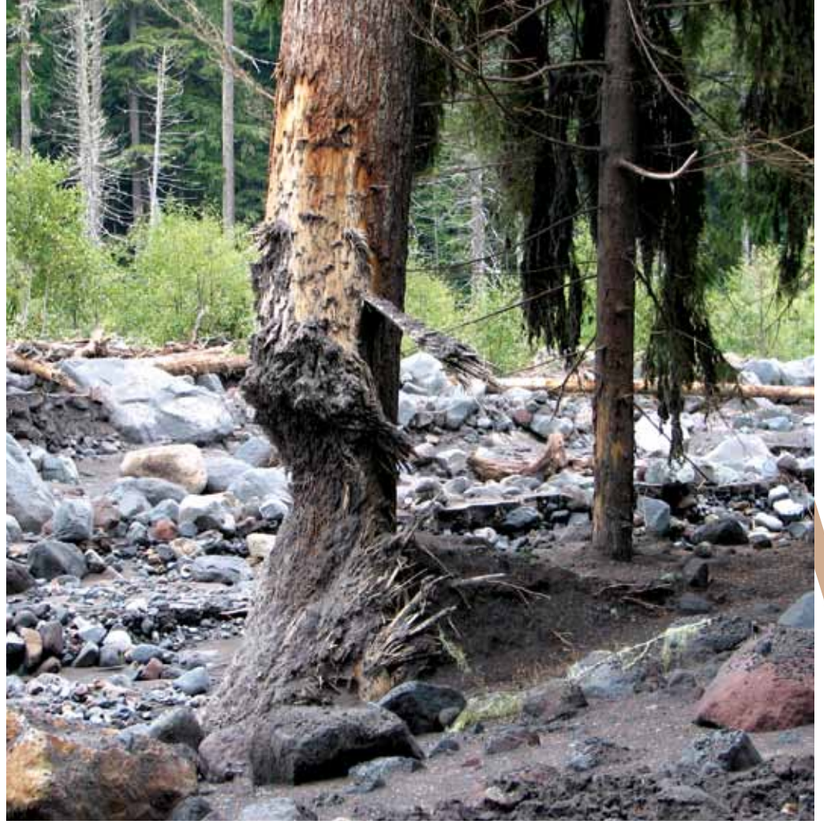
freshwater

All photos from the November 2006 flood on Mt. Rainier. Courtesy of National Park Service.



Rivers Gone WILD

Mountain River Response to a Warming Climate in the Pacific Northwest

by Tim Abbe, Scott Beason, Paul Kennard and Jim Park

Rivers move. They change course, jump banks, move trees and carve canyons. In balance, rivers generally do these things on geological timelines, over decades and centuries. Climate change disrupts this balance by violently accelerating changes in river architecture.

In November 2006, an intense storm dumped 17.9 inches of rain in 36 hours on Mount Rainier National Park in southwest Washington state. The deluge carried massive amounts of sediment down the heavily-glaciered mountain, overwhelming stream capacity and washing away trails and roads park-wide. The extensive damage to Mount Rainier closed the park for an unprecedented six months and cost tens of millions of dollars to repair.

In December 2007, a similar storm slammed Southwest Washington, shutting down Interstate 5 for four days and causing millions of dollars in damages. Sadly, the dangerous flooding conditions also took the lives of five people. The increase in large storms is a trend — six of the largest storms on record have occurred in the last 25 years.

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For article references, please visit www.thefreshwatertrust.org/publications, under Case Studies and Research.

Because the Pacific Northwest is an important climatic region, home to an abundance of natural resources and hundreds of glaciers that are critical to freshwater supplies, geologists and scientists are studying recent, catastrophic flood events and asking important questions. Are floods getting worse in the Pacific Northwest, and, if so, is it linked to climate change? Is the sediment being released by receding glaciers contributing to flooding? Was the damage on Mount Rainier in 2006 a warning of things to come?

Changing river courses have always poised a challenge to park planners, who are charged with preserving visitor access and maintaining roads and infrastructure near, and sometimes in, the pathway of the park's rivers. – National Park Service

Rivers convey not only water, but also sediment and debris, like wood. The form of a river is a balance between the supply of sediment to the river and the river's ability to move it. The primary variables driving a river's transport capacity are the quantity of water it conveys and the steepness (slope) of its channel. When these variables are not balanced, a river will respond by changing its shape. Rivers that suddenly change their character after long periods of relative stability indicate some sort of disturbance in a river's delicate balance.

