Factsheet #4

Drivers of water cycles

Water fluxes in a savanna landscape

Water is a crucial element in every ecosystem but in savannas it is particularly precious. From a plant perspective, the total amount of rain is less relevant than the amount that can be utilized by plants within the root zone, the so-called effective rainfall. Its availability is driven by various landscape features, e.g., soil, wildlife activity and the vegetation itself. The effects of vegetation on water fluxes are shown in Fig. 1 and have been the main target of our studies.

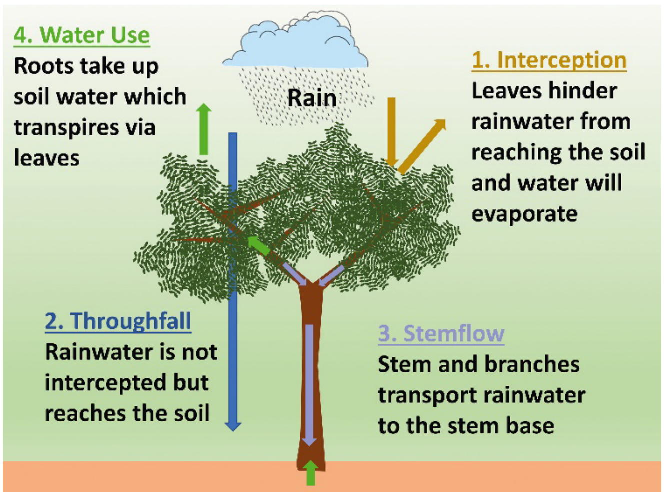

Figure 1: Water fluxes and rain partitioning by trees. For the soil moisture budget, throughfall and stemflow (but locally restricted) are a gain while interception and water use by plants (transpiration) are losses.

We conducted our studies between 2019 and 2022 on Etosha Heights Private Game Reserve in Kunene Region (~ 350 mm MAP). We set up rain gauges under canopies to measure throughfall, installed self-made collectors to assess stemflow and used special sensors to quantify water use (Fig. 2). Climate data were recorded by a weather station next to our main study site and by remote sensing data (Climate Engine and Google Earth Engine API) to cover a larger area.

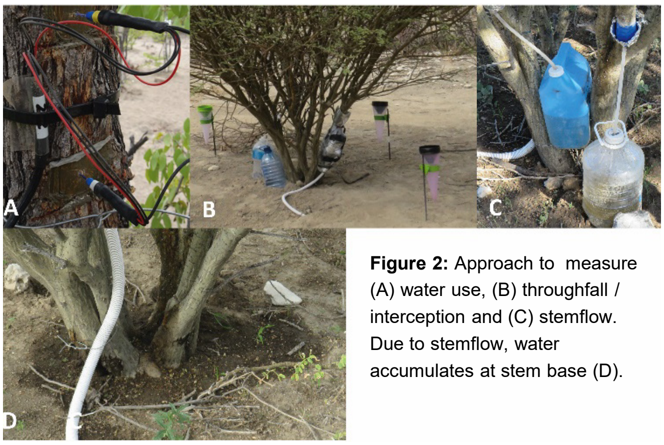

Figure 2: Approach to measure (A) water use, (B) throughfall / interception and (C) stemflow. Due to stemflow, water accumulates at stem base (D).

Effect of woody species on water fluxes

Most of the trees and shrubs we examined intercept about 20 % of rainwater but species differ (Fig. 3). While blackthorn *(Senegalia mellifera)* prevents nearly 30 % of rainwater from reaching the soil, mopane trees *(Colophospermum mopane)* allow almost 80 % to pass through the canopy. For most species, stemflow accounts for 10 % of rainwater. Only in mopane, stemflow seems to be negligible. Throughfall is most relevant because it allows an even distribution of rainwater and high values can be considered to have positive effects like increasing soil moisture, facilitating seedling germination and allowing grasses to grow (see last paragraph).

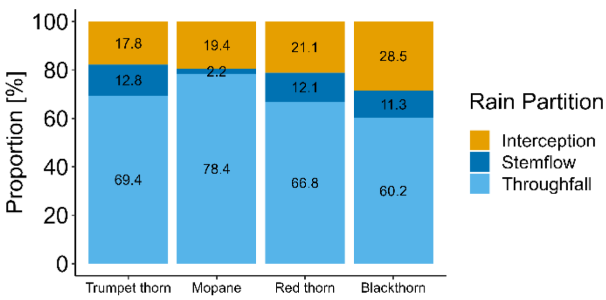

Figure 3: The impact of four woody species on the fate of rainwater.

