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Quantifying sources of fine sediment supplied to post-fire debris flows using fallout radionuclide tracers

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The supply of fine sediment and ash has been identified as an important factor contributing to the initiation of runoff-generated debris flows after fire. However, despite the significance of fines for post-fire debris flow generation, no investigations have sought to quantify sources of this material in debris flow affected catchments. In this study, we employ fallout radionuclides (Cs-137, excess Pb-210 and Pu-239,240) as tracers to measure proportional contributions of fine sediment (<10 μm) from hillslope surface and channel bank sources to levee and terminal fan deposits formed by post-fire debris flows in two forest catchments in southeastern Australia. While Cs-137 and excess Pb-210 have been widely used in sediment tracing studies, application of Pu as a tracer represents a recent development and was limited to only one catchment. The estimated range in hillslope surface contributions of fine sediment to individual debris flow deposits in each catchment was 22-69% and 32-74%, respectively. No systematic change in the source contributions to debris flow deposits was observed with distance downstream from channel initiation points. Instead, spatial variability in source contributions was largely influenced by the pattern of debris flow surges forming the deposits. Linking the sediment tracing with interpretation of depositional evidence allowed reconstruction of temporal sequences in sediment source contributions to debris flow surges. Hillslope source inputs dominated most elevated channel deposits such as marginal levees that were formed under peak flow conditions. This indicated the importance of hillslope runoff and sediment supply for debris flow generation in both catchments. In contrast, material stored within channels that was deposited during subsequent surges was predominantly channel-derived. The results demonstrate that fallout radionuclide tracers may provide unique information on the changing source contributions of fine sediment during debris flow events.