The hydrological characterisation and water budget of a South African rehabilitated headwater wetland system

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Abstract

This paper presents a synopsis of the findings of a valley bottom wetland monitoring study in which dominant hydrological processes maintaining the system are quantitatively defined. The Craigieburn-Manalana is a wetland subjected to technical rehabilitation, at the headwaters of the Sand River in the lowveld savanna region of South Africa.

Findings include the identification of a rapid water delivery mechanism from the surrounding hillslopes to the wetland following a threshold-exceeding precipitation event, when hillslope-toe soil matric potential is close to 0, leading to a raising of the wetland water table by >0.7 m within 3 h. A summary of quantified fluxes and associated water budget of the wetland and its contributing catchment is developed. It is revealed that this wetland does not necessarily conform to the typical assumptions that wetlands augment low flows. Surface layer scintillometry shows actual wetland evapotranspiration to dominate the water budget during the dry season (2.3–3.5 mm/d) compared to its contributing catchment (0.9–2.2 mm/d), whilst stream discharge had ceased. Hydrograph separation, based on stable isotopes (^{18}O), revealed that the wetland does not attenuate peak flows during the summer rains when the wetlands soil moisture deficit is close to 0, since more than 66% of stream discharge comprised event water. These results are discussed within the context of current hydrological understanding of southern African headwater wetlands, such as *dambos*.

Keywords: hillslope processes, hydro-geomorphology, water budget, dambos, rehabilitation, wetlands

Introduction

There is a general dearth of knowledge of the hydrology of wetland systems in Africa, and this has duly been noted for Southern Africa also (Grenfell et al., 2005). Where hydrological studies have been undertaken on wetlands in the region, they are constrained by the heterogeneous geomorphic templates of the landscape, which cause each wetland to seemingly operate in different ways; this precludes the development of a unifying wetland hydrological process framework. The southern African sub-continent differs vastly from the temperate northern continents in a number of ways: firstly it has an ancient and relatively tectonically stable land-mass which sits at a high mean elevation; second, the region escaped recent glaciation episodes that have shaped the landscapes in other regions; third, southern Africa has significantly lower average rainfall than other continents coupled with a high evapotranspiration demand. These factors combine to limit the extent of the majority of wetlands in the region to stream networks. This means that general underscoring principles of wetland management, gathered now quite comprehensively in the temperate regions of the world, are unlikely to be suitably applied to the wetlands of southern Africa (Ellery et al., 2008). Nevertheless, as the systems of southern Africa are studied in more detail, it is hoped that a sphere of overarching principles will emerge by which the sustainable management of their processes and resources may be secured in the future. This issue is of tantamount importance given that great emphasis is being placed on wetland rehabilitation, particularly in South Africa, through poverty relief strategies. This is a laudable undertaking for political, social and environmental reasons; however the environmental component of this objective may well be undermined by unsatisfactory understanding of the hydro-geomorphic controls and fluxes that would otherwise characterise these wetlands in a natural state, possibly leading to inappropriate rehabilitation measures (Tooth and McCarthy, 2007).

This paper summarises the hydrology of a riparian headwater wetland in the semi-arid north east of South Africa, the degradation of which through significant gully erosion is similarly experienced in other wetlands in the area. This degradation is assumed to be a compound effect of, firstly, the local geological and climatic conditions – i.e., steep granitic geology and intense rainfall due to being located close to the northern Drakensberg Escarpment. Secondly, historical political legacies have asserted a significant anthropogenic pressure on this landscape through forced resettlement and consequent expansion of population pressure on this sensitive region of the South African lowveld. The lowveld is a South African bioregion characterised by woody savanna dominated by *Combretrum* and *Terminalia* vegetation (Mucina and Rutherford, 2006). A major pressure in this landscape is the extensive use of the valley bottom wetlands for subsistence agriculture. An extensive assessment of the causal mechanisms of wetland degradation in the Sand River headwaters is provided by Pollard et al. (2006) and the assumption outlined is that this degradation, along with streamflow reduction by commercial forestry, has contributed to the loss of baseflow in the Sand River system. Essentially these conditions have fostered a switch in the Sand River from being a major perennial tributary of the Sabie River to one that is now dominated largely by a seasonal flow regime. The Sand River's flow regime and issues related to its deterioration are discussed in Pollard et al. (2011, 2012). Pollard et al. (2006) reports on an exploratory modelling exercise using ACRU (Schulze, 1995) at a variety of scales, which supported the notion that loss of wetland extent in the headwaters of the Sand

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