Cover photo: Katja Geißler; other photos: Tim Herkenrath

Remarkably, a medium-sized, multi stemmed mopane tree used almost 2 l of water per day whereas a similar-sized blackthorn used a tenth of it only. A medium-sized trumpet thorn seems to use the smallest amount of water per day (53 ml). However, because trees (both individuals and species) differ in size, it is reasonable to compare water use per canopy area. Here, mopane trees still have the highest demand while blackthorn has the lowest needs and trumpet thorn is in between (see Tab. 1).

Tab. 1: Mean daily water use per tree (medium-sized) within a 5-week period (90 mm of rain) during wet season. Values will differ during drier times of the year.

Species	Canopy area [m²]	Daily water use [l]	Daily water use per m² canopy [l or mm]
Mopane	11	1.89	0.17
Blackthorn	11	0.16	0.01
Trumpet thorn	0.7	0.53	0.76

How does wildlife shape water fluxes?

Animals that feed on trees and shrubs might shift the water fluxes described above. Experimental browsing pressure increased throughfall with increasing browsing intensity. A leaf removal of e.g., 50 % lead to a shift of throughfall portion from 69 to 75 % in trumpet thorn. This observation makes sense, because a less dense canopy will be more permeable for rainwater. Browsing does not affect the flow of rainwater only but also water use by plants.

In all 3 species, we found that low browsing intensities stimulate water use while high levels of browsing lead to a reduced water use (Fig. 4).

Effective rainfall determines grass growth

To determine the start of grass growth and activity, the minimum effective rainfall is crucial. We identified the main rooting zones of grasses and found the highest root density in a depth between 0 and 10 cm. Therefore, we used soil moisture measurements in 5 cm depth and observed the response in grass growth (Fig. 5 + 6). We could show that 16 mm effective rainfall is the minimum requirement for grasses to start growing. This corresponds to 20 % volumetric soil moisture in most soil types.

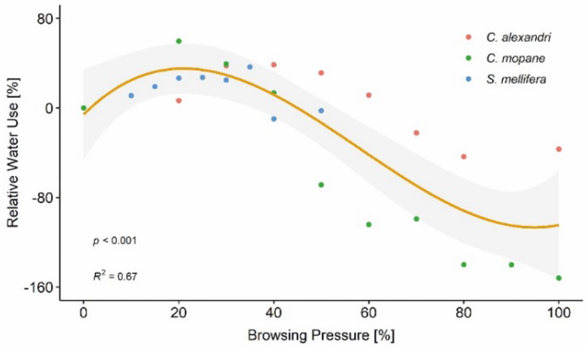

Figure 4: Change in water use in response to simulated browsing

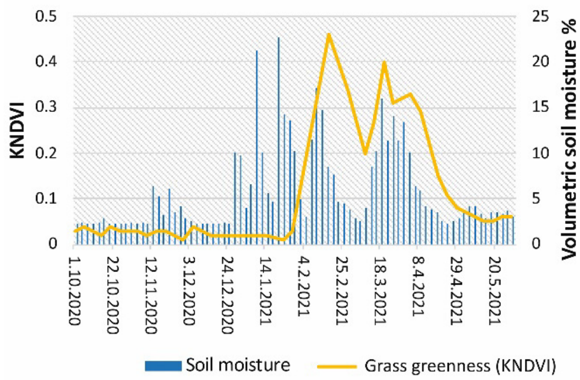

Figure 5: Response of grasses (indicated by KNDVI) to soil moisture in 5 cm depth exemplary at one of our study sites. One can see the start of grass growth a few days after the threshold of about 20 % soil moisture has been reached.

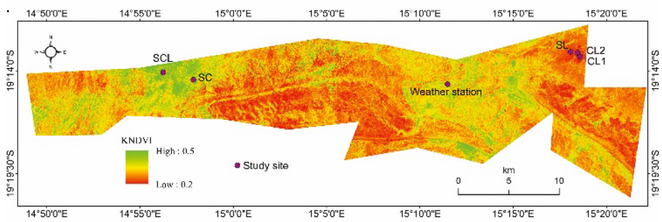

Figure 6: Maximum KNDVI as an indicator of grass growth for the entire study area. Intense green areas represent high grass activity. Visit our homepage or use QR-code for larger display.

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The ORYCS Project

The German-Namibian research project "ORYCS – Options for sustainable land use adaptations in savanna systems" aims to assess the suitability of wildlife management strategies in Namibia as options for adapting land use to climate change in savanna ecosystems.

www.orycs.org

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