Climate change in Montana: its evidence, debate, and solutions

Thomas Bisom

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In Montana, climate change is easily observed. Governor Bullock (2015 email to me; unreferenced) explains, "[Montanans] are outdoors people and we see the effects of climate change on our everyday lives, including increased wildfires and smoky valleys, lower stream flows and shorter fishing seasons, and enormous rain and crop damage that are affecting our agricultural producers and communities." Also, Glacier National Park in Montana is recognized as the "Poster-child of climate change" (National Park Service 2015b). Climate change possibly results from accumulation of greenhouse gases that trap infrared radiation from the sun (Brown et al. 2015, p.789). Greenhouse gases include carbon dioxide, methane, hydrofluorocarbons (HFCs), and chlorofluorocarbons (CFCs) (Brown et al. 2015, p.790). However, whether climate change is caused by greenhouse gases that humans mainly are responsible for is constantly debated. Greenhouse gases are not the only possible factors attributed to the observed change in climate. For example, changes in solar activity can produce temporary cooling effects, and when the effects end, a dramatic increase in temperature can occur (Payne 2014, p.267). Still, Montanans have been and will most likely continue to experience the warming effects of climate change. In Montana, glaciers in Glacier National Park are diminishing; biological communities in Glacier National Park are beginning to be significantly altered, and drought is affecting agriculture throughout the state. Moreover, there is debate across the state regarding whether these incidents are caused by anthropogenic climate change or natural cycles, which is complicating possible solutions, but Montanans are able to and must begin to reduce greenhouse gases to prevent dangerous effects of climate change in the future.

Glacier National Park is widely known for showing clear signs of climate change because at Glacier Park, glaciers are diminishing, and weather patterns have been indicated as the causes. For many visitors to Glacier Park, the glaciers are interpreted as physical evidence of climate change (Goldstein & Howard 2013). Hall & Fagre (2003, p.131-132) note that glaciers, unlike animals or plants, cannot adapt in ways that will mitigate effects of climate change, and rather than collectively responding to temporary year-to-year trends in climate, they will respond to decadal changes in climate. Although there is the possibility glaciers are not shrinking because of human activities, they are showing clear signs of a

change in climate. From 1990 to 2013, the mean annual temperature at Glacier Park increased by 1.3 degrees Celsius; snowmelt occurred up to a month earlier, and more precipitation fell as rain rather than snow (Goldstein & Howard 2013). Also, by analyzing tree rings of climate sensitive trees at Glacier Park –namely, Douglas Fir (*Pseudotsuga menziesi*) and Limber Pine (*Pinus flexilis*)— Pederson et al. (2006, p.18) found that since the middle of the nineteenth century, summer drought has generally been more severe than in previous centuries, and when drought was more frequent and snow was less frequent, the glaciers experienced moderate retreat rates. Pederson et al. (2006, p.20) explain if this pattern of hot, dry summers coupled with low snowpack continues, others – namely, Hall & Fagre— predict the glaciers at Glacier Park will mostly be gone by 2030. In 1910, when Glacier Park was founded, 150 glaciers were present (Goldstein & Howard 2013), but now, only 25 remain (National Park Service 2015a). Effects of climate change are clear and accessible at Glacier Park. Weather patterns are quickly diminishing glaciers and altering conditions at the park.

Due to increasing temperatures, biological communities at Glacier National Park are also being altered. Climate change is expected to cause larger, more severe, and more frequent fires in Western forests (Cheng et al. 2015, p.120). This may cause disturbances in distribution of species and even existence of some species. Canada lynx (*Lynx canadensis*) is listed as federally threatened in the United States, and over half of suitable habitats for this species have burned in wildfires (Cheng et al. 2015, p.121). Canada lynx are also dependent on snowshoe hares (*Lepus americanus*), which are their primary prey (Cheng et al. 2015, p.121). At Glacier Park, Cheng et al. (2015, p.129) found that compared to dominant canopy trees, snowshoe hares were more abundant in regenerating lodgepole pine stands of 1988 burn sites. Cheng et al. (2015, p.132) suggest snowshoe hares could benefit from increased frequency of wildfires: that is, if tree density is sufficient in regenerating forests. Although snowshoe hares are the primary food source of Canada lynx, existence of Canada Lynx might still be at risk. Canada Lynx den in mature forests and are dependent on sufficient mature habitats for reproduction (Cheng et al. 2015, p. 132). By increasing snowshoe hare density, there could be potential for limited wildfires to benefit both Canada Lynx and snowshoe hare populations, but larger and more frequent wildfires could

