# GROUNDWATER

## Assessing groundwater reclamation benefits of clearing invasive alien trees — insights from the Atlantis aquifer

*A recently completed study in the Western Cape has yielded valuable insights into the water reclamation benefits of removing alien invasive plants. Article by Jorisna Bonthuys.*

The link between water security and catchment health in water-stressed parts of South Africa has been in the spotlight in recent years, including in the greater Cape Town region.

This has particularly been the case since a recent multi-year drought (2016-2018) which almost resulted in a 'Day Zero' situation in Cape Town – the day that dams would essentially run dry.

Luckily, Cape Town survived this historic three-year drought that threatened to shut down the city's water supply at the height of the crisis. The drought highlighted the water security situation in the region, and the need to protect water source areas from land cover changes that would decrease usable runoff.

Since then, various options to improve water security, including dealing with alien plant infestations, have been explored.

"There is a real and urgent need to deal with water losses due to invasive alien trees in our catchments in a consistent and long-term manner," says hydrogeologist Richard Bugan. He works for The Nature Conservancy (TNC) in South Africa.

This global non-profit organisation is involved in catchment

restoration efforts and green infrastructure solutions at scale. TNC established the Greater Cape Town Water Fund in 2018, a public-private partnership programme to utilise nature-based solutions to improve water security in the greater Cape Town region. This fund is one of over 40 water funds globally, and the second on the African continent.

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**The scale of the challenge**

Many known negative impacts of invasive trees in South Africa are highlighted in the comprehensive open-access book ***Biological Invasions in South Africa*** published by Brian van Wilgen and co-authors in 2020**.** Invasive alien trees consume about 5% of our scarce water resources and reduce the carrying capacity of our natural rangelands. These trees are also a direct threat to the survival of almost half of 1 600 native species listed in South Africa's Red Data List.

Particularly damaging species include trees introduced from elsewhere in the world, including countries like America, Europe and Australia. These invasive alien species invade catchments, reduce water runoff, increase the severity of veldfires, and threaten indigenous species.

These invasive species are introduced without their natural enemies, such as insects and pathogens, giving them a competitive advantage over indigenous species that evolved over millennia.

Although South Africa has invested in programmes such as Working for Water to reduce the negative impacts of these widespread invaders on ecosystem services, much more action is needed.

Invasive alien plants are a significant problem in many ecosystems. Nationally, the impacts of invasive alien plants on surface water runoff are estimated at 1.44–2.44 billion $m^3$ per year. The most affected primary catchments (>5% reduction in mean annual runoff) are located in the Western and Eastern Cape, and KwaZulu-Natal.

If no remedial action is taken, reductions in surface water runoff could increase to 2.59–3.15 billion $m^3$ per year by 2032 – about 50% higher than current reductions. This is pointed out by Dr David le Maitre and co-authors in a chapter in ***Biological Invasions in South Africa.*** This chapter focuses on the impacts of plant invasions on terrestrial water flows in South Africa.

The scientists warn of the destructive impact of invasive plants on dam catchment inflows, among others. Riparian invasions, and those in areas where groundwater is accessible to these plants, have 1.2 to 2 times the impact of invasive plants in dryland areas.

**Spotlight on the Western Cape**

Invasive alien plants – including pine and black wattle – are water-thirsty and have a significant impact on water yield in the province.

With seven species in the list of 25 most invasive alien plant species in the country, the Australian acacias are also considered to be some of the main culprits. The most densely invaded areas in the province are in the Boland Strategic Water Source Area. From here, water gets distributed across the landscape via rivers, dams and pipelines into our taps.

Over two-thirds of the catchments supplying the Western Cape Water Supply System are affected by alien plant infestations, reducing the amount of water that reaches the rivers and dams that feed the region by 55 billion litres (55 $Mm^3$) per year. This equates to about two month's water supply for Cape Town.

If no action is taken, these water losses could double in only two decades to 100 billion litres per year.

In the Cape Floristic Region, estimates show that available water resources have been reduced by 15% due to alien invasive plants. This could rise to 37% (from 6 765 to 4 271 million $m^3$ per year) if invasions were allowed to grow and proliferate unchecked over the next three decades.

Studies informing the Greater Cape Town Water Fund business case launched in 2018 showed the highest return on investment could be achieved by clearing invasive alien plants in seven priority sub-catchments (54 300 ha) where 76% of the current water losses occur.

"The 55 billion litres which are lost annually, across these priority sub-catchments, could be reclaimed within only six years, through the implementation of invasive alien plant removal," Bugan explains.

When it comes to securing Cape Town's future water supply, clearing invasive alien plants from within the key water catchments will bring a better return on investment than building desalination plants as an example. It is more cost-effective to eliminate invasive alien trees in key catchments, as a nature-based solution, rather than traditional engineering strategies.

Ongoing, long-term and systematic clearing, follow up, and maintenance of cleared areas are needed to reduce the spread of these invasive plants.