As an almost three-mile high obstruction to Pacific Ocean storms, Mount Rainier receives prodigious amounts of rain and snow. Because the volcano's steep mountain slopes are comprised of very weak rock (ask the climbers!), the high amounts of precipitation send large amount of sediment into the eight rivers that drain Mount Rainier. As a result, there is a constant battle as to which prevails at any given time — too much sediment means the river channel fills in (aggrades), too much water means the river channel gets deeper (degrades).

Another factor that comes into play on most glacier-sourced rivers is "braiding." During floods, enormous amounts of sediment and wood are moved downstream. As the floods subside, much of this load is unceremoniously dumped in-place, forcing the river to flow around the obstacles, creating a braided channel morphology. Historically, Mount Rainier's rivers have been unruly, but in recent years it appears the balance has been seriously disrupted. Consuming ancient forests and posing new historic threats to park infrastructure, the volcano's rivers have truly gone wild.

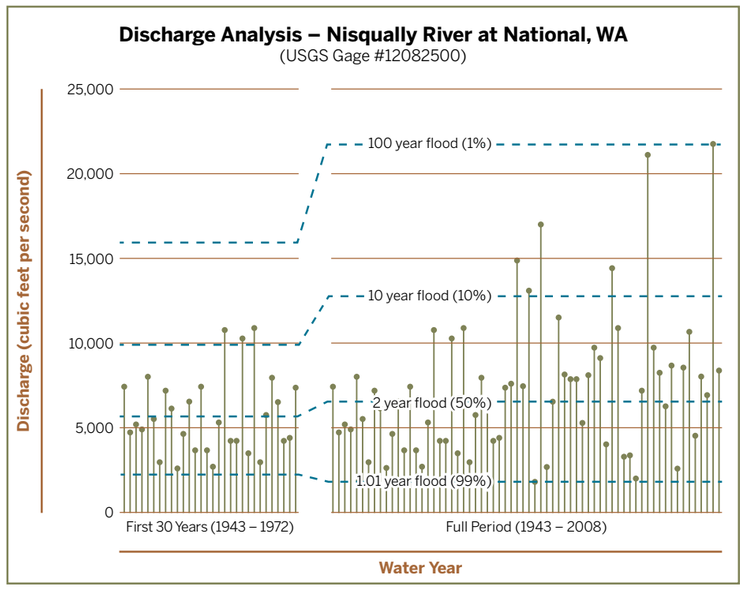
A "Rainy-er" Rainier

Recent research on Mount Rainier shows that its rivers have been gradually aggrading at about four inches every decade for most of the last century. But something very strange has happened in the last decade causing the rivers to aggrade at rates of more than 36 to 48 inches — and in some cases up to six feet. Scientists looking for answers wonder if climate change is responsible for these extraordinary transformations.

Support of the warming climate comes from several lines of evidence. According to the Climate Impacts Group for the State of Washington, temperatures west of the Cascade Mountains are rising and are at the highest levels in 1,300 years. These warmer temperatures are resulting in rising freezing levels — up 300 feet in the last 40 years — causing more precipitation to fall as rain instead of snow. And more rain means more rapid runoff (since snow stores water and slowly releases it), higher peak flows and lower summer flows (less snow to melt).

For example, rainfall events exceeding three inches in 24 hours at a weather station on Mount Rainier have grown by an additional inch of precipitation between 1976 and 2006. This systematic increase in peak flows challenges the ability to understand and reliably predict the frequency and magnitude of big floods.

Big flood events, commonly known as 100-year floods, statistically occur an average of once every century. However, in looking at Rainer's Nisqually River as an example, flood levels have increased from about 16,000 cubic feet per second in 1972 to 22,000 cubic feet per second in 2008 (see graph on left). This means what was a 100-year event in 1972 now has a recurrence interval closer to a 15-year event today.



Graph adapted from U.S. Geological Survey

State of Northwest glaciers

Consistent with increasing temperatures, glaciers throughout the northern hemisphere are melting, according to the Intergovernmental Panel on Climate Change. Of the total land area covered by glaciers in the western states (excluding Alaska and Hawaii), 75 percent lies in Washington state. Mount Rainier alone has 25 glaciers covering an area of 34 square miles — more than all the other Cascade volcanoes combined. And all of them are shrinking at a faster rate than ever.

Based on a study from Portland State University, Mount Rainier lost 25 percent of its total glacier volume from 1913 to 1994. But what's more disconcerting is preliminary data from Mount Rainier National Park indicating that the glacier has lost another 18 percent of its volume just since 2003. Moreover, the south-facing Nisqually Glacier retreated more than one mile since 1840, but in the last seven years its recession rate has seen a three-fold increase. Once covered in snow and ice, more than 5,000 acres of ground are now bare.

