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Fluvial incision in postglacial rivers: distribution, rates and controls

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Following deglaciation, rivers take over from glaciers as the main geomorphic agents in glaciated landscapes. Postglacial bedrock rivers rework glacial debris, incise bedrock and reassert hydraulic scaling over the glacially-conditioned valley floor slopes, potentially driving rapid topographic change and sediment transport. We assess the distribution, timing and rate of postglacial fluvial incision in the post-orogenic, postglacial terrain of the northwest Scottish Highlands using a combination of cosmogenic nuclide surface exposure dating of strath terraces, field mapping and digital topographic analysis.

Average Holocene fluvial incision rates of 0.4–1.3 $\pm$ 0.1 m/kyr, quantified from strath terraces formed 1–4 kyr after deglaciation (14.0–11.7 kyr), are a function of stream power and bedrock resistance. On the basis of these erosion rates, analysis of the distribution of channel entrenchment in three mapped streams indicates that 63% of bedrock gorges (1–12m depth) reflect postglacial fluvial incision. Fluvial incision is focused at knickpoints formed where rivers have inherited glacially steepened reaches (riegels). Deep gorges (12-22m depth), probably cut by sub-glacial meltwater, account for 37% of bedrock reaches, mainly in steep valley-floor areas proximal to breached drainage divides.

Erosion rates of $\sim$0.1 m/kyr, derived from cosmogenic ^{10}Be concentrations on active channel beds, are significantly lower than the Holocene average, suggesting that declining paraglacial sediment flux may control fluvial incision rates. The long-term reduction in fluvial incision rates would prolong the timescale for fluvial adjustment and thereby also the persistence of glacial landforms in the northwest Scottish Highlands.