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Process-based modelling of vegetation to investigate effects of climate and tree cover change on catchment hydrology

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Abstract Studies examining changes in long-term streamflow over large catchments invariably involve empirical approaches to simulating forest development and transpiration, and often classify land cover into broad groups such as forest or non-forest. Water use of different land uses depends on factors including climate, soil, landscape position, species and management, and is closely linked with vegetation growth. A forest growth model linked with a hydrologic model was applied to a forested catchment in southeastern Australia. Scenarios were developed to examine the effects of changes in land use and climate, and their combined effects, on evapotranspiration and streamflow generation within the catchment. Predictions suggest that catchments with a higher proportion of plantations are likely to experience relatively large reductions in streamflow under a drier and warmer climate. With deeper rooting systems, tree-based land uses are able to maintain higher ET than pasture-based systems in areas where water is not the most limiting factor, thereby reducing streamflow even further. Results indicate that at the catchment scale, water may begin to limit transpiration and rainfall interception only under a severe climate change scenario with 13.8% reduced rainfall and 2.4ºC increase in temperature. Results highlighted the importance of the length of simulation period and incorporating plantation age, because there are species-specific differences in the temporal development of LAI and water use. This study shows the value in adopting an approach in which forest growth is linked with hydrology to identify the contribution of land use in modifying catchment response to climate change. The proportion of the catchment covered by forests, plantations and pasture-based systems influence the degree to which total ET and streamflow is affected, and the spatial pattern of change across the catchment. The relationship between reductions in rainfall and reductions in contributions to streamflow are modified by land use, and leads to a far greater range and variability than suggested by integrated results at the catchment outlet.

Key words land-use change; climate change; streamflow; water balance; process-based modelling