The Impact of Climate Change on Montana's Outdoor Economy

Prepared for the

Montana Wildlife Federation

by

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The Economic Impact of Climate Change in Montana

Executive Summary

1. Climate Science and Projected Climate Change in Montana

The Intergovernmental Panel on Climate Change has made it abundantly clear that human-caused greenhouse gas emissions are the dominant cause of the observed warming of the earth since the mid-20th century and that the warming will continue through into the next century. Using geographically more detailed versions of Global Climate Models, the earth's observed and predicted warming can be brought down to a regional U.S. state level and smaller sub0state regions to analyze geographically much more specific observed and predicted changes. Using the Third National Climate Assessment, we break Montana out of the Great Plains states to view the likely changes that Montana will see in the future due to climate change. We focus on a business-as-usual scenario where the world does not successfully work to reduce the release of greenhouse gasses and, as a consequence, the mean global temperature is predicted to rise by 6.5 degrees (F) by 2100.

We focus on the two most dominant variables for climate change in Montana: temperature and precipitation.

Temperature: Montana is predicted to see a temperature rise of 4-5 degrees (F) by 2055. The temperature change will be greater in the winter with a temperature change of as much as 6.5 degrees (F) in the northeastern portion of the state. Montana is predicted to have a decreased number of days where the temperature drops below 10 degrees (F) (at least 15 fewer days and as many as 30 depending on the geographic location). Montana is predicted to see a decrease in the number of days that the temperature drops below 32 degrees (F) (at least 20 fewer days and as many as 40 depending on the geographic location). For the winter it is the increased number of warm days and the increase in precipitation that has the largest effect on the plants that grow within the different Montana ecosystems.

Montana is predicted to see an increase in the number of days where the temperature exceeds 95 degrees (F) (at least 5 more days and as many as 15). Montana is predicted to see an increase in the number of freeze-free days (at least 15 more and as many as 35 depending on the geographic location). For the summer, it is the days of extreme heat and the lack of precipitation that has the largest effect on the plants that grow within the different Montana ecosystems.

Precipitation**:** Although precipitation is less certain within the more geographically detailed Global Climate Models because of the existence of multi-year weather cycles (like El Nino or the Pacific Decadal Oscillation) and the lack of data specifically looking at these cycles, precipitation is an important and controlling variable for plant growth in the different Montana ecosystems.

Montana is predicted to get more precipitation by 2055. Most of Montana is predicted to receive 3-6 percent more precipitation while the northeast portion will receive 6-9 percent more precipitation. The ecologically critical point for precipitation is when it falls. Significantly more precipitation will fall in the winter and significantly less precipitation will fall in the summer. This is especially true for western Montana where precipitation will be 5-10 percent lower in the summer and 10-15 percent higher in the winter.

Because Montana is predicted to warm in the winter, less precipitation will fall during the winter as snow and more will come in the form of rain. Because Montana is predicted to get less precipitation in the summer and the summer is predicted to be hotter, there will be significant plant stress due to drought and extreme heat during the summer. The combination of changes in precipitation and temperature may have large impacts on the industries in Montana that are dependent on a climate that many Montanans mistakenly see as largely stable despite its wide range of variability at any given time.

Less snowpack in the high country means less runoff for our streams in late spring and early summer, and the runoff will come earlier.

Wildlife will stay in the high country for longer periods both because they will seek cooler temperatures there and they will not be pushed down by early winter snowfalls. Migration patterns for wildlife may change as autumn drags on longer and the spring comes earlier. Less snowpack in the high country means less runoff for our streams in late spring and early summer stressing of fish because of higher stream temperatures and lower stream levels. The runoff will come earlier stressing native fish as they compete against invasive species that are better suited to warmer water, changing runoff timing, and a change in the timing of the hatches that native fish feed on. In turn, hunters and anglers in Montana will either have to change their habits or will have diminished returns with respect to the “normal” environment that they grew up with and have come to rely on.

Skiers, snowmobilers, and winter recreationists of all sorts will have to recreate in a winter that is significantly shorter, significantly warmer, and has significantly less snowpack as more precipitation comes in the form of rain as opposed to snow. Ski areas will be forced to either make more snow if the temperatures at lower elevation are cold enough and the ski areas can obtain secure water rights in an increasingly competitive market for those rights or move up the mountain in search of cooler temperatures. Snowmobilers and other recreationalists will be forced to travel farther and higher and face a significantly shorter season.

Visitors to Montana and residents alike will deal with summers that are hotter and have significantly longer fire seasons with increased incidence of wildfire. The National Parks in Montana (Glacier and Yellowstone), which combined see visitation in excess of 5 million visitor days per year, will see a dramatic decrease in visitation as fire closes parts of the parks and smoke deters visitors from entering the parks and eventually deters them from coming to the parks during the extended fire season at all.

Disease and beetle kill will increase as the temperature increases and the summer moisture decreases and the native trees are too stressed to resist. The very composition of our forests will change causing the loss of the white bark pine and a transition from Ponderosa Pine and Douglas-fir to spruce-fir. The grasslands of Montana will convert to sage brush and other scrub brush dominant species.

Forest managers and scientists project that the acreage burned by wildfires in Montana will double between 2016 and 2050 because of the stress on trees and other vegetation from higher summer temperatures in the face of limited moisture. At the same time, in the pursuit of the natural amenities associated with living in Montana's forested mountains and valleys, more and more Montanans are projected to build their homes on the privately owned land adjacent to public forest land. These private lands that can be developed for residential living have been labeled the Wildland-Urban Interface (WUI), an area of human habitation especially at risk to wildfire.

As wildfires grow more numerous, more intense, and larger, more and more of these homes will be at risk of loss to wildfire and the cost of trying to control those wildfires will rise as more firefighting resources are devoted to protecting those homes. Insurance companies are tracking these residential location decisions and the risk of home loss. This has provided information that allows the estimation of the property values at risk.

2. The Sectors of the Montana Economy Most Likely to Be Significantly Impacted by Climate Change

Based on the application of the recent climate science projections for Montana, we concluded that the greatest economic impacts would be on the activities of Montanans that rely on the natural landscapes, Montana's *outdoor economy*. Those economic sectors include activities in our forests, grasslands, rivers, lakes, and mountains.

In particular this report focuses on the following activities:

- Outdoor recreation including
    - Wildlife watching and sightseeing
    - Visits to Yellowstone and Glacier National Parks
    - Angling and sport fishing
    - Big game hunting
    - Winter sports, especially
        - Alpine skiing and snowboarding
        - Snowmobiling
- Forest-based activities including
    - The cost of wildfire control
    - The impact of wildfires and the smoke they create on outdoor activity, health, and quality of life.
- The impact of catastrophic wildfire on residences within the Urban-Wildland Interface
    - Homes lost
    - Value of property destroyed
    - Cost of fighting wildfires
    - Discouragement of in-migration to Montana

3. The Relative Importance of the Economic Sectors Most Impacted by Climate Change

Forecasted climate change in Montana puts aspects of all of the activities listed above at risk of significant change and potential serious loss. For that reason we obtained estimates of the relative importance of these different activities to Montanans and the Montana economy.

The recreation and tourism sectors of the economy, directly or indirectly, have been estimated to be the source of 34,000 to 89,000 Montana jobs, depending on how the recreation and tourist activities of Montana residents within Montana are accounted for. If the recreation and tourist activities of Montana residents are ignored because they do not bring new income into the state, the job estimate is 34,000. If the in-state recreation activities and trips of Montana residents are included in the estimate of relative economic importance of the recreation and tourism sectors, their measured relative importance in the Montana economy is much larger, 89,000 jobs. Our report discusses the advantages and disadvantages of each of these approaches to relative economic importance.

In terms of labor earnings that result from this recreation and tourist activity, it is the source of about $1.0 billion to $2.3 billion per year. The smaller estimate, again, is associated with an exclusive focus on non-resident recreation and tourist activity in Montana and ignoring Montana's residents recreation and tourist activities.

Table Sum-1 provides a more detailed view of the relative importance of the various recreation and tourist sectors.

Clearly the recreation-tourist sectors of the Montana economy is of significant importance. In total, it is responsible for over $1 billion in labor earnings and about 42,000 jobs. Climate change that threatens these sectors, poses a serious threat to the overall Montana economy.

4. The Estimated Economic Losses Associated with Climate Change in Montana

Both climate change and economic impacts are difficult to calculate. Both require professional judgement based on the best evidence available. In public discussion of public policies aimed at reducing human releases of greenhouse gases (GHG), there tends to be a heavy emphasis on the economic *costs* associated with adopting those policies. When these costs of controlling GHG are discussed, there is rarely a similar discussion of the economic *benefits* that are the objective of those climate change public policies, namely avoiding the future costs associated with climate change. The result is a cost-only analysis that typically projects large costs associated with policies aimed at reducing future human-caused climate change.

A "cost only" analysis of climate change public policy clearly is an incomplete *economic* analysis since it is the net costs or net benefits after both the benefits and costs of a public policy have been estimated that matter. Implicit in typical cost-only analyses is the assumption that the benefits of reducing human-caused climate change are known in precise, quantitative, detail, namely, that they are zero. As this report will demonstrate, the overwhelming scientific evidence is that this precise quantitative value of slowing or stopping human-caused climate change is wrong. The future costs associated with climate change that could be avoided are not zero, they are large and significant.

Table Sum-1.

Summary of Montana Recreation-Tourist Relative Economic Importance: 2011-2014		
	Jobs	Labor Earnings
Estimates of the Total Montana Importance		
Montana Non-Resident Visitors ITRR	53,280	$1,565,440,000
Montana Outdoor Recreation-Southwick	89,000	$2,262,275,000
"MT Non-Resid Tourist & Recreation" Total	33,977	$998,283,648
Components of Montana Tourism and Recreation Activity		
Glacier-Yellowstone NPs Visitation	9,992	$281,247,800
Wildlife Viewing	11,102	$245,218,783
Hunting Activities	11,140	$281,270,023
Sport Fishing	5,375	$147,910,383
MT Skiing / Snowboarding	2,850	$83,148,800
Snowmobiling	1,544	$27,787,470
SubTotal of Listed Components	42,003	$1,066,583,259

Sources: See Table 3 of this report for citation identification and explanation.

In the analysis below we combine the quantitative information that is available with expert judgement to produce estimates of the likely economic costs associated with climate change in Montana if no public policy steps are taken to reduce human GHG emissions. That expert judgement is tied a half-century of experience analyzing the Montana economy, the role that natural and social amenities have contributed to economic vitality in Montana, and long run economic trends within the state and region. In our professional judgement, these estimated economic costs of projected climate change in Montana are far more reliable and accurate than the common alternative assumption that there are zero costs associated with that ongoing, human-caused, climate change in Montana.

i. Visitation to Yellowstone and Glacier National Parks, Wildlife Watching, and Sight-Seeing

The hotter, drier, and longer summers will increase the frequency, intensity, and size of wildfires and the duration of the wildfire season. This will lead to active fires in and around Montana's national parks. The threat and actuality of wildfires and the smoke associated with them will lead to more frequent closures of parts of those National Parks. The smoke will obscure vistas and cause discomfort and health problems. The increased frequency and prevalence of these problems will lead potential visitors to avoid or be diverted from Montana's National Parks.

Available data and research indicate that visitation to these Montana National Parks will decline by a third. The economic impacts will be the loss of 3,300 jobs and $94 million in labor earnings. Although Montana's National Parks have experienced record or near record visitation levels despite the 2015 wildfires, we explain why this is unlikely to continue with ongoing climate change.

These same problems associated with climate change and wildfire will also discourage wildlife watching and sight-seeing activities in Montana. Available data and research indicate a 25 percent decline in that activity. The projected economic impact would be the loss of 2,800 jobs and $61 million in labor earnings.

ii. Big Game Hunting

Montana's traditional archery hunting season, September to early October, and rifle hunting season, late October to late November, will be warmer and drier. Big game will move into the high country and stay there longer to avoid the higher temperatures and because snowfall will come later. This will make hunting more difficult because the game will be more distant from road access and snowfall to assist in tracking will be less likely. Meat spoilage will be more of a problem. Milder springs will increase the survival of calves and fawns and big game populations will periodically exceed the sustainable carrying capacity of the habitat. This will lead to more big game gathering on farm- and ranchland during winter months, contributing to disease problems and damage to farm and ranch lands. Wildlife managers will face increasing pressure to implement out-of-season culls or "hunts" to thin and disperse these big game populations.

Available data and research indicate that the increased difficulty and productivity of big game hunting and the deterioration of the quality of the hunting experience will reduce big game hunting by about 15 percent by the middle of the century. The economic losses associated with this would be about 1,600 jobs and $39 million in labor earnings.

iii. Angling and Sport Fishing

Hotter, longer, and drier summers combined with less snowpack and earlier runoff of snow melt will lead to lower and warmer stream flows in the late spring and summer. This will lead to more frequent and longer restrictions on fishing to protect the fish already suffering from heat stress. The warmer temperatures will also advantage invasive fish species that will out-compete and/or interbreed with native Montana fish. Some native species are likely to be lost and popular fisheries will decline.

The impact of these expected climate changes is projected to be a one-third decline in angling days. The economic losses associate with this will be about 1,800 jobs and $49 million in labor earnings.

iv. Winter Sports: Alpine Skiing and Snowboarding and Snowmobiling

Montana's ski areas will face significantly degraded snow conditions. Less winter precipitation will come as snow and more as rain. The elevation at which reliable snowpack will be found will rise above current base ski areas. Warmer temperatures and competition over water rights will limit the ability to produce artificial snow at lower elevations. Ski areas will face costly adjustments to their infrastructure. Montana ski areas will open later and close earlier or, in some years, not open at all.

Snowmobilers will face similar problems as snow recedes to higher elevations that are more difficult to access. Since snow-making is not practical for snowmobile trails, accessible snowmobiling terrain will shrink in size.

Available data and research indicate that skiing and snowmobiling activity days will shrink by a third with a loss of about 1,500 jobs and $37 million in labor earnings.

Table Sum-2.

Projected Economic Losses Due to Climate Change in Components of the Montana Recreation and Tourism Activities		
	Jobs	**Labor Earnings ($millions)**
Glacier-Yellowstone NP Visitation	3,331	$94
Wildlife Watching & Sight-Seeing	2,775	$61
Hunting	1,560	$39
Sport Fishing	1,792	$49
Skiing, Snowboarding, Snowmobiling	1,465	$37
Total Economic Losses in Recreation and Tourism	**10,922**	**$281**

Sources: See Tables 6 through 10 of the Report.

v. Wildfire, People, and Property.

Climate change in Montana will produce more frequent, larger, and more intense wildfires. Because the most densely populated regions of Montana are in the forested mountains and valleys of western and southwestern Montana, these future, more ferocious, wildfires represent a serious risk to Montanan's communities, homes, and lives. The extent of land burned by wildfires is expected to increase dramatically compared to earlier decades, increasing 200 to 500 percent depending on the location in Montana.

The 2000 Wildland-Urban Interface (WUI) across all of Montana contained about 261,000 homes. Valued in 2011 dollars those homes would be worth $47 billion. A 2015 estimate of the homes at risk to wildfire in Montana estimated that 60,000 homes were at "high" or "very high" risk of loss to wildfire. The replacement cost of those homes was estimated to be about $17 billion (in 2014 dollars).

Our estimated risks of home loss are built around conservative estimates of the time interval before a wildfire intense enough to destroy homes occurs. These vary with the risk category into which the Montana WUI homes fall. This average time to a home-destroying fire is assumed to be stochastic with a known average value. From this a geometric probability function was used to estimate the probability of loss within the next 35 years.

If we conservatively assume that no new homes are built in the WUI between now and mid-century, the potential annual losses would be 227 homes and the value of that *annual* loss of homes would be $53 million (all in 2014 constant dollars).

In addition, we have estimated other economic costs associated with wildfires that are more frequent, burn more acreage, and are more intense. In addition to more homes being destroyed by fire, the cost of controlling wildfires will increase, and the overall impact of climate change, especially fire, on the attractiveness of Montana as a place to live, work, raise a family, and do business will decrease the rate of in-migration of new residents and businesses. This will reduce employment and labor earnings growth. Those impacts of more destructive wildfires are summarized in Table Sum-3 below.

Table Sum-3.

Economic Costs Associated with More Destructive Wildfires

Type of Cost	Cost or Impact ($millions)
Loss of Homes (replacement cost, 2014$)	
Annual Loss of Homes 2016-2050	$53
Cumulative Loss of Homes	$1,900
Increased Cost of Controlling Wildfire (annual, 2014$s)	$261
Decreased Rate of In-Migration to Montana	
Average Annual Labor Earnings Reduction 2016-2050 (2014$)	$858
	Number of Jobs
Average Annual Employment Reduction 2016-2050	1,700

Sources: Section V.7 of this report.

Clearly the economic cost of taking a business-as-usual approach to climate change in Montana will be far removed from the precise zero cost that is often casually assumed during discussions of the appropriate public policy response to mitigate future climate change in Montana.

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I. Global Climate Change and Montana Impacts

The Intergovernmental Panel on Climate Change (IPCC) released their fifth assessment in 2014.[1] In that assessment the Panel made clear that human-caused greenhouse gas (GHG) emissions were the dominant cause of the observed warming of the earth since the mid-20th century. On July 3rd of 2015, at the Lindau Nobel Laureate Meetings, a group of 39 Nobel Winners from different scientific fields signed a declaration warning that the world faces a threat that is comparable to the nuclear threat of nearly 60 years ago for which a similar group of Nobel Laureates signed a warning declaration.[2] In the recent declaration the Nobel Laureates expressed their confidence in the fifth IPCC report calling it the "the best source of information regarding the present state of knowledge on climate change."[3]

What has become increasingly clear is that there is no longer a credible debate among scientists who study global warming. Global warming is happening, the primary driver of global warming is human GHG emissions, and unless humans collectively do something about it, every inhabitant of earth will be affected by it. In this report we seek to understand what the likely impacts of global warming will be on various economic sectors of the Montana economy.

Although global climate models (GCM), like the ones that are used in the IPCC reports have been around for quite some time, the geographic detail of those models has been relatively poor until recently when scientist began "downscaling" their GCM. The resolution of the downscaled models allows the large grid size of the global models, which are generally 60-120 miles[4] and could potentially miss large scale regional features such as mountain ranges, to be downscaled to local data sets with a resolution of 7.5 x 7.5 mile (1/8 degree).[5] This finer geographic detail allows very specific future climate predictions to be analyzed at a sub-state level in Montana.

The Third National Climate Assessment (NCA3) was published in 2014 by the U.S. Global Change Research Program. In that assessment the state of Montana was grouped with the Great Plains states.[6] That regional and state climate assessment was supported by an analysis carried out by the National Oceanic and Atmospheric Administration (NOAA) and published in 2013.[7] We use these predictions of future climate change in Montana as a basis for our

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[1] https://www.ipcc.ch/report/ar5/index.shtml
[2] http://www.lindau-nobel.org/wp-content/uploads/2015/07/Mainau-Declaration-2015-EN.pdf
[3] Ibid.
[4] Ibid. page 7.
[5] Downscaled CMIP3 and CMIP5 Climate Predictions. Bureau of Reclamation. May 7, 2013. Page 4. http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/techmemo/downscaled_climate.pdf
[6] http://nca2014.globalchange.gov/report/regions/great-plains The eastern two-thirds of Montana is part of the Great Plains geographic region. The western and southwestern third, from the eastern foothills of the Rocky Mountains to the Montana-Idaho border is often classified as part of the Pacific Northwest or Northern Rocky Mountain geographic region.
[7] Regional Climate Trends and Scenarios for the U.S. National Climate Assessment, Part 4. Climate of the U.S. Great Plains. National Oceanic and Atmospheric Administration. 2013.

analysis. These predictions were made using the same GCM and the same scenarios that the IPCC reports use but applies them to much smaller geographic regions.

The scenario on which we are focusing our study is "A2" in the NOAA Great Plains study mentioned above. Scenario A2 is the closest to what is traditionally called the "business as usual" scenario. It is a scenario where the "underlying theme is self-reliance and preservation of local identities"[8] which means that the world does not come together to try and abate the collective emissions of the many different countries. The end result for the earth is a mean global temperature rise by the year 2100 of about 6.5 degrees (F). We must then look to the downscaled or regional climate models to see what this increase in GHG and the accompanying change in temperature and precipitation are predicted to be in Montana. It should be noted that the time periods that we are looking at do not always match up. In a perfect world all of the scientists would choose to look at the same time periods for their different climate change predictions. However, in practice they do not all choose the same time periods. Wherever possible we choose to present the projections that are as close to 2055 as possible. Although the time periods of the different projections do not always match up the trend of the change is always in the same direction.

1. Climate Change in Montana

We will begin by focusing on the two most dominant effects of climate change in Montana: temperature and precipitation. The general trend in Montana, like the world trend mentioned above, is that Montana gets warmer. Precipitation patterns are a little less well understood with GCM but generally precipitation in Montana increases. Warmer air can hold more moisture than cold air and allow more moisture to be carried into the state during the winter months which is not offset by the reduced moisture during the summer months.

A. Temperature changes in Montana

Montana is predicted to see a temperature rise of 4-5 degrees (F) by 2055.[9] This temperature increase will be greater in the winter with a temperature change of as much as 6.5 degrees (F) in the northeastern part of the state and smaller in the spring with an average temperature rise of 3 degrees for most of the state.

Montana is predicted to see an increase in the number of days when the temperature exceeds 95 degrees (F). By 2055 Montana is predicted to have between 5 and 15 more days where the

[8] Ibid. Page 6.
[9] Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 4. Climate of the U.S. Great Plains. Figure 14, page 38. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. January, 2013.

temperature reaches above 95 degrees (F).[10] The western portion of the state will see the lower end of the extreme heat (mainly due to the mountains) while the central and eastern portions of the state see the larger end of the extreme heat days.