Bugan and a team of experts are currently tracking the impacts and the benefits of clearing dense invasive alien tree stands in priority catchment areas on the catchment water balance and the biodiversity.

As part of these efforts, the Greater Cape Town Water Fund partnership is working in the rugged Boland mountain catchments to cut down water-thirsty invasive trees.

**Zooming in on Atlantis**

Bugan is the author of a study titled 'Assessing water losses as a

*The scientists conducted sap flow measurements to quantify plant water use. They inserted sap flow sensors into the xylem vessels of tree stems. The probes tracked the movement of water through the trees by using heat as a tracer.*

result of invasive alien plants in the Atlantis Aquifer' in which he and a team of experts assessed water losses due to invasive alien trees in the Atlantis aquifer region.

The Atlantis aquifer is situated approximately 50 km north of Cape Town. The available water resources in the area are under increasing pressure from competing users, while climate change and the growing threat from invasive alien plants only worsen the situation.

TNC and partners has been involved in restoration efforts in the aquifer area since 2018.

Significant infestations of ***Acacia cyclops*** (rooikrans) and ***Acacia saligna*** (Port Jackson) occur in the area. These trees pose problems particularly in water-scarce areas such as Atlantis because of their ability to alter the local hydrology. They compete with and displace indigenous vegetation and reduce human access to water.

The team's research was the first of its kind to consider the actual water use of invasive alien plants in the area. At the time, Bugan worked in the CSIR's Hydrosciences Research Group, who was commissioned by TNC to do the research.

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The goal of this study was to close this important information gap by quantifying the actual volume of water that is consumed by the invasions. "We sought insights into the potential water

savings that can be achieved by clearing the invasions and restoring the area with indigenous vegetation under different water availability scenarios," Bugan explains.

This was determined by comparing the evapotranspiration rates of invaded areas and areas covered by the indigenous vegetation (fynbos).

**Unpacking the science**

The transpiration rates of Acacia trees growing in the Atlantis region were measured at hourly intervals over one year, using the heat pulse velocity sap flow method. The researchers inserted sap flow sensors into the xylem vessels of the tree stems. Xylem is the part of a plant that conveys water from the roots to the leaves and stems, transporting nutrients along with it.

"The probes tracked the movement of water through the trees by using heat as a tracer of sap movement through the tree's transpiration stream," Bugan explains.

Sap is more than 99% water, and therefore, the volume flow of the sap is considered to be equal to the transpiration rate.

Two study sites were equipped, spanning a water availability gradient, from wet (shallow groundwater levels) to dry (deeper groundwater levels).

Remote-sensing and an automatic weather station provided more data. The station's sensors measured rainfall, solar radiation, temperature and humidity, wind speed and wind direction and the signals processed at hourly and daily intervals.

**Implications on water savings**

The scientists say removing invasive plants and restoring indigenous fynbos could result in the reclaiming of between 830 000 litres per hectare per year and 2 million litres per hectare per year in the area.

"This is a significant amount of water which can improve water security in the region," Bugan says.

The reclamation benefit of 2 million litres per hectare per year only considers the differences in evapotranspiration between the invaded site and a site covered by fynbos.

Researchers fed the study data into a hydrological model to translate this to actual groundwater recharge. The results indicated that over the simulation period the total groundwater recharge was 52 mm under the Acacia trees and 135 mm under fynbos. The difference of 83 mm, equates to 830 000 litres of water per hectare per year, represents the increase in groundwater recharge resulting from invasive alien plant removal.

The authors explained that negligible water savings can be achieved in areas where the invasions are sparsely populated and groundwater is not readily accessible.

"In places where water is not readily available to these acacias and where there are fewer trees per hectare, little or no water may be recovered by removing the invasions although these areas are important to clear to avoid spreading and protect biodiversity."

"This information may be used to prioritise implementation areas where the greatest benefit can be achieved," Bugan says. "Clearing invasive plants is also about restoring biodiversity." Good planning, long-term systematic clearing, follow up and monitoring are needed.

The results of these and other studies can now be used in water-supply system studies to estimate the impacts of invasive alien plants on water resources, Bugan says. It provides measured data of the water reclamation benefit of removing these invasive plants. Decision-makers can also use this information to prioritise areas for clearing and rehabilitation.

**Long-term experiments underway**

Bugan is currently gathering streamflow information from hydrological monitoring equipment set up at six remote stream sites in priority sub-catchments of the main dams in the Boland mountain catchment areas.

These are part of long-term paired catchment experiments, he says. These experiments are done to validate the science that underpins the water benefits of the Greater Cape Town Water Fund's interventions.

So far, the results have been "extremely encouraging", he says. The data observed from catchment pairs exhibit very high correlations, which is a key requirement during the baseline data collection period of the experiments.

This research will provide direct measurements of the gains in streamflow which may be achieved through the removal of invasive trees in mountain catchments.