Spatiotemporal changes to low flow and catchment storage following a step change rainfall decline in Southwest Western Australia

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Understanding how summer low flows in a Mediterranean climate are influenced by climate and land use is critical for managing both water resources and in-stream ecohydrological health. The Eucalyptus forest ecosystems of southwestern Australia are experiencing a drying and warming climate, with a regional step decline in rainfall in the mid-1970s. Reductions in catchment water storage may be exacerbated by the deep rooting habit of key overstorey species (>30 m has been reported), which can buffer against drought during dry years. Root exploitation of deep soil moisture reserves and/or groundwater can accelerate the long term decline in summer low flows, with a trend towards more ephemeral flow regimes. In contrast, conversion of forests to agricultural land in some catchments can lead to counter-trends of increased low flows due to a rise in groundwater pressure. These are invariably associated with an increase in stream salinity as regolith stores of salt are mobilized. There has also been extensive reforestation of farmland in some catchments.

In this study we perform a detailed analysis of changes to annual summer seven day low flow trends in perennial catchments and flow duration curves in ephemeral catchments across 39 catchments in south-western Australia that have long term records of runoff, rainfall and land cover. Results showed that 15% of catchments exhibited increased low flows and 85% decreased flows or decreased flow days since the 1970s. Significant downward step changes in low flows were observed in 17 catchments (44%). The earliest downward step changes occurred in three catchments between 1981-82 (a lag of one decade after the rainfall decline), with the most recent step changes for five catchments occurring in 2001-2004 (three decades after rainfall decline). Eleven catchments were already ephemeral in the 1970s, but exhibited continued declines in the number of annual flow days over subsequent decades. Step changes occur when groundwater becomes disconnected or reconnected to the stream invert, with disconnection associated with rainfall decline and vegetative water use.

The statistical methods we used in this study can be applied to any catchment in order to aid land and water managers assess the impact of climate change and land cover manipulation on low flow response.