

Do invasive alien plants really use more water? STUDY INVESTIGATES

All photographs courtesy CSIR



Prosopis invaded floodplain of the Doorn River at Brandkop farm in the Northern Cape.

The threat posed to South Africa's scarce water resources by invasive alien plants is well known. But can one alien plant species really have that big of an effect on groundwater? A team from the CSIR is investigating.

The threat of groundwater-dependent alien invasive plants individually consuming up to 50 l/day of water, presents a myriad of challenges for an already water-scarce South Africa. Approximately 10 million hectares of land have been invaded by alien invasive plants in South Africa.

Prosopis is a dominant groundwater dependent alien invasive species found in the arid and semi-arid parts of South Africa. A deep-rooted shrub, the plant originates from Central America, and was first introduced to Namibia and the north-western parts of South Africa mainly for fodder, fuel and shade in the late 1800s. This species is well-known for its ability to thrive under semi-desert conditions by accessing groundwater using its deep tap root. Tap roots have been found at depths exceeding 50 m.

Various *Prosopis* species have become invaders and have spread to other parts of the country. They have invaded the Nama karoo and arid savannah in parts of the Western Cape, Eastern Cape, North West and Limpopo, and are spreading into adjacent grasslands. In the Northern Cape alone, studies by the North West University have found that *Prosopis* has invaded about 1.5 million ha or 8% of land in the province by 2007.

The rapid spread of this invasive alien plant, particularly along river courses and floodplains where it forms impenetrable thickets, has raised concerns about its impact on groundwater resources, especially for groundwater-dependent farmers and rural communities. These concerns have led to a three-year project aimed at determining the impacts of *Prosopis* invasions on groundwater.

The project, funded by the Water Research Commission with support from the Working for Water programme of the Department of Environmental Affairs, is being conducted by a multidisciplinary team of researchers led by Dr Sebinasi Dzikiti from the Hydrosociences Research Group at the

CSIR in Stellenbosch. The study is now in its second year.

The main purpose of the study is to quantify the long-term patterns of groundwater use by *Prosopis* invasions and compare them with co-occurring indigenous trees. This information on the impacts can then be used to prioritise areas for clearing *Prosopis* and protecting groundwater.

“Researchers have recognised that deep-rooted indigenous trees, such as acacias also use groundwater,” notes Dr Dzikiti. “Therefore, we also need baseline information on groundwater use by the indigenous vegetation that would normally replace *Prosopis* after it has been cleared. This will enable us to determine the increment groundwater use by the invasive plant and whether this could have adverse environmental impacts, such as drying up boreholes and streams, loss of biodiversity and productive grazing land.”

Right: Research team member, Dr David le Maitre of the CSIR and Brandkop farm owner Peter Louw inspecting a dry well in the *Prosopis* invaded area.



Below: Project team members installing an automatic weather station in the project site area.



MONITORING THE INTERACTION OF INDIGENOUS AND ALIEN VEGETATION WITH GROUNDWATER

The research team found a site which is heavily infested by *Prosopis* and also has good stands of *Acacia karroo* in the floodplain of the Doorn River at Brandkop farm near the groundwater-dependent town of Nieuwoudtville in the Northern Cape. According to the farm owner, Peter Louw, the size of the invaded area on his property is about 400 ha, and much of the grazing land for his sheep has been invaded.

Acacia karroo is the dominant indigenous tree species that relies on groundwater in the area. It is an important indigenous species, which provides nesting sites for birds and a habitat for a range of animals.

To understand the water use of both tree species, researchers are monitoring the volumes of water taken up by both *A. karroo* and *Prosopis* in relation to the weather, soil water content and groundwater levels. They are also measuring the water uptake by the roots of both species using water flow sensors installed on the tap and lateral roots of selected trees.

The sources of water transpired by the trees (whether soil water or groundwater) are being determined by matching the stable isotope signatures of water from twigs with different water sources. The first one-and-a-half years of the project involved monitoring the site with both species present. *Prosopis* invasions will then be cleared and detailed monitoring will continue of the remaining indigenous vegetation for the remaining research period.

