Reconstructing of anthropogenic environmental change in a mountain watershed by terrestrial cosmogenic ^{10}Be: application of the new usage in the Tanakami Mountains, central Japan

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This study presents a new concept and approach for terrestrial cosmogenic ^{10}Be to quantify anthropogenic sediment yield and to reconstruct the environmental change in mountain watershed. We verified the methodological applicability in the Tanakami Mountains, central Japan. In this target area, watersheds have different types of soil and vegetation cover, distributing adjacent each other as a result of longstanding consumption of forest resources and subsequent acceleration of hillslope erosion. The total mass loss during the transition regime was quantified by measuring the ^{10}Be concentration in fluvial sand collected from preserved watershed and devastated watershed. We also performed sediment coring in the terrestrial sink near to the most severely devastated watershed for reconstructing the anthropogenically accelerated hillslope erosion via ^{10}Be depth profiling of the sediments and ^{14}C dating of buried organic materials. For a fair comparison between the datasets, we normalized the ^{10}Be concentration by the nuclide production rate, which represents residence time of the sand particles transported through the soil and shallow bedrock zones. The residence times in the preserved and devastated watersheds were 10.5 ±1.8 kr and 5.4 ±1.4 ky, reflecting the contrasting anthropogenic effects on the watershed. The ^{10}Be and ^{14}C archives indicate the ^{10}Be concentration in the legacy sediment has been diluted at shallower depths and shows marked fluctuations over the last 300 yr. Total mass loss from devastated watersheds was 5.3×10^5–2.9×10^6 g m^{-2}, which can be converted to removed thickness of 0.3–1.8 m by assuming the density of subsurface materials as 1.6×10^6 g m^{-3}. These outputs were characterized by the complete removal of the soil cover from the hillslopes in the devastated watershed, and subsequent active erosion of the exposed bedrock. The fluctuation of the ^{10}Be profile can be attributed to sediment mixing from both the preserved and devastated hillslope in the watershed during the transition regime. The dilution of the ^{10}Be concentration was attributed to the exhumation of weathered bedrock with low-^{10}Be-bearing particles by anthropogenic devastation. The timing and duration of anthropogenic devastation coincided with a period of extensive forest overharvesting documented in historical records. Given that the forest resources in this area were first exploited 1400 years ago, the soil would have taken several hundred years to be removed completely from the watershed hillslopes. These results give us an implication that regulated consumption of forest resources can prevent irreversible destruction of the environment, representing the existence of a tipping point at which the environment cannot return to its original state once anthropogenic disturbance has progressed.

Keywords: Anthropocene, environmental transition, soil sustainability, legacy sediment, accelerated erosion

