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## High-Altitude Melting: A Message for Civilization

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# High-Altitude Melting

*A message for civilization*

**Christopher Johnson**



WITH KEEN ANTICIPATION, I SLOWLY HAUL MYSELF UP THE TRAIL toward Grinnell Glacier—the most accessible and perhaps the most famous glacier at Montana’s Glacier National Park, which is often referred to as “the Crown of the Continent.” The trail passes an alpine meadow dotted with fluorescent purple plants and then, at the 2-mile point, clings precariously to the side of a cliff. At one point, water drips down the face of the cliff and splashes across the trail. For stability, I place my right hand against the cliff and feel ice water spritz onto my skin.

After three miles, the trail embarks on a series of steep switchbacks that ascend a moraine. Finally, I reach the top of the moraine, where the trail spills onto the vista I’d been anticipating: the Grinnell Glacier Overlook. In the foreground stands Upper Grinnell Lake, scattered with jagged icebergs. Across the lake is the glacier itself, lying like a sleeping giant in the arms of the enveloping mountains.

As I gaze on this wonder of nature, I can’t help feeling ambivalent. It’s an extraordinary sight, but I know that this famous glacier is much diminished from what it had once been—the local consequence of global climate change. Grinnell Glacier is still big—150 acres across—but it used to be three times that size.<sup>1</sup>

Dr. Dan Fagre (FAY-gree), who studies glaciers’ changes as the research ecologist and climate change research coordinator for the Northern Rocky Mountain Science Center of the U.S. Geological Survey, says, “In 2001, the glacier was about 15 meters deep, or about 50 feet. I walk on dry land where there used to be 50 or 60 feet of ice over my head. Not in ancient times, but just last decade.”

The shrinkage of Grinnell Glacier is the inexorable result of rising global temperatures. The latest report from the Intergovernmental Panel on Climate Change pegs that increase at 1.53 degrees Fahrenheit since 1880.<sup>2</sup> Temperatures at Glacier National Park have risen 1.8 times higher than the global average due to meteorological conditions in the northern Rockies.<sup>3</sup> In 1850, 150

1. Christopher White, *The Melting World* (New York: St. Martin’s Press, 2013, 5).

2. Intergovernmental Panel on Climate Change, *Climate Change 2014 Synthesis Report: Summary for Policymakers*, 2, [http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5\\_SYR\\_FINAL\\_SPM.pdf](http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf).

3. Crown of the Continent Research Learning Center, *Climate Change Fact Sheet* (Glacier National Park), 2, [http://www.crownsience.org/download\\_product/1213/0](http://www.crownsience.org/download_product/1213/0)

*Hikers traversing a ledge witness the diminishing ice visible from the Upper Grinnell Glacier Trail in Glacier National Park.* LISA DENSMORE BALLARD



*These two photographs, taken in 1887 and 2013, show the dramatic shrinkage in the Grinnell Glacier. The photos are part of the USGS's Repeat Photography Project, which can be accessed at [nrmssc.usgs.gov/repeatphoto/](http://nrmssc.usgs.gov/repeatphoto/). 1887 PHOTO COURTESY OF GLACIER*

*NATIONAL PARK ARCHIVES. 2013 PHOTO BY DANIEL FAGRE*

glaciers blanketed the national park. By 1966, there were only 37 glaciers, and by 2008, the number had shrunk to 27.<sup>4</sup> In a voice tinged with regret and resignation, Fagre says, “Probably by 2030, we’ll have only a small number of functioning glaciers left. By 2080, there probably won’t be a scrap of ice in the park.”

The shrinkage of the glaciers has been well publicized. Less well known, though, are the effects of warming temperatures and melting glaciers on the park’s ecosystems: on wildlife, vegetation, water temperatures, and fire behavior. The changes are subtle, yet they are slowly transforming the very fabric of life in this remarkable landscape. According to Fagre, “The glaciers are connected to the entire landscape. What happens with these glaciers doesn’t just affect one part of the park. Everything is connected.” He and his colleagues

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4. White, 7.





at the U.S. Geological Survey, the U.S. Fish and Wildlife Service, and the National Park Service are studying these effects to understand the consequences of climate change—and to preserve as much of the ecological integrity and biodiversity of this and other national parks as possible.

To understand the impact of rising temperatures, go right to the top—of the mountains. There, temperatures are warming faster than at lower elevations. Fagre said researchers examine this elevation-dependent warming because the phenomenon is evident in many mountain ranges. The trend means that glaciers and snowpacks are subject to even more warming than are lower-elevation ecosystems.