According to Dr Dzikiti, this intensive monitoring is the first of its kind in South Africa to involve detailed assessments of the interactions of both invasive alien and indigenous trees with groundwater in the drier parts of the country.

Interestingly, the greatest challenge of the experiment to date was for the team to keep their equipment running as planned at such a remote site. “Vandalism of the equipment by baboons that frequently pulled probes out of trees or used the equipment as steps to climb trees has been a major challenge,” notes Dr Dzikiti. “We have had to go to great lengths to protect our equipment using several layers of fencing.”

FINDINGS TO DATE

Contrary to popular belief, the amount of water transpired by individual *Prosopis* trees has been found to either be equal to, or lower than, that of an *A. karroo* of the same size. This was because the water transport pathway (sapwood area) of the invasive alien plant stems is substantially narrower than that of the indigenous plant. However, if water use by the whole population of each species is considered, *Prosopis* transpires at least four times more water than *A. karroo*.

“This is because the alien invasive plants were very dense compared with the indigenous vegetation,” explains Dr Dzikiti. “So the ability of the *Prosopis* to form dense thickets with large numbers of plants per unit area, rather than high transpiration by individual trees, is the main reason why their water use exceeds that of indigenous vegetation.”

The researchers have further observed an interesting phenomenon during the root water uptake studies. They found that *Prosopis* is manipulating the available water in this exceedingly dry region to its advantage while the indigenous *A. karroo* is not. Groundwater taken up by the *Prosopis* tap root is not all immediately transpired. Much of the root water leaks out into the upper soil profile, presumably for use later when there is less water available.

The result is a greater average soil water content under *Prosopis* than under *A. karroo*. Scientists call this phenomenon of water movement ‘hydraulic redistribution’, or more accurately ‘hydraulic lift’. While the indigenous *A. karroo* also uses groundwater, no water redistribution occurs, and all the water absorbed by the tap roots is immediately transpired, leaving the trees with no buffer against periods of water shortage.

Besides creating a water reserve for the trees, studies around the world have found that hydraulic redistribution also plays a critical role in the survival of the associated shallow-rooted plants, which cannot directly access groundwater. Moreover, the moister soil profile under *Prosopis* is known to improve nutrient cycling.

All these factors combine to significantly enhance the chances of survival of young *Prosopis* seedlings, probably contributing to the rapid increase in the populations of this species compared to co-occurring indigenous trees. Stable isotope data shows that *Prosopis* obtains about 77% of its water from

groundwater compared with 53% for *A. karroo*, during the peak summer period.

The findings of this study were rather surprising, notes Dr Dzikiti. Firstly, the fact that individual *Prosopis* trees are not really extravagant users of water as is widely believed was quite unexpected. “The adverse impacts of this species on groundwater and the environment at large seem to arise from the very dense plant populations whose combined effect is significant.”

“Secondly, given that the growth form of *A. karroo* is not very different from that of *Prosopis*, we did not expect trees of the two species growing next to each other to have different water uptake patterns,” he adds. “However, we do know that when *Prosopis* invasions increase, indigenous vegetation gets replaced.”

The study results to motivate for the clearing of *Prosopis* invasions with a specific focus on stands found along river courses and on floodplains. The research does suggest, however, that water savings from clearing *Prosopis* are unlikely to be significant in areas where there are comparable densities and sizes of deep-rooted indigenous trees as there are of *Prosopis*, or where there are more indigenous trees than *Prosopis*.

It is hoped that the final results and recommendations from this study will go a long way towards growing the required knowledge for South Africa effectively manage the problem of invasive alien plants. □

Below left: Dr Sebinasi Dzikiti from the Hydrosociences Research Group at the CSIR installing a soil water content sensor in the root zone of *Prosopis*.

Below top: A closer view of the transpiration and root water uptake equipment.

Below bottom: An eddy covariance flux tower for measuring evapotranspiration over the invaded area.