further endanger Canada Lynx species in the United States. Furthermore, snowshoe hare populations could increase. Climate change is also having a considerable effect on plant species at Glacier Park. Since increased temperature is resulting in drier and hotter summers, soil, which is usually cool and steadily moisturized in the summer, is becoming unfit for many plant species. Thus, species are migrating, disappearing, or becoming prevalent in those areas where the other species once lived. Lesica (2014, p.329) notes that since the mid-1980's, warmer temperatures in spring and summer have diminished summer snowpack, and this has most likely resulted in warmer and drier soil in lower regions at Glacier Park. In his study at Glacier Park, Lesica (2014, p. 329-331) found upward migrations of low-elevation species. The migrations observed might be possible for some species, but for others, the need to change soil could be threatening. Some species can only live in certain soil types, so migrating to higher elevations would not aid their continued existence (Goldstein & Howard, 2013). Lesica (2014, p.331) found that dicots were more prone to decline than monocots. He notes declines in *Gentianella progpinque*, *Polygonum viviparum*, *Salix arctica*, and *Salix reticulata* (Lesica 2014, Table 2). Growth form is expected to determine arctic species' responses to climate change (Lesica 2014, p. 331). Lesica (2014, p. 331) found graminoids and other monocots –5 species in the Cyperacceae— increased or remained stable more than broad-leaved forbs and shrubs over the course of his study. Also, Lesica's findings (2014, p.331) were consistent with expectations that taller shrub populations will increase with climate change, but dwarf shrubs will decline; as noted, *Salix arctica*, and *Salix reticulata* declined, but there was no change in the taller shrub *Salix vesita*. Migration of some plants, disappearance of species, and increased abundance of species will alter the forestry of Glacier National Park, and these changes can be traced back to climate change. The species persisting are better suited for warming climate, and species that are disappearing and migrating are more sensitive to warmer and drier climates. These and other changes of wildlife populations, such as snowshoe hare and Canada lynx populations, at Glacier National Park are currently in effect.

Since increasing temperatures are resulting in warmer summers and quicker snowmelts, drought is occurring more frequently, and agriculture in Montana is being affected. Yung, Phear et al. (2015,

p.284) interviewed ranchers in the Big Hole Valley, Blackfoot Valley, and Rocky Mountain Front, and identities of ranchers were kept anonymous. Yung, Phear et al. (2015, p. 284) report, "Ranchers described drought conditions as [‘]prolonged[’] … and [‘]continual[’] … with less snow in the winter, earlier snowmelt, reservoirs not filling, springs drying up, and less rain in the summer." The drought conditions are believed to be causing social and psychological stress amongst ranchers and their families (Yung, Phear et al. 2015, p.285). Also, Yung, Phear et al. (2015, p. 285) state that in response to the conditions, debt is increasing amongst many ranchers, and the responses resemble coping more than adaptation. Furthermore, throughout Montana, the dry conditions are worsening. Noon (2015) reports "A warm spring has nearly depleted what little snowpack Montana saw this year, draining the state of water necessary to combat worsening drought conditions, officials said Thursday." Moreover, she states, "State and federal officials who monitor water supplies said at a monthly meeting that reservoirs now at capacity could easily come up short for agricultural use" (Noon 2015). Due to the early snowmelt and above-average stream flows in March and April, farmers were actually able to plant crops and move herds earlier than usual, but according to director of the state Department of Natural Resources and Conservation John Tubbs, this optimism for farmers will be short-lived (Noon 2015). Although farmers were able to finish their work earlier, warming temperatures are gradually depleting supplies of snowmelt. In other words, the above-average stream flows are warning signs and not opportunities. Also, changing the timing of field operations may seem beneficial because crops could be obtained before the weather becomes too hot and dry. However, Qiu & Prato (2012, p.223) studied crops in Flathead Valley in Flathead County, and they compared crop yields with crop enterprise adaptations, which included crops planted with flexible schedules, to crop yields without crop enterprise adaptations. They found, "Average crop yields without crop enterprise adaptation and with flexible scheduling are very similar. This implies that simply adjusting the timing of field operations in response to the changing duration of the growing season is not sufficient to offset the losses in crop yields from climate change" (Qiu & Prato 2012, p.235). However, with continuing drought and its effects on agriculture in Montana, adaptations of some kind

will most likely be necessary for future agriculture, but this can become complicated because some Montanans believe the observed changes in weather are natural and temporary.