Destructive debris

Large piles of loose sediments left behind by melting glaciers on steep slopes are highly unstable and can fail catastrophically, sending destructive debris miles down the mountain. Consisting of a mixture of water, dirt and wood, this can move like wet concrete. Indeed, the flows are so dense they not only transport large amounts of sediment, but can also move house-sized boulders — and anything else in the way.

The effects of multiple debris flows are impressive. The South Tahoma Glacier on Mount Rainier experienced a spectacular glacier outburst flood in August 1967. Water stored inside of the glacier catastrophically broke out of the glacial surface at 7,000 feet, severing the icepack into two. Flowing to Tahoma Creek, the flood escalated into a debris flow and obliterated the Tahoma Creek campground. And with dozens of continued debris flow events since, destruction to the area around Tahoma Creek continues.

Before 1967, lower Tahoma Creek was a relatively stable braided channel with mature old-growth forest on either bank. However, the accumulation of continued debris flow deposits has raised the historic river channel more than 20 feet. As the creek filled in, the water spilled into the adjacent forest, resulting in the burial and smothering of acres of old-growth forests. Additionally, as the river literally fell off its elevated bed, the channel widened more than 500 feet, behavior consistent with a stream that is dangerously out of balance.

This "river gone wild" threatens the wildlife that depends on the river — most notably, fish species and their spawning and rearing grounds — as well as challenges the management of park infrastructure. Westside Road along Tahoma Creek will likely be permanently closed, as the river has essentially moved the road and sediment deposited into Tahoma Creek by the debris flows continues to be reworked by subsequent floods. And as the debris makes it way downhill, these sediment pulses also threaten to shut down access to other parts of the park.

Melting but not moving

There are other concerns about the melting glaciers on Rainier. Currently the lower Nisqually Glacier is becoming "stagnant." Stagnant glacier ice stores large amounts of melt water beneath its surface which can be cataclysmically released during times of rapid melting. This type of event is referred to as a glacier outburst flood or jökulhlaup, a word from Iceland, where the phenomena are relatively common. Fortunately, there have not been many damaging jökulhlaups on Mount Rainier. However, the threat of one is real.

Changing climate, changing rivers

The evidence of increasing temperatures, greater precipitation and rainfall, higher river flood flows, receding glaciers and aggrading rivers surely provides a wake-up call that climate change impacts our rivers — and the changes will only become more pronounced in the coming years. While the changes we see on places like Mount Rainier are happening quickly because of their proximity to the headwaters, changes downstream will certainly become more significant if the current trends continue. Flooding outside the park, related to these changes will surely increase.

Observations by the National Park Service indicate that the lower glacier — which normally moves up to 29 inches per day in the summer melt season — moved less than an inch per day in the summer of 2009.

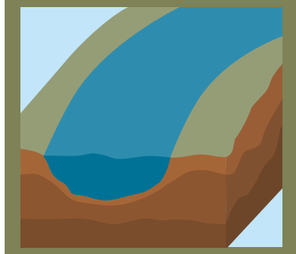
Of course this all brings up many more questions. But the one confirmed conclusion as it relates to climate change is that as long as the climate changes, we can expect rivers to also change. Only time will tell how our communities, culture and wildlife will adapt to these drastic and sweeping changes.

Rivers are dynamic systems, and change is natural. The violent, unpredictable events brought on by climate change, however, pose serious challenges to these fragile ecosystems. Only time will tell how agencies charged with overseeing natural places, as well as wildlife and communities, will adapt to these drastic and sweeping changes.

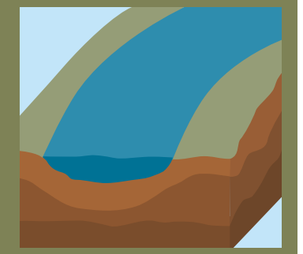
RIVERS SHIFT AND CHANGE OVER TIME

But sudden and violent flood events, brought on by climate change accelerate these natural functions of a river to the detriment of communities, wildlife and aquatic species.

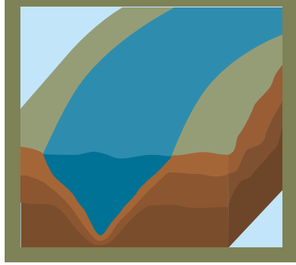
BASELINE — a river system with "ideal" conditions.



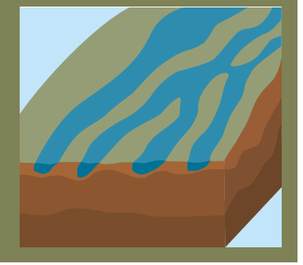
AGGRADATION occurs as sediment fills in a river channel.



DEGRADATION refers to the deepening or carving of a river channel.



BRAIDING occurs when sediment causes the river to divide into smaller channels.



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