One consequence is that as temperatures moderate, trees are slowly creeping up the sides of the mountains. As Fagre says, “The trees at treeline are colonizing more, and the biomass is thickening.” The upper elevations of the park’s mountains used to be dominated by *krummholz*, the stunted vegetation found in subalpine landscapes. Now those upper elevations are sprouting trees, despite the thin soils. “They indicate that the weather conditions are not quite as ferocious as they used to be,” Fagre says.



*Glacier National Park's alpine meadows, which give this mountain goat a view of any animals that might attack it, are transitioning into forests because of rising average temperatures.* MARC CHALUFOUR

Land that was once alpine meadow is transitioning into forest. “We have seen in the last 50 years lots of small tree seedlings invading and colonizing these areas,” Fagre says. “They have actually closed off the meadows. This is key because alpine mammals, birds, and bees all use these meadows for food. But when you have a closed-canopy forest, all those creatures disappear because they don’t feed on trees.”

Melissa Sladek, a science communication specialist at the Crown of the Continent Research Learning Center at the park, adds that the spreading forests are affecting mountain goats—one of the charismatic mammals that populate the park. She explains, “Mountain goats depend on having an open meadow so they can see their predators. They don’t like to be in more vegetated areas.”

The changing climate affects mountain goats in another way, by ushering in spring a few weeks earlier. “Think about the timing of things,” Sladek says. “The mountain goat has a baby during a certain time of year, which corresponds to when the plants are most nutritious because the females have to nurse. Now the plants are at their most nutritious earlier, but the goats can’t adapt fast enough, so you have a mistiming. The babies might not survive because they don’t have enough milk.”

What's happening at the tops of mountains even has an impact at their base. Bears work their way up avalanche chutes as they search for the huckleberries and other plants that form their diets. But forests are beginning to fill in those chutes, blocking avalanches. "If trees fill in those chutes, you lose habitat for many, many creatures in this area," Fagre says. Avalanches also transport large amounts of soil from mountains into valleys." In a sense, avalanches rejuvenate valleys, but if vegetation blocks the snow, that affects the rejuvenation process.

As average temperatures have risen, Glacier National Park is getting slightly more precipitation than it used to, but in the form of more rain and less snow, lowering the snowpack. This change affects many of the animals of the park. The wolverine, for example, depends on digging snow caves for its young and storing food for them. "Wolverines have adaptations, like very big feet, to motor all over this environment in the snow," Fagre says. One researcher found that in about an hour, a wolverine wearing a radio collar had climbed more than 7,000 feet over a mountain, to the other side. It was an incredible amount of movement in a short time. The hardy little creatures have to range that widely to find food. But, Fagre says, "The tight connection between wolverines and snow suggests that they may not be with us once it gets warmer."

The meltwater stonefly, a tiny insect that thrives in snowmelt-runoff streams with waters below 50 degrees, is also declining. As the glaciers melt, there is less frigid runoff, and stream temperatures rise. The stonefly cannot adapt fast enough to survive in these warmer temperatures. The U.S. Fish and Wildlife Service has designated the stonefly a candidate for the Endangered Species list.

Another animal at risk is the bull trout. According to Fagre, "The bull trout has been called the polar bear of fish because it needs extremely cold temperatures and highly oxygenated water, so almost all of its habitat is found close to glaciers and snowfields." The bull trout's population has declined dramatically for two reasons. First, it cannot compete with larger lake trout, which were introduced into the park as a game fish early in the 20th century. And, second, the extremely cold temperature habitats that it loves are disappearing. Fagre says, "These are examples of a very direct connection in how climate change will affect some organisms."

The forests that carpet much of Glacier are undergoing transformations that are just as pervasive as those affecting wildlife. "What we've been finding is that in many lower-elevation forests, tree stress has been going up," Fagre

says. “The trees just die.” It appears as though the trees can handle a great deal of stress from drought and heat, but then they reach a breaking point. According to Fagre: “Scientists have been studying these sudden mortality events all around the world. A whole forest starts dying, and people wonder what’s going on. It’s just that they’ve all reached that threshold.” In the Southwest, piñon junipers that drape the landscape made it through four years of drought, but then, during the fifth dry year, hundreds of square miles of trees died.