Montana is predicted to have a decreased number of days where the temperature drops below 10 degrees (F). The change is not as homogenous as the increased temperature, but all of Montana is predicted to have at least 15 fewer days below 10 degrees and as many as 30 fewer such days in the southwest portion of the state.[11] These future temperature predictions fit the research of Pederson who looked at what climate change in Western Montana has already taken place and found that:

> The last extremely cold day of the winter season, however, has changed significantly, arriving an average of 19 days earlier. During the early-20th century (1900–1910) extremely cold temperatures (*t*min ≤ −17.8◦C) typically ended on winter [year day] YD 248 (~March 5). Over the past decade (1996–2006) the end of winter season's extremely cold events has occurred on average by winter YD 228 (~February 15). The earlier termination of extreme cold events (*t*min ≤ −17.8◦C) documented here reflects the autumn/spring asymmetry in warming noted below.[12]

Montana will have a decreased number of days where the temperature drops below 32 degrees (F). Again the change is not as homogenous as the temperature increases across Montana. There is a range of decreased days when the temperature drops below 32 degrees ranging from 40 less days in the northwest portion of the state to 20 less days in the eastern and northeastern third of the state.[13]

Montana will have an increased number of freeze-free days by 2055. The western part of the state, which is also the mountainous region, will see the largest increase in freeze-free days with an increase of 36 days, and the northeastern corner of Montana will see the smallest increase with 15 days.[14] Again Pederson confirms that these predictions about the direction and magnitude of temperature trends in Montana have already begun:

> With a demonstrated increase in number of "hot" days (≥32.2◦C) experienced per year across western Montana, it follows logically that a reduction in number of "cold" days per year should be evident. With few exceptions, western Montana meteorological stations have experienced a decrease in annual number of freeze/thaw days (*T*min ≤i0◦C), and extremely cold days (*T*min ≤ −17.8◦C). The average loss of number of days at or below the freeze/thaw threshold (*T*min ≤ 0◦C) in western Montana is approximately 16 days, declining from an average of

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[10] Ibid. Figure 17, page 44.
[11] Ibid. Figure 18, page 45.
[12] YD refers to "year day." Pederson et al. A Century of climate and ecosystem change in Western Montana: what do temperature trends portend? *Climate Change*. 98:133-154. 2010.
[13] Ibid. Figure 19, page 46.
[14] Ibid. Figure 21, page 49.

~186 to ~170 days−yr. The sharpest decline in number of freeze/thaw days has occurred within the last 20 years.[15]

By 2055 Montana will have an increase in the number of cooling degree days.[16] Western Montana will see an increase of 200 cooling degree days and eastern Montana will see an increase of 400 cooling degree days.[17] By 2055 Montana will also have a large decline in the number of heating degree days.[18] Southwestern Montana will see -1,650 heating degree days while most of the eastern half of Montana will see -1,250 heating degree days.[19] Heating degree days are a measure of the temperature relative to a benchmark (65 degrees F). A decrease in heating degree days then describes a Montana future where there are far less days below 65 degrees and the magnitude of the heating degree days describes how far above 65 degrees it will be over the year. For each day and each degree above 65 degrees, one heating degree day is added. So, for example, if there is one heating degree day where the temperature is 75 degrees (F), that represents 10 heating degree days.

The overall trend for Montana is that the winters will be warmer and a little wetter while the summers will be hotter and a little drier. This is a trend that has already begun and is increasing as Pederson points out. The distribution of temperature changes is not homogenous with the northeastern portion of the state receiving the most severe changes and the mountain west receiving slightly more muted changes.

B. Precipitation

As noted above, the predicted change in precipitation is a little less certain within the more geographically detailed GCM. This uncertainty is largely related to the models' ability to capture multi-year cyclical events that can have large influences on the moisture that Montana receives. The Pacific Decadal Oscillation, El Nino, and La Nina would be examples of multi-year cycles that are poorly represented in the climate change models.[20] Because of this lack of clarity associated with these cyclical events and in part because detailed climate records only go back 60 years (which doesn't capture enough of the multi-year cycles) precipitation is modeled with less confidence than temperature going forward.

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[15] Pederson et al. A Century of climate and ecosystem change in Western Montana: what do temperature trends portend? *Climate Change*. 98:133-154. 2010.

[16] Cooling degree days are a summation of the temperature above 65 degrees (F) for each day of the year. http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/ddayexp.shtml

[17] Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 4. Climate of the U.S. Great Plains. Figure 22, page 51. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. January 2013.

[18] Heating degree days are a summation of the temperature below 65 degrees (F) for each day of the year. http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/ddayexp.shtml

[19] Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 4. Climate of the U.S. Great Plains. Figure 23, page 52. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. January 2013.

[20] Ibid. Page 9.

Montana is predicted to get more precipitation by 2055. Most of Montana will receive 3-6 percent more precipitation while the northeastern portion of Montana will receive 6-9 percent more precipitation.[21] The precipitation is not constant over the different seasons. Significantly more precipitation will fall in the winter and significantly less precipitation will fall in the summer. This is especially true for western Montana where summer precipitation will be 5-10 percent less in the summer and 10-15 percent more in the winter.[22] As was discussed earlier, the increase in winter precipitation is closely linked to the temperature changes that are predicted for Montana's winters. As the winters become warmer more moisture is able to be carried into Montana in part because warm air can carry more moisture.

As Montana's winters become warmer, more precipitation will fall as rain as opposed to snow. Headwater Economics, in their report on the climate impacts on the Montana skiing and sport fishing industry sum up the predicted changes in precipitation succinctly:

> Changes in precipitation patterns are predicted to include a greater proportion of winter precipitation falling as rain than snow, decreased snow season length at most elevations, decreased spring snowpack, earlier snowmelt runoff and peak streamflow, increased frequency of droughts and low summer flows, and amplified dry conditions due to increased evapotranspiration, even in places where precipitation increases, as mentioned above. These changes have important implications. Historically, moisture delivered through snowmelt provided inputs to aquifers, rivers, and streams gradually throughout the summer.[23]

How the different sectors of the Montana economy will deal with the temperature and precipitation changes in the future is an open question. The ability of many industries in Montana to adapt is unknown. In this report we take the same approach as the climate modeling that we relied on for the temperature and precipitation changes. That is, we will assume a business as usual approach to the Montana economy and assume that some portion of the impacted sectors will decline due to a changing climate to which they cannot adapt.

In some sectors of the economy this "business as usual" approach makes a lot of sense because of the unknown reliability of adaptations and their costs. In other sectors of the economy there appear to be recognized adaptations that may help mitigate the coming climate change at an affordable cost. Because the predicted impact of climate change can be mitigated to some degree, any forward cast that looks at the impact of climate change always has some speculation in it. This does not mean that analysis of those "business as usual" impacts does not provide useful information.[24] This report is meant to highlight what will likely happen if

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[21] Ibid. Figure 24, page 55.

[22] Ibid. Figure 25, page 57.

[23] The Effects of Climate Change on the Downhill Skiing and Recreational Fishing Economy in the Crown of the Continent. Headwater Economics. Page 19. January, 2011.

[24] Projections that are often made about the negative economic impacts of reducing the use of coal or other fossil fuels suffer from the same weakness: They assume, for instance, that if a coal mine or an electric generator is shut down that all associated jobs and earnings are lost forever. The adaptation of the economy to provide those energy services from other sources, e.g. renewable resources, improved energy efficiency, less carbon intensive fuels, etc., and the reemployment of the now under-utilized labor and capital resources in other valuable economic activities are ignored.

nothing is done to mitigate climate change and adaptation is either not possible or perceived to be too expensive.

A good example of this type of adaptation or the lack of ability to adapt is the ski industry in Montana. If the elevation of the base of a particular ski area is low enough that climate change brings rain where there was once snow in the winter, then the ski area will have to adapt. They can either move their base area facilities higher, force people to ride the lifts down to the bottom, or mechanically make more snow. If the number of days where it gets down to a temperature where a ski area can make snow is too few to make enough snow (assuming they otherwise could have gotten increased access to water to make additional snow and could afford the cost), then the only alternative may be to move the base area up the hill, losing vertical skiing height. There is a possibility that the ski area will be able to offset their lost revenue by having a longer summer season and offering more summer related activities (mountain biking, zip lining, hiking, mountaineering, summer concerts, etc.), but there is also a chance that significantly fewer people will visit the ski area in the future because climate change has fundamentally altered the character of the ski area in a negative way so that people no longer ski as much, or potentially at all, and summer visitors do not offset this loss.

It is within this complex backdrop of future climate conditions and the economic implications of those climate changes that we investigate the potential economic cost of climate change in Montana.

What will climate change look like for a selected group of important economic sectors in Montana?

We will begin this section by looking at how the climate change that we described above will likely impact different sectors of the Montana economy that are potentially vulnerable to climate change. Climate change will not affect all industries equally and climate change will be different across the state of Montana. We have focused on a group of sectors of the Montana economy that are potentially more vulnerable to climate change. We will begin by looking at how the climate changes projected by climate science for Montana are likely to impact those industries. Then we will look at the potential economic implications of those impacts.

The sectors of the Montana economy on which we will focus are largely economic activities tied to Montana's natural resource base: recreation/natural amenities (winter sports, fishing, and nature-based tourism), and forested landscapes and wildfire. In a separate study we have analyzed the impact of climate change on Montana agriculture, especially cattle raising and wheat crops.[25]

[25] "The Economic Impact of Climate Change on Montana's Agricultural Economy," prepared for the Montana Farmers Union, November 2015.

2. Recreation/Natural Amenities/Tourism

A. Wildlife: Fishing and Hunting

i. Hunting

Detailed expenditure data for Montana hunters is available only for big game hunting although data on the hunters' expenditures from all types of hunting are available. This allows us to separate big game hunting and all other hunting activity including upland bird and water fowl hunting. In 2011 big game hunting was responsible for 69 percent of all hunting expenditures in Montana.[26] So a focus on big game hunting provides a good deal of information on overall hunting activity in Montana. We know, however, that the estimated economic impacts of all hunting based only on big game hunting understates the overall importance of hunting by almost a third (31 percent).

Big game hunting typically starts in Montana with archery hunting in September and rifle hunting in the last week of October. That rifle hunting season used to coincide with the beginning of reliably cooler weather and the first snowfall of the year.

For early season backcountry rifle hunters and bow hunters (which both start hunting season before the general rifle season) warmer fall temperatures mean a much greater chance of meat spoilage. Hunters trying to contend with much warmer temperatures will either have a reduced number of days that it is cool enough to harvest an animal and get it out of the field, or they will have to hunt closer to their vehicles where they can quickly transport the harvest to cooler conditions. This may limit the pursuit of big game in the high country.

Deer and elk appear likely to be fairly resilient in the face of climate change since they possess the ability to adapt to a variety of different environments. In addition, climate change may reduce stress on them during their critical birthing seasons in the spring which will be warmer and begin earlier. Warmer temperatures may move elk farther into the high country for longer periods of the year.[27] For hunters this means that they will have to travel farther to come in contact with the game that they are chasing. Another aspect of climate change is that fall in Montana is projected to be warmer and winters are projected to be shorter. This means that there will be less fresh snow on the ground that allows hunters to track their big game prey. It also means that big game will stay longer in the high country when, in the cooler past, they would have been pushed toward the valley floor in search of better foraging as snow accumulated in the high country. All of these changes will make successful big game hunting more demanding in terms of time and effort, which may discourage some hunters.

The lack of cold temperatures and the implications of climate change on big game hunters in Montana have not gone unnoticed by the Montana hunting population. For instance, during

[26] "2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: Montana," Fish and Wildlife Service, FHW/11-MT (RV) Revised December 2013, Table 18, p. 27.
[27] Beyond Seasons' End. A Path Forward for Fish and Wildlife in the Era of Climate Change. Page 76.

hunting season, the newspaper in Montana's second largest city, the Missoulian, is now typically flooded with anecdotal stories of how tough big game hunting has become due to the lack of snow and big game staying in the high country.[28] Although the deer and elk may be able to survive in a changing world, the hunting tradition that Montanans have grown up with for many generations may be dramatically altered.

One consequence of the shorter period of cold weather and snow in Montana is likely to be that more elk calves and deer fawns will survive cold spring weather. This could lead to growth in overall elk and deer populations. While that may appear to be a positive aspect of an overall warming trend for hunters, with reduced hunter success because of the same warming trend, this may mean the development of elk and deer populations in excess of the long-run carrying capacity of the habitat and lead to periodic population collapses and recoveries, which, though natural, are unpleasant for most citizens to observe.[29] It also may lead to large herds of elk moving on to ranch and farm land during the peak of the shorter winter after hunting season. The risks of disease transmission (e.g. brucellosis in the Greater Yellowstone region) and game damage to crops and forage will be elevated, resulting in greater pressure on wildlife managers to implement late season "hunts" to disperse and move the elk off of the ranch land.[30] This killing of big game standing in herds in farmers' fields undermines the hunting ethic of fair chase.

To attempt to counter the longer fall season and later first snows there has been some discussion of moving the hunting season later into the year. If the hunting season started later and went longer into the winter there is a strong possibility that hunters would then harvest noticeably pregnant animals or discover the animals they have taken were pregnant when they dress out the animals.

ii. Sport Fishing

Many of the changes that are projected to happen in the winter will spill over into summer recreation activities. One of the most profound changes is projected to be in streamflow. Currently, the streams in Montana are predominately fed by melting snowpack in the mountains.

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[28] Ochenski, G. Climate change trashing hunting tradition. *Missoulian*. November 3, 2014. http://missoulian.com/news/opinion/columnists/climate-change-trashing-hunting-tradition/article_c8cff9c5-fc4b-5bf1-9f90-973aa9d3fd06.htm And Stalling, D. Hunters and anglers need to act on climate change. *Missoulian.* December 13, 2013. http://missoulian.com/news/opinion/columnists/hunters-and-anglers-need-to-act-on-climate-change/article_a72bc2b6-6401-11e3-97e4-001a4bcf887a.html l

[29] Op. cit. "Beyond Season's End," pp. 76-77.

[30] "Montana wildlife officials green-light expanded elk-kill plan," Alison Noon, Associated Press, August 6, 2015. http://missoulian.com/news/state-and-regional/montana-wildlife-officials-green-light-expanded-elk-kill-plan/article_c8d88a65-3af8-5ce7-836c-f82da7510dcf.html

When the melting is occurring earlier in the year, and more precipitation in the winter time is coming as rain instead of snow, the peak stream flows will come earlier in the year.[31] This leaves less water in the streams during the summer time, which is projected to be longer, more extreme, and hotter. As a result the streams and rivers in Montana are projected to become warmer with much lower flows and lower water depths.

Montana's Department of Environmental Quality has phrased the concerns as follows:

> In Montana, the availability of adequate late-summer instream flows is an important consideration to the health and viability of certain fish species. Over the past two decades, Department of Fish, Wildlife & Parks managers and fisheries biologists have called for an alarming number of mid- and late-summer fishing closures on certain streams to protect the resources. Drought conditions in recent seasons have led to diminished access to other forms of water recreation as well, such as boating and rafting. Drought conditions also affect agricultural production. The allocation of water becomes more contentious as the resource becomes scarce. Drought conditions put government and tribal holders of instream rights at odds with historic consumptive uses for agricultural purposes. Low stream flows and warmer temperatures also may allow invasive species to advance while forcing native species to retreat to higher elevation waters.[32]

In fact, as this report was being prepared at the beginning of July 2015, river restrictions for anglers were already being put into place, in July rather than in mid- or late-August. This is the earliest that river restrictions for anglers have ever been put into place in Western Montana.[33] This trend is projected to increase in the future. A temperature increase of 3 degrees Celsius is projected to coincide with a loss of trout habitat of 42-54 percent.[34] This is for all of the trout in the Rocky Mountain Region. If one looks closer at individual species, like the iconic Bull Trout, then the story becomes even more disturbing. Because of the timing of the spawning of Bull Trout, the combination of warming water and the seasonality and timing of streamflow, Bull Trout populations are projected to fall by as much as 90 percent.[35] Westslope Cutthroat trout are also projected to decline by as much as 65 percent.[36]

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[31] Saunders, S. and Easley, T. Glacier National Park In Peril The Threats of Climate Disruption. Prepared by the Rocky Mountain Climate Organization and National Resource Defense Council. April, 2010. Page 14.

[32] Climate Change and Water Drought. Montana.GOV Official State Website. Accessed 7.8.2015. http://deq.mt.gov/ClimateChange/NaturalResources/Water/Drought.mcpx

[33] Chaney, R. 'Hoot-owl' restrictions limit fishing time on Bitterroot, Blackfoot, Clark Fork. Missoulian, July 1, 2015. Accessed 7.8.2015. http://missoulian.com/news/local/hoot-owl-restrictions-limit-fishing-time-on-bitterroot-blackfoot-clark/article_e80d722a-0779-5f0b-9562-456cbf7994f5.html

[34] The Effects of Climate Change on the Downhill Skiing and Recreational Fishing Economy in the Crown of the Continent. Headwater Economics. Page 22. January, 2011. *and* Saunders, S. and Easley, T. Glacier National Park In Peril The Threats of Climate Disruption. Prepared by the Rocky Mountain Climate Organization and National Resource Defense Council. April, 2010. Page 19.

[35] Ibid. page 25. And Saunders, S. and Easley, T. Glacier National Park In Peril The Threats of Climate Disruption. Prepared by the Rocky Mountain Climate Organization and National Resource Defense Council. April, 2010. Page 19.

[36] Ibid. page 19.

As the streams become warmer and the runoff comes earlier in the year, native Montana fish will become stressed and unable to compete as well against invasive species.[37] As the earlier timing of high water flows, higher water temperatures, the timing of the hatches that the fish feed on, and an increased incidence of disease impact the native fish of Montana that have evolved in Montana streams, other invasive species that are more suited to the "new normal" will be able to outcompete native Montana fish. For fish like the Westslope Cutthroat it may not be simply competition but the interbreeding with Rainbow Trout (non-native) that ultimately leads to their decline. Since the two can interbreed and because the "rapid increase in hybridization is highly associated with climactic changes in the region,"[38] the Westslope Trout now occupies less than 10 percent of its historic range. Because the Rainbow is not native to western Montana, the hybridization that produces the "cut-bow" trout may be maladapted to the local environment.

The impact is then not only on the native species of fish in Montana but also on the people of Montana, and the people that come to Montana to enjoy fishing those rivers. As was mentioned above, when the river becomes too warm, the fish become stressed and can die from the heat. The high temperatures of the rivers and streams in Montana can be from a combination of low water and high heat (prolonged warm weather events) that are typical of August in Montana. Or they can be from prolonged high heat events beginning in July or earlier. In either case the rivers can have restricted fishing hours imposed on them or they can be closed all together. In a report of the impacts of climate change on Glacier National Park, the authors point out how often rivers in Montana have been regularly closed to fishing since 2000.

> In eight out of the last dozen years, drought and higher temperatures have led to fishing closures and restrictions in the state to sustain fish populations for the future. From 2001 through 2006, 119 segments of rivers were either entirely closed to fishing or subject to access restrictions for morning-only fishing or bag limits. The summer of 2007, with record setting temperatures across the state, was even worse. By mid-August, 40 streams and lakes were closed, with 13 of those facing full 24-hour closures. Farther to the south, the National Park Service closed 232 miles of streams in Yellowstone National Park to fishing.[39]

It turns out, as one would expect, that when there are closures and/or restrictions put on fishing, the number of angler-days of fishing goes down. A report by Headwaters Economics[40] found that when there were angling restrictions in place on the Blackfoot River (in Western Montana) in 2001 and 2007, the angler-days of fishing activity dropped by 42 percent in 2001 compared to

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[37] The Effects of Climate Change on the Downhill Skiing and Recreational Fishing Economy in the Crown of the Continent. Headwater Economics. Page 23.
[38] Soileau, S. et al. Climate Change Accelerates Hybridization between Native and Invasive Species of Trout. *USGS Newsroom*. 5.25.2014. http://www.usgs.gov/newsroom/article.asp?ID=3903#.VaP1nflVhBe
[39] It should be noted that the statistics that are given in this paragraph relate to 2010 and before. Saunders, S. and Easley, T. "Glacier National Park In Peril The Threats of Climate Disruption." Prepared by the Rocky Mountain Climate Organization and Natural Resource Defense Council. April, 2010. Page 26.
[40] The Effects of Climate Change on the Downhill Skiing and Recreational Fishing Economy in the Crown of the Continent. Headwater Economics. Page 35.

1999 and by 26 percent in 2007 compared to 2005. In the years when there were no fishing restrictions, the angling days on the Blackfoot largely recovered to a more stable value of about 18,000 fishing days from the 13,000 fishing days in the years with angling restrictions in place.

In addition, the collapse of a popular fishery can have a major impact on fishing activity. When the introduction of Mysis shrimp into Flathead Lake helped lead to the loss of the kokanee salmon fishery there, fishing on that lake fell precipitously to 40 percent of its previously level, from a high of over 100,000 angler days in 1983 to a low of 38,000 in 2005.[41]

The results of climate change, on the fishing industry in Montana, were summed up by Headwater Economics:

- Restricted fishing seasons and seasonal closures;
- More conflicts among irrigators, anglers, fishing guides, and municipalities for increasingly scarce water;
- Degradation and loss of habitat due to warming water temperatures, post-fire sediment and debris flows, and increased frequency of extreme events such as floods and late summer drought;
- Smaller fish stocks and smaller fish;
- Increased disease;
- Displacement and cross-breeding of native trout with non-native species;
- Negative economic impacts on fishing guides, stores, restaurants, hotels, and other businesses that sell goods and services to anglers.[42]

3. The Winter Recreation Season: Snow Sports

As was discussed above, winter is projected to see more warming when compared to the average change across the entire year. While Montana as a whole is projected to warm by three degrees (F) on average during the year, during the winter, particularly in the western (mountainous) portion of the state, it is projected to warm 5-7 degrees (F). Along with this warming there will be a pronounced shift in the timing of winter. With 30 less freezefree days, the winter season is projected to be at least a month shorter. Warmer and shorter winters with more freeze-free days mean that the modest increase in precipitation will be falling as rain instead of snow for a large portion of what has historically been considered winter. A study on the climate impacts on the winter tourism economy in the U.S. clearly spells out what this could mean to winter recreation in Montana.

