Economic Impacts of Climate Change on Colorado

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INTRODUCTION

Policymakers across the country are now seeking solutions to curb greenhouse gas emissions and to help us adapt to the impending impacts triggered by past emissions. The debate to date has primarily focused on the perceived costs of alternative solutions, yet there can also be significant costs of inaction. Climate change will affect our water, energy, transportation, and public health systems, as well as state economies as climate change impact a wide range of important economic sectors from agriculture to manufacturing to tourism. This report, part of a series of state studies, highlights the economic impacts of climate change in Colorado and provides examples of additional ripple effects such as reduced spending in other sectors and resulting losses of jobs, wages, and even tax revenues.

A Primer on Climate Change

Earth's climate is regulated, in part, by the presence of gases and particles in the atmosphere which are penetrated by short-wave radiation from the sun and which trap the longer wave radiation that is reflecting back from Earth. Collectively, those gases are referred to as greenhouse gases (GHGs) because they can trap radiation on Earth in a manner analogous to that of the glass of a greenhouse and have a warming effect on the globe. Among the other most notable GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). Their sources include fossil fuel combustion, agriculture, and industrial processes.

Each GHG has a different atmospheric concentration, mean residence time in the atmosphere, and different chemical and physical properties. As a consequence, each GHG has a different ability to upset the balance between incoming solar radiation and outgoing long-wave radiation. This ability to influence Earth's radiative budget is known as climate forcing. Climate forcing varies across chemical species in the atmosphere. Spatial patterns of radiative forcing are relatively uniform for CO_2, CH_4, N_2O and CFCs because these gases are relatively long-lived and as a consequence become more evenly distributed in the atmosphere.

Steep increases in atmospheric GHG concentrations have occurred since the industrial revolution (Figure 1). Those increases are unprecedented in Earth's history. As a result of higher GHG concentrations, global average surface temperature has risen by about 0.6°C over the twentieth century, with 10 of the last 12 years likely the warmest in the instrumental record since 1861.

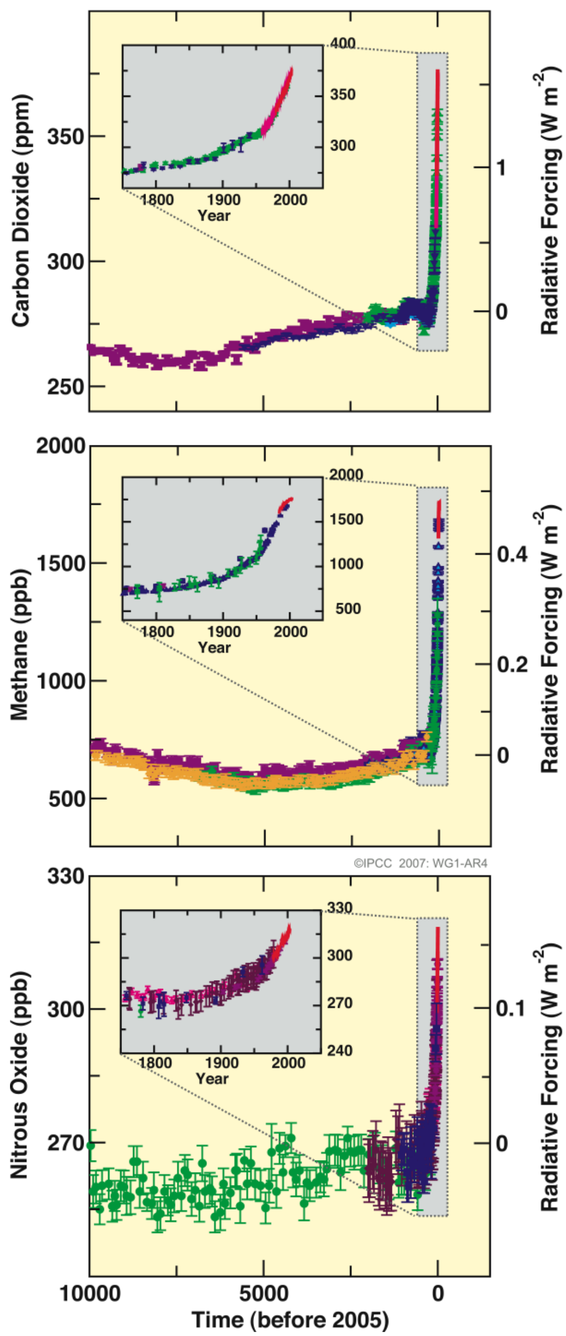

Figure 1: Atmospheric Concentrations of Carbon Dioxide, Methane and Nitrous Oxide (Source: IPCC 2007a)