Conifers in Montana and throughout the West have also died because of the mountain pine beetle, which invades conifers and burrows through the bark to lay its eggs in the inner bark. The larvae then disrupt the distribution of water and nutrients throughout the tree, eventually causing the tree’s demise.<sup>5</sup> In recent years, mountain pine beetle infestations have multiplied because warmer temperatures allow the insect to reproduce faster and to attack defenseless trees at higher elevations.<sup>6</sup>

As temperatures become warmer, the ecosystem grows more inviting for invasive plants. Fagre cites the examples of the spotted knapweed and yellow hawkweed, explaining, “Hawkweed is an attractive plant, but according to biologists, it’ll take over everything if it isn’t controlled.” The park has a good program for weed control, including backcountry weed-pulling events. “But are you just holding back a disaster, like the finger in the dike?” Fagre asks.

Forests are equally vulnerable to another climate-related threat: wildfire. Rising temperatures have disrupted natural fire cycles, creating the conditions for disaster. The fire season is 78 days longer than it used to be, the atmosphere is hotter and drier, and the trees have less moisture content. The results were abundantly obvious when I visited Glacier. As I drove west on Going-to-the-Sun Road, which bisects the park, I could smell burned wood and saw acre upon acre of charred timber—the result of the 4,300-acre fire at Reynolds Creek, east of Logan Pass. It was one of three fires that burned major portions of Glacier National Park in summer 2015. Sladek sums it up well when she says, “What you’re looking at right here is what you see. Smoke. Huge fires. Intense fires. Lots of fires. Longer fire season. Less water in the streams.”

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5. U.S. Forest Service, “Mountain Beetle: Frequently Asked Questions,” 1, [http://www.fs.usda.gov/Internet/FSE\\_DOCUMENTS/stelprdb5304956.pdf](http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5304956.pdf).

6. Andrew Nikiforuk, “Bark Beetles, Aided by Climate Change, Are Devastating U.S. Pine Forests,” *Washington Post* (December 5, 2011), 3.





*Lying like a sleeping giant—a shrinking giant—among the mountains, a snowfield once connected to Grinnell Glacier overlooks Upper Grinnell Lake.* LISA DENSMORE BALLARD

The effects of climate-related ecological changes at Glacier reach far beyond the boundaries of the park, with a particular impact on Montana's agricultural economy. Because precipitation comes in the form of more rain and less snow, the mountains build up less snowpack. "On a global scale, 50 percent of the water that humans consume comes from mountains, which is why they've been called the water towers of the world," Fagre says. "But the water towers of the world are getting smaller. When people ask why it's relevant that Grinnell Glacier is going away, I say, 'Well, do you like water?' Then its relevance is almost brutally obvious." The low snowpack directly affects Montana's farmers, who get nearly 70 percent of their irrigation water from the mountains.

Lower snowpack also means that the region's rivers and streams dwindle as the tourist season progresses, with a direct impact on whitewater rafting. "If your water isn't that good, then some of the companies may have to close up," Sladek says. "A few already did because there's just not enough water." Fishing is also affected. Glacier offers some of the finest fly-fishing in the world. In addition to bull trout, the park abounds in westslope cutthroat, rainbow, and

brook trout. However, according to a study at the University of Wyoming, if temperatures rise by 4.8 degrees Fahrenheit, the habitat for trout will decline by 42 to 54 percent in the interior West, including Glacier.<sup>7</sup>

The National Park Service and the managers at Glacier National Park have fully recognized the impact of climate change and have adopted strategies to attempt to preserve as much of the park's ecological integrity and biodiversity as they can. In 2010, the Park Service, under the leadership of Director Jonathan Jarvis, released *Climate Change Response Strategy*, which detailed four strategies for mitigating climate change and managing its impact on national parks:

- Using the best **science** and having national parks available to researchers so that park managers have the best information to make good resource decisions.
- Helping to **mitigate** climate change by reducing the carbon imprint of national parks, making national parks role models for visitors.
- **Adapting** the management of national parks to account for higher temperatures, changing precipitation patterns, increased storms, and other climate-related trends. "It's clear that ecosystems are changing quickly, so we have to be more flexible, and we have to adapt and manage differently," Sladek says.
- **Communicating** to the public about the effects that climate change is having. "We need, as an agency, to communicate to our visitors, to our neighbors, to the businesses, to the concessionaires, and to the media," Sladek says.

Sladek gives credit to the park's superintendent, Jeff Mow, for leading staff in implementing all four strategies. "He's looking at different scenarios," she says. "For example, if it gets hot really quick—this is one scenario. If we have slower change, that's another scenario. If we have the park turning into more of a Colorado climate, that's another scenario." Park managers are developing plans for responding to each of these possibilities.

