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The impacts of commercial plantation forests on groundwater recharge: A case study from George (Western Cape, South Africa)

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Abstract

The benefits of the commercial plantation forestry sector (income generation and job provision) come at considerable environmental costs, particularly the impact of the industry on water resources. Plantation forests exhibit higher evapotranspiration rates compared to indigenous forests/grasslands. A reduction of the water yield in a catchment is one of the most frequently reported impacts of afforestation. Afforestation also significantly impacts groundwater, which is becoming an increasingly important resource for water supply in South Africa. Very few studies have however quantified in detail the impact of different commercial forests grown in South Africa on groundwater and the interactions with surface water. This study sought to contribute to addressing this important knowledge gap. The main objective was to compare groundwater recharge dynamics in commercial plantation forests and co-occurring indigenous forests. The HYDRUS-2D model was used to simulate the hillslope hydrological dynamics along 3 study transects, i.e. a Pinus radiata transect, a Pinus elliotii transect and in the Groenkop indigenous forest, during the period 1 October 2016 to 30 September 2017. The model was used to simulate the interaction between the vegetation, unsaturated zone and the saturated zone in order to better understand the groundwater recharge dynamics along each transect. As a precursor to model application a detailed conceptual model of the recharge processes occurring in the study areas was developed. The model considered the prevailing geomorphological and hydrogeological conditions. HYDRUS-2D was able to adequately simulate the soil hydraulic properties and vegetation water use characterizing the study transects. The hydrological dynamics of the simulation results also conform to the conceptual understanding of groundwater recharge processes evident in the study area. Over the entire simulation period (365 days), fluxes which left the Pinus elliotii, Pinus radiata and Groenkop forest model domains via the lower boundary amounted to 36 mm, 14 mm and 169 mm respectively. The total drainage observed at the three transects was largely influenced by the evapotranspiration losses. Rainfall intensity and frequency was observed to be a driving variable for the occurrence of deep drainage. The groundwater recharge dynamics observed during this study conforms to the notion that groundwater recharge is driven by single or multiple events and not by annual averages. The study has provided further evidence of increased transpiration rates associated with plantation forests when compared to indigenous forests. This in turn, has also resulted in reduced deep drainage and potential groundwater recharge. These results highlight the importance of accurately accounting for ET losses in groundwater recharge assessments and estimation techniques.