Geomorphic Assessment of Significant Sediment Loading in Tahoma Creek

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Importance

Glaciers through out the world have been retreating as the earth warmed out of the last glacial maximum, around 12,000 years ago. As these glaciers retreat, they leave behind massive amounts of unconsolidated sediment stored in terminal and lateral moraines. This material is readily entrained into stream channels when heavy rains or glacial outburst floods trigger debris flows.

In Tahoma Creek, a glacial stagnation event in the late 1960's initiated a period of very rapid glacial retreat, numerous outburst floods, and consequently, a high volume of debris flows. This material caused significant damage to the West Side Road, and resulted in reduced or restricted access to much of the west side of the park. This material also has a downstream impact - the increased sediment inputs appear to be causing the elevation of the river beds to rise, or aggrade. Given that much of the infrastructure of Mount Rainier National Park lies along the valley floors of these streams, aggradation could pose a significant threat to park operations. This issue was illustrated by the massive 2006 flood event - while damaging in it's own right, aggraded streams have less flood conveyance, and so are more likely to spill water overbank, and are also more laterally dynamic, shifting their course with potential to attack previously stable areas. The damage at Longmire and the destruction of Sunshine Point campground illustrate these issues. On Tahoma Creek, concern mostly lies in the fate of the Tahoma Creek Bridge, seen in figure 1. With only modest clearance between the river and the span's base, even moderate aggradation could wash out this structure.

The goal of this research is to assess the processes and rates of aggradation within this valley to help guide management decisions regarding the bridge, as well as to gain a more detailed understanding of the broader dynamics at play. While this study is focused, the issue of river response to a changing climate is a broad one, with impacts through out the Park, as well as for downstream communities.

Status and Trends

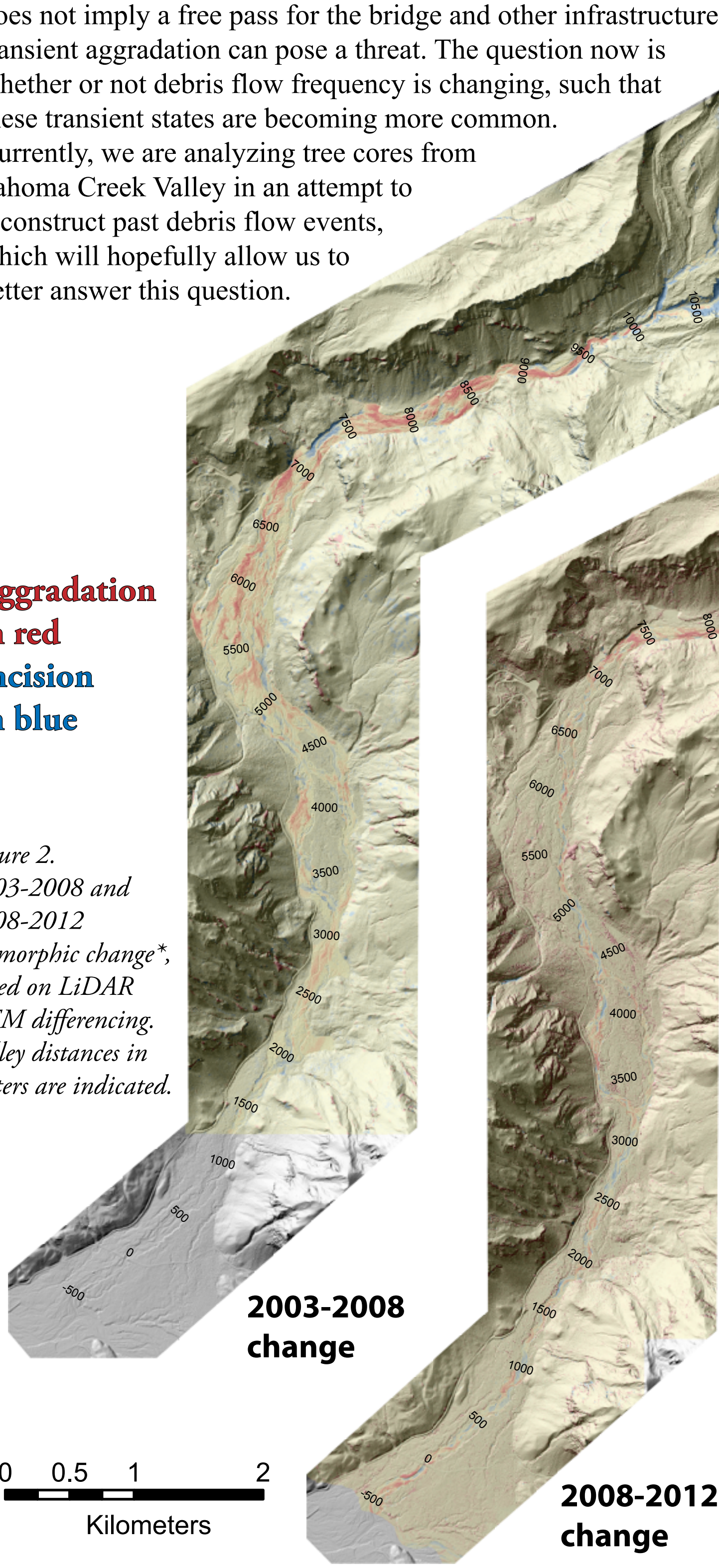
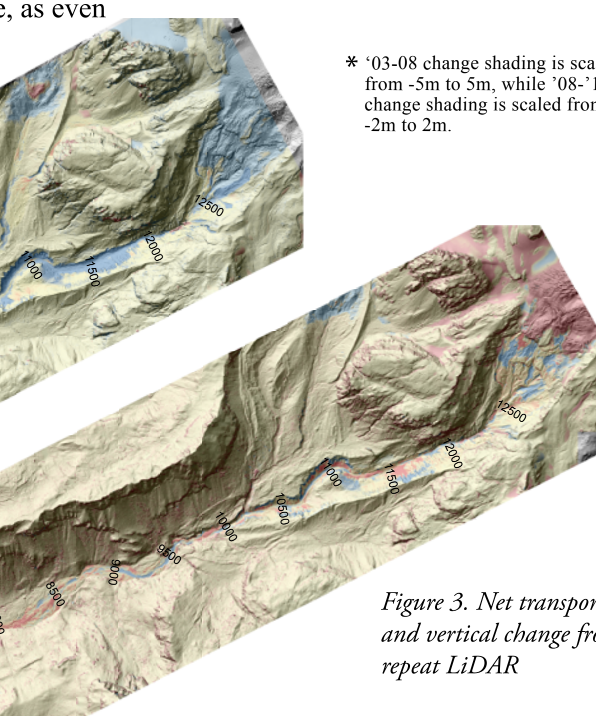
Tahoma Creek is unique in that it has been surveyed through aerial LiDAR three separate times, providing extremely detailed topography for 2003, 2008, and 2012. By differencing two sequential datasets, we are able to detect change down to ~10cm, providing a detailed map of incision and aggradation over the entire basin. The results of the 2003-2008 and 2008-2012 differencing are seen in figure 2 - mean vertical change over 100 meter increments is shown in the blue lines in figure 3. Both time periods shown similar spatial trends, with debris flows sourced in lateral moraines moving sediment downstream to a broad depositional zone, and then a remarkably stable lower channel. The 2006 event moved immense amounts of material, on the order of a million cubic meters ($2x10^9$ kg), resulting in over an order of magnitude more transport for the first time step when compared to the second. The stability of the lower channel seen in the LiDAR does not mean aggradation does not occur - the loss of clearance under the bridge over the past few years attests to this. However, it suggests that aggradation is a transient response to individual debris flow events, and not a persistent feature of the stream system.

