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Understanding the sources and transit times of water contributing streamflow from intermittent headwater catchments in semi-arid areas

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Intermittent headwater catchments constitute a significant proportion of many stream networks. In semi-arid climates, intermittent headwater streams flow only following periods of sustained rainfall. There is commonly a rapid response of streamflow to rainfall; however, whether this is the input of recent rainfall or displacement of water stored in the catchments for several years is not well known. Understanding the sources and transit times of water that contribute to streamflow is important for the maintenance of stream health and predicting the response of land-use changes.

The study focuses on two intermittent streams from two contrasting land-use (pasture and forest) in southeast Australia. The native eucalyptus forests in this region were originally cleared for grazing following European settlement ~180 years ago and then partially replaced by plantation in the last ~15 years. Stream water and groundwater from the riparian zone adjacent to the streams were sampled between May and October 2018.

The stream water has ³H activities of 1.30 to 3.17 TU in the pasture and 1.84 to 3.99 TU in the forest, with higher activities recorded during the higher winter flows. Groundwater from the riparian zone has ³H activities of 0.16 to 0.79 TU in the pasture and 2.01 to 4.10 TU in the forest. Aside from one riparian zone groundwater sample, all ³H activities of groundwater in the riparian zone are lower than those of recent local rainfall (~2.79 TU). The single high ³H activity in riparian zone possibly reflects recharge by winter rainfall with higher ³H activities.

The mean transit times (MTTs) of water were estimated using a range of tracer lumped parameter models. The riparian zone groundwater has greater MTTs of hundreds of years in the pasture and up to 9 years in the forest. At high streamflow, the stream water has MTTs of <6 years in the pasture and the forest. The MTTs of stream water at low streamflow vary from 15 to 42 years in the pasture and from 3 to 16 years in the forest. The long MTTs of water from streams indicate that the source water is not just recent rainfall, rather water stored in the riparian zone is mobilised at the commencement of flow and recent rainfall makes a larger contribution at higher flows. The observation is consistent with the major ion geochemistry of the stream water, which

most closely represents that of the riparian zone groundwater. The differences in MTTs of stream water between two contrasting land-use imply that the streamflow has been being most likely impacted by land-use changes. Thus, it is necessary to improve the strategies for catchment management to protect stream health from land-use practices.