Water use of grasslands, agroforestry systems and indigenous forests

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Abstract

The biotic and abiotic components of ecosystems affect each other through complex interactions and processes. These dynamic interactions give ecosystems their distinct identities and provide ecosystem services critical to human survival (e.g. water, energy and nutrients). However, human activities (e.g. commercial forestry, agriculture) have placed increasing demands on specific ecosystem services. The effect of these activities on ecosystem processes has been the focus of numerous Water Research Commission (WRC) studies. Some of these have determined man's impact on plant-water use, biomass production (energy) and water use efficiency (biomass produced per unit of water transpired, termed productive green-water use). For example, measurements of evapotranspiration (ET_a) from different vegetation types showed that annual water use is strongly related to the proportion of the year in which a dense canopy of transpiring leaves is maintained. Thus, evergreen vegetation such as riparian fynbos and plantations of introduced tree species exhibit a relatively high annual ET_a, when compared to seasonal grasslands and deciduous trees that only maintain their transpiring canopy during summer. Quantification of the annual volumes of water used by these different vegetation types, under differing climatic and site conditions, has been possible through these studies. At a stand scale, measurements of the different components of evapotranspiration have allowed the partitioning of beneficial (transpiration) and non-beneficial (evaporation) fluxes. At a catchment scale measurements have quantified the proportional allocation of water to the different components of the water balance. Three case studies are presented to illustrate this. In a stand of *Jatropha curcas,* measurements of daily total evaporation rates during December to February (summer) on clear hot days ranged between 3 $mm \cdot d^{-1}$ to 4 $mm \cdot d^{-1}$. However, due to the deciduous nature of the species, water use was negligible (< 1 $mm \cdot d^{-1}$) during winter (May to August). At a catchment scale, studies in a montane grassland ecosystem of the KwaZulu-Natal Drakensberg showed that the partitioning of the main hydrological fluxes into streamflow and evaporation was dependent on the wetness of the hydrological year. In average to wet years (>1 200 mm precipitation) the hydrological flux was equally split between evaporation (650 mm) and runoff (550 mm), while in drier years evaporation became the dominating component of the water balance (752 mm vs. 356 mm, respectively). The data provided an important baseline for comparison with other impacted ecosystems (especially commercial forestry). Finally, results of a variety of studies on the growth and water use of indigenous trees growing in natural forest and plantation systems suggest that, compared to introduced tree species, indigenous species use substantially less water, show lower water use efficiency, and grow more slowly. Advantages to such indigenous systems potentially include lower management costs, higher product values, a wider range of non-wood products and a lower hydrological impact. Their usefulness may be greatest on sensitive sites (e.g. riparian zones, water-stressed catchments, land cleared of alien plants, land with a high erosion risk, degraded forest) where land use systems with a reduced environmental impact are required.

Keywords: evaporation, transpiration, grassland, indigenous trees, *Jatropha curcas*