There is debate throughout Montana about whether climate change is anthropogenic and what should be done to address the issue; for some, there is no intention to react to the issue, and others believe response is necessary. Among ranchers, the current conditions may arouse caution and concern, but for others, making long-term adjustments in response to climate change may seem impractical. In the study by Yung, Phear et al. (2015, p.285), some ranchers said they had never seen conditions like those that are occurring, but others said their older family members experienced the same conditions. Although preparing for the long-term effects of climate change might be reasonable for some, there could still be a chance these conditions are natural and will fade or have an effect beyond any sort of control Montanans could have over the issue. Thus, some ranchers may not be able to risk assuming that the changes in climate will continue. One rancher explains, "I'm not going to try and guess what's going to happen five years from now and try to run my operation that way because if I make the wrong guess, then I'm in trouble"(Yung, Phear et al. 2015, p. 286). Responding to climate change is difficult because there is not a guarantee it will help with the issue, and such action could interfere with some situations. Senator Steve Daines (2015 email to me; unreferenced) states, "While I believe we all have a moral responsibility to be good stewards of the environment, the current uncertainty surrounding climate change requires us to consider very carefully any legislation that would cost jobs and hurt families with only the promise of an extremely small impact on the reported problem." However, other influential people in Montana believe climate change needs to be addressed. Governor Bullock (2015 email to me; unreferenced) states, "I am concerned about climate change and believe we must take action to address its impacts." Governor Bullock (2015 email to me; unreferenced), however, also acknowledges the risks of some policies, and he believes the Environmental Protection Agency (EPA) imposing the largest emissions cut of any state on Montana is unfair. He notes that in Montana, high quality coal is mined for Midwestern power plants, and Montana's energy industry provides well-paying jobs for middle class families (Governor Bullock 2015 email to me; unreferenced). Thus, drastically reducing emissions could affect Montanans involved with

those occupations. In Montana, there are risks associated with implementing policies or practices intended to mitigate or prepare for future climate change, but doubt about the impact of reducing greenhouse gases or changing agricultural practices also involves risks. Climate change could become more severe, and persistent observations made throughout Montana indicate it is an issue that cannot be ignored. Debate about the issue complicates enacting some solutions, but there are, at least, known possible solutions to the issue.

If the observed change in climate continues, there are multiple solutions to either mitigate or prepare for future events in Montana: such as continuing to inform more people about what is occurring, reducing greenhouse gas emissions, and using genetically modified organisms (GMOs) in agriculture. To prepare for future effects of climate change, drought-resistant GMOs can possibly be used for agriculture in Montana. According to Hu & Xiong (2014, p.716), there has been progress in improving and developing drought-resistant crops, and these crops can be used in response to climate change. In Montana, GMOs might help with adapting to climate change, but other methods need to be used to motivate people to take action that can prevent climate change from worsening. At Glacier Park, a 15-minute "Goodbye to Glaciers" climate change program is given by rangers at Logan Pass Visitor Center, where effects of climate change can be readily observed (Barrett & Mowen 2014, p.11). In the summer of 2012, Barrett & Mowen (2014, p. 13) collected surveys from visitors at the conclusions of 28 programs. They found that among most attendees the program evoked favorable stewardship responses, and the program was perceived as non-confrontational and effective in communicating the impacts of climate change on Glacier Park (Barrett & Mowen 2014, p. 17). Thus, by communicating climate change in non-confrontational ways and in manners that wide ranges of people can relate to, such as through programs like those at Glacier Park, more people might be able to understand the impacts of climate change, and this could be one of the first steps in motivating people to resolve the issue. The major step in resolving the issue is reducing emissions of greenhouse gases. However, as discussed, this is problematic in Montana because of risks involved. Thus, transitions that need to be made to reduce emissions might need to be gradual and take longer than what is demanded by the EPA, but these transitions are still necessary.

Montanans need to reduce emissions of greenhouse gases because whether or not the observed change in climate is anthropogenic, greenhouse gases will probably only make the problem more severe.

Climate change is readily observed in Montana, and there is no debate it is happening. The debate is what should be done about it. In Montana, many people cannot afford to alter what they are doing to prepare for future climate change. Ranchers cannot make long-term adaptations that will put them into or farther into debt, so they can prepare for weather that might not be present in the future. Politicians cannot allow legislation to pass that only might be helpful but will certainly cost the jobs of some Montanans. Before sacrifices are made, concrete evidence needs to be present. Steve Daines (2015 email to me; unreferenced) asserts, "My education trained me to base decisions on sound math and science. I will not support policies that would harm America's economy while having an insignificant or uncertain benefit to the environment." However, this seems to be the most complicated aspect of the issue because if humans do have an impact on the climate, action needs to be taken now, when conditions are less severe, than when human action becomes fruitless, and the dangers of climate change have fully manifested. The signs are present. Glaciers are disappearing. Wildfires are increasing. Plant and animal populations are being altered. Drought is becoming more severe, and agriculture is becoming more complicated. Increasing temperature is at the heart of these problems, and greenhouse gases will have a greater chance of making them more severe. The change in climate might not be solely anthropogenic, but human activities are most likely adding to the effects. The effect Montanans can have on the future is not understood, but with increasing temperatures, Montanans have every capability, at present, to reduce the gases that are trapping heat and may ultimately one day alter the planet and jeopardize the existence of humankind.

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