A change in average temperatures may serve as a useful indicator of changes in climate (Figure 2), but it is only one of many ramifications of higher GHG concentrations. Since disruption of Earth's energy balance is neither seasonally nor geographically uniform, effects of climate disruption vary across space as well as time. For example, there has been a widespread retreat of mountain glaciers during the twentieth century. Scientific evidence also suggests that there has been a 40 percent decrease in Arctic sea ice thickness during late summer to early autumn in recent decades and considerably slower decline in winter sea ice thickness. The extent of Northern Hemisphere spring and summer ice sheets has decreased by about 10 to 15 percent since the 1950s (IPCC 2007a).

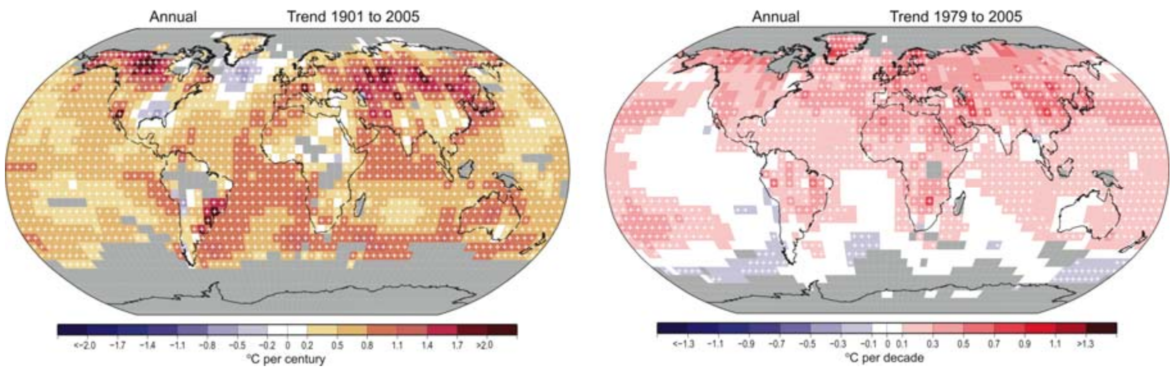

Figure 2: Annual Temperature Trends (Source: IPCC 2007a)

The net loss of snow and ice cover, combined with an increase in ocean temperatures and thermal expansion of the water mass in oceans, has resulted in a rise of global average sea level between 0.1 and 0.2 meters during the twentieth century, which is considerably higher than the average rate during the last several millennia (Barnett 1984; Douglas et. al 2001; IPCC 2001).

Changes in heat fluxes through the atmosphere and oceans, combined with changes in reflectivity of the earth's surface and an altered composition of may result in altered frequency and severity of climate extremes around the globe (Easterling et. al 2000). For example, it is likely that there has been a 2 to 4 percent increase in the frequency of heavy precipitation events in the mid and high latitudes of the Northern Hemisphere over the latter half of the twentieth century, while in some regions, such as Asia and Africa, the frequency and intensity of droughts have increased in recent decades (IPCC 2001). Furthermore, the timing and magnitude of snowfall and snowmelt may be significantly affected (Frederick and Gleick 1999), influencing among other things, erosion, water quality and agricultural productivity. And since evaporation increases exponentially with water temperature, global climate change-induced sea surface temperature increases are likely to result in increased frequency and intensity of hurricanes and increased size of the regions affected.

Impacts of Climate Change throughout the US

This study on the economic impacts of climate change in the State of Colorado is part of a series of state-focused studies to help inform the challenging decisions policymakers now face. It builds on a prior assessment by the Center for Integrative Environmental Research, US Economic Impacts of Climate Change and the Costs of Inaction, which concluded that throughout the United States, individuals and communities depend on sectors and systems that are expected to be greatly affected by the impacts of continued climate change.

- The **agricultural sector** is likely to experience uneven impacts throughout the country. Initial economic gains from altered growing conditions will likely be lost as temperatures continue to rise. Regional droughts, water shortages, as well as excess precipitation, and spread of pest and diseases will negatively impact agriculture in most regions.

- Storms and sea level rise threaten extensive **coastal infrastructure** – including transportation networks, coastal developments, and water and energy supply systems.