> "By the end of the current century, winter temperatures are projected to increase an additional 5° F to 7° F under a higher emissions scenario if delays in development of renewable energy continue. As a result, snow depth is expected to decline 50 percent

[41]Ibid. p. 33. By 2007, angling days on Flathead Lake had begun to rebound.
[42]Ibid. Page 23.

to 100 percent in the southwestern mountains and between 10 percent and 50 percent in the northwestern part of the state relative to 1960–1990 averages. The severe declines in winter snowpack will undoubtedly stress water resources, which will limit the viability of snowmaking as an adaptation strategy."[43]

A study on the potential for climate disruption in Glacier National Parks looks even more pessimistic for the winter and Glacier's winter snowpack. By 2089 Glacier NP's winters are projected to be more than two months shorter.[44] Snowpack is projected to melt 41 days earlier and have 70 less days where snow covers the ground. When snow does not cover the ground the albedo, or light reflecting ability, of the ground fundamentally changes and more heat can be absorbed by the far darker bare earth. This is a feedback loop that helps amplify the melting and the warming of the snowpack leading to increased snow melt. It also provides a longer period of time for soils and potential fuels on the ground to dry out.

The impact of shortened winters in places that have winter tourism economies can be profound. The winter of 2011-2012 was the fourth warmest winter on record (as of 2012 [45]). As a result "the ski resort industry "experienced its most challenging season since 1991–92." According to the National Ski Area Association's "Kottke End of Season Survey," 50 percent of responding ski areas opened late and 48 percent closed early, with every region experiencing a decrease in overall days of operation."[46]

It is not mere speculation that when snow conditions at ski areas are poor, ski activity falls dramatically. A comparison of skier days during high snow years and low snow years at ski areas around the nation documents this impact. The historical difference between good and bad snow conditions was estimated at over a billion dollars in ski area revenues and 13,000 to 27,000 jobs nationwide.[47] This is very likely an underestimate of what the impact of worsening snow conditions at ski areas due to climate change would be. Many skiers make reservations at ski areas in advance of knowing what snow conditions will be and travel to the ski areas even when snow conditions are not good. As snow conditions systematically deteriorate due to climate change, skiers are unlikely to gamble that ski conditions will be good and will not make the reservations in advance. The result will be a systematic decline in skiing due to the more frequent and chronic poor snow conditions.

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[43] Climate Impacts on the Winter Tourism Economy in the United States. Burakowski, E. and Magnusson, M. Prepared for Protect Our Winters (POW) and the National Resource Defense Council. Page 26. December, 2012.

[44] Glacier National Park In Peril The Threats Of Climate Disruption. Saunders, St., and Easley, T. Prepared for the Rocky Mountain Climate Organization and the National Resource Defense Council. April, 2010. Page 13.

[45] The Winter of 2015 was the second warmest winter on record according to NOAA. So the winter of 2012 is now the 5th warmest winter on record (http://www.ncdc.noaa.gov/sotc/summary-info/national/201502).

[46] Climate Impacts on the Winter Tourism Economy in the United States. Burakowski, E. and Magnusson, M. Prepared for Protect Our Winters (POW) and the National Resource Defense Council. Page 3. December, 2012.

[47] "Climate Impacts on the Winter Tourism Economy in the United States," Elizabeth Burakowski and Matthew Magnusson, prepared for the Natural Resources Defense Council (NRDC) and Protect Our Winters, December 2012, p. 14 and Appendix I.

Clearly winter in Montana is projected to change dramatically. The result of these changes was summed up by Headwater Economics into a series of bullet points:

- Less snow
- More unpredictable and unreliable snow patterns
- Wetter, denser snow and more rain-on-snow events
- Changing avalanche conditions
- More extreme events like landslides resulting from melting of permafrost and changing vegetation
- Increased use of water to make artificial snow
- Increased need to create water transportation and storage facilities
- Ski seasons that start later and end earlier
- Closure of low elevation ski terrain[48]

This does not have negative implications only for skiing activity. Other important and popular winter recreation activities such as snowmobiling will also be negatively impacted. Given the much more dispersed character of snowmobile recreation, snowmaking is not a practical way of maintaining winter activity at lower elevations and during a significantly shorter period with snow on the ground.

4. Wildfire: Impacts on Visitors, Residents, and Potential Residents

All recreation and tourist activities in Montana are not focused on hunting, fishing, and skiing. Montana has the oldest National Park in the U.S. (Yellowstone NP), one of the most visited National Parks (Glacier NP), the seventh largest amount of wilderness in the U.S.,[49] and a thriving tourist economy. In 2014 Yellowstone NP saw more than 3 million visitors making it the third most visited National Park in the country. Glacier NP saw more than 2 million visitors making it the tenth most visited National Park in the country.[50] The state of Montana has a population of only about 1 million people which helps put those visitor numbers and the impact of that National Park visitation into perspective.[51]

As the climate in Montana gets warmer and drier there will be an increased frequency of forest fires in Montana and surrounding states and Canadian provinces. As Pederson points out in his study on a century of climate and ecosystem changes in Western Montana,[52] consecutive days

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[48] The Effects of Climate Change on the Downhill Skiing and Recreational Fishing Economy in the Crown of the Continent. Headwater Economics. Page 20. January, 2011

[49] Wilderness Statistics Report. Wilderness.net. Accessed on 7.10.2015. http://www.wilderness.net/NWPS/chartResults?chartType=AcreageByStateMost

[50] The ten most visited: National Park Figures. Accessed on 7.10.2015. http://www.npca.org/exploring-our-parks/visitation.html?referrer=https://www.google.com/

[51] Montana Quick Facts. U.S. Census. Accessed on 7.10.2015. http://quickfacts.census.gov/qfd/states/30000.html

[52] Pederson et al. A Century of climate and ecosystem change in Western Montana: what do temperature trends portend? *Climate Change*. 98:133-154. 2010. Page 149.

of high temperatures, combined with earlier snowmelt, and a longer dry summer season lead to increased forest fires.

The fire regime of Montana is controlled by temperature and precipitation. So increases in temperature and decreases in summer precipitation will leave Montana forests more vulnerable to forest fire. Between 2000 and 2010 some 45 percent of the forested landscapes in Montana were impacted by forest fires and tree killing insect outbreaks covering approximately 11.5 million acres of the 25 million total acres of forest in Montana.[53] The predictions for future fire conditions indicate that the future may be far smokier than it has been. According to Steve Running, Regents Professor of Ecology at the University of Montana, wildfire activity in the Northern Rockies, including Montana, may double by 2100.[54] In a report published by the U.S. Forest Service in August 2015, the agency responsible for all of the National Forests commented that:[55]

> "Climate change has led to fire seasons that are now on average 78 days longer than in 1970. The U.S. burns twice as many acres as three decades ago and Forest Service scientists believe the acreage burned may double again by mid-century."

In the summer of 2003, 10 percent of the acreage in Glacier National Park burned. During that same summer the visitation during August, which is typically Glacier's busiest month, fell off by 50 percent.[56] In 2015, wildfires again burned in Glacier National Park during August, closing for two weeks the popular Going to the Sun Highway that transverses the park. This time visitation during August dropped 14 percent while overnight stays declined by 43 percent. This may have disproportionately reduced visitor expenditures.[57] Even in years where there are no major fires *in* National Parks, but there are fires in the surrounding region that are producing heavy smoke, it can impact park visitation in parks that are dozens or hundreds of miles away. Glacier NP's neighbor in Canada, Waterton Lakes National Park, for example, saw a 7, 17, and 15 percent decline in visitation during the months of July, August, and September (respectively) during the summer of 2003 when so much of Glacier National Park, across the border in the U.S., burned even though there were no fires in that Canadian Park itself. High fire danger during wildfire season can also lead to parts of the natural landscape being closed to visitors to avoid human

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[53] Kolb, P. Climactic Influences on Forests across Montana-Strategies for Conservation and Functional Retention. Montana State University Extension Forestry Specialist. http://www.msuextension.org/forestry/Resources/pdf/FF_Climate%20Change%20Impacts%20on%20Montana%20Forests_PK.pdf

[54] Running, S. Impacts of Projected Climate Change on Pacific Northwest Ecosystems: Analyzing Carbon/Water Balance Vulnerability to 2100. Final Report to Stratus Consulting and National Commission on Energy Policy. March, 31 2009. Page 43.

[55] "The Rising Cost of Wildfire Operations: Effects on the Forest Service's Non-Fire Work," p.2, U.S. Forest Service, U.S. Department of Agriculture, August 4, 2015..

[56] Saunders, S. and Easley, T. Glacier National Park In Peril The Threats of Climate Disruption. Prepared by the Rocky Mountain Climate Organization and National Resource Defense Council. April, 2010. Page 25.

[57] National Park Service, report period: August 2015; August 2014 to August 2015 comparison. https://irma.nps.gov/Stats/SSRSReports/Park Specific Reports/Park YTD Version 1?RptMonth=8/1/2015&Park=GLAC

caused fires and to protect visitors from possible wildfires. For example, during the summer of 2015 the eastern part of the Going to the Sun Highway in Glacier NP was closed for two and a half weeks because the Reynolds Creek Fire burned up to the edge of the highway and threatened visitors. That famous highway, which crosses Glacier NP's mountains at a high pass, is typically traveled by most visitors since is allows visitors to travel across the Park, from the Great Plains foothills in the east to the Rocky Mountain valleys in the west.

As residents in the western U.S. are becoming all too familiar, forest fires that burn in the region produce smoke that is distributed by the complex wind currents to areas hundreds of miles away. As a result areas where people are living or visiting, quite some distance from the actual fires can become very uncomfortable from the thick smoke trapped in valleys that obscures vistas, blocks sunlight, and irritates people's breathing. This is not "just" an aesthetic concern. There is a large body of literature looking at the ill effects of forest fire on humans. For instance medical visits for respiratory illnesses increased 52 percent during the week of the fifth largest forest fire in the U.S. (during 1999) in the Hoopa Valley Indian Reservation that was directly adjacent to the fire.[58] Similar results were found during 1987 when 1,500 fires burned in California forests and the six counties that were most effected were surveyed. In that survey the six counties reported a 30-40 percent increase in hospital visits among people with asthma, COPD, and a host of other respiratory disorders.[59]

Forest fires are predicted to increase as Montana's climate changes. Those changes may have a dramatic effect on the character of Montana. Montana's tourist economy and the State's very attractiveness as a place in which to live are tied to its natural beauty and its outdoor recreation potentials. If the future is a smoky future where the danger of wildfire is regularly very high for an increasingly longer part of the year, then the quality of life in Montana will be diminished and people will have to weigh that diminished quality of life when they consider Montana as a place in which to live or visit.

Put somewhat differently, climate change is already imposing costs on Montanans, visitors to Montana, and the Montana economy in the form of more wildfires, more intense fires, and fires extending over a longer fire season. The threat of wildfire to people, their homes, and their property will grow, and the actual experience with wildfires and their impact will become more common. In addition, the smoke and particulate pollution from the fires may make Montana an unhealthy, uncomfortable, and unattractive place to live and visit. In the most intense events, the growing impacts of wildfire are likely to raise the question of just how habitable parts of Montana actually are. This is a serious cost to residents as well as a serious threat to part of the tourist and recreation economy. And the projections are that it will only get seriously worse.

Disease and increased beetle kill are also predicted to increase due to the warmer winters and lack of extreme winter temperatures. As the Montana forests attempt to come into equilibrium with their new climate reality, grasslands will become sage brush, Douglas-fir may become

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[58] Mott, J. et al. Wildland forest fire smoke: health effects and intervention evaluation, Hoopa, California, 1999. *Western Journal of Medicine.* May, 2002 176(3): 157-162.
[59] Duclos, D. et al. The 1987 Forest Fire Disaster in California: Assessment of Emergency Room Visits. *Archives of Environmental Health: An International Journal*. Volume 45, Issue 1, 1990.

spruce-fir, and the sub-alpine environment as well as the low land forests of Ponderosa Pine and Douglas-fir may become dominated by spruce-fir.[60] Fire and beetle kill will alter the natural environment speeding the process of turnover between the different species of vegetation. During the long transition, recreation and tourism are likely to be negatively impacted by landscapes covered by dead trees and tangles of fallen trees, widespread wildfires, heavy smoke, and large areas of burned vegetation.

The nature and character of Montana's forests and grass lands may be changed forever. We are not attempting to cast a judgment on one type of ecosystem over another; we are simply noting the changes that scientists are telling us will happen. Montana will not be ecologically "ruined" by these types of changes; similar changes have been happening over millions of years. However, Montana will be different and this time the climate change will be human caused and not induced, for instance, by orbital eccentricity, the axis of the earth, and the direction that the axis tilts which in the distant past produced Ice Ages as the amount of solar radiation that the earth received changed.[61]

5. Catastrophic Wildfire

Climate change will lead to wildfire impacts beyond those we have mentioned above, the impacts on recreation and tourism. Climate change will lead to more frequent, larger, and more intense wildfires that will threaten the homes and lives of Montanans. As was briefly mentioned above, the nation is predicted to see a 100 percent increase in the area burned by wildfire by 2050.[62]

> "The U.S. burns twice as many acres as three decades ago and Forest Service scientists believe the acreage burned may double again by mid-century. Increasing development in fire-prone areas also puts more stress on the Forest Service's suppression efforts."

As Montana is predicted to get hotter (4 to 5 degrees by 2050 across the year for the state as a whole) and its forests face increased stress due to limited summer moisture, wildfires will take place more often, burn more acreage, and be more intense. The National Research Council predicts that with a rise in temperature of only 1.8 degrees (F) northwestern Montana will see a 241 percent change in the area burned, most of eastern Montana will see a 393 percent change in area burned, and southwestern Montana will see a 515 percent change in the area burned.[63]

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[60] Keane, R. Climate change effects on historical range and variability of two large landscapes in western Montana, USA. *Forest Ecology and Management*. 254 375-389. 2008.
[61] Milankovitch cycles are widely accepted to be the reason that the earth experiences ice ages due to changes in the amount of solar radiation that the earth receives.
http://www.climatedata.info/Forcing/Forcing/milankovitchcycles.html
[62] "The Rising Cost of Wildfire Operations: Effects on the Forest Service's Non-Fire Work," p.2, U.S. Forest Service, U.S. Department of Agriculture, August 4, 2015.
[63]National Research Council, 2011, ***Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia.*** Washington, DC, National Academies Press. Figure 5.8, p. 180.It is

This increased acreage predicted to be burned by wildfire in Montana is not without historical precedence. In 1910 wildfires burned over three million acres of land in northwest Montana and northern Idaho. Over that spring and summer approximately 1,700 fires burned three million acres across a broad swath of forestland 90 miles wide and 200 miles long stretching along both sides of the Bitterroot Mountains that mark the Montana-Idaho border.[64] This "fire storm" was anomalously large in the ultimate intensity of the wind-driven fire, the number of the fires, the acres burned, the structures burned, and the death toll that it left in its wake. We are not suggesting that there will be reoccurring fires of this size or scope. We are simply pointing out that there is the potential to burn much more of the forest in Montana than currently burns in any given year.

In 2007 and 2012, wildfires in Montana and Idaho burned almost as many acres as the 1910 fire.[65] In terms of the scale of the area burned, the 1910 wildfire is no longer an outlier. However, between 1910 and 2014 the population of the region where the 1910 fires burned has grown dramatically. A significant part of that population has sprawled out into the forested areas to enjoy the natural amenities of exurban living in the forested mountains and valleys.

We will analyze the economic implications of people living in these fire-prone exurban areas or Wildland Urban Interfaces (WUI) as it has come to be called. We will discuss the number of houses that are now situated in the WUI and the way they have been categorize in terms of the likelihood of being burned by wildfire at some future date.

The result is that there is a relatively small risk that a home in the WUI will burn in any given year but a significantly larger risk of burning over the next 35 year time period. For example, a very high risk scenario might be homes that on average would be burned by wildfire over the next 150 years. Although the average annual risk of home destruction by wildfire over that time period might be only 0.7 percent, using a geometric probability function, we estimate the risk that such a house would burn by 2050 to be 15 percent. This risk in the highest fire-prone areas over the next 35 years is set against the large value of the homes that have expanded into the WUI. Even a small chance of burning a small portion of the WUI produces very large economic consequences.

important to note that the science points to a much larger rise in temperature than the 1.8 degrees (F) that was modeled. On the other hand, the future area burned in Montana is stated relative to the 1953-2003 average acreage burned. The doubling that was mentioned in the preceding paragraph was relative to current conditions which, as shown in that paragraph, have burned significantly more in the last three decades.

[64] Cohen, S., Miller, D.1978. *The Big Burn: The Northwest's Forest Fire of 1910*. Pictorial Histories Publishing Co: Missoula, Montana.

[65] https://www.nifc.gov/fireInfo/fireInfo_statistics.html

II. The Relative Importance of Different Sectors of the Montana Economy

1. Measuring the Relative Importance of Different Parts of the Local Economy

There are a variety of ways of quantifying the relative importance of a particular set of economic activities in the overall regional economy, e.g. the state of Montana as a whole or a county or set of counties. Each economic measure describes the economy in a somewhat different way. In the discussion below, we will use two different measures: the number of jobs and the labor earnings associated with those jobs.[66]

Other measures of relative economic importance that are often used include the sales value of output and value-added. We do not use those measures because total sales value tends to exaggerate the value actually created when multiple sales transactions are involved. Value-added, the measure of economic value preferred by economists is not used because it is not a concept with which most participants in the economy are familiar. Most citizens, however, are very familiar with the concepts of jobs and paychecks.

The measurement of the relative importance of a particular industry can be presented in two quite different ways. One is to simply ask how much of all the jobs or labor earnings in the state or a county is directly associated with that industry.

Often that straightforward measure is not used because the potential “ripple” impacts of a particular industry in promoting additional jobs and payrolls in other sectors of the overall economy would be ignored. One common way of looking at the local economy does not treat all jobs and earnings as of equal importance. Some jobs, those that draw income into the local economy, are seen as the engine of local economic change. As that income is spent and re-spent within the local economy additional jobs are created and additional income is generated. These “more powerful” jobs or income flows typically are labeled “basic” jobs and all of the other jobs, which are assumed to be “caused” by those basic jobs, are labeled “secondary” jobs.[67] In this view, “basic” jobs and income have “ripple” or “multiplier” impacts elsewhere in the economy that also have to be measured and included when evaluating the relative importance of those “basic” jobs and income.

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66 “Jobs” need to be distinguished from “employed persons.” A person can hold more than one job. ”Jobs” sum up full- and part-time jobs without distinguishing between them. So the “jobs” are *not* “full-time equivalent” jobs. “Jobs” also include the self-employed and “labor earnings” include the net income they realize. “Employee Compensation” includes wages and salaries plus the value of non-wage benefits such as insurance, pensions, etc.

67 The basic jobs and income are labeled “direct” impacts. The secondary impacts are broken into “indirect” and “induced” jobs. Indirect jobs and income are those associated with economic activity supplying the basic sectors with required inputs. Induced jobs are those stimulated by workers in the basic industries spending their paychecks.

When we look at the relative importance of the “travel industry” in Montana and various Montana counties, the focus of many analyses is only on the *non-resident* travelers’ impacts. Local residents who engage in the same spending behavior in restaurants, casinos, drinking establishments, and other recreation and entertainment activities are treated as if they do not have any impacts of their own on the local economy since they do not bring *new* income into the local economy but only spend money that some other basic industry has brought into the local economy. In the context of the economic base view of the local economy, it is only non-residents who travel into Montana or into a particular county that have multiplier impacts and stimulate the local economy. Of course, if those local residents traveled out of state for that entertainment and recreation, there would be a negative impact as money leaked out of the state economy, causing a negative multiplier impact. Because of that, the ability of the local economy to provide attractive recreational experiences so those local dollars stay in the local economy *does* have an important positive impact similar to a non-resident coming into the local economy. In addition, many Montana residents travel to other locations in Montana, and their spending there represents “new” money brought into the local economy, triggering the same types of “ripple” effects.

Thus, although using the “basic” and “secondary” dichotomy in analyzing local economies provides some valuable insights into the dynamics of a local economy, critics point out that the “ripple” or “multiplier” impacts are actually caused by locally-oriented “secondary” businesses capturing and re-circulating those dollars within the local economy. It is the interconnected web of local economic activities that actually make up the bulk of the local economy and determines the relative size of the ripple or multiplier impacts. If the money injected into the local economy immediately “leaks out” of the local economy because there is not a sophisticated web of locally-oriented businesses, the multiplier impact can be near zero. In that sense, locally-oriented businesses are not “secondary” in economic importance but an important part of the local economic base.

