Environmental and ecological implications of aggradation in braided rivers at Mount Rainier National Park

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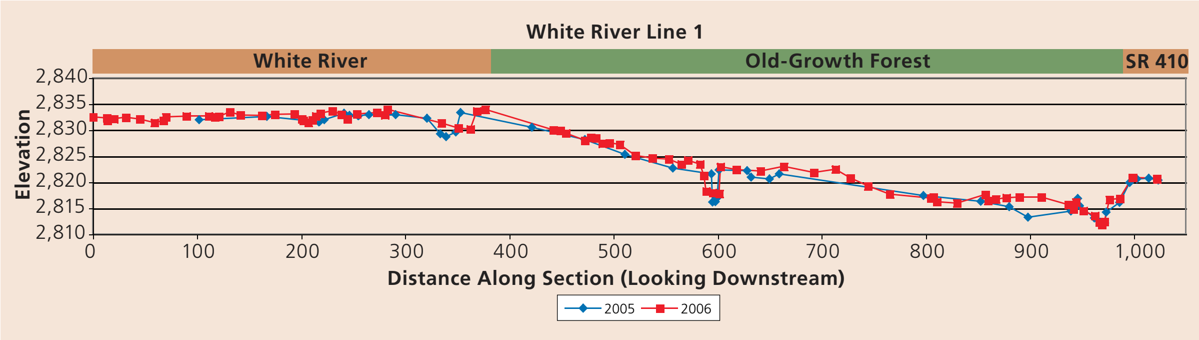
IN NOVEMBER 2006 A MAJOR STORM DROPPED nearly 18 inches (46 cm) of rain in 36 hours at Mount Rainier National Park, Washington. This event caused severe park-wide damage, but the resulting flood was not entirely to blame for the destruction. The geologic setting, physical characteristics of the rivers, and injudicious placement of park infrastructure made the devastation inevitable.

At Mount Rainier, glacially fed braided rivers radiate outward from the 14,410-foot (4,392 m) volcano. These streams carry materials ranging in size from silt to boulders. As gradients decrease away from the mountain, rivers deposit their sediment loads. The height of the river channels rises while streambanks and floodplains remain at their present elevations. Through this process, called aggradation, rivers at Mount Rainier National Park have been inexorably increasing in height over time.

Exact rates of river aggradation in the park were unknown until a 2006 study, which incorporated survey data from 1997 and 2005. Using 1910 longitudinal profiles and historical topographic maps, the National Park Service and cooperating scientists compared current and earlier rates of aggradation, focusing on river areas near popular visitor destinations and primary park infrastructure. Investigators surveyed and created cross sections of current river channels, which they analyzed using Geographic Information System (GIS) software. Depending on the channel slope and confinement, the background aggradation rate of braided rivers at the park is approximately 6 to 14 inches (15 to 36 cm) per decade. At areas in the park with recent debris flows, however, aggradation is much higher. For example, during a single event, approximately 6 feet (1.8 m) of material was deposited over an area of 107,000 square feet (9,940 m^2) in the Nisqually River above Longmire, a primary park visitor and work area.

In many places, park buildings and roads are literally within aggrading rivers, and several locations in the park are below rivers (i.e., one walks uphill to get to the river channel). For instance the bed of the White River is as much as 16 feet (4.8 m) above the surrounding area through which a major highway, State Route 410, passes. Also, the main village at Longmire is 29 feet (8.8 m) below the Nisqually River. This juxtaposition contributed to the majority of the dramatic damage to the park infrastructure following the November 2006 flood. However, the flooding did not "clean" the system of aggrading material, but rather added to it.

As a result of this study, investigators have identified an increasing rate of aggradation in the park over the last 30 years, and attribute this escalation to global climate change. As temperatures increase, glaciers in the park recede. When the ice retreats, it no longer buttresses the steep, unconsolidated lateral moraines and outwash plains, making them prone to landsliding. These types of failures supply rivers with tremendous amounts of sediment and have caused several recent debris flows. Additionally, the results of this study revealed a relationship between suspended sediment load and air temperature at the park. As air temperature increases, sediment provided to the rivers



This cross section shows the elevation of the White River as compared with State Route 410. The river is shown from 0 to 350 feet. The remaining cross section includes an old-growth forest and State Route 410. At this point the river is 2,832 feet (863 m) above sea level (asl), while the road is 2,820 feet (860 m) asl, or about 12 feet (3.7 m) below the river. Just downstream from this location, the difference is 16 feet (4.9 m).

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increases exponentially, in the long and short terms. This is scientifically important, because the measured increased aggradation is consistent with climate change. It is also important for park planning because as the global climate continues to warm, more material will be supplied to river channels, further increasing the rate of aggradation.

Though this research has greatly illuminated the process of riverbed aggradation, researchers have just begun to understand the ecological impacts on channel form, aquatic habitats, and riparian succession. Therefore the current research priority is to understand the effects of aggradation on floodplain ecosystems and dynamics. Investigators want to be able to characterize and describe the effects of aggradation on subsurface and surface water flows, channel patterns (i.e., braided, meandering, and straight), diversity and persistence of habitat types, and spatial and temporal dynamics of floodplain vegetation.

Despite many remaining questions, some trends are emerging. Based on observations where the channel bed has aggraded 38 feet (12 m) in the last 100 years, the water table has risen with the bed and the river has not disappeared (i.e., running subsurface below the new sediment deposits). This occurs despite the relative coarseness of the riverbed sediment (coarser sediments are relatively porous and generally support intergranular flow). As a result, fish can still navigate the river, even during low water flow. Additionally, in the last 10,000 years, coniferous forests have been encroaching on valley bottoms, gradually constraining the potential zone of river-channel migration. Recent flooding deposited copious amounts of sediment in these old-growth forests, killing acres of trees and drastically slowing and possibly stopping the rate of valley floor reforestation.

Mount Rainier National Park is an active, dynamic geologic environment capable of dramatic change over short time periods. Most people think of volcanic activity as the principal agent of change in the park. However, as recent flooding and the results of this study show, rivers, by way of aggradation, modify the environment in extreme ways and will continue to present challenges for park planning and development in the years to come. ■

(Top) The braided rivers at Mount Rainier National Park have been aggrading at increasing rates over the past 30 years. Added to the overall aggradation process was sediment deposited during the 2006 flood. Before the flood the space between river level and the bridge over Tahoma Creek was double the amount shown here.

(Bottom) Some reaches of the White River have aggraded to the point of being above the surrounding landscape, including park infrastructure.

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