- Current **energy** supply and demand equilibria will be disrupted as electricity consumption climbs when demand grows in peak summer months. At the same time, delivering adequate supply of electricity may become more expensive because of extreme weather events.

- Increased incidence of asthma, heat-related diseases, and other respiratory ailments may result from climate change, affecting **human health** and well-being.

- More frequent and severe **forest fires** are expected, putting ecosystems and human settlements at peril.

- The reliability of **water supply networks** may be compromised, influencing agricultural production, as well as availability of water for household and industrial uses.

As science continues to bring clarity to present and future global climate change, policymakers are beginning to respond and propose policies that aim to curb greenhouse gas emissions and to help us adapt to the impending impacts triggered by past emissions.

While climate impacts will vary on a regional scale, it is at the state and local levels where critical policy and investment decisions are made for the very systems most likely to be affected by climate change – water, energy, transportation and public health systems, as well as important economic sectors such as agriculture, fisheries, forestry, manufacturing, and tourism. Yet, much of the focus, to date, has been on the perceived high cost of reducing greenhouse gas emissions. The costs of inaction are frequently neglected and typically not calculated. These costs include such expenses as rebuilding or preparing infrastructure to meet new realities and the ripple economic impacts on the state's households, the agricultural, manufacturing, commercial and public service sectors.

The conclusions from our nation-wide study highlight the need for increased understanding of the economic impacts of climate change at the state, local and sector level:

- Economic impacts of climate change will occur throughout the country.
- Economic impacts will be unevenly distributed across regions and within the economy and society.
- Negative climate impacts will outweigh benefits for most sectors that provide essential goods and services to society.
- Climate change impacts will place immense strains on public sector budgets.

- Secondary effects of climate impacts can include higher prices, reduced income and job losses.

Methodology

This report identifies key economic sectors in Colorado which are likely affected by climate change, and the main impacts to be expected for these sectors. The report provides examples of the direct economic impacts that could be experienced in the state and presents calculations of indirect effects that are triggered as impacts on individual sectors in the economy ripple through to affect others.

The study reviews and analyzes existing studies such as the 2000 Global Change Research Program National Assessment of the Potential Consequences of Climate Variability and Change which identifies potential regional impacts. Additional regional, state and local studies are used to expand on this work, as well as new calculations derived from federal, state and industry data sources. The economic data is then related to predicted impacts of climate change provided from climate models. To standardize the results, all of the figures used in this report have been converted to 2007 dollars (BLS 2008).

Since the early 1990s, and especially during the 21st century, significant progress has been made in understanding the impacts of climate change at national, regional, and local scales. The Canadian and Hadley climate change models are cited most frequently and we look first to these, yet there are many other valuable models used by some of the specialized studies we cite in this report.

In addition to using data that illustrates the direct economic impacts of climate change, the report also provides examples of the often overlooked ripple economic effects on other sectors and the state economy. To calculate these, we employed a modified IMPLAN™ model from the Regional Economic Studies Institute (RESI) of Towson University. This is a standard input/output model and the primary tool used by economists to measure the total economic impact by calculating spin-off impacts (indirect and induced impacts) based upon the direct impacts which are inputted into the model. Direct impacts are those impacts (jobs and output) generated directly by the project. Indirect economic impacts occur as the project (or business owners) purchase local goods and services. Both direct and indirect job creation increases area household income and results in increased local spending on the part of area households. The jobs, wages, output and tax revenues created by increased household spending are referred to as induced economic impacts.

After reviewing climate and economic information that is currently available, the study identifies specific data gaps and research needs for further understanding of the significant economic impacts. There is no definitive total cost of inaction. Given the diversity in approaches among existing economic studies and the complexity of climate-induced challenges faced by society, there is a real need for a consistent methodology that enables more complete estimates of impacts and adaptation costs. The report closes with basic recommendations and concluding lessons learned from this series of state-level studies.

Not all environmentally induced impacts on infrastructures, economy, society and ecosystems reported here can be directly or unequivocally related to climate change. However, historical as well as modeled future environmental conditions are consistent with a world experiencing changing climate. Models illustrate what may happen if we do not act now to effectively address climate change and if adaptation efforts are inadequate. Estimates of the costs of adapting environmental and infrastructure goods and services to climate change can provide insight into the very real costs of inaction, or conversely, the benefits of maintaining and protecting societal goods and services through effective policies that avoid the most severe climate impacts. Since it is typically at the sectoral and local levels where those costs are borne and benefits are received, cost estimates can provide powerful means for galvanizing the discussion about climate change policy and investment decision-making.