In the discussion below of the relative importance of particular types of economic activity in the local economy, we will present the results in two ways. One way the relative importance will be stated is the percentage of total *basic* jobs and *basic* labor earnings that originate in that particular set of *basic* economic activities. That approach implicitly assumes that all local economic activity is *caused* by basic economic activities and all non-basic economic activity is passively determined by the basic jobs and earnings. In that setting, Montana residents’ expenditures on recreation and sightseeing trips within the state are ignored in the measurement of the relative economic importance of recreation and tourism in the Montana economy. The second measure of relative economic importance will include the spending of Montana residents on recreation and tourism within the state along with the spending of non-residents. When a particular sector of the economy is dominated by non-resident spending (e.g. visitation to Montana’s National Parks) or by sales to non-residents (e.g. grain crops and beef production), we will measure relative economic importance ignoring the spending by local residents. In other sectors of the recreation-tourism economy where Montana residents are the dominant participants (e.g. skiing and snowmobiling, wildlife watching, hunting and angling), we will include the expenditures of Montana residents in measuring relative economic importance.

2. Economic Value *versus* Local Economic Impacts

The fact that the relative economic importance of high quality natural landscapes is often measured by the impact of *non-resident visitors'* spending on the local commercial economy should provide an important warning about the difference between the economic value of those high quality natural landscapes to *residents* and the *local economic impact* of *visitor* spending. When calculating the local economic *impact*, resident's enjoyment of local amenities is assumed to have zero value. It is only the visitors' activities that matter. It is assumed, of course, that many local residents will benefit financially from those visitors' spending, but implicitly it is also assumed that local residents do not otherwise value the natural environment and the recreation and other services it provides to them. Only non-resident visitors, apparently, value those natural landscapes.

It may well be, however, that local residents value the natural and social amenities of a local area even more than non-resident visitors do. Many residents are likely to have moved to their place of residence or stayed in that place because of the quality of life in that location, including the quality of the natural and social environment. They may have sacrificed a broader array of job opportunities and higher pay in those jobs at other locations around the nation in order to live in high amenity areas where a more crowded job market increases competition for jobs and reduces pay levels. Such sacrifices document the value of the local amenities to residents. Those sacrifices are the "price of admission" to enjoy the local quality of life as a resident as opposed to a temporary visitor. Put the other way around, the value of those local natural and social amenities are a "second paycheck," a non-monetary one that supplements somewhat lower local wages and employment opportunities in attractive locations.

The important point here is that high quality natural landscapes are not *only* economically valuable to non-resident visitors. They are also valuable to local residents and that value should not be ignored.[68] We will return to this important point later.

III. The Relative Importance of the Visitor Economy in Montana

1. Different Measurements of the Relative Size of the Visitor Economy

Montana's natural landscapes and wildlife draw large numbers of visitors. Yellowstone and Glacier National Parks (NP) are the most dramatic examples of this. In 2014 there were 3.5

[68] The direct economic value of the outdoor recreational activities in which Montana residents engage could conceptually be measured. But such estimates require costly and careful surveying of participants and are very site specific. In a sense we are using the expenditures of Montana residents on outdoor recreation as a crude proxy for the economic value of those recreational activities to Montana residents.

million visitor-days to Yellowstone NP and 2.3 million visitor-days to Glacier NP.[69] The visitors to Yellowstone NP spent $421 million while the visitors to Glacier NP spent $193 million in the regions around these National Parks in 2014.[70] This type of visitation to enjoy the particular natural or cultural amenities of a region is often labeled "tourism." However, people visit local areas for many reasons. Sometimes they are just passing through on their way to somewhere else. Sometimes they are visiting friends and relatives. Some of the visitors are there on business. Others may come to engage in shopping that is not possible in their home communities.

There were almost 11 million visitors to Montana in 2014.[71] Of these only 3.7 million said they were "on vacation." Another 1.8 million said they are visiting friends and family. If these two groups of visitors are classified as "tourists," about half, 5.5 million, of the 11 million visitors might be classified as tourists. Those just passing through totaled 3.1 million while 1.6 million were in Montana on business.[72] So "visitors" are not necessarily tourists and all visitors do not have the same impact on the Montana economy. A visitor "passing through" spends on average only one day on the "visit." A person "on vacation" spends about 6 days and someone visiting friends and relatives spends about 7 days on the visit. As a result, the 3.1 *million* visitors passing through spent $193 million in 2014 while the 3.7 million visitors who were on vacation spent $1.7 *billion* that same year, almost nine times as much.[73]

It is the total impact of all non-resident visitor impacts that is typically studied, not the impact of the more narrow "tourism" sector. This is the usual focus because it is difficult to separate the different types of visitors when they are engaged in spending in the same types of Montana businesses.

The highest estimate of the relative importance of the non-resident visitor economy is that it was the source of about one-eighth (13 percent) of employee earnings in Montana in 2014. That high estimate is built around estimating the worker earnings generated by each of the basic sectors of the Montana economy, i.e. those sectors that bring new income into the state. The relative importance of the visitor economy is then measured by looking at what part the visitor economy represents of that total set of basic industries. This approach assumes that it is only these basic industries that drive the rest of the economy through their direct, indirect, and induced impacts. That is, multiplier impacts are included in this estimate of relative economic importance.

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[69] Visitor-days are a count of the number of people entering a national park each day. An individual or group staying outside of the park would get counted each time they visited the park during their stay in the vicinity of the park.
[70] 2014 National Park Visitor Spending Effects, Catherine Thomas et al. National Park Service, Natural Resource Report NPS/NRSS/EQD/NRR—2015/947, 2015, Appendix, Table 3.
[71] Note that by definition, these are *non-resident* visitors. Montanans visiting other areas of their state are not included. Also note that this is a count of the number people visiting the state, not a count of visitor – days such as the National Park Service uses. One could multiply the number of visitors by the length of their stay in Montana to get a crude measure similar to the National Park Services visitor-days.
[72] Op. cit. Kara Grau, 2015, p. 5.
[73] Ibid. p. 5.

The lowest estimate of the relative importance of the non-resident visitor economy is obtained by comparing the direct impacts of visitor spending to the whole of the Montana economy without singling out one set of economic activities as the primary engine driving the local economy (and implicitly demoting most economic activities in the state to secondary importance). As a part of the total Montana economy, the direct impact of the visitor economy is the source of about 3 percent of all employee earnings but about 6 percent of all jobs. The difference between the relative importance as a source of jobs and relative importance as a source of labor earnings is tied to the relatively low annual pay associated with many of the jobs in the visitor economy sectors.

Table 1.

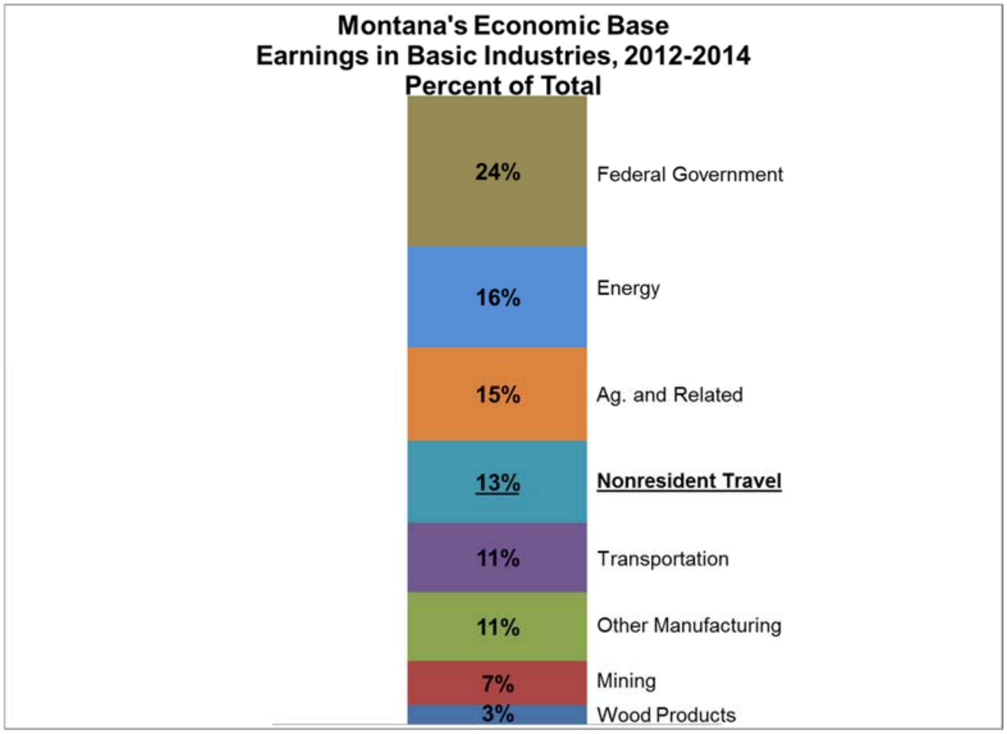
The Relative Importance of Non-Resident Visitors' Expenditures on the Montana Economy, 2014			
Type of Economic Impact	Non-Resident Visitor Impacts	Total Montana Economy	Relative Importance of Visitor Support Industry in Montana
A. Percent of Total Montana Economy: Direct Impacts Only			
Number of jobs	38,220	645,747	5.9%
Employee Earnings	$862,320,000	$27,566,234,000	3.1%
B. Percent of Montana "Economic Base: Multiplier Impacts Included			
Number of Jobs	38,220	151,502	25.2%
Employee Earnings	$862,320,000	$6,600,000,000	13.1%
C. Total of Direct, Indirect, and Induced Impacts: Multiplier Impacts Included			
Number of jobs	53,280	645,747	8.3%
Employee Earnings	1,316,760,000	27,566,234,000	4.8%
Sources:			
A: K. Grau, ITRR, 2015, Table 2, p. 3.			
B: P. Barkey, UM BBER, 2015, p. 13, Figure 5. The "economic base" is the *direct* source of only about a quarter of total labor income and jobs. BEA Regional Economic Information System.			
C: K. Grau, ITRR, 2015, Table 2, p. 3.			

An analysis including the estimated indirect and induced impacts associated with the spending by non-resident visitors indicates an intermediate result: The non-resident visitor spending is the source of about 4.8 percent of all employee earnings in Montana and about 8.3 percent of all jobs. Again, the reason for the larger employment impact compared to the impact on earnings, the employment impact being almost twice as large, is that the annual earnings associated with jobs in the visitor economy are low given that many of the jobs are part-time or seasonal and pay entry-level wages. See Table 1 above for these results and their sources.

A national survey of the relative economic impact of outdoor recreation estimated a significantly larger impact than indicated in Table 1 above. The total jobs associated with outdoor recreation in Montana were estimated at 89,000, about 70 percent larger than the 53,000 jobs estimated above to be associated with all non-residential visitors' spending. The labor income associated with these outdoor recreation jobs was also 70 percent higher.[74]

Any approach to estimating the relative importance of the visitor economy in Montana indicates that the visitor economy is a major source of earnings and jobs. The low end estimate is that about a billion dollars of labor earnings and 40,000 to 50,000 jobs are generated by the spending of visitors to the state. At the upper end, if basic industries are projected to be the source of all earnings and jobs in the state, the spending of those visitors is the source of $3.6 billion dollars in earnings and 163,000 jobs.

Figure 1.



Source: "Montana Economic Outlook: More Balanced, but Slower Growth Ahead," PatrickM. Barkey, ***Montana Business Quarterly***, Spring 2015, Figure 5, p. 13, Bureau of Businessand Economic Research, University of Montana.

Evaluated in the context of Montana's "economic base," non-residential visitor expenditures in the 2012 to 2014 period have been the source of more than four times the earnings associated with wood products, almost twice the earnings associated with mining, and about the same share of earnings as from the manufacturing, agriculture, or energy sectors. See Figure 1 above. Serious damage to the visitor economy would clearly have major impacts on the overall Montana economy.

[74] This analysis appears to have included both resident and non-resident outdoor recreation spending in its modeling. "The Economic Contributions of Outdoor Recreation: Technical Report on Methods and Findings." Southwick Associates, prepared for the Outdoor Industry Association, March 15, 2013.

2. The Importance of Recreation-Tourist Expenditures on Local Economies

There is not really a "Montana economy." Rather there are a variety of interconnected local and regional economies. Different industries play considerably different roles in different local economies. The relative importance of agriculture, wood products, mining, energy production, visitor expenditures, etc. varies considerably. As a result, some local economies are more reliant on visitor expenditures that others.

A recent analysis of the Non-Resident Visitor spending in all Montana counties where that spending exceeded $20 million per year showed the diversity of relative impacts on county economies.

Table 2.

The Relative Importance of the Visitor Economy in Different Montana Counties: 2013-2014						
County	Economic Impacts of Visitor Spending		Size of the County Economy		The Relative Importance of the Visitor Economy to the County	
	Total Jobs Associated with Visitor Spending	Total Earnnings Associated with Visitor Spending	Total Jobs	All Earnings	Jobs	Earnings
Park	2,410	$55,060,000	9,362	$270,570,000	25.7%	22.5%
Glacier	1,110	$27,410,000	6,574	$291,521,000	16.9%	10.7%
Toole	550	$12,660,000	3,340	$191,277,000	16.5%	9.0%
Flathead	9,520	$224,300,000	58,897	$2,307,841,000	16.2%	11.8%
Carbon	770	$13,760,000	5,298	$139,490,000	14.5%	11.9%
Gallatin	9,570	$234,670,000	70,269	$2,786,202,000	13.6%	10.0%
Custer	970	$23,880,000	7,978	$329,258,000	12.2%	8.1%
Beaverhead	580	$11,790,000	5,744	$194,252,000	10.1%	7.0%
Madison	570	$17,030,000	5,894	$189,682,000	9.7%	10.4%
Lincoln	780	$13,980,000	8,571	$276,521,000	9.1%	7.1%
Cascade	3,490	$82,920,000	49,814	$2,216,021,000	7.0%	4.5%
Richland	610	$20,000,000	9,600	$559,526,000	6.4%	4.1%
Dawson	340	$8,880,000	5,717	$234,974,000	5.9%	3.9%
Silverbow	1,120	$26,540,000	20,418	$1,177,575,000	5.5%	3.2%
Missoula	4,150	$102,400,000	76,586	$3,078,232,000	5.4%	3.3%
Yellowstone	4,920	$134,790,000	102,284	$4,862,833,000	4.8%	3.0%
Lewis and Clark	1,950	$46,780,000	46,300	$2,127,515,000	4.2%	2.4%

Sources: "Economic Contribution of Nonresident Travel Spending in Montana, Travel Regions and Counties 2013-2014," Kara Grau, 2015, Institute for Tourism and Recreation Research, University of Montana. U.S. Bureau of Economic Analysis, Regional Economic Information System.

The Montana counties most dependent on non-resident visitor spending for jobs and earnings often are relatively rural counties such as Park (Yellowstone NP), Glacier (Glacier NP), Toole, Carbon (Yellowstone NP), Custer, Beaverhead, Madison, Richland and Dawson. See Table 2 above.

Some of Montana's more urban counties are also heavily dependent on visitor expenditures, led by Flathead County (Kalispell area, Glacier NP), where one out of every six jobs and one out of every eight dollars of earnings are associated with visitor spending. Gallatin County (Bozeman area, Yellowstone NP) is as dependent on the visitor economy. See Table 2 above.

3. The Role of Different Segments of the Recreation-Tourist Sector in the Montana Economy

A. A Summary of the Role of Different Segments of the Recreation-Tourist Sector in the Montana Economy

Before discussing several important segments of the Montana recreation-tourist economy, we summarize our findings here as a preview and guide.

Table 3.

Montana Recreation-Tourism Relative Economic Importance: Contribution to Total Jobs and Labor Earnings				
	Jobs	Labor Earnings		
Estimates of the Total Montana Importance				
Montana Non-Resid Visitors ITRR	53,280	$1,565,440,000		
Montana Outdoor Recreation-Southwick	89,000	$2,262,275,000		
"MT Non-Resid Tourist & Recreation" Total	33,977	$998,283,648		
Components of Montana Tourism and Recreation Activity			**Percentage of MT Non-Residential Tourism and Recreation Total**	
			Jobs	**Labor Earnings**
Glacier-Yellowstone NPs Visitation	9,992	$281,247,800	29%	28%
Wildlife Viewing and Sight-Seeing	11,102	$245,218,783	33%	25%
Hunting Activities	11,140	$281,270,023	33%	28%
Sport Fishing	5,375	$147,910,383	16%	15%
MT Skiing / Snowboarding	2,850	$83,148,800	8%	8%
Snowmobiling	1,544	$27,787,470	5%	2.8%
SubTotal of Listed Components	42,003	$1,066,583,259	124%	107%

Sources**:** Outdoor Recreation: "The Economic Contributions of Outdoor Recreation: Technical Report on Methods and Findings." Southwick Associates, prepared for the Outdoor Industry Association, March 15, 2013. "Non-Residential Tourist & Recreation" Total: Vacation and Visiting Friends and Relatives, "2014 Nonresident Visitation, Expenditures, and Economic Impact Estimates," Kara Grau, Institute for Tourism and Recreation Research, University of Montana, Table 2, p. 3.Jobs and Labor Earnings for different segments of the Recreation-tourist Economy: See text below.

The top section of Table 3 presents three different estimates of the size of the Montana "recreation-tourist" economy. The first focuses on only travelers who are not residents of Montana. But it includes all visitors, including those who are not usually considered "tourists" or "recreationists, i.e. those who are just passing through on their way to somewhere else, here for business, or shopping. The "outdoor recreation" estimate includes the spending of all those in Montana who travel to engage in outdoor recreation, both Montana residents and non-residents. The Montana non-residential recreation-tourist estimate is approximated by excluding visitors who travel to Montana to engage in business, are just passing through, or are in Montana for retail shopping. This was approximated by including only those who are "on vacation" or are "visiting friends and family."

As one would expect, focusing only on travelers who are not Montana residents, produces a smaller impact than also including Montana residents who travel within the state to engage in outdoor recreation and spend money in other Montana communities. Also, eliminating those visitors who are not here to enjoy Montana's natural or social amenities also reduces the estimated size of the "recreation-tourist" economy.

The bottom section of Table 3 provides estimates of the impact of various segments of "recreation-tourist" economy measured in terms of jobs and labor earnings, including multiplier impacts. In the lower right section of Table 3, the relative contribution of each segment of the "recreation-tourist" economy is stated in terms of its percentage contribution to the total jobs and labor earnings associated with non-residential tourism and recreation.

It should be noted that even though we have considered only some segments of the "recreation-tourist" economy in Montana, those for which we have recent estimated impacts, the total impacts as indicated in the bottom of Table 3 are greater than 100 percent for the jobs in recreation and tourism. The reason for this is that some of the measures of the impact of particular segments of the "recreation-tourist" economy include both Montana residents and non-residents. Yet we compare those impacts to a total that is based only on recreation-tourist spending by non-residents. This conflict over the appropriate measurement of the importance of tourism and recreation spending is discussed in the following sections discussing each segment of the visitor economy.

B. The Role of the Yellowstone and Glacier National Parks in the Montana Economy

Yellowstone and Glacier National Parks play a vital role within the overall Montana visitor economy. Averaged across 2013 and 2014, the top two counties in Montana in terms of non-resident visitor expenditures are the primary gateway communities for the two national parks: Flathead County adjacent to Glacier and Gallatin adjacent to Yellowstone. The next two counties with high non-resident visitor expenditures are the two metropolitan areas closest to each of the parks: The Yellowstone Metropolitan Statistical Area (MSA) for Yellowstone Park and the Missoula MSA south of Glacier NP. About half of all Montana non-resident visitor expenditures take place in these four counties. If Park County also adjacent to Yellowstone NP and Glacier County adjacent to Glacier NP are included, those six counties were the location of 60 percent of the entire Montana visitor economy measured in terms of non-resident visitor expenditures.[75]

Of course, the trade centers in these metropolitan areas and adjacent counties do not just serve national park visitors nor do all national park visitors spend all of their money in these counties. The National Park Service regularly estimates the local economic impacts associated with the visitation to each national park and the expenditures national park visitors make in the surrounding local economies. Approximately a third of the total Montana tourist impact is associated with Montana's two large national parks if one approximates the "tourist" part of total non-resident visitor spending by those visitors who identify themselves as "on vacation" or "visiting friends and relatives." If the relative importance of Yellowstone and Glacier NPs are measured against *all* non-resident visitors to Montana, including those whose visits are not associated with the state's natural landscapes and wildlife, the two national parks are the source of about a fifth of the Montana visitor economy. See Table 4 below.

Table 4.

The Relative Importance of Yellowstone and Glacier NPs within the Montana Visitor Support Industry, 2014					
Measure of Economic Impact	Yellowstone and Glacier NPs	Approximate "Tourist" Visitors	All Montana Visitors	National Parks as % of MT Tourism	National Parks as % of All MT Visitors
Visitor Days	5,619,058	34,807,000	54,776,700	16.1%	10.3%
Expenditures	$609,276,200	$2,514,726,757	$3,943,422,156	24.2%	15.5%
Employee Earnings (Dir, In-Dir, Induced)	$281,247,800	$839,700,005	$1,316,760,000	33.5%	21.4%
Employment Impact (Dir, In-Dir, Induced)	9,992	33,977	53,280	29.4%	18.8%
Sources:					
NP visitor days: 2014 National Park Visitor Spending Effects, Catherine Thomas et al. NPS, Natural Resource Report NPS/NRSS/EQD/NRR—2015/947, 2015, Appendix, Table 3.					
Approximation of "Tourist" sector of the Visitor Economy: Vacation and Visiting Friends and Relatives, "2014 Nonresident Visitation, Expenditures, and Economic Impact Estimates," Kara Grau, Institute for Tourism and Recreation Research, University of Montana, Table 2, p. 3					
Direct, Indirect, and Induced impacts, Kara Grau, Op. Cit.					
Expenditures by type of use: Numbers of groups x Daily Expenditure per Group x size of group. Kara Grau, Op. Cit.					
Visitor days for Montana visitors: Number of visitors x average visitor stay. Kara Grau, Op. Cit.					

