QRC Research Award Report
Project: River incision driven by changes to woody debris and sediment retention

Goal
Bedrock incision is theorized to be dependent on sediment supply and transport capacity (e.g., Sklar and Dietrich, 2001; Turowski et al., 2008), whereby an increase in sediment supply over transport capacity leads to the formation of a protective alluvial cover. We hypothesized that an alluvial cover can develop, independent of a change to sediment supply, through in-channel structures such as large wood jams and rockfall that inhibit sediment transport and increase sediment retention. Woody debris was previously noted to convert channels from bedrock to alluvial (Montgomery et al., 1996; Faustini and Jones, 2003), and we postulate that removal of wood will convert alluvial channels to bedrock, thus exposing bedrock to erosion. To test our hypothesis, we mapped and dated landforms associated with the rapid removal of in-stream wood during deforestation in the early 1900s. Study sites are: the Willapa River, southwest Washington; the Teanaway River, central Washington Cascades; the Luckiamute River, central Oregon Coast Range; and Mill Creek, central Oregon Coast Range. Sites represent a variety of lithologies and tectonic regimes. At each site, we mapped terraces and floodplains, surveyed cross sections, and dated relict and developing floodplains, especially those carved into bedrock, using AMS of charcoal and plant debris and dendrochronology.

Results
All four study sites contain evidence of bedrock incision that post-dates early deforestation and wood removal. In the two Washington sites and the Luckiamute River, incision into erodible sedimentary bedrock created incipient strath terraces, dated 50 to 203 14C yr BP. Above the bedrock, terraces often contain 10-30 cm of small woody debris overlain by up to 2 m of sand deposits. Based on the historic age of woody debris and presence of metal cables and rebar (see Graphic), we conclude that the sand was deposited after initial deforestation c. 100 ya and may represent the hillslope response to forest clearing. At Mill Creek, Oregon, strath terraces are absent in the harder basalt bedrock, but an alluvial meander cutoff, dated to 140 14C yr BP, indicates erosion of ~2.5 m of sediment from the meander surface to the current bedrock channel.

Implications
Our initial findings, which will be supplemented with dendrochronology and lidar analyses, suggest the removal of large wood and subsequent decrease in sediment retention led to the removal of alluvial covers and terrace formation in only a century. As such, these rivers are now mostly bedrock with a thin alluvial cover. Habitat implications include decreased spawning habitat, decreased riparian areas and habitat, and evolving flood hazards as rivers continue to entrench.

Although our findings are limited to the Pacific Northwest, deforestation occurred globally in the last 4 ky and likely led to decreased retention and river incision in other rivers. River incision globally has formed numerous strath terraces in the last 4 ky – this time is the most frequent period of strath formation – and yet little is known about why incision occurred (Schanz et al., in prep). Our results introduce a previously unrecognized control on river incision, which may shed light on the formation of those terraces.
References
Schanz, S.A., Montgomery, D.R., Collins, B.D., Duvall, A.R., in prep “Multiple paths to straths: a review and reassessment of terrace genesis” Invited review to Geomorphology