douglass. "Changing Properties of Snowpack in the Great Salt Lake Basin, Western United States, from a 26-Year SNOTEL Record." *The Professional Geographer* 60(3): 374-386, 2008.
- Colorado River:** Western Water Assessment, CIRES, University of Colorado, 2012.
- Seager, Richard. "Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America." *Science* 316: 1181, May 2007.
- Hoerling, M. and J. Eischeid. "Past Peak Water in the Southwest." *Southwest Hydrology* 6: 18-35, 2007.
- Rainwater Harvesting:** "Holistic Approach to Sustainable Water Management in Northwest Douglas County." Colorado Water Conservation Board, January 2007.
- Agriculture:** Ward, Ruby A., et al. "The Economic Impact of Agriculture on the State of Utah." Utah State University Dept. of Applied Economics, January 2010.
- Al-Hamdani, Safaa and Glenn W. Todd. "Effect of Temperature Regimes on Photosynthesis, Respiration, and Growth in Alfalfa." Oklahoma State University Department of Botany and Microbiology, 1990.
- USDA disaster declaration: <http://ag.utah.gov/news/AgDeclaration09.html>
- Tubiello, Francesco N., et al. "Crop and pasture response to climate change." National Academy of Sciences of the USA, 2007.
- Hauser, Rachel, et al. "The Effects of Climate Change on U.S. Ecosystems." U.S. Global Change Research Program, November 2009.
- USDA Economic Research Service: <http://www.ers.usda.gov/StateFacts/UT.htm#FI>
- Forests and Fires:** Hanson, Chad. "The Myth of 'Catastrophic' Wildfire: A New Ecological Paradigm of Forest Health." John Muir Project, 2010.
- Westerling, A.L. "Warming & Earlier Spring Increase Western U.S. Forest Wildfire Activity." *Science* 313: 940-943, August 2006.
- Running Steven W. "Is Global Warming Causing More, Larger Wildfires?" *Science* 313: 927, 2006.
- "Increased Risk of Catastrophic Wildfires: Global Warming's Wake-Up Call for the Western United States." National Wildlife Federation, 2008.
- Santiestevan, Christina. "Changing Climate, Shifting Forests" *American Forests*: 26-31, Winter 2010.
- Tar Sands and Oil Shale:** Western Resource Advocates. "Oil Shale Basic Facts." <http://www.westernresourceadvocates.org/land/oilshalebasics.php>
- Canyonlands Watershed Council: <http://www.farcountry.org/resources.cfm>
- United States Bureau of Reclamation. "Colorado River Basin Water Supply & Demand Study." <http://www.usbr.gov/lc/region/programs/crbstudy.html>
- Wilshire, Howard G., et al. *The American West at Risk: Science, Myths, and Politics of Land Abuse and Recovery*. Oxford: Oxford UP, 2008. Print.
- Air Quality:** "Climate Change and Public Health in Utah" Utah Department of Health, 2012.
- Environmental Protection Agency: <http://www.epa.gov/glo/health.html>
- Economic Development Corporation of Utah: <http://www.edcutah.org/>
- SLCGreen: <http://www.slcclassic.com/slccgreen/climate/>
- Water Quality:** "Climate Change and Public Health in Utah" Utah Department of Health, 2012.

Utah Knows Conservation

“Conservation is conservative. I’m not ashamed to be a conservationist. When Teddy Roosevelt came here, he thanked Utahns for being good conservationists. I think that there is an ethos that exists in our state that still very much believes in that.”

“Climate change [is] one of the most compelling issues of our time. Dealing with it in my opinion is not a choice but, rather, an imperative.”

“If we do this right, our citizens are going to have a better quality of life, we’re going to spawn new technologies and industries, and we’re going to leave our most important belongings in better shape for the next generation.”

Jon Huntsman, Jr.
16th Governor of Utah