These cost estimates may understate impacts on the economy and society to the extent that they simply cover what can be readily captured in monetary terms, and to the extent that they are calculated for the more likely future climate conditions rather than less likely but potentially very severe and abrupt changes. The broader impacts on the social fabric, long-term economic competitiveness of the state nationally and internationally, changes in environmental quality and quality of life largely are outside the purview of the analysis, yet likely not trivial at all. Together, the monetary and non-monetary, direct, indirect and induced costs on society and the economy provide a strong basis on which to justify actions to mitigate and adapt to climate change.

CLIMATE CHANGE IN COLORADO

In the last century Colorado has experienced rising temperatures, increased precipitation, and altered surface water hydrology as a result of climate change. Since 1900, average annual temperatures for the state have increased most in the highest altitudes while areas with lower altitudes such as the Eastern plains have experienced smaller temperature increases (US EPA 1997; US GCRP 2000; NOAA Satellite and Information Service 2008). For example, the average annual temperature at Fort Collins (high altitude) has increased by 4.1° F while the Arkansas River Valley (lower altitude) has increased by 0.5° F (US EPA 1997; US GCRP 2000). Altogether, winter and summer temperatures have increased more than spring and fall temperatures in Colorado and the state as a whole has warmed faster than both the global and US average (See Figure 3).

Precipitation has generally increased in the state's high altitudes (5-20 percent in the 20^{th} century) and decreased slightly in the leeward Eastern plains (US GCRP 2000; US EPA 1997). Seasonal temperature changes and increased precipitation, less of which is falling as snow, has led to decreased snow pack and earlier spring melting in the Rocky Mountains (US GCRP 2000; IPCC 2007b; US EPA 1997).

As climate change intensifies over the next 100 years, Colorado can expect temperatures to further increase, precipitation to increase, and water resources to become more volatile (US GCRP 2000; US EPA 1997) . Temperatures will continue to increase most in the highest elevations with winter and summer temperatures increasing by 5-6° F and spring and fall temperatures increasing by 3-4° F (US EPA 1997; IPCC 2007b) . Precipitation will increase with altered weather patterns and as warmer temperatures facilitate more rainfall (US GCRP 2000). Winter precipitation could increase by 20-70 percent and changes will be most extreme at high altitudes (US EPA 1997). Surface waters from the major rivers that originate in the Rocky Mountains will likely shift from historic seasonal flow patterns in the coming century, which could exacerbate downstream summer drought (US GCRP 2000; IPCC 2007b) . In addition, extreme events such as drought and catastrophic forest fire will become more prevalent as a result of arid weather and longer growing seasons. Flooding may also become a factor because arid weather makes the soil less permeable to rain and more rain is expected to fall in heavy events (US GCRP 2000; IPCC 2007a).