C. The Role of Wildlife Viewing in the Montana Economy

Every five years the U.S. Fish and Wildlife Service in cooperation with state fish and wildlife agencies and conservation groups conducts a national survey of fishing, hunting, and wildlife-associated recreation. The most recent study covered 2011 and was published in 2014. Among

[75] "Economic Contribution of Nonresident Travel Spending in Montana Travel Regions and Counties, 2013-2014, Kara Grau, Institute of Tourism and Recreation Research, University of Montana, 2015, Figure 1, page 2.

the reports based on that survey are economic impact analyses of different types of wildlife-related recreational activities including wildlife viewing.[76]

In Montana there were an estimated 406,000 wildlife watchers sixteen and older.[77] The 2013 estimated Montana population of those sixteen and over was 816,000.[78] That suggests that about half of that part of the Montana population engages in some wildlife watching. The estimated economic impacts on Montana of wildlife viewing in 2011, (including multiplier impacts) were about 11,100 jobs and $245 million in salaries and wages.[79]

This economic analysis did not focus only on out-of-state visitors who came to Montana to observe wildlife. It focused on trips taken by Montana residents and non-residents away from their homes to engage in this recreation activity. In addition, expenditures made by residents in their home towns to purchase equipment associated with their wildlife viewing trips were also included but were limited to the part of those expenditures that stayed in Montana. That is, the cost of importing that equipment from out-of-state was not included in the economic impacts. As one would expect, this inclusion of recreational expenditures by both state residents and non-residents significantly increased the size of the estimated economic impact.

If we focus on away-from-home wildlife watching trips in Montana, over half, 55 percent, of those trips in 2011 were taken by non-residents.[80] Non-residents also spent considerably more on their trips to hire outfitters, guides, and equipment. As a result the average expenditures per participant were twice as high for non-residents. The net result was that 60 percent of the total expenditures by wildlife watchers in Montana in 2011was associated with non-residents.[81] It is not clear, however, that the other 40 percent of the total expenditures, namely those by Montana residents, should be ignored. Clearly the commitment of time and money to these wildlife watching activities by half of Montanans confirms the economic value of those experiences to residents.

Of course, it is not only wildlife that leads residents and visitors to explore Montana's natural landscapes. The diversity and beauty of those natural landscapes also draws people away from their homes to enjoy "Big Sky Country." We do not have a quantitative measure of that "sight-seeing," but it certainly is an important part of outdoor recreation. In that sense, our focus primarily on wildlife watching is a very conservative proxy for all visits to explore Montana's natural landscapes.

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[76] "Wildlife Watching in the U.S.: The Economic Impacts on National and State Economies in 2011: Addendum to the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, Report 2011-2."
[77] Ibid.
[78] American Community Survey, U.S. Census Bureau, 2013, population by age.
[79] Op. cit. Wildlife Watching in the U.S., 2011,Table 6.
[80] 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation, Montana," FHW-11-MT (RV), Revised December 2013, Table 25.
[81] Ibid. Table 31.

D. The Role of Hunting in the Montana Economy

Working with the data from the 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation carried out by the U.S. Census Bureau for the U.S. Fish and Wildlife Service, Southwick Associates estimated the relative importance of all types of hunting in each state economy, including Montana.[82] That study estimated the employment impact of hunting activities in Montana, (including multiplier impacts) to be about 11,100 jobs and about $281 million in labor earnings. This estimate does not focus only on non-Montana hunters who come to the state to hunt. It includes the spending of Montana residents who go on hunting trips within the state. It also includes the purchase of supplies and equipment to support that hunting but counts only the part of that spending that stays in the state.

If the focus was only on non-resident hunters, 78 percent of expenditures on hunting trips and equipment in Montana would be ignored. The vast majority of hunters and hunting trips in Montana and expenditures by hunters involve Montana residents.[83]

E. The Role of Sport Fishing in the Montana Economy

A 2013 study of the economic role of sport fishing in all fifty states was carried out for the American Sportfishing Association. It estimated the total job impact (including multiplier impacts) in Montana in 2011 was about 5,400. The salaries and wages associated with those jobs was about $148 million.[84]

These estimates include both Montana residents and non-residents who go on fishing trips, incurring trip and equipment costs in Montana. If only non-resident anglers were included, 86 percent of fishing trip expenses and equipment purchases in Montana would be ignored. The vast majority of anglers, fishing days, and spending on fishing in Montana involves Montana residents.[85]

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[82] "Hunting in America: An Economic Force for Conservation," prepared for the National Shooting Sports Foundation in partnership with the Association of Fish and Wildlife Agencies, 2012, all hunting activities, p. 12.

[83] 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation, Montana," FHW-11-MT (RV), Revised December 2013, Table 21.

[84] "Sportfishing in America: An Economic Force for Conservation," Southwick Associates, January 2013. P. 8, all types of fishing.

[85] 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation, Montana," FHW-11-MT (RV), Revised December 2013, Table 21.

F. The Role of Winter Sports in the Montana Economy: Skiing, Snowboarding and Snowmobiling.

Winter outdoor recreation in Montana extends beyond downhill skiing, snowboarding, and snowmobiling. It includes cross-country skiing, snowshoeing, backcountry skiing and camping, ice climbing, among other winter activities. Unfortunately there is detailed data and analysis in Montana only of downhill skiing, snowboarding, and snowmobiling. Thus our focus on this particular set of winter outdoor recreation understates the overall importance of winter outdoor recreation.

i. Skiing

The Institute of Tourism and Recreation Research (ITRR) at the University of Montana conducted a study in 2010 of the economic impact of the 2009-2010 Montana ski season.[86]

The ITRR focused its estimation of the economic impact on the state as a whole. In that context it focused only on non-Montanans who came to ski. For that reason Montana residents who skied, even those who traveled considerable distance from their homes, were assumed to have no impact on the state economy as a whole even though those skiers may have been "non-residents" of the area where the ski area was located. In addition, at least some of those Montana residents who skied within the state might well have traveled out-of-state to ski if there had been no attractive skiing opportunities within Montana. That would drain income out of the state, producing a negative economic impact within Montana.

Montana residents were responsible for 65 percent of the skier-days in the 2009-2010 season, 882,000 skier days. They were responsible for a similar amount of the total skier expenditures, $63 million compared to non-resident skiers' expenditures of about $35 million for a total expenditure on ski trips of about $100 million.[87] The ski industry is of particular importance to the Missoula and Bozeman area economies. Montana's two major universities, the University of Montana and Montana State University, respectively, are located in those two cities. Part of the attraction of those universities to out-of-state students is the recreational opportunities both areas offer to students, including the presence of several ski areas within commuting distance from those schools. The loss or degradation of the winter sports opportunities could negatively impact enrollment at those schools and the positive impact they have on their respective regional economies.

Ignoring the Montana skiers' expenditures on their ski trips significantly reduces the estimated relative importance of the Montana ski industry in the overall Montana economy.

[86] "Economic Impact and Skier Characteristics: Montana: 2009-'10 Ski Season,", Norma Nickerson and Kara Grau, Research Report 2010-3, June 2010.
[87] Ibid. p.2. Total expenditures calculated by multiplying the expenditures per skier day for each group times the number of skier days. Skier expenditures per day calculated by dividing ski group expenditures per day by the number of skiers per group.

The ITRR skiing economic impact study found that *just non-resident* expenditures were the source of about 1,000 jobs and about $30 million in worker earnings, including multiplier impacts. The impact would be about 2,900 jobs and $83 million in labor earnings if we include the expenditures of both resident and non-resident skiers.

ii. Snowmobiling

The Bureau of Business and Economic Research (BBER) at the University of Montana published two studies of Montana recreational snowmobiling in 2014.[88] The studies primarily focused on the spending patterns of snowmobilers in Montana, but they did estimate the impact of that recreation on the Montana economy as a whole.

These studies estimated the total snowmobiling activity days in the 2013-2014 season at about 1.3 million days. Only 97,000 of those snowmobiling days were by non-residents, about 7 percent. Put differently, 93 percent of Montana snowmobiling activity was residents enjoying this form of winter recreation.

Resident snowmobilers spend less per activity day because they often return home at the end of the day and do not spend as much on food and lodging. The average daily expenditures for residents were about $56 while the daily expenditures were about $147 for non-residents. Residents also spent money within the state purchasing and repairing snowmobiling equipment, while non-residents are likely to have made those expenditures out-of-state. The net result is that the share of total expenditures by non-resident snowmobilers is somewhat higher than the share of activity days, about 13 percent of total expenditures as opposed to the 7 percent of activity days.

In an economic base context, which these studies adopted, Montana residents who snowmobile are assumed to have no impact on the overall economy because they do not bring new income into the state. Since almost all snowmobiling expenditures in Montana, 87 percent of them or $96 million dollars, come from Montana residents, the BBER estimated only a very small impact on the state economy as a whole from non-resident snowmobile activity even though total spending by all snowmobilers in Montana totaled over $110 million in the 2013-2014 season.

Clearly the $96 million that Montana residents spent on this outdoor recreation had a positive impact on the Montana businesses where those resident snowmobilers shopped. To the extent that Montana urban residents travelled to distant rural areas to snowmobile and spent money on those trips within Montana, their spending was also non-resident spending in those rural areas. If Montana residents had to leave the state to engage in snowmobiling, there would be negative economic impacts due to that "leakage" of income out of the state.

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[88] "Snowmobiling in Montana," James T. Sylvester, ***Montana Business Quarterly***, Winter 2014, pp. 18-24. Also "Montana Recreational Snowmobiles: Fuel-Use and Spending Patterns," James T. Sylvester, July 2014, Bureau of Business and Economic Research

The BBER's estimate of the economic impacts of only the *non-resident* snowmobiling expenditures ($14.3 million) on the Montana economy in 2013 was 200 jobs and $3.6 million in labor earnings. If the spending of Montana residents on snowmobiling is also included in the measure of the relative importance of snowmobiling in the Montana economy, its contribution would be about 1,500 jobs and $28 million in labor earnings.

IV. Estimated Impacts of Climate Change on the Recreation-Tourism Economy

Having described the likely future impact of climate change on the natural landscapes of Montana and the importance of those natural landscapes to the state and local economies, we now turn to the estimation of the potential economic impact of a "business-as-usual" public policy strategy that makes no attempt to moderate or reduce the cumulative impact of greenhouse gas (GHG) pollutants on those natural landscapes and wildlife and the recreation and tourist activities they support.

Both climate change and economic impacts are difficult to calculate. Both require professional judgement based on the best evidence available. In public discussion of public policies aimed at reducing human releases of GHG, there tends to be a heavy emphasis on the economic *costs* associated with adopting those policies. When these costs of controlling GHG pollution are discussed, there is rarely a similar discussion of the economic *benefits* that are the objective of those climate change public policies, namely avoiding the future costs associated with climate change. The result is a cost-only analysis that typically produces very large quantitative measures of the costs associated with policies aimed at reducing future human-caused climate change.

A "cost only" analysis of climate change public policy cannot be categorized as an *economic* analysis since it is the net costs or net benefits after both the benefits and costs of a public policy have been estimated that matter. Implicit in typical cost-only analyses of reducing future impacts of climate change is the assumption that the benefits of reducing human-caused climate change are known in precise, quantitative, detail, namely, that they are zero. The overwhelming scientific evidence is that this precise quantitative value of slowing or stopping human-caused climate change is wrong. The future costs associated with climate change that could be avoided are not zero.

In the analysis below we combine the quantitative information that is available with expert judgement to produce estimates of the likely economic costs associated with climate change in Montana if no public policy steps are taken to reduce human GHG pollution. That expert judgement is tied a half-century of experience analyzing the Montana economy, the role that natural and social amenities have contributed to economic vitality in Montana, and long run economic trends within the state and region. In our professional judgement, these estimated economic costs of projected climate change in Montana are far more reliable and accurate than the explicit alternative assumption that there are zero costs associated with that ongoing climate change in Montana.

Table 5 below summarizes each of our estimated economic costs of climate change. In the sections below, we discuss each estimated economic cost in turn.

Table 5.

Projected Economic Losses Due to Climate Change in Components of the Montana Recreation and Tourism Activities		
	Jobs	**Labor Earnings ($millions)**
Glacier-Yellowstone NP Visitation	3,331	$94
Wildlife Watching & Sight-Seeing	2,775	$61
Hunting	1,560	$39
Sport Fishing	1,792	$49
Skiing, Snowboarding, Snowmobiling	1,465	$37
Total Economic Losses in Recreation and Tourism	**10,922**	**$281**

Sources: See Tables 6 through 10 below.

1. Visitation to Yellowstone and Glacier National Parks

One of the most disruptive impacts of climate change on Montana recreation and tourist activities is wildfire. Wildfires are expected to be larger, more intense, more frequent, and to burn in more months, rather than just July and August. The physical threat of wildfire, the damage the smoke produced does to visibility, comfort, and health, and the changes in the character of the post-fire landscapes have negative implications for visitation to Montana's Yellowstone and Glacier National Parks.

Although climate change is already underway in Montana, the ultimate breadth of its impact on National Park visitation has not yet been apparent. Thus far there have been intermittent years of "unexpectedly" large fires in and around these two National Parks that have significantly reduced park visitation. Because these were "unexpected" events, and visitors had already planned their trips, often the visitors arrived anyway and coped as best they could with the closures and choking smoke that eliminated the possibility of even viewing the parks from a distance. As wildfire and smoke in and around these National Parks and their surrounding landscapes for hundreds of miles become a common occurrence, people are not as likely to make reservation to visit these parks and adjust their travels as the extended fire season develops. Some will shift their visitation to other natural landscapes that do not face as regular a threat from wildfire and smoke.

Climate change will bring other changes to the landscapes of Yellowstone and Glacier National Parks. Glacier NP will lose its iconic glaciers. Fires and insect infestations will regularly kill huge acreages of trees leading ultimately to tangled masses of deadfall trees on the ground, making hiking both difficult and dangerous. Lower elevation forests will be displaced by grasslands or shrub lands including sagebrush. The types of forests will change with some, such as the Whitebark pine, going extinct. As will be discussed when we focus on angling and fisheries, the opportunities inside Montana's two National Parks to fish for native species will also decline.

As discussed above wildfire and smoke has impacted National Park visitation in the past, reducing visitation as much as 50 percent during the time of the fires. Even the smoke from distant fires reduced visitation by 10 to 20 percent. If climate change proceeds with no decrease of GHG and the fire frequency, size, intensity, and fire season all increase, these impacts on visitation will increase and be more frequent. If the cumulative impact is that there will be significant wildfire and smoke problems every few years, *planned* visitation will decline. Thus, in addition to the declines in visitation when fires actually close parts of the parks, there will be a decline in visitation overall as people seek to avoid parks and areas that are known to be regularly smoky and where vacationers regularly get turned back because of frequent fires. If visitation declines by 20 percent to these parks because of the threat of fire and smoke *and* if, in addition, there are major wildfires and smoke in the parks or on surrounding natural landscapes once every three years, visitation and associated expenditures could decline by about a third. These impacts are shown in Table 6 below.[89]

Changes over time in the visitation to Glacier and Yellowstone National Parks of this magnitude are not beyond the historical record. In 2003 visitation to Glacier NP was about 30 percent below the 2014 level. That was not an exceptionally low visitation year: From 1996 to 2003 visitation to Glacier NP averaged about 25 percent below the 2014 level. For Yellowstone NP, visitation averaged about 30 percent below 2014 levels from 1985 to 1987. Our projections of visitation to these national parks as fires in and around the parks become larger and more frequent and the character of the parks is degraded by climate change is that visitation will

[89] Some have argued that warmer temperatures due to climate change will boost visitation at northern National Parks like Glacier and Yellowstone NP because visitors can come to the parks in the "shoulder" periods in spring and autumn when in the past northern parks were not attractive because of frigid weather, remaining winter snow pack, or autumn snowfall. While admitting that extreme summer temperatures deter visitation, with a warming climate, spring and autumn would open an alternative attractive visitation period.(Protected Area Tourism in a Changing Climate: Will Visitation at US National Parks Warm Up or Overheat?", Nicholas A. Fisichelli et al., ***PLOS ONE***, June 17, 2015.) This article did not analyze the impact of change in temperature over time on National Park visitation. Rather is simply noted that National Park visitation in northern parks peaks heavily in the summer, leaving relatively under-utilized shoulder seasons to which visitors discouraged by hot and extreme summer temperatures could turn. This is largely speculation that ignores climate impacts other than summer temperature and that would require a dramatic change in school and work schedules so that families could visit National Parks in April and May and September and October. Whether such changes in school and work schedules are likely is certainly unknown if not unlikely. It should also be noted that Glacier and Yellowstone are high elevation parks that allow only limited access during the fall, winter, and spring. Even with lower snowpack in future years, snow will still close some park roads for much of the year. In addition, as fire season extends back into spring and forward into autumn, many of the same climate change fire and smoke problems would plague earlier and later visitors.

decline over the next 40 years to levels that were common 15 years ago in Glacier NP and 30 years ago in Yellowstone NP.

It should be pointed out that despite wildfires closing parts of Glacier NP during August of 2015 and reducing visitation significantly during those fires, projections were that Glacier NP would still set a new record in overall attendance during 2015. This is partially due to the decision by the National Park Service to keep all of the Going to the Sun Highway open two weeks longer during the fall of 2015. It is warmer weather that allows that extension of the time period that Glacier is open. Also, it needs to be kept in mind, as discussed above, that wildfire is still an “unexpected” occurrence in Glacier and Yellowstone National Parks. Visitors have to make their visitation plans well ahead of time or risk not being able to find a place to stay in the park or surrounding communities during peak summer visitation times. As wildfires become a recognized risk associated with planning summer visitation to these National Parks, one can expect planned visitation to fall off as travelers plan to visit locations where their vacation will not be degraded or ruined by wildfire and accompanying smoke.

Table 6.

Projected Impact of Climate Change on Yellowstone and Glacier National Park Visitation		
	Jobs	**Labor Earnings ($millions)**
Size of Economic Sector at Risk: Montana National Park Visitation	9,992	$281
Loss of Jobs and Income Due to Climate Change	3,331	$94

Source: For size of sector see Table 4, column 4.

2. Wildlife Watching and Other “Sight-Seeing” Activities

Wildlife watching will be affected by all of the climate change impacts that are likely to reduce visitation to Montana’s National Parks: Active fires and fire suppression activity, heavy smoke from fires reducing visibility and making it unhealthy to engage in outdoor activity. One cannot “watch wildlife” or “see sights” through dense smoke. Large tracts of dead trees from insect infestations and wildfire will make travel through forests difficult and dangerous. In addition, wildlife is expected to move up the mountains and stay longer in the high country in order to access a cooler environment. This may put much wildlife viewing outside the existing transportation infrastructure. High and extreme temperatures throughout summer and into spring and fall for longer periods will make strenuous outdoor activity less pleasant and attractive. Finally, during the most active parts of the extended fire season, public lands are often closed to visitors to reduce the likelihood of human caused wildfires.

We expect a similar reduction in these wildlife watching and sight-seeing activities as we projected for National Park visitation in Montana. With a larger range of alternative sites in Montana to visit for wildlife watching, we have reduced the percentage impact from what we projected for Montana's National Parks to one-quarter. Recall, however, that our measure of impact is based only on wildlife watching. Other, relatively extensive, exploration of Montana's natural landscapes, non-wildlife sight-seeing, is being ignored in estimating the impact of climate change. Recall also that we are speaking only of people who go out to see wildlife and not the impact of climate change on the wildlife. As habitat is diminished there will be less wildlife to watch even if people were not impacted by the heavy smoke that is predicted in our future. For those reasons, this estimate is quite conservative. See Table 7 below.

Table 7.

Projected Impact of Climate Change on Wildlife Watching and Sight-Seeing in Montana		
	Jobs	**Labor Earnings ($millions)**
Size of Economic Sector at Risk: Montana Wildlife Watching and Sight-Seeing	11,100	$245
Loss of Jobs and Income Due to Climate Change	2,775	$61

Sources: For size of sector see "Wildlife Watching in the U.S.: The Economic Impacts on National and State Economies in 2011 Addendum to the 2011 National Survey of Fishing, Hunting, and Wildlife – Associated Recreation, U.S. Fish and Wildlife Service, Report 2011-2.Table 6.

3. Hunting

As discussed earlier, climate change will make a late October to late November big game hunting season more difficult and less productive. Warmer temperatures and lack of snowfall during that period will lead elk to stay in the high country more distant from roads, make tracking animals quite difficult, and make it difficult to protect meat from spoilage. It may also undermine some tenets of the North American Model of Wildlife management as pressure grows on wildlife managers to kill big game that concentrates on private lands outside of hunting season. One alternative would be shifting hunting season into the winter months so that it can be conducted in cool weather when big game come down from the high country. This would allow hunters a better chance to keep their meat from spoiling and would increase the chance that there would be snow on the ground for tracking. But such a shift could also increase the likelihood that obviously pregnant elk and deer would be killed and would shift hunting season to far outside of what has been a Montana tradition for generations. In any case, climate change will tend to undermine key characteristics of big game hunting in Montana and make it less attractive to both hunters and the non-hunting public.

We project that big game hunting could decline by a fifth to a quarter. As mentioned above, 69 percent of all of the expenditures on hunting in Montana are associated with big game hunting. If upland bird and water fowl hunting are also similarly affected by climate change, the economic cost would be a 20 to 25 percent decline in hunting's employment and labor earnings impact. If, on the other hand, upland bird, water fowl, and small game hunting are unaffected by climate change, this would mean that hunting expenditures would decline by 14 to 17 percent. Conservatively, we have used a 14 percent decline in Table 8 to show the impact of climate change in reducing the economic activity associated with hunting in Montana.

Table 8.

