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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Groundwater

Ephemeral hydrological processes in savannas

A completed Water Research Commission (WRC) study offers new insight into the landscapes of the Kruger National Park.

Background

There is a tight coupling of hydrological, geological and ecological processes in the semi-arid setting of the lowveld savannas of South Africa.

In the Kruger National Park (KNP) this has resulted in distinct landscape patterns closely organised around the hierarchical drainage network of seasonal and ephemeral streams which dominate the landscape. These patterns have resulted from a relatively stable geological template, the topographical redistribution of water and the resultant geomorphic setting one sees in the park today.

Over time this has led to the establishment of unique soil and vegetation assemblages in the landscape at both the hillslope and catchment scale.

South African National Parks (SANParks) embarked on a long-term research strategy to study both the biotic and abiotic components of savannah ecological interactions in an integrated, transdisciplinary manner on unmanipulated sites. The KNP Supersites were established as living laboratories in order to grow this integrated ecological science and inform management in order to allow extrapolation of knowledge to other parts of the KNP, the broader lowveld landscape, and other savannah systems.

Augmenting existing data

A completed WRC project describes a key component of the abiotic template for dominant landscapes in the KNP. Focusing on granite and basaltic terrains the research has determined the extent of surface water, groundwater and vadose zone interactions with the drainage hierarchy of first to third order streams presented within the KNP Supersites.

The research had the following core objectives centred on the concept of hydrological connectivity:

- Quantify the role of hydrological inter-connectedness between hydrological process domains; and
- Determining the spatio-temporal variability of this interconnectedness in order to understand the hydrological fluxes that drive these savannah systems.

Four sites were established as Supersites in the KNP in 2011 and the research presented here focuses on two in the south of the park: Stevenson-Hamilton on granite (Southern Granites or SGR); and Nhlowa on basalt (Southern basalt or SBAS). Both sites are situated on the hydrological divide (watershed) between the perennial Sabie and Crocodile rivers.

The hydrological approach was the same for both sites in order to allow for inter-comparison of hydrological connectivity across geological settings and included: intense geophysical surveys; drilling and characterisation of a piezometric borehole network; ephemeral streamflow gauging; hydrochemical tracer sampling; hydro-pedological classification of catena sequences; associated soil moisture monitoring network; quantification of catena actual evapotranspiration through remote sensing, and a variety of other factors.

Key findings

Key findings on the Southern Granite site included:

- The identification of two distinct hydrogeological zones: a shallow responsive aquifer system in the consolidated hard rock likely linked to regional processes with drainage toward the perennial rivers in the KNP.
- The groundwater systems do not follow the surface topography at the scale of the individual catchments investigated but rather run parallel to the surface

drainage network with groundwater flow from the first to the third order catchment.

- The first order stream is gaining and sustained from shallow perched aquifer contributions, while the second order stream was found to lose water to the groundwater system along the stream conduit following significant rainfall sequences. This is likely to result from morphological changes in the catchment as one shifts scale from first to second order. The second and third order stream reaches were found to experience significant transmission losses
- It was noted that event water significantly dominates (60-100%) the intermittently connected streamflow responses at all orders.
- At the hillslope scale there are both similarities and differences moving across scales. In all three orders the crest soils had similar hydraulic properties, of vertical free drainage (high groundwater recharge potential) and interflow soils on the midsclopes (although poorly represented at the first order). However, the footslopes different in their hydraulic responses with saturation excess responsible soils at the first order, interflow soils at the second order, and freely drained potential recharge soils at the third order.
- Overall the first order catchment had the greatest actual evapotranspiration with the third order the least.

Key findings on the Southern Basalt site included:

- Two distinct hydrogeological zones: a weathered zone aquifer system and deeper fractured hard rock aquifer system. Similar to the granite, the general groundwater flow direction was parallel to the stream network with a west-east sloping gradient. This was most apparent in the first and second order catchments, which are deemed entirely disconnected from the stream network.
- At the third order the groundwater flow direction is also parallel to stream network in the hard rock. However, the weathered aquifer system at this order generally influences the stream network with a perpendicular orientation allowing the stream to gain.
- The third order stream network intersects the regional groundwater table at the lower end of the reach. The stream here becomes an important groundwater discharge point at the geological contact between the basalts and rhyolite geology (of the Lebombo formation)
- The third order reach on the southern basalts had the most persistent event-driven flows. Event water contributions to streamflow were typically greater than 60% at the third order and around 100% at the first order stream
- Hillslopes at all orders show the same hydraulic characteristics of extensive interfluvial areas dominated by recharge (potential groundwater recharge) soils, with relatively rapid wetting-drying cycles. Lateral connectivity to the stream network is limited to the immediate riparian zone soils by surface runoff only.
- Approximately 21% of incident rainfall following a series of rainfall sequences infiltrates beyond the root suction zone to constitute potential groundwater recharge.
- Typically all orders showed similar actual evapotranspiration, although this was around 200 mm less than on the granites during summer. At the scale of remote sensing analysis, the crest regions in general showed the greatest actual evapotranspiration, marginally higher at lower orders, which is attributed to both lower topographic gradients and deeper soil moisture storage.

Further reading:
To order the report, *Ephemeral hydrological processes in savanna* (**Report No. TT 619/14**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.