Figure 1. Tahoma Creek Bridge, 1905 and 2011

To assess this, a number of young alders growing on recently active gravel surfaces were cored and aged. These ages represent the time at which the surfaces began to stabilize, and are interpreted as the time at which a transient pulse of aggradation peaked and the river began to re-incise the bed. Results (figure not shown) show a strong pulse in alder establishments ~5-10 years after the most recent suite of debris flows, with a similar but muted response seen following the debris flows in the 60's and 70's.

Discussion

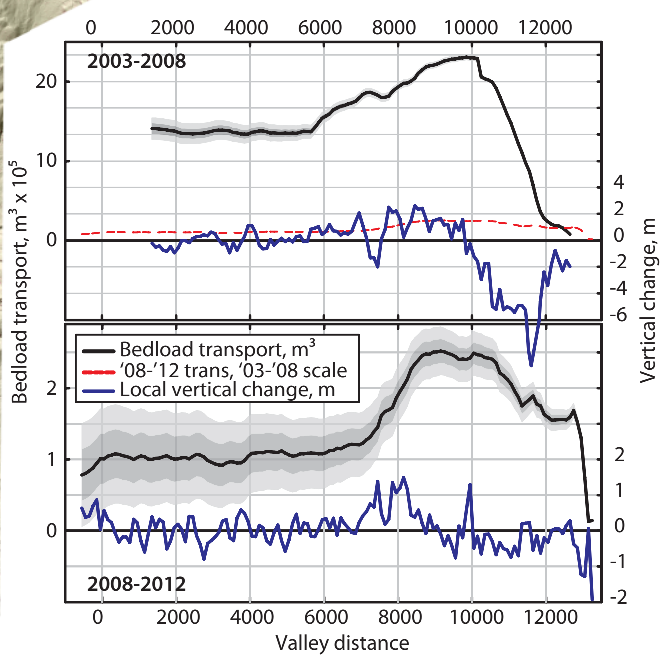
The results shown here suggest that Tahoma Creek is not in a persistent aggradational state, but instead has shown transient aggradation in response to specific debris flow events. These pulses of aggradation appear to persist for five to ten years, after which the channel is able to effectively process the elevated sediment load, and return to it's previous elevation and normal background sediment loads. These results are bolstered by field evidence of long term stability and Carbon-14 dates that indicate little to no long-term aggradation over the past 1000 years. However, this does not imply a free pass for the bridge and other infrastructure, as even transient aggradation can pose a threat. The question now is whether or not debris flow frequency is changing, such that these transient states are becoming more common. Currently, we are analyzing tree cores from Tahoma Creek Valley in an attempt to reconstruct past debris flow events, which will hopefully allow us to better answer this question.

* '03-08 change shading is scaled from -5m to 5m, while '08-'12 change shading is scaled from -2m to 2m.

Figure 2. 2003-2008 and 2008-2012 geomorphic change, based on LiDAR DEM differencing. Valley distances in meters are indicated.*

Figure 3. Net transport and vertical change from repeat LiDAR



More info

This fact sheet represents only part of an ongoing research effort. The final results will be present to the Park and also published in a peer-reviewed journal. For more info, please contact:

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