Projected Impact of Climate Change on Montana Hunting		
	Jobs	**Labor Earnings ($millions)**
Size of Economic Sector at Risk: Montana Hunting Activities	11,140	$281
Loss of Jobs and Income Due to Climate Change	1,560	$39

Sources: "Hunting in America: An Economic Force for Conservation," prepared for the National Shooting Sports Foundation in partnership with the Association of Fish and Wildlife Agencies, 2012, all hunting activities, p. 12..

Hunting in Montana for many residents is part of a way of life. If the experience becomes degraded to the point that hunters are discouraged from participating in it, then Montana hunters will be losing a significant part of their quality of life. Hunting is one of the things that ties Montanans to the land. If the land has changed so that it no longer is recognizable because the trees have burned or the species have changed, the valleys have become sage brush, and the animals stay in the high country throughout hunting season, then Montana may become a less desirable place for big game hunters to live. Since most of those who hunt in Montana are Montana residents, not only do resident hunters suffer a significant loss, but this could have significant economic impacts as potential in-migrants interested in big game hunting in Montana choose other locations and current residents who value hunting choose to relocate to places that do not have degraded experiences. Although it is hard to put a quantitative value to the *quality* of a hunting experience, that does not mean that it has no value. Quite the opposite is likely to be true: Big game hunting is part of the identity of many Montanans and the reason that they live in Montana. This loss to resident hunters should not be ignored by focusing on the minority of hunters who are from out-of-state.

4. Angling and Sport Fishing

As discussed above, lower winter snow pack, rain on snow events during the winter and spring, and warmer springs and early summers will shift peak stream flow to earlier in the year, leaving summer stream flows lower while summer temperatures are hotter and extreme for longer periods of time. Water temperatures in streams and lakes will rise stressing native fish populations. This will lead to more limitations on fishing in the form of reduced daily hours when fishing is allowed or outright closure of streams and lakes to fishing. That is already happening in Montana and adjacent states and provinces and the frequency and duration of these limits on angling will continue to increase.

With lower stream and river flows there will also be conflicts between water users, especially between instream flows for fish and the water rights of farmers to divert water from streams to irrigate summer crops. This is likely to reduce stream flows even further where agricultural water rights are superior to the claims for instream flows. Disease and stress on the fish will increase fish mortality. There may be significant summer fish losses as a result. This will lead to lower angling success and smaller fish.

The stress on native fish that have difficulty adapting to the warmer water temperatures will increase the successful competition of non-native fish and the hybridization of native and non-native fish. This loss of the iconic native fish that anglers pursue may reduce the interest in fishing Montana's "blue ribbon" trout streams.

Finally, the increased frequency, size, and intensity of wildfires and the expanded duration of the wildfire season will remove vegetation from stream and river banks, increasing water temperatures further. Post-fire sediment and debris flows combined with extreme events such as floods and droughts will further degrade fish habitat.

As discussed above, we know that fish closures during hot weather and low stream flows can reduce angling-days of 25 to 40 percent. We know that the collapse of popular fisheries can reduce angling activity by 60 percent. The high quality associated with Montana trout fishing is tied to attraction to native species that are increasingly threatened and may be lost. We estimate that as a warmer, drier spring and summer climate continues to develop, at least a third of the angling activity may be lost. Table 9 shows that economic impact.

Table 9.

Projected Impact of Climate Change on Montana Angling and Sport Fishing		
	Jobs	**Labor Earnings ($millions)**
Size of Economic Sector at Risk: Montana Angling and Sport Fishing	5,375	$148
Loss of Jobs and Income Due to Climate Change	1,792	$49

Sources: "Sportfishing in America: An Economic Force for Conservation, "Southwick Associates, January 2013. P. 8, all types of fishing.

5. Winter Sports: Skiing, Snowboarding, and Snowmobiling

Lower snowpack and no snow at lower elevations, combined with warmer winters with more precipitation falling as rain, threatens to undermine the attractiveness of downhill skiing and snowboarding in Montana. Additional snow-making equipment can be used if the temperature is low enough. This is unlikely at many ski area's lower elevation base areas. At higher elevations more snow-making may be possible although this is costly and will require additional water rights to expand, something that may be difficult to acquire in periods of drought when there is conflict over the use of reduced stream and river flows.

There is no dispute that poor snow conditions lead to dramatically lower skiing activity and skiers' expenditures. In the future skiers are less likely to make skiing reservations given the much higher risk of extremely poor ski conditions. As a result, there will be fewer skiers who come to ski areas because of the past poor conditions. The result will be that some ski areas will open later and close earlier or, in some years, will not open at all. We project that the impact of poor snow conditions on skiing activity will be twice that observed thus far.

Snowmobiling may face even more of a challenge. Snow-making is not practical for linear trails that are miles long. Road closures to vehicles may make access to trailheads impossible or require miles of driving snowmobiles on dirt roads, something many snowmobilers will not do.

As with hunting in Montana, winter sports are directly tied to residents' quality of life. Again the quantification of the impact of the loss or simply the degradation of the winter sports experience is difficult. People choose to come and live in Montana because they can engage in winter sports. If the quality of the winter sports becomes so poor that residents no longer engage in them then the quality of life for those user groups can dramatically decline. The ability to get out of the house and avoid "cabin fever" in the winter time, when, in Montana the shortest day of the year has only eight hours of daylight, is very important to many Montanans. This loss to residents cannot be ignored while focusing only on the minority of out-of-state visitors expenditures on winter sports in Montana. The quality of life for Montanans and the attractiveness of Montana as a place to live are directly tied to the quality of winter recreation in Montana.

As a result of this loss of reliable snow cover, we project the loss of a third of skier and snowmobiling days and spending. Table 10 shows the impact of that on Montana economic activity.

Table 10.

Projected Impact of Climate Change on Montana Skiing, Snowboarding, and Snowmobiling		
	Jobs	Labor Earnings ($millions)
Size of Economic Sector at Risk: Montana Skiing, Snowboarding, and Snowmobiling	4,394	$111
Loss of Jobs and Income Due to Climate Change	1,465	$37

Sources: Size of economic sector: "Economic Impact and Skier Characteristics: Montana: 2009-'10 Ski Season,", Norma Nickerson and Kara Grau, Research Report 2010-3, June 2010. "Snowmobiling in Montana," James T. Sylvester, ***Montana Business Quarterly***, Winter 2014, pp. 18-24. These estimates were expanded to account for the expenditures of resident skiers and snowmobilers.

It should be pointed out that there are other winter sports that are not included in this total, such as cross-country skiing and snowshoeing, which are also likely to be negatively impacted.

V. Climate Change, Wildfire, and Residential Settlement Patterns: People and Property at Risk in the Montana Wildland-Urban Interface

In addition to threatening particular sectors of the Montana economy such as recreation, tourism, and agriculture, climate change, in the form of more frequent, larger, and more intense wildfires, also threatens the homes and lives of Montanans. In this section we expand on those aspects of the economic cost of climate change.

1. Looking Back and Looking Forward: The 1910 Fires in Montana and Idaho

The forest fires of 1910 traumatized the newly created United States Forest Service and captivated the nation. With the assistance of the U.S. Army and thousands of volunteer fire fighters, the Forest Service fought a valiant but losing battle against thousands of wildfires in Western Montana and North Idaho. In the end, the fires swept over forests, firefighters, towns, rivers, and mountain ranges. Ultimately the wildfires were only extinguished by the same variable weather conditions that created them: In this case late August rain, mountain snow, higher humidity, lower temperatures and calmer winds quieted down the fires and ultimately put them out.

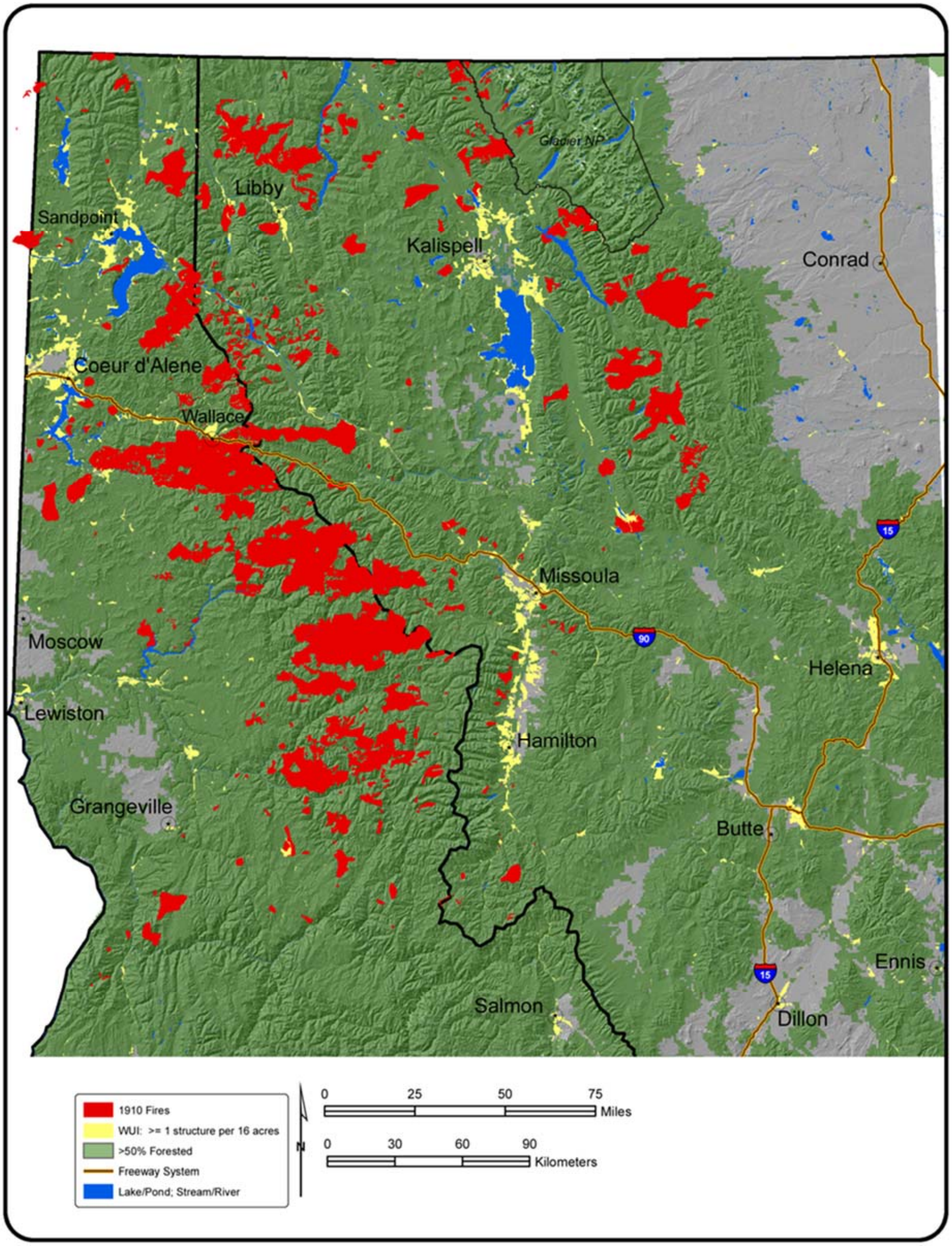
What set the 1910 "year of the fires" in the Northern Rockies apart was not the death toll but the sheer scale of the fires. Over the spring and summer approximately 1,700 fires burned three million acres across a broad swath of forestland 90 miles wide and 200 miles long stretching along both sides of the Bitterroot Mountains that mark the Montana-Idaho border.[90] From south of Missoula, Montana, to east of the Spokane-Coeur d'Alene urban areas and almost to the Canadian border, forests were ablaze. An estimated 75 percent of this acreage burned over a two-day period as hurricane-force winds created a fire storm on August 20-21st. Residents of the area fled to safety by train, sometimes over burning trestles, often hanging on the outside of overcrowded trains. Others sheltered in train and mine tunnels or stood in lakes and rivers to avoid the uncontrollable flames. The red shading on Figure 2 on the following page shows the extent of the fires of 1910. Also shown in yellow are the Wildland-Urban Interface (WUI) where current residential housing is mixed into forested landscapes or where clusters of homes are found in close proximity to heavily forested landscape through which wildfires can move.[91]

In order to capture some of the implications of more frequent, larger, and more intense wildfires in Montana, we will estimate what fire seasons similar to 1910 would mean in the contemporary Northern Rockies. It should be recognized that the 1910 wildfires burned about 2.8 million acres in Montana and Idaho.[92] In 2007 and 2012, wildfires in Montana and Idaho burned almost as many acres. In terms of the scale of the area burned, the 1910 wildfire is no longer an outlier. However, between 1910 and 2014 the population of the region where the 1910 fires burned has grown dramatically. A significant part of that population has sprawled out into the forested areas to enjoy the natural amenities of living in forested mountains and valleys. In addition the economy has diversified. Although the forest products industry remains important to the region, recreation and tourism have grown in economic importance. In addition, the regional economy has been increasingly driven by net in-migration, drawn to the region by both the social amenities of Montana's relatively small cities, rural living, and the natural amenities of forested mountains, river valleys, and lakes.

What we wish to explore are the contemporary economic implications of large and intense wildfires similar in scale to 1910. Climate change scientists are projecting that the scale of wildfires in Montana and other areas of the Northern Rockies will increase dramatically.

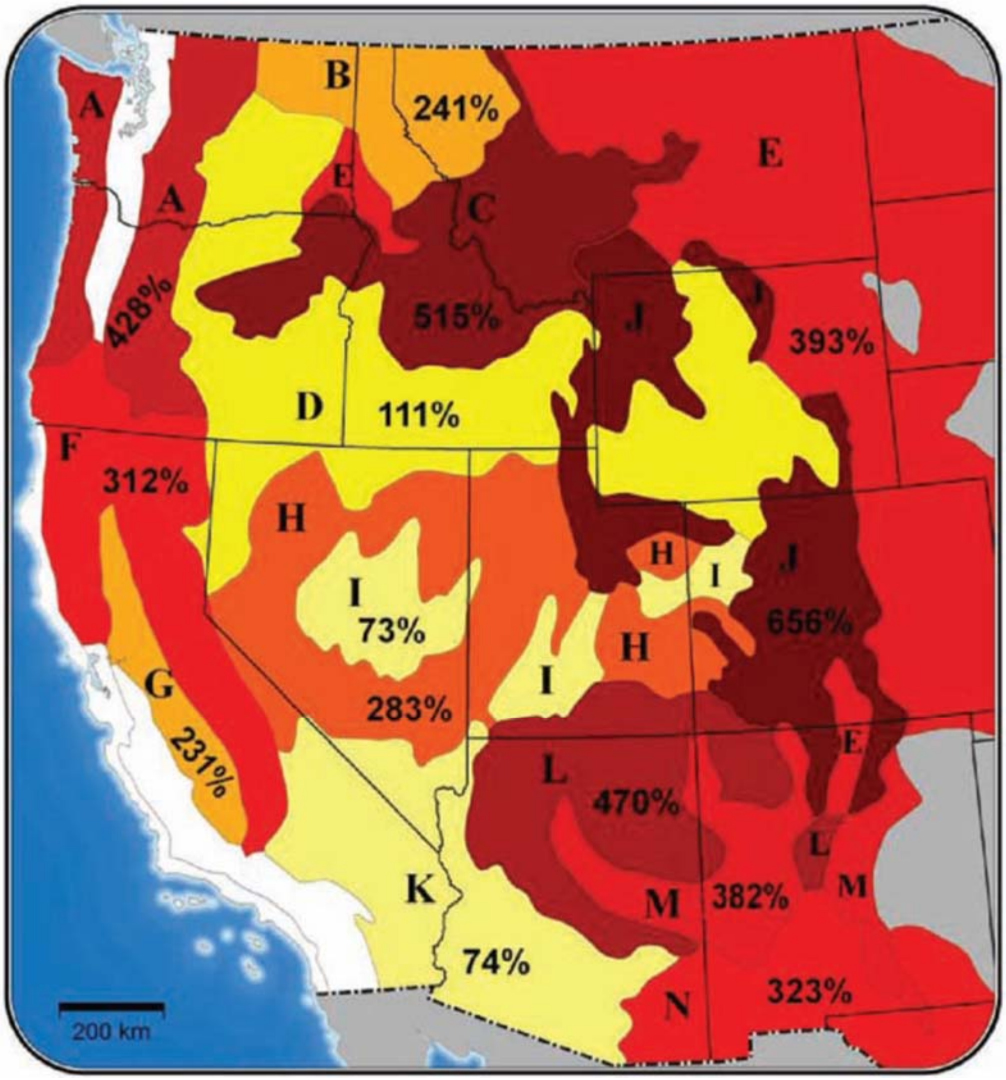
[90] Cohen, S., Miller, D.1978. *The Big Burn: The Northwest's Forest Fire of 1910*. Pictorial Histories Publishing Co: Missoula, Montana.
[91] The wildland-urban interface (WUI) shown is based on the 2000 Census of Housing and Population.
[92] National Inter-Agency Fire Center, www.nifc.gov/fireinfo/fireinfo_statistics.html .

Figure 2.



Region of the 1910 Fires in Northern Idaho and Western Montana showing the location of the fires and the 2000 Wildland-Urban Interface. Source: Authors.

Figure 3.



The percentage changes in the area burned by wildfire for a one degree Celsius (1.8 degrees F) increase in global average temperatures. Change measured relative to the median annual area burned during 1950-2003. Source: National Research Council, 2011, ***Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia.*** Washington, DC, National Academies Press. Figure 5.8, p. 180.

Cooler and wetter northwestern Montana would see about a 250 percent expansion in areas burned by wildfire relative to the median annual area burned during 1950-2003. Drier and hotter southwestern Montana would see about a 550 percent increase in the area burned. Eastern Montana would see about a 400 percent increase in the area burned by wildfires. See Figure 3 above.

2. The Change in Settlement Patterns in the Northern Rockies

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One of the dramatic differences between 1910 and 2014 is that human settlement in Western Montana had increased substantially. In 2014 the population of the nine Western Montana counties impacted by the 1910 fires had three to five times as many residents. And that population continues to grow. Between 1970 and 2010, in-migration of people into this forested area of Western Montana boosted the population by more than 50 percent. See Table11 below.

Table 11.

Change in Population in the 1910 Fire Counties: Western Montana

County	Population		Percent Change in Population 1910-2014	Net In-Migration	
	1910	2014		1970-2010	as % of 1970 Level
Flathead	18,785	94,924	405%	36,054	91%
Granite	2,942	3,209	9%	83	3%
Lewis and Clark	21,853	65,856	201%	17,257	52%
Lincoln	3,638	19,125	426%	-2,588	-14%
Mineral	***	4,257	***	432	15%
Missoula	23,596	112,684	378%	25,429	44%
Powell	5,904	6,909	17%	-256	-4%
Ravalli	11,666	41,030	252%	22,565	157%
Sanders	3,713	11,364	206%	3,147	44%
9 W. MT Counties	92,097	359,358	290%	102,123	56%

***In 1910 the county was part of an included adjacent county or contained all or part of an adjacent county.
Sources: U.S. Bureau of the Census and University of Wisconsin Applied Population Laboratory, Net Migration Patterns for U.S. Counties, http://www.netmigration.wisc.edu/ accessed 8/19/2015

As a result of that growth, the population of two of the urban areas, Missoula to the south and Coeur d'Alene to the north passed the 100,000 mark in the 1990s and were classified as Metropolitan Statistical Areas. Almost continuous urban-suburban-exurban settlement areas now stretch from Hamilton through Missoula to Kalispell in Western Montana. In North Idaho a similar settlement belt stretches from Coeur d'Alene to north of Sandpoint. As the yellow shading on Figure 2 above shows, WUI areas snake along the forest mountain valleys throughout the 1910 fires area. In high wildfire years between 2000 and 2015, these areas of human settlement within or adjacent to the Northern Rockies' forests were regularly surrounded by wildfires.

Exurban sprawl beyond the more densely settled urban-suburban areas has grown significantly since 1980 in the 1910 fire area. If we focus on the land in each county that is open to private development by removing the federal and other public lands, the percentage of developable land committed to exurban residential settlement increased by almost 50 percent between 1980 and 2000 in the nine Western Montana Counties. If this pattern and pace continue, the projection was that in 2020 the developable area committed to exurban settlement would increase by almost a third again in those 1910-fire Montana counties compared to 2000. For the 40-year period 1980-2020, the percentage of developable land in exurban settlement will have almost doubled across those nine Montana counties, adding almost 400,000 acres to exurban residential sprawl in these counties.[93] See Table 12 below.

Table 12.

Exurban Sprawl in the 1910 Fire Area 1980-2020

County	Shift in Acreage from Rural to Exurban Residential			Percentage Increase in Exurban Residental Land Use on Developable Lands		
	Actual 1980-2000	Projected 2000-2020	1980-2020	Actual 1980-2000	Projected 2000-2020	1980-2020
Flathead	104,251	60,614	164,865	139%	34%	220%
Lake	35,239	7,875	43,114	98%	11%	120%
Ravalli	17,895	53,065	70,960	15%	39%	61%
Powell	996	1,297	2,293	22%	24%	51%
Sanders	6,637	5,293	11,930	33%	20%	59%
Mineral	2,357	-1,090	1,268	42%	-14%	22%
Missoula	7,297	38,698	45,995	10%	48%	63%
Lewis and Clark	13,506	23,153	36,660	22%	31%	60%
Granite	69	-667	-598	1%	-10%	-9%
9 MT Ctny	188,248	188,238	376,487	47%	32%	94%

Source: Theobald, D. 2005. "Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society 10(1): 32. http://www.ecologyandsociety.org/vol10/iss1/art32/.

Almost all of this exurban settlement will be in the WUI where these people and structures will be exposed to increasingly frequent, large, and intense wildfires. This, of course, increases the likely costs associated with wildfires: more people killed, more structures destroyed, and considerably more resources expended trying to protect people and structures and control the wildfires.