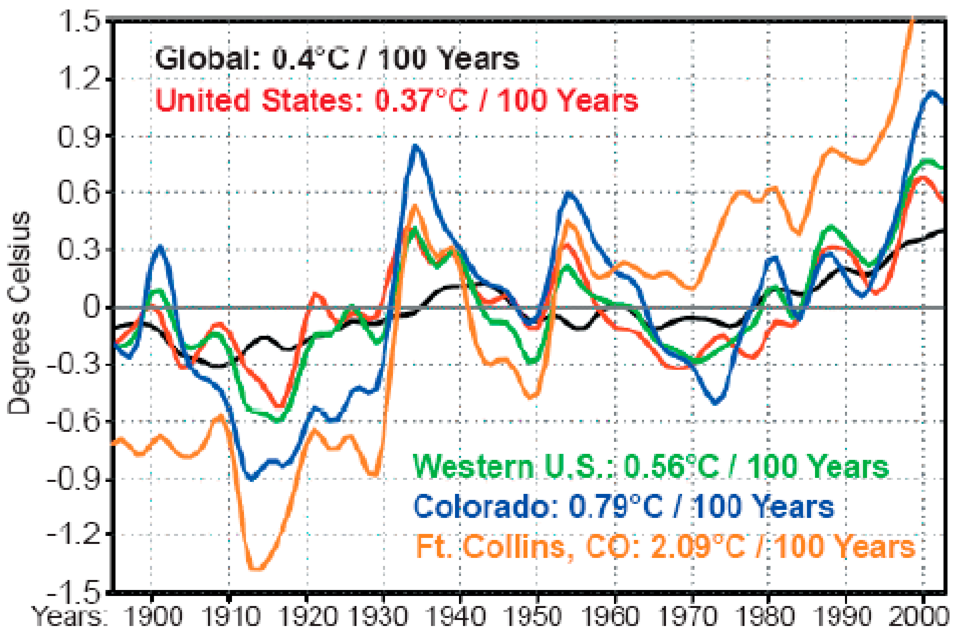

Figure 3. Average Annual Temperature Change in Colorado Relative to US & World (Source: Assoc. of CA Water Agencies and Colorado River Water Users Assoc., 2005)

MAJOR ECONOMIC IMPACTS

One of the largest economic impacts of climate change for Colorado will be on its **tourism** sector and in particular, **skiing** and related winter activities. As the number one ski and snowboard state in the US with 23.1 percent of the market share and an estimated $1.92 (2007) billion worth of revenue generated annually, Colorado's economy benefits immensely from skiing and ski-related tourism (CTO 2008; US GCRP 2000; BLS 2008). However, the state's most popular tourist activity is at risk from climate change.

Under a scenario of continued emissions (700 ppm of CO_2 by 2100), the snowline could increase by 328-1,312 feet and the snow season could become 30 days shorter (Woodford et. al 1998). The rise in the snowline should be less of a concern given Colorado's high altitude, but a shortening season could seriously imperil Colorado's ski industry. Consider that the typical ski resort needs 100-105 days of skiing to secure the average industry profit margin of 6.5-7 percent (US GCRP 2000). This number indicates that regardless of increases in snowfall the bottom-line for ski resorts is heavily dependent on total days of skiing. Furthermore, less precipitation will fall as snow and the IPCC predicts that a 1.8° F increase in annual global temperatures will decrease snow pack by 20 percent in the Northern Hemisphere (IPCC 2007b). As an illustration of the economic impact of less snow, the Denver Post reported that the Vail Ski Resort recorded a $2 million loss in second quarter revenue earnings in 2008 relative to 2007 because of scarce snowfall (Shore 2008). Additionally, the 2006 Colorado College State of the Rockies Report Card highlights the significant losses predicted in snow pack for the state (See Table 1). Given all of these factors, skiing in Colorado will become less reliable and the industry as a whole will take a loss as the effects of climate change become more tangible. As a result of just a 1 percent annual decrease in the amount of tourists visiting Colorado's ski resorts each year, we can expect a total economic loss of over $375 million by 2017 and over 4,500 jobs lost (RESI 2008).

Table 1. Projected Loss in Snow Pack by 2085 with no Greenhouse Gas Reductions

County	Loss in Snow Pack	Resort Impacted
San Miguel	82 percent	Telluride
Eagle	57 percent	Vail and Beaver Creek
Grand	54 percent	Winter Park
Summit	50 percent	Breckenridge and Copper Mtn.

The ski industry is also linked with Colorado's $42.17 billion (2007) insurance, real estate, and leasing sector because so many tourists, vacationers, and homeowners want to buy or rent homes or condos near the ski resorts (COED&IT 2006). The profitability of the real estate sector may decrease alongside reduced opportunities for skiing and winter recreation in Colorado. Moreover, it should be noted that with an increase in winter temperatures, earlier spring thawing, and more precipitation falling as rain, the likelihood of mudslides and avalanches increases considerably (Woodford et. al 1998).

In addition to skiing, tourists visit Colorado's national and state parks, forests, and recreational areas for a variety of outdoor activities. The state has 41 wilderness areas, 28 recreational trails, and countless acres of state and federal public land that serve to attract a wide range of interests. Climate change will impact these natural areas and subsequently, the economic activity they generate. In 2006, nearly 27 million overnight tourists in Colorado spent a total of $9.15 (2007) billion (US GCRP 2000; CTO 2008;

BLS 2008). It is estimated that this economic activity generates 112,000 jobs and $1.81 (2007) billion in payroll revenue (BLS 2008). Climate change will adversely affect winter related activities such as snowmobiling and skiing, however it is possible spring, summer, and fall activities like whitewater rafting, hiking, and camping may do well under a scenario of longer seasons and higher minimum temperatures (US GCRP 2000).

