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# Evaluating the effects of tracer selection, source dominance and source number on the accuracy and sensitivity of source apportionment using sediment fingerprinting.

**Simon Vale**[1], Andrew Swales[2], Hugh Smith[1], Greg Olsen[2], and Ben Woodward[2]
[1]Manaaki Whenua Landcare Research, Soils and Landscapes, New Zealand (vales@landcareresearch.co.nz)
[2]National Institute of Water and Atmospheric Research, Hamilton, New Zealand

Sediment fingerprinting is a technique for determining the proportional contributions of sediment from erosion sources delivered to downstream locations. It involves selecting tracers that discriminate sediment sources and determining contributions from those sources using tracers. These tracers can include geochemical, fallout radionuclides, magnetic properties, and compound specific stable isotope (CSSI) values of plant-derived biotracers that label of soils and sediment. A range of tracer applications and developments in source un-mixing have been demonstrated in the literature and, while the basis for discriminating sediment sources is reasonably well understood, research has drawn increasing attention to limitations and uncertainties associated with source apportionment. Numerical mixtures provide a way to test model performance using idealized mixtures with known source proportions. Although this approach has been applied previously, it has not been used to test and compare model performance across a range of tracer types with varied source contribution dominance and number of sources.

We used numerical mixtures to examine the ability of two different tracer sets (geochemical and CSSI), each with two tracer selections, to discriminate sources using a common source dataset. Sources were sampled according to erosion process and land cover in the Aroaro catchment (22 $km^2$), New Zealand. Here we sampled top-soils and sub-soils from pasture (n = 12 sites), harvested pine (12), kanuka scrub (7) and native forest (4) locations. Composite soil samples were collected at 0-2 and 40-50 cm depth increments to represent surface and shallow landslide (subsoil) erosion sources. Stream sediment (11) samples were also collected for initial unmixing. Here, we focus on using numerical mixtures with geochemical and CSSI tracers for an increasing number of sources (3 to 6) where each individual and pairwise combination of sources were systematically set as the dominant source. Since mixing models for CSSI tracers produce source contributions based on isotopic proportions (Isotopic%) instead of soil contributions (Soil%), CSSI numerical mixtures were created for Isotopic% and Soil% to assess the impact this correction factor may have on model performance. In total, over 400 model scenarios were tested.

Numerical mixture testing indicated that the dominant source can have a significant impact on model performance. If the dominant source is well discriminated, then the model performs well but accuracy declines significantly as discrimination of the dominant source reduces. This occurs more frequently with an increasing number of sources. The geochemical dataset performed well for erosion-based sources while both tracer sets produced larger apportionment errors for land cover sources. CSSI model performance was generally poorer for Soil% than Isotopic%, indicating high sensitivity to the percent soil organic carbon in each source, especially when there are large differences in organic matter between sources.