We can use the number of homes within the WUI to indicate the value of homes and the number of people who will be increasingly at risk to large and intense wildfires. The WUI home count is based on the block-level data from the 2000 Census.[94] We have used the average home value in each county in 2000 to value the homes within WUI. We have also used the average people per housing unit countywide to estimate the number of people inhabiting the WUI.

Table 13 below summarizes the results by each Montana county within the 1910-fire area. In 2000 there were about 100,000 homes worth about $13 billion inhabited by about 217,000 people living in these Western Montana WUI areas. This region is no longer a lightly inhabited area with few permanent residents.

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[93] "Exurban" is distinguished from "urban/suburban" and purely "rural" on the basis of housing density. "Suburban" involves housing densities at 1.7 acres per dwelling and less. Rural is defined as 1 dwelling per 40 acres of less. "Exurban" involves housing densities in between these two.

[94] In August 2015, the count of homes in the WUI in Montana counties was not readily available even though the WUI definition and inventory of structures had been updated based on the 2010 Census.

Table 13.

2000 Homes, Home Values, and Residents in the Wildland-Urban Interface in the 1910 Fires Northern Rockies Area			
County	# of Housing Units in WUI	Value of Homes in WUI	Estimated Number of Residents in WUI
Flathead	23,749	$2,982,874,400	46,842
Granite	1,396	$109,306,800	1,911
Lewis and Clark	19,477	$2,185,319,400	41,015
Lincoln	6,720	$555,072,000	13,527
Mineral	1,329	$117,350,700	2,602
Missoula	32,377	$4,419,460,500	67,766
Powell	2,203	$161,920,500	5,432
Ravalli	12,943	$1,726,596,200	31,730
Sanders	3,266	$270,751,400	6,800
9 Montana Ctny	103,460	$12,528,651,900	216,686

SILVIS Laboratory, Forest and Wildlife Ecology, University of Wisconsin-Madison, The Wildland Urban Interface, http://silvis.forest.wisc.edu/maps/wui_main .

For all of Montana in 2000, the total number of homes in the WUI areas was 261,000. The nine northwestern Montana counties contained about 40 percent of all Montana WUI homes. Based on the median value of homes in each Montana county in the 2009-2013 period, those 261,000 Montana WUI homes would have a total value of $47 billion in 2011 dollars.[95]

A 2015 report by the private consulting firm, CoreLogic Inc., estimated the number of residences built adjacent to forest and grasslands that were prone to wildfires. It estimated the risk of those residences being destroyed by wildfire based on proximity to those fire-prone wildlands and the character of the residential lot and home. On the basis of that analysis, it estimated for each state the number of residences at risk and the reconstruction cost value of those threatened homes.

That report found that there were about 317,000 Montana homes at risk to wildfire, but 77 percent of them were rated as at low risk. About 73,000 homes adjacent to wildlands in Montana were rated as having moderate risk or higher. About 60,000 homes were rated as having a high or very high risk to wildfire. The total value of the homes at high or very high risk to wildfire was about $14 billion. See Table 14 below.

Coping with the fire seasons similar in magnitude to the 1910 fires in this setting where the edges of the forests are increasingly heavily settled has become a more and more challenging task. The scope of the problem and its costs can only grow as exurban sprawl continues while the risk of such wildfires increase as Montana summers get hotter and drier. This represents one of the greatest threats associated with Montana's changing climate.

[95] We used the estimates of median value of owner-occupied homes in each Montana county for the 2009-2013 period to value the homes identified in the Montana WUI in 2000 provided by the American Community Survey carried out by the U.S. Census Bureau. Detailed data by county on the Montana WUI based on the 2010 Census was not readily available.

Table 14.

Montana Residential Properties at Risk to Wildfire: 2014							
Risk Score	**1-50**	**51-60**	**61-80**	**81-100**	**1-100**	**51-100**	**61-100**
Risk Characterization	**Low**	**Moderate**	**High**	**Very High**	**Total**	**Moderate to Very High**	**High and Very High**
Number of Homes	243,990	13,114	27,301	32,348	316,753	**72,763**	**59,649**
Value of Homes: $millions	$52,686	$2,998	$6,339	$7,640	$69,663	**$16,977**	**$13,979**

Source: CoreLogic Inc., "Wildfire Hazard Risk Report," 2015, Howard Botts, et al., Tables 9 and 10.
http://www.corelogic.com/research/wildfire-risk-report/2015-wildfire-hazard-risk-report.pdf

3. Wildfire Impact on Amenity-Supported Economic Vitality

Attractive natural environments do not just draw temporary visitors whose expenditures support local economic vitality. Those attractive natural environments also draw new permanent residents who have a longer-run impact on the local economy. Tourism and such natural amenity-supported in-migration are not unrelated. It is often the case that in-migrants learned about the attractive qualities of an area as result of visits to the area in the past and, on the basis of those visits, decide to relocate there.

Changes in the American economy have made workers, families, and businesses increasingly mobile, allowing them to make location decisions on a basis other than just where jobs are or where raw materials are located. Improvements in transportation (the Interstate Highway System, inexpensive air travel) and communications (the Internet, courier delivery service, cable and satellite television) have reduced the cost of isolation. Changes in what the economy produces have also reduced the importance of transportation costs as the economy has shifted from a focus on natural resource extraction and heavy manufacturing to a focus on light manufacturing and services. This increases the value to weight ratio, reducing transportation costs as a barrier to doing business in previously isolated locations. Changes in the sources of personal income have also impacted mobility. Thirty to forty percent of personal income is no longer tied to current wages and salaries. Retirement income, supported by both public and private pensions and Medicare reimbursement, and investment income (dividends, rent, and interest) follow the recipients no matter where they choose to live. This means that the recipients of these types of “non-labor” income have greater flexibility in their residential location decisions.[96]

As a result of this complex set of changes, both businesses and families have more flexibility to act on their preferences for what they perceive to be attractive places to live. People certainly still follow jobs, but jobs also follow people as firms seek locations where they can easily and cheaply attract and hold the workforce they seek while also remaining connected to markets. The result is that the attractiveness of a place for people to live, work, and raise a family has

[96] For a more detailed discussion of the potential impact on the local economy of new in-migrants, see the author’s “Seeking Greener Pastures: Residential Choice and Local Economic Vitality,” Chapter 2, pp. 29-56, in *Lost Landscapes and Failed Economies: The Search for a Value of Place*, Thomas M. Power, Island Press: Washington DC, 1996.

become an important part of the local economic base. This type of amenity-supported economic vitality has been identified as the driving economic force behind the stability and growth found in many rural economies, including those of Western Montana and North Idaho, despite the declines in the traditional rural economic base: agriculture, forest products, mineral extraction, and federal government payrolls.[97]

This pattern has clearly been visible over the last four decades in the 1910-fire area of Montana. There has been significant net in-migration into the area since 1970. During the 1970s and the 1990-2010 period, the population of the area saw in-migration boost the population by 10 to 20 percent each decade. The 1980s were a period of decline in both mining and forest products in Western Montana. There was net out-migration in two-thirds of the 1910 fire counties in Western Montana during that period. But, despite the trauma of the 911 attacks and the Great Recession, in-migration continued during the 2000-2015 period. The rate of net in-migration slowed significantly in the 2000s but was still at a double-digit rate, 11 percent for that decade. See Table 15 below.

Table 15.

In-Migration Rates: 1910 W. MT Fire Counties				
	1970s	1980s	1990s	2000's
Flathead	22%	5%	20%	17%
Granite	-9%	-10%	11%	10%
Lewis and Clark	19%	1%	11%	10%
Lincoln	-14%	-10%	4%	6%
Mineral	10%	-17%	14%	8%
Missoula	18%	-6%	14%	9%
Powell	-3%	-8%	7%	1%
Ravalli	51%	7%	40%	10%
Sanders	14%	-5%	15%	13%
9 Ctny	**17%**	**-2%**	**16%**	**11%**

Sources: U.S. Bureau of the Census, Decennial Censuses of Population; University of Wisconsin Applied Population Laboratory, Net Migration Patterns for U.S. Counties, http://www.netmigration.wisc.edu/ accessed 8/19/2015

It is also true, however, that the 2000-2014 period in the Northern Rockies was also characterized by repeated high wildfire seasons. For instance, in Montana, in four of those years, wildfires burned 700,000 acres or more. In the worst two of those 14 years (2006 and

[97] For supporting evidence from the Western states see: “Amenities Increasingly Draw People to the Rural West,” Gundars Rudzitis, and “Jobs Follow People in the Rural Rocky Mountain West,” Alexander C. Vias, ***Rural Development Perspectives,*** 14(2), August 1999. For the Great Plains see “Net Migration in the Great Plains Increasingly Linked to Natural Amenities and Suburbanization,” John B. Cromartie, ***Rural Development Perspectives***, 13(1), June 1998. For the South see “Migrants in the Rural South Choose Urban and Natural Amenities, John B. Cromartie, ***Rural Development Perspectives***, 14(4), February 2001. Also, Nord, Mark and John B. Cromartie. 1997. Migration: The Increasing Importance of Rural Natural Amenities. *Choices*, 12(3):22-23.

2012), more than a million acres burned in Montana. The impact of repeated wildfire crises in Montana reported by the national media and the experience of smoke choked valleys during the summer on existing and potential visitors' evaluation of the Northern Rockies as a place to live has not, to the best of our knowledge, been studied. However, these fires and the damage they did could not have helped the region attract and hold new residents and businesses. Climate projections, unfortunately, indicate that this wildfire problem and its consequences will get significantly worse. The consequences of that may be the loss of one of the primary sources of economic vitality in Montana over the last fifty years, the attraction of in-migrating people and businesses.

4. The Size of Wildfire Control Costs in Montana and the Western U.S.

The cost of attempting to control or suppress wildfires in Montana is substantial. The weather, the size of the fire, the difficulty of the terrain, and the extent of human habitation near the fire influence the control costs. Between 1999 and 2014 the total Montana wildfire suppression costs have been in the $100 to $350 million range in four years (2000, 2003, 2007, and 2012). At the other extreme wildfire control costs were less than $20 million in six years (1999, 2002, 2004, 2009, 2010, and 2014). In the remaining years, wildfire control costs were in the $20 to $100 million range. All of these costs are expressed in constant dollars.[98]

These are just the costs incurred in seeking to actively control a wildfire once it is ignited. Federal wildfire control agencies such as the U.S. Forest Service and the Bureau of Land Management also incur annual costs to stand ready to fight a wildfire when it is ignited. Those "preparedness" costs cover hiring and training personnel, ensuring adequate equipment is available, and making fire predictions. In years with fewer fires, the preparedness costs can easily exceed the amount of money spent on active fire suppression. Averaged over the 2002 to 2012 federal fiscal years, the budget for wildfire preparedness was $964 million.[99] If these preparedness costs are added to the actual federal national fire suppression costs which were about $1.7 billion, the average annual expenditures on controlling wildfires was about $2.7 billion.[100] The preparedness costs added about 55 percent to the overall wildfire control costs.

Of course, it is not just the federal government that is spending money on wildfire control. Western states have their own agencies managing state grasslands and forest lands where they, too, have to stand ready to actively control wildfires on their lands. Local fire departments also get involved in fighting wildfires that threaten property and lives in their jurisdictions. Unfortunately data on net state expenditures is not regularly available. Those state expenditures are supposed to be reported and included in reports to the National Inter-Agency Fire Center so that they can be included in the estimated costs associated with each fire. In FY 2013 which would have covered the 2012 fire season, the State of Montana expended almost $72 million on wildfire suppression of which almost $58 million was the state government's responsibility to

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[98] All cooperating wildfire control agencies in the West file a wildfire Incident Status Summary (ICS-209) with the National Wildland Fire Coordinating Group.

[99] Dollar amounts expressed in constant dollars. "The Rising Cost of Wildfire Protection," Ross Gorte, Headwaters Economics, June 2013, Figure 2, p. 14 and Addendum: How Wildfire Protection is Funded, pp. 14-15.

[100] This is conservative. The federal fire control budget information shows fire suppression and fire preparedness costs to be about equal. That would call for a 100 percent increase in fire suppression costs to estimate total fire control costs, not just a 55 percent increase.

pay.[101] The federal estimates of the total fire suppression costs for the 2012 fire season in Montana were about $114 million. For the seven-year period 2006 to 2012 the State of Montana's expenditures on fire suppression averaged about $31 million of which about $13 million was reimbursed for a net average annual cost to the state for this seven-year period of about $18 million per year.[102] The average federal estimate of all wildfire suppression costs in Montana during those years was about $55 million per year. Clearly the State of Montana's contribution to wildfire suppression is significant. Unfortunately, the expenditures of local fire departments that also contribute to fire suppression and home protection are not systematically reported.

5. The Impact of Wildfire Control Costs on Management of Public Lands

As discussed above, climate change is expected to produce larger, more intense, and more frequent wildfires across Montana. In addition the wildfire season will not be just a July and August phenomenon; it will stretch across more and more of the year. The U.S. Forest Service described the new and future wildfire situation in a report published in August 2015:[103]

> Climate change has led to fire seasons that are now on average 78 days longer than in 1970. The U.S. burns twice as many acres as three decades ago and Forest Service scientists believe the acreage burned may double again by mid-century.

Mid-century is 35 years away.

The data on acres burned by wildfires over the last three decades that show that doubling also show that the cost (with inflation removed) of federal fire suppression *more* than doubled, a 135 percent increase, over the same time period.[104]

It is not just the substantial increase in the acres burned by wildfires that has been driving up the cost of wildfire control. As discussed above there has been substantial human residential settlement of the private lands adjacent to or within public forest lands. Since protection of human lives and property are a priority when fighting wildfires, substantial resources have to be committed to protecting those homes in addition to trying to stop the spread of the wildfire through the forest-, grass-, or scrub-lands.

Surveys of U.S. Forest Service land managers in 2006 reported estimates that 50 to 95 percent of firefighting costs were attributable to protection of private property.[105] This high estimate by

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[101] http://leg.mt.gov/content/Publications/fiscal/interim/2013_financecmty_Sept/Wildfire-update.pdf Montana Legislative Branch, Legislative Fiscal Division, memo from Roger Lloyd to the Legislative Finance Committee, September 26, 2013.
[102] http://leg.mt.gov/content/Committees/Interim/2011-2012/EQC/Meeting-Documents/July-2012/fire-suppression-costs.pdf , Montana Legislative Branch, Legislative Fiscal Division, July 19, 2012 Memo from Christina Allen to Members of the Environmental Quality Council, "Update on Fire Suppression Costs," page 1.
[103] "The Rising Cost of Wildfire Operations: Effects on the Forest Service's Non-Fire Work," p.2, U.S. Forest Service, U.S. Department of Agriculture, August 4, 2015.
[104] The average for 1985-1999 was compared to the average for 2000-2014. Inflation was removed using the CPI. The data on acreage burned and federal fire suppression costs are from the National Inter-Agency Fire Center, http://www.nifc.gov/fireInfo/fireInfo_documents/SuppCosts.pdf .

Forest Service professionals may be tied to the assumption that if wildfires were not threatening communities, residents, or property, those wildfires, especially those ignited by lightening, could be allowed to burn. A more empirically detailed study of wildfires in Montana, done for the Montana State Legislature, found that there was, in fact, a correlation between the number of homes threatened by wildfire as well as the dispersal of those homes within the forest and the cost of wildfire suppression efforts.[106] It estimated that the presence of homes in wildfire areas in 2006 and 2007 added about 35 percent to wildfire suppression costs over that two year period.[107] That study also estimated that if the rate of growth of homebuilding in the Montana WUI from the 1990s continued through 2025, fire suppression costs (for the same fire conditions) would increase by about 43 percent in real, constant dollar, terms.

The U.S. Forest Service is especially concerned about these projections and the impact of climate change on wildfires because it has gotten more and more costly to fight the larger and more frequent wildfires. As a result, more and more of the Forest Service's appropriated budget has been shifted away from the broad array of forest management activities for which the Forest Service is responsible in order to focus primarily on controlling the damage done by active wildfires. This change in Forest Service budget priorities has direct implications for Montana's economy.

Twenty years ago 16 percent of the Forest Service's annual appropriated budget was spent on fire control. In 2015 more than half of that budget was spent on fire control. The projection ten years out based on that trend is that two-thirds of the Forest Service's budget will be devoted to fire control. By then the Forest Service projects its average annual spending over a moving ten-year period will be $1.8 billion dollars a year on fire control compared to the average of about $1.1billion in the ten-year period ending in 2013.[108]

That would divert another $700 million away from Forest Service non-fire programs such as forest, rangeland, soil and water restoration and enhancement activities aimed at maintaining the National Forest system as healthy and productive ecosystems providing a broad range of valuable environmental services to visitors and surrounding areas. In addition the Forest Service has not been able to invest in maintaining the recreation facilities that allow it to serve millions of visitors to the National Forests. The Forest Service's Recreation, Heritage and Wilderness programs that have sought to offer a diverse range of recreational opportunities across National Forest lands has had to be cut back, undermining the National Forest's support for the growing recreational economy in many rural areas. The budgets for wildlife and fisheries habitat management have also been cut back.[109]

As discussed above in the Recreation and Tourism section, wildfire, the threat of wildfire and the smoke associated with it directly reduce recreational activity. It also is indirectly limiting the ability of the managers of public lands to maintain those lands in a way supportive of recreational use which further impacts the Montana economy by reducing the value of the

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105 USDA Office of Inspector General, *Audit Report: Forest Service Large Fire Suppression Costs*, Report No. 08601-44-SF (Nov. 2006).
106 Montana Wildfire Cost Study Technical Report, Headwaters Economics, 8-8-2008.
107 Ibid. p. 12. The Northern Rockies Coordinating Center estimated annual wildfire suppression costs for Montana were used to calculate the percentage.
http://gacc.nifc.gov/nrcc/predictive/intelligence/ytd_historical/ytd_historical.htm
108 Op. cit. "The Rising Cost of Wildfire Operations," 2015, p. 3.
109 Ibid. pp. 8-16.

National Forests to residents as well as visitors, further damaging the recreation and tourism sectors of the economy.

6. Conclusions

Climate change in Montana will produce more frequent, larger, and more intense wildfires. Because the most densely populated regions of Montana are in forested mountains and valleys of western and southwestern Montana, these future, more ferocious, wildfires represent a serious risk to Montanan's communities, homes, and lives. The extent of land burned by wildfires is expected to increase dramatically compared to earlier decades, increasing 200 to 500 percent depending on the location in Montana.

The 2000 Wildland-Urban Interface (WUI) across all of Montana contained about 261,000 homes. Valued in 2011 dollars those homes would be worth $47 billion. A 2015 estimate of the homes at risk to wildfire in Montana estimated that 60,000 homes were at "high" or "very high" risk of loss to wildfire. The replacement cost of those homes was estimated to be about $17 billion (in 2014 dollars).

Federal wildfire suppression costs across the West for the 2000-2014 period increased 135 percent over the 1985-1999 period. Just those wildfire *suppression* costs have averaged $1.7 billion over the last decade and a half. In high wildfire years in Montana, federal fire control agencies spend over $300 million on fire suppression in the state. The Montana state government has struggled to cover its firefighting costs that in high wildfire years have been over $50 million.

Clearly many Montanans will face increasing risk to themselves and their homes as climate change supports more and more dangerous fires. Most Montanans also face a degraded quality of life and threat to their health from more and more frequent exposures to dense smoke from those wildfires. That could seriously undermine one of the engines of economic growth in Montana over the last half-century, namely the in-migration of people and businesses seeking to take advantage of the high quality natural and social environments and the outdoor recreation they support. As climate change spawns more and more wildfires that threaten communities and neighborhoods and causes more and more weeks of health-threatening smoke-shrouded valleys, existing residents and potential new residents are likely to question the habitability of Montana, especially during the increasingly long, hot, and dry summers.

7. Estimated Economic Costs Associated with Climate Change Increasing the Risks Associated with Wildfire

A. The Value of Homes Lost to Increased Wildfire Threat

As discussed above, in 2014 Montana had about 60,000 homes worth $14 billion at "high" to "very high" risk of destruction by wildfire on the Wildland-Urban Interface. It had another 13,000 homes at "moderate" risk of loss to wildfire worth another $3 billion.

As the area burned by wildfire increases to multiples of the acreage we now experience and more and more homes are built within the Montana WUI, home losses to wildfire will increase substantially. We consider three different scenarios of actual home losses to wildfire. Over the coming 35 years (2016-2050), we model three possible meanings of "moderate," "high," and "very high" risk of loss. See Table 16 below.

Table 16.

Assumed Risk of Loss of Montana WUI Homes Due to Wildfire: 2016-2050			
Risk Scenario	**Average Time to Next Home-Destroying Fire**	**Risk of Loss in Next 35 Years**	**Average Annual Probability of Loss in Next 35 Years**
Very High	150 years	15%	0.42%
High	250 Years	9%	0.25%
Moderate	400 Years	6%	0.16%

These estimated risks of home loss are built around conservative estimates of the time interval before a wildfire intense enough to destroy homes occurs. These vary with the risk category the Montana WUI homes fall into. This average time to a home-destroying fire is assumed to be stochastic with a known average value. From this, a geometric probability function was used to estimate the probability of loss within the next 35 years.[110]

If we conservatively assume that no new homes are built in the WUI between now and mid-century and apply the quantitative definitions of the three risk scenarios found in Table 16 above to the 2015 CoreLogic Inc. "Montana Residential Properties at Risk to Wildfire", the potential *annual* home losses would be 227 homes and the value of that *annual* loss would be $53 million (all in 2014 constant dollars).[111] See Table 17 below.

Since these are substantial lost investment values (not to mention the emotional losses), it is appropriate to sum these losses over the 35-year period to mid-century to see the cumulative loss. For our most likely scenario, almost 8,000 homes worth $1.9 billion would be lost.