OTHER ECONOMIC IMPACTS

Aside from the present danger climate change poses to skiing and general winter tourism in Colorado, a number of other economic sectors will be threatened including natural resources, agriculture, and public health.

Natural Resources

Natural resources including species diversity, water, and forests play a critical role in Colorado's economic and cultural identity. Today, Colorado's natural resources sectors account for 2 percent of the state's workforce, or about 63,000 jobs, and $2.12 (2007) billion in revenue (COED&IT 2006; BLS 2008) . In addition to the use value of Colorado's natural resources, the citizens of the state and the US as a whole derive significant benefit from the resources' existence value. Climate change is liable to affect both the use and existence value as temperature and precipitation changes stimulate statewide changes in **forest** health, **biodiversity**, and **water** availability.

Forests are probably the single most threatened natural resource, as foreign and native pests and diseases, as well as forest fires, will all thrive under a warmer climate. Warmer temperatures and longer seasons have encouraged population growth and range expansion from species such as the western spruce budworm, the pinon ips beetle, and the mountain pine beetle. For example, the mountain pine beetle, which benefits from an earlier spring and a protracted autumn, killed 1.2 million alpine trees in 2004 and 1.5 million lodgepole pines since 1996 (Colorado Forest Advisory Board 2005; Hartman 2008) . The cost of forest thinning and management involved with cleaning up beetle infested trees on ski resorts and other private land runs about $100 per tree; Vail Ski Resort cut down 2,000 tees at a cost of $200,000 in 2008 (Williams 2008). Additionally, Summit County estimates it costs roughly $2000 per acre to thin infected trees. With beetles infecting roughly 500,000 acres last year, full thinning of forests would have cost $1 billion (Williams 2008; Hurst 2008) .

Thinning of infected forests is critical partly because dead trees function as hazardous fuel for wildfires – a problem that has recently worsened in Colorado and the entire Western US irrespective of invasive infestations. The average annual amount of acres burned on Forest Service protected land from 1910 to 1999 was around 450,000; between 2000 and 2002 this figure averaged 1.1 million (Linton 2004). The 2002 Hayman Fire, which is Colorado's largest in history, burned 138,000 acres, 133 homes, and had a total suppression cost of $39 million (Colorado Forest Advisory Board 2005). Based on California's Fall 2007 fires, a conservative estimate for the average damage costs per acre burned is about $2,500 (NPR 2007). With the median amount of private land acres burned in significant fires totaling 9,127 since 2000 in Colorado, the median annual cost of private land damage is around $22.8 million (CSFS 2007). If the median annual forest fire damage on private land increases by 2 percent each year for the next 10 years, we can expect total costs of almost $8 million per year by 2019 (RESI 2008). These large catastrophic fires will become more common as warmer summer temperatures create drought-like conditions and as destructive forest pests create more hazardous fuel.

Biodiversity in Colorado will come under threat as native species accustomed to Colorado's unique climate regions become ill suited to survive under warmer temperatures. For instance, Colorado's characteristically dense alpine forests could shift up in elevation by 350 feet for each degree Fahrenheit increase (US EPA 1997). Furthermore, drought caused from warmer summer temperatures could inhibit dense clustering of trees and ultimately, the composition of some forests (US EPA 1997). Cold-water trout, which have historically prospered in the cold headwaters of the Rocky Mountains, will suffer from an increase in water temperatures (US GCRP 2000; Woodford et. al 1998). One scientist suggests Western Trout populations may decline by as much as 64 percent as a result of climate change (Williams 2007). Large charismatic animals like deer and moose may benefit from warmer temperatures at high altitudes where they prefer to graze while other animals such as bears may migrate north to colder climates (US GCRP 2000). A wide range of smaller scale dynamics will occur through the next century as insects and pests typically excluded from cold, high-altitude places infiltrate the region and alter the entire food web. As the makeup of Colorado's ecosystems comes to resemble less familiar territory, revenue from fishing, hunting, and sightseeing in the state could decrease; fishing and hunting annually contributes $1 billion to the state's economy (COED&IT 2006).