The park has also taken practical steps to lower its own emissions and to educate visitors, who numbered 2.34 million in 2014. The park managers are

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7. Steven Kinsella, "The Impacts of Global Warming on Trout in the Interior West," Natural Resources Defense Council Issue Paper, July 2008, 10. <https://www.nrdc.org/sites/default/files/trout.pdf>.

retrofitting buildings when there's money, they have changed the lighting and the water faucets, and they're installing more water-saving facilities. The new Apgar Visitor Center, which opened in 2014, is certified "gold" by the Leadership in Energy and Environmental Design program.

In addition, park interpreters weave information about climate change into their presentations. During my visit, I go on a guided hike to Avalanche Lake—one of Glacier's 762 lakes. When we reach our destination, we find that the water level of the lake is very low. The ranger connects the low levels to drought conditions and, in turn, relates those to climate change. Scientific information about climate change has made its way into brochures, interpretive exhibits, and articles in the park guide and the visitor center.

"We have a Climate Change Teacher Workshop that we've done for four years," Sladek says. "This learning center and the educational center come together, and a resource specialist speaks to teachers." Sladek and her team also have prepared ready-to-teach lesson plans that are available to teachers. "We've taught about 80 teachers now, and when you think about how many students they teach, we've reached about 10,000 students."

Climate change can seem like an overwhelming problem that sows pessimism about the future. Yet the people who are closest to Glacier National Park and who care deeply about it convey a sense of hope that humanity is beginning to grapple with this enormous challenge. Noah Long, a senior attorney for the Natural Resources Defense Council who works with the organization's energy program, says, "Most of the polling I've seen over the past few years indicates that the public largely and increasingly gets it, both with impacts at some of their favorite places like this park and others in the West, but also with regard to the changes they're seeing in their home states, whether it's increased droughts and wildfire, hotter summers, or milder winters."

Long also sees hope in the Environmental Protection Agency's Clean Power Plan, which the Obama administration issued in August 2015. The plan calls for reducing carbon dioxide emissions by 32 percent from 2005 levels by 2030 through greater use of renewable energy, better energy efficiency, and other strategies. Long explains: "We've done a fair amount of economic analysis on this, as has the Environmental Protection Agency. I think every serious economic analysis of the Clean Power Plan has shown that there are significant net benefits, not just in reducing pollution and health impacts, but also in providing a strong rationale for states to invest in energy efficiency."

As I descend the boulder-strewn switchbacks from Grinnell Glacier, I have a strange feeling. I'd seen photographs of the glacier from twenty years before, and I now grasp just how much the glacier has shrunk. It's the most dramatic evidence of climate change I've ever seen, and the sight pierces my heart. With stark realization, I know that in another twenty years, the glacier will be gone.

Yet the people I talk to, who care so deeply about Glacier National Park, convey a sense of optimism that the changes at Glacier have motivated people around the world to acknowledge climate change and begin taking action to mitigate its impact. Fagre says, "When people see what's going on here, it connects viscerally." Sladek adds, "We always put hope in our educational efforts, because you have to have hope." Her words are good to hear. They give me hope.

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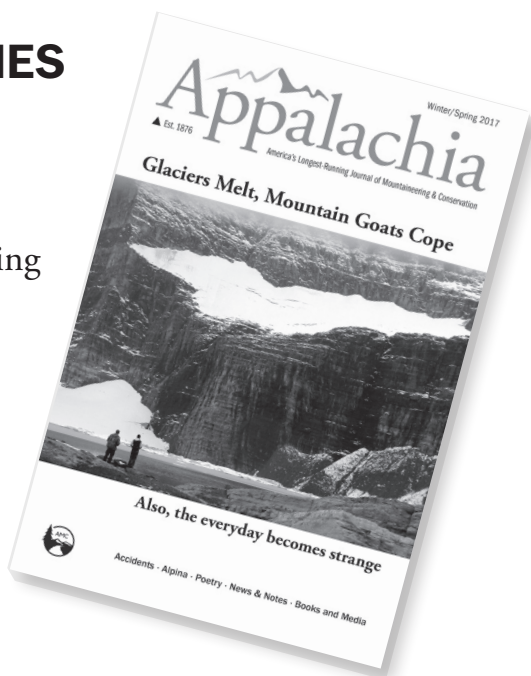
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