In the above discussion we have focused only on the loss of homes directly to wildfire. Unfortunately, the loss of mountain forests to wildfire can lead to flooding and debris flows off of the mountains and into inhabited areas below for years after the wildfires took place. That secondary loss of homes to wildfire damage has not been included in these estimates.

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[110] See "Estimating Mean Fire Interval: Methods," in ***Wildlife, Fire & Climate: A Forest Ecosystem Analysis,*** Brendan Mackey, et al. editors, 2002, CSIRO Publishing, Collingwood, Victoria, Australia, pp. 32-33.

[111] "Wildfire Hazard Risk Report," 2015, Howard Botts, et al., Tables 9 and 10.
http://www.corelogic.com/research/wildfire-risk-report/2015-wildfire-hazard-risk-report.pdf

We have assumed that the home losses are spread uniformly over the 35-year period. That, of course, will not be true. The risk and losses will rise as climate change progresses and the wildfires become more frequent and intense and larger. On the other hand, in the early years there will, in fact, be ongoing home construction in the WUI, increasing the risk of loss in both early and later in the 35-year period.

Table 17.

Estimated Economic Cost of WUI Homes Lost to Wildfire between 2016 and 2050		
Risk Scenario	Annual Number of Homes Lost	Annual Value of Homes Lost ($ Millions)
Very High	137	$32
High	69	$16
Moderate	21	$5
Total	**227**	**$53**

Source: The number of homes at risk to wildfire and their value are from "Wildfire Hazard Risk Report," 2015, Howard Botts, et al., Tables 9 and 10, CoreLogic Inc.
http://www.corelogic.com/research/wildfire-risk-report/2015-wildfire-hazard-risk-report.pdf
The risk probabilities in Table 16 were applied to the number of homes and value at risk estimated in the CoreLogic Inc. report cited above.

B. The Cost to the Economy of Reduced In-Migration of People and Businesses

As discussed above, projected climate change in Montana will lead to more frequent and intense and larger wildfires. Wildfire puts people and property in the path of the wildfires at risk and creates air quality problems that threaten the health and quality of life of a much larger number of people. Fire risk reduction and suppression efforts will also limit and disrupt access to public wildlands during an extended fire season.

A good part of the Montana population lives in river valleys surrounded by forested mountains. As a result, Montanans in recent years have had the unpleasant and sometimes dangerous experience of coping with heavy smoke from both nearby and distant fires. These wildfires have a serious negative impact on the quality of life. Montana cannot sell its "Big Sky" to new residents and business when that sky if full of unhealthy and irritating smoke that blocks all vistas. If more and more of the summer and some of the spring and fall are going to be characterized by extensive wildfires, the attractiveness of Montana as a place to live, work, do business, and play will be degraded. The economic vitality that Montana's natural amenities provided will diminish. Employment opportunities and labor earnings will grow more slowly.

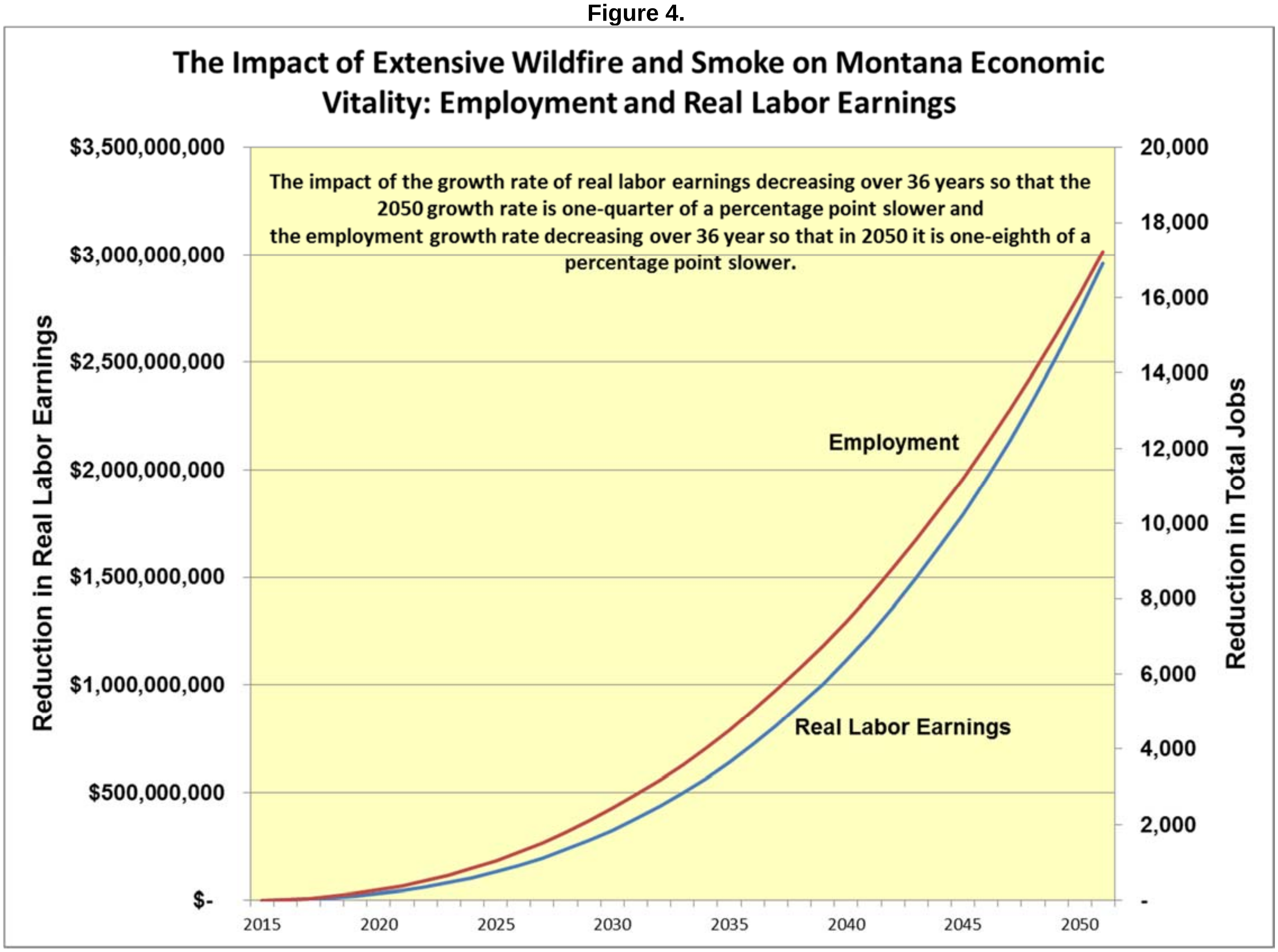
We have modeled this impact of climate change on Montana's economic vitality by looking at the impact of a slight reduction in the rate of growth of jobs and labor earnings in Montana. Between 1970 and 2010 (excluding the 1980s, a period of contraction and very slow growth), real labor earnings have grown between 2 and 3 percent per year. Job growth was between 1 and 3 percent per year.[112] Projections of real labor earnings growth for the near future have been about 2.5 percent per year. Projections of employment growth have been slower, about 1.2 percent per year.[113]

[112] U.S. Bureau of Economic Affairs annual labor earnings and employment by state.
[113] Labor earnings projections by the Bureau of Business and Economic Research, University of Montana, 2015 Annual Economic Outlook. Employment projections by the Department of Labor and Industry, 2014-2024 employment projections by industry.

We have calculated the impact of slowing the rate of growth of employment by one-eighth of a percentage point (0.125 percent, from 1.22 to 1.096 percent per year) over 35 years and the rate of growth of labor earnings by one-quarter of a percentage point (0.25 percent, from 2.5 to 2.25 percent per year) over the 35-year period 2016-2050. That is, the cumulative decline in the growth rates over the 2016-2050 period were 0.125 and 0.25 percent. We then tracked the impact of that very small change in economic vitality from 2015 to 2050.

The impacts on employment and real labor earnings begin very small and then grow more and more rapidly. In 2020 employment is down 381, but by 2025 employment is down about 1,300. In 2035 employment is about 5,000 jobs lower. By mid-century total jobs would be over 17,000 lower. The pattern for reductions in total labor earnings is similar but the numbers are larger. The reduction in labor income in 2020 is over $45 million. By 2035 real labor earnings are $719 million lower. By mid-century total labor earnings would be almost $3 billion lower. See Figure 4 below.

Figure 4.



Source: See text in the two preceding paragraphs. Calculations by the authors.

C. The Increased Costs Associated with Wildfire Control in Montana

U.S. Forest Service scientists project that the area of National Forest land in the U.S. that is burned each year will double over the next 35 years relative to what it is now. Other climate science projections of the increased annual acreage *in Montana* that will burn predict much larger acreages impacted by wildfire, 3 to 6 times the median acreage burned in the 1950-2003 period.[114] A doubling of the area burning each year will more than proportionately increase the cost of fire suppression. During the 2000-2014 period, when the average annual acreage burned by wildfire doubled compared to the 1985-1999 period, wildfire suppression costs increased 135 percent in real terms.

Between 1999 and 2014 the estimated total cost of suppressing wildfires in Montana has averaged about $87 million per year in real terms.[115] As discussed above, to this must be added the preparedness costs which add 55 percent, bringing the average wildfire control costs in Montana for that period to about $135 million. If these increase by 135 percent by mid-century because of the 100 percent increase in acreage burned, the Montana wildfire control cost in 2050 would be $318 million in real dollars.

However, wildfire control costs will also rise because more and more homes will be built in the WUI, forcing wildfire control efforts to focus substantially more resources on protecting residents' lives and homes in addition to trying to control the spread of the wildfire. If the growth of residential settlement in the Montana WUI continues at past rates, there will be many more homes to be protected. A Montana study of the impact of residential housing in the Wildland-Urban Interface on wildfire suppression costs, estimated that if the WUI residential settlement growth that typified the 1990s continued through the 2000-2025 period wildfire control costs would rise by about 43 percent. If this exurban sprawl impact is included, the total wildfire control costs at mid-century would be $397 million, an increase of about $261 million or 193 percent over the 1999-2014 average costs.[116] See Table 18.[117]

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[114] Note that the doubling projection is using 2015 as a reference point and the much larger projection in the acreage burned is using an earlier reference point when the acreage burned by wildfires was smaller. So these two projections cannot be directly compared.

[115] Costs in constant 2014 dollars. The estimated costs come from the National Inter-Agency Fire Center. The Northern Rockies Coordinating Center provides historical fire data by state for all fires larger than 100 acres. http://gacc.nifc.gov/nrcc/predictive/intelligence/ytd_historical/ytd_historical.htm The CPI was used to convert the costs to 2014 dollars.

[116] The impact of the increase in residential settlement in the Montana WUI was terminated in 2025 on the assumption that the experience with wildfire and threat of loss of life and property, the health problems associated with the smoke, and the degrading impact of the smoke on outdoor activity would make living in Montana less attractive.

[117] Because wildfire control in the western states is largely paid for by the federal government, some might argue that these federal *costs* are actually a *benefit* to Montana since they bring more federal funds into Montana. This is a perverse distortion of the economic reality: The wildfires impose a broad range of very real costs on Montana as discussed throughout this report. Federal government support for dealing with these "natural disasters," is similar to federal emergency support to areas faced with other natural

Table 18.

Projected Increase in Wildfire Control Costs in Montana 2015-2050	
Type of Fire Control Cost Adjustment	**(Real 2014$)**
Average fire suppression costs (real) 1999-2014	$87,159,321
Increase to include preparedness costs	$48,210,819
Average total fire control costs 1999-2014	$135,370,139
Increase for doubling in acres burned	$182,882,142
Increase for 2015-2025 growth in WUI homes	$78,378,061
Projected 2050 wildfire control costs	$396,630,343
Dollar Increase over 2015 (2014$)	$261,260,204

Source: See text immediately above.

VI. Conclusions

Given that climate change in Montana will impact two of the most important economic sectors of the state economy, it should not be surprising that the impact is significant. The total impact on employment is the loss about 36,000 jobs and almost a billion dollars in labor earnings. See Table 19 below.

Table 19.

Projected Economic Losses Due to Climated Change on Components of the Monana Economy		
Sectors of the Montana Economy	**Jobs**	**Labor Earnings ($millions)**
Glacier-Yellowstone NP Visitation	3,331	$94
Wildlife Watching & Sight-Seeing	2,775	$61
Hunting	1,560	$39
Sport Fishing	1,792	$49
Skiing, Snowboarding, Snowmobiling	1,465	$37
Cattle Raising	12,167	$364
Grain Crops	12,457	$372
Total Climate Change Economic Losses	35,546	$1,017

Sources: Tables 6 through 12 above.

In addition, we have estimated economic costs associated with wildfires that are more frequent, burn more acreage, and are more intense. More homes will be destroyed by fire, the cost of controlling wildfires will increase, and the overall impact of climate change, especially fire, on the attractiveness of Montana as a place to live, work, raise a family, or do business will

disasters: floods, hurricanes, tornados, earthquakes, etc. All federal taxpayers ultimately share in that burden.

decrease the rate of in-migration of new residents and businesses. This will reduce employment and labor earnings growth. Those impacts of more destructive wildfires are summarized in Table 20 below.

Table 20.

Economic Costs Associated with More Destructive Wildfires	
Type of Cost	**Cost or Impact ($millions)**
Loss of Homes (replacement cost, 2014$)	
Annual Loss of Homes 2016-2050	$53
Cumulative Loss of Homes	$1,900
Increased Cost of Controlling Wildfire (annual, 2014$s)	$261
Decreased Rate of In-Migration to Montana	
Average Annual Labor Earnings Reduction 2016-2050 (2014$)	$858
	Number of Jobs
Average Annual Employment Reduction 2016-2050	1,700

Sources: Section VI.7 above.

Clearly the economic cost of taking a business-as-usual approach to climate change in Montana will be far removed from the precise zero cost that is usually casually assumed during most discussions of the appropriate public policy response to mitigate future climate change in Montana.

Bibliography

Barkey, P. Montana Economic Outlook: More Balanced, but Slower Growth Ahead. *Montana Business Quarterly.* p. 13, Figure 5. Spring 2015.

Brekke, L., Thrasher, B., Maurer, E., and Pruitt, T. Downscaled CMIP3 and CMIP5 Climate Projections. May 2013. http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/techmemo/downscaled_climate.pdf

Burakowski, E. and Magnusson, M. Climate Impacts on the Winter Tourism Economy in the United States. Prepared for Protect Our Winters (POW) and the National Resource Defense Council. December, 2012

Caudill, J. Wildlife Watching in the U.S.: The Economic Impacts on National and State Economies in 2011: Addendum to the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. U.S. Fish and Wildlife Service. Report 2011-2. February 2014. http://digitalmedia.fws.gov/cdm/ref/collection/document/id/1906

Chaney, R. 'Hoot-owl' restrictions limit fishing time on Bitterroot, Blackfoot, Clark Fork. Missoulian, July 1, 2015. Accessed 7.8.2015. http://missoulian.com/news/local/hoot-owl-restrictions-limit-fishing-time-on-bitterroot-blackfoot-clark/article_e80d722a-0779-5f0b-9562-456cbf7994f5.html

Duclos, P., Sanderson, L., and Lipsett, M. The 1987 Forest Fire Disaster in California: Assessment of Emergency Room Visits. *Archives of Environmental Health: An International Journal*. Volume 45, Issue 1, 1990.

Fisichelli , N., Schuurman, G., Monahan, W., and Ziesler, P. Protected Area Tourism in a Changing Climate: Will Visitation at US National Parks Warm Up or Overheat?" *PLOS ONE*. June 17, 2015. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0128226

Grau,K. 2014 Nonresident Visitation, Expenditures, and Economic Impact Estimates*. Institute for Tourism and Recreation Research*, University of Montana. Table 2, p. 3. 2015. http://www.itrr.umt.edu/files/2014-NonresVisitation-Expenditures-EconImpact.pdf

Guttmann, M., Parton, W., Cunfer, G., and Burke, I. Population and Environment in the U.S. Great Plains. Population, Land Use, and Environment: Research Directions. National Academic Press. 2005. http://www.ncbi.nlm.nih.gov/books/NBK22969/

Headwater Economics. The Effects of Climate Change on the Downhill Skiing and Recreational Fishing Economy in the Crown of the Continent. January, 2011.

Holems, K. Montana:Stories of the Land. Chapter 18, page 354. http://svcalt.mt.gov/education/textbook/chapter18/Chapter18.pdf

IPCC. 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. 2014.

Keane, R. Climate change effects on historical range and variability of two large landscapes in western Montana, USA. *Forest Ecology and Management*. 254 375-389. 2008.

Kolb, P. Climactic Influences on Forests across Montana-Strategies for Conservation and Functional Retention. Montana State University Extension Forestry Specialist. 2012. http://www.msuextension.org/forestry/Resources/pdf/FF_Climate%20Change%20Impacts%20on%20Montana%20Forests_PK.pdf

Mott, J., Meyer, P., Mannino, D., Redd, S., Smith, E., Gotway-Crawford, C., and Chase, E. Wildland forest fire smoke: health effects and intervention evaluation, Hoopa, California, 1999. *Western Journal of Medicine.* May, 2002 176(3): 157-162.

National Shooting Sports Foundation in partnership with the Association of Fish and Wildlife Agencies. Hunting in America: An Economic Force for Conservation. 2013. http://www.nssf.org/PDF/research/HuntingInAmerica_EconomicForceForConservation.pdf

Nobel Laureates. Mainau Declaration 2015 on Climate Change. Lindau Nobel Laureate Meetings. 2015. http://www.lindau-nobel.org/

National Parks Conservation Associations. Ten Most Visited Parks. 2014. http://www.npca.org/exploring-our-parks/visitation.html?referrer=https://www.google.com/

National Oceanic and Atmospheric Administration. Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 4. Climate of the U.S. Great Plains. NOAA Technical Report NESDIS 142-4. January 2013.

National Oceanic and Atmospheric Administration. Climate Monitoring: Summary Information. http://www.ncdc.noaa.gov/sotc/summary-info/national/201502

Noon, A. Drought dings quality of winter wheat in Northwest. Associated Press. July 20, 2015. http://bigstory.ap.org/article/b760c73ba3214a95ac917abc74405363/drought-dings-quality-winter-wheat-northwest

Ochenski, G. Climate change trashing hunting tradition. *Missoulian*. November 3, 2014. http://missoulian.com/news/opinion/columnists/climate-change-trashing-hunting-tradition/article_c8cff9c5-fc4b-5bf1-9f90-973aa9d3fd06.htm

Pederson, G., Graumlich, L., Fagre, D., Kipfer, T., and Muhlfeld, C. A century of climate and ecosystem change in Western Montana: what do temperature trends portend? *Climactic Change*. 98:133-154. 2010.

Piao et al. Net carbon dioxide losses of northern ecosystems in response to autumn warming. Natue Letters. Vol. 451. January 2008. Doi:10.1038/nature06444

Running, S. Impacts of Projected Climate Change on Pacific Northwest Ecosystems: Analyzing Carbon/Water Balance Vulnerability to 2100. Final Report to Stratus Consulting and National Commission on Energy Policy. March, 31 2009.

Saunders, S. and Easley, T. Glacier National Park In Peril The Threats of Climate Disruption. Prepared by the Rocky Mountain Climate Organization and National Resource Defense Council. April, 2010.

Southwick Associates. The Economic Contributions of Outdoor Recreation: Technical Report on Methods and Findings. Prepared for the Outdoor Industry Association. March 15, 2013. https://outdoorindustry.org/pdf/OIA-RecreationEconomyReport2012-TechnicalReport.pdf

Stalling, D. Hunters and anglers need to act on climate change. *Missoulian.* December 13, 2013. http://missoulian.com/news/opinion/columnists/hunters-and-anglers-need-to-act-on-climate-change/article_a72bc2b6-6401-11e3-97e4-001a4bcf887a.html

Strahn, D. Historic Homesteads. *Distinctly Montana*. 4.4.2007. http://www.distinctlymontana.com/montana-history/04/04/2007/frontier-homestead

Sylvester, J. Montana Recreational Snowmobiles: Fuel-Use and Spending Patterns. Prepared for Montana State Parks by the *Bureau of Business and Economic Research, University of Montana*. July 2014. http://www.bber.umt.edu/search/..%5Cpubs%5Csurvey%5CMontanaSnowmobiling2014.pdf

Thomas, C., Huber, C., Koontz, L. 2014 National Park Visitor Spending Effects. *Natural Resource Stewardship and Science.* National Park Service, Natural Resource Report NPS/NRSS/EQD/NRR—2015/947, 2015, Appendix, Table 3. http://www.nature.nps.gov/socialscience/docs/VSE2014_Final.pdf

U.S. Bureau of Economic Analysis. Regional Economic Information System. http://www.bea.gov/regional/

U.S. Census Bureau. American Community Survey. https://www.census.gov/programs-surveys/acs/

U.S. Census Bureau. State and County Quick Facts: Montana. http://quickfacts.census.gov/qfd/states/30000.html

U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. FHW/11-MT (RV) Revised December 2013. https://www.census.gov/prod/2013pubs/fhw11-mt.pdf

U.S. Forest Service, U.S. Department of Agriculture. The Rising Cost of Wildfire Operations: Effects on the Forest Service's Non-Fire Work. August 4, 2015.

Wilderness.net. Wilderness Statistics Reports: Wilderness Acreage by State. http://www.wilderness.net/NWPS/chartResults?chartType=AcreageByStateMost

Wildlife Management Institute and the Theodore Roosevelt Conservation Partnership. Beyond Seasons' End: A Path Forward for Fish and Wildlife in the Era of Climate Change. Bipartisan Policy Center. 2009.