Although Colorado generally has plentiful **water resources** as the origin for five major rivers in the American West, complex water rights, warmer temperatures, and population growth could more than offset their advantageous position in the coming century. Currently, an estimated three-fourths of the yearly water flow for the major rivers of the Rockies comes from snowmelt in the spring. Nonetheless, with snow packs decreasing by as much as 80 percent in parts of Colorado and melting occurring earlier in the season, late summer and fall water stress could become a regular occurrence in Colorado (Colorado 2006). Also, the West receives 85 percent of their water from surface waters – a significant figure considering evaporation affects lakes, rivers, and reservoirs significantly more than subsurface water sources (e.g., Ogallala Aquifer) (US GCRP 2000). In 2002, when Colorado's reservoir shortage was only 48 percent of average levels, the state lost an estimated $1 billion dollars in revenue because of drought with tourism and agriculture being the hardest hit industries (CSU 2002). The overall severity of the water shortage problem depends on the amount of summer precipitation, but regardless of fluctuations, water shortages will likely arise as summer temperatures increase throughout the next century.

Agriculture

Colorado's **agriculture** sector is not forecasted to benefit from climate change. The combination of more arid temperatures on both the Eastern plain and Western slope as well as the predicted water strain will cause a decrease in productivity for grains by 8-33 percent; hay yields may increase (See Figure 5) (US EPA 1997). Currently, an estimated 80 percent of water goes towards irrigation for agriculture in the Western US (US GCRP 2000). With a population of 4.7 million and a growth rate of 10.7 percent per year in Colorado, and the effects of climate change worsening, less water will be available for irrigation in the future (COED&IT 2006). One study examining lower water supplies in California predicts a reduction in the value of farmland by an average of 36 percent, which is a loss of about $1,700 per farm (Schlenker et. al 2005).

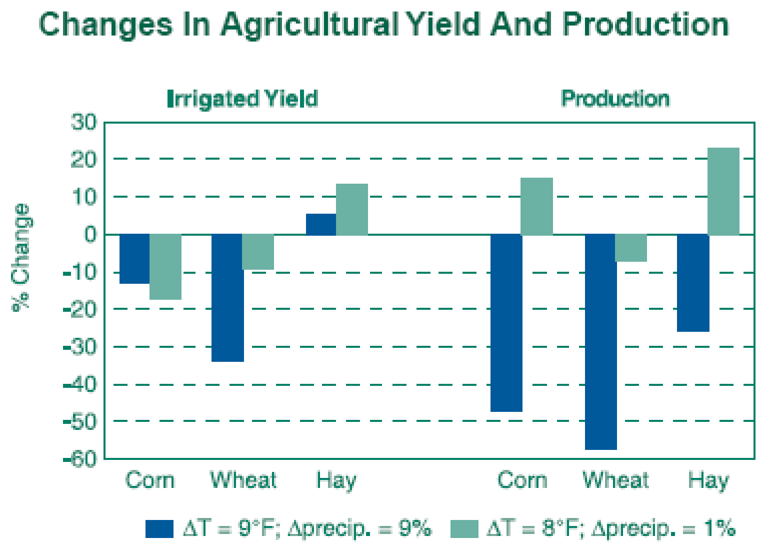

Figure 5. Agricultural Production and Yield Based on Two Climate Change Scenarios (Source: US EPA 1997)

The value of all agricultural goods in Colorado, in 2002, was $4.5 billion with crops accounting for about a fourth of the total value and livestock and poultry goods accounting for three-fourths. Livestock and poultry production will be impacted by climate change as heat stress inhibits healthy development of animals. One estimate shows that dairy cows begin to lose milk productivity when temperatures exceed 75° F because of heat stress (Frumhoff et. al 2007). In 2006, Colorado produced 2.5 billion pounds of milk and other dairy goods worth $284 (2007) million (US DA 2002). If dairy production decreases by just 10 percent in Colorado an estimated $28 million will be lost relative to current value; a stymied dairy industry will mean roughly $30 million in indirect costs and an estimated 520 jobs lost (RESI 2008). The Eastern plains of Colorado, which have been prime real estate for livestock grazing in the past, may no longer be suitable with a temperature increase of 3-4 degrees Fahrenheit; ranchers may respond by shifting grazing activity northward to Wyoming and Nebraska (US GCRP 2000).

Health

Negative **health** impacts will occur as a result of long-term changes such as a warming summer temperatures, the introduction of foreign pests and diseases to the state, and increased contamination of water supplies. Short-term extreme events such as forest fires and flooding will also create health problems. Ground level ozone could increase as a result of warmer summer temperatures causing respiratory illnesses such as asthma (US EPA 1997). Temperature increases will be higher in cities and developed regions relative to surrounding rural areas as a consequence of heat absorbing buildings and concrete. Known as the urban heat island effect, this phenomenon will have a detrimental impact on densely populated regions such as Denver. Another serious threat associated with an increase in temperature is the expansion of the habitat range for disease-carrying insects such as mosquitoes. A 5-9 degree Fahrenheit increase in temperature would cause a northern shift in Western equine encephalitis outbreaks and similar diseases such as the Hantavirus pulmonary syndrome (US EPA 1997).

Higher temperatures increase evaporation, which reduces supply and increases demand for drinking water and irrigation. Reduced water supplies also can lead to a higher concentration of bacteria, pesticides and other unwanted bodies than would be present under past conditions. Moreover, warmer water and longer seasons facilitate the growth of algae and harmful bacteria that lead to fish kills and general water contamination. Short-term events such as forest fires release harmful chemicals into the air, which can cause respiratory illnesses. Also, flooding could increase as arid conditions create dry impermeable land and as more precipitation comes from large, single events. Total losses from Colorado flooding between 1900 and 1993 included 331 people killed and $4.74 (2007) billion in property damage (Colorado Department of Local Affairs 1999),

MISSING INFORMATION AND DATA GAPS

Colorado is a geographically and topographically complex state with a great deal of variance between areas, which results in many sub-climates. The variance within the state was accounted for as best as possible by avoiding generalities where they did not apply. More precise data should be garnered on Colorado’s sub-climates to gain the clearest picture of how climate change will affect Colorado. Overall, this study is subject to the uncertainties inherent in measuring global climate change and climate change itself and attempts to reflect this to the best possible extent through use of scenarios and ranges of confidence intervals. Additionally, quantifying the economic impacts of climate change deserves significantly more focus as this paper and much of the literature on the topic primarily qualify the potential impacts. Further, data gaps exist between the effects of climate change in one particular sector and the ripple effects that manifest in interconnected sectors. Analysis of this sort would be useful to policy-makers and businesses at all levels and sizes.

CONCLUSIONS

The state of Colorado’s greatest challenge is likely to be in adapting to climate change along its mountain corridor, where the most significant economic and ecological impacts will occur. The state’s tourism, natural resources, and agriculture industries are most vulnerable, so it is recommended more research be done to examine the stability of these industries. Along the same line, further development in these industries needs to be carried out with the understanding that the future conditions for success are relatively uncertain, if not foreboding. Lastly, legislators may want to consider legislation to circumvent health related impacts of climate change related to the urban heat island effect, air pollution from forest fires, and decreases in fresh drinking water quantity and quality. The urban heat island effect can be mitigated through careful city planning and smart growth (e.g., incorporating more green space into development sites). Maintaining water resources could be accomplished through careful monitoring and if need be, regulation of agricultural irrigation.

Lessons Learned

As we begin to quantify the potential impacts of climate change and the cost of inaction, the following five lessons are learned:

1. There are already considerable costs to society associated with infrastructures, agricultural and silvicultural practices, land use choices, transportation and consumptive behaviors that are not in synch with past and current climatic conditions. These costs are likely to increase as climate change accelerates over the century to come.

2. The effects of climate change should not be considered in isolation. Every state's economy is linked to the economies of surrounding states as well as to the national and global economy. While the economic costs of climate change are predicted to vary significantly from state to state, the negative impacts that regional, national and global markets may experience are likely to affect all states and many sectors.

3. While some of the benefits from climate change may accrue to individual farms or businesses, the cost of dealing with adverse climate impacts are typically borne by society as a whole. These costs to society will not be uniformly distributed but felt most among small businesses and farms, the elderly and socially marginalized groups.

4. The costs of inaction are persistent and lasting. Benefits from climate change may be brief and fleeting -- for example, climate does not stop changing once a farm benefited from temporarily improved growing conditions. In contrast, costs of inaction are likely to stay and to increase.

5. Climate models and impact assessments are becoming increasingly refined, generating information at higher spatial and temporal resolutions than previously possible. Yet, little consistency exists among studies to enable "summing up" impacts and cost figures across sectors and regions to arrive at a comprehensive, state-wide result.

6. To provide not just a comprehensive state-wide assessment of impacts and cost, but to develop optimal portfolios for investment and policy strategies will require support

for integrative environmental research that combines cutting-edge engineering solutions with environmental, economic and social analysis. The effort and resources required for an integrative approach likely pales in comparison to the cost of inaction.

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