POLICY BRIEF

Alien Tree Invasion in South Africa

Status and Impacts on Water in Strategic Water Source Areas

Alanna J. Rebelo, Liam S. Cogill, Thandeka Skosana, Karen J. Esler, Errol Douwes, Jackie Jay, Sipho Magagula, Bonani Madikizela, Christo Marais, Nicky McLeod, John Phangisa, Tendai Sawunyama

The findings presented in this brief are based on the Water Research Commission-funded MapWAPS Project —*Mapping Woody invasive Alien Plant Species* (Project Number C2022/2023-00901). Additionally, synthesised insights from one-on-one engagements with key experts in the field informed this brief — including representatives from national government departments (DFFE, DWS), catchment partnerships, catchment management agencies, provincial parks agencies, metropolitan municipalities, and non-profit organisations.

The project used freely available satellite imagery and machine learning to map invasive alien trees within catchments that intersect with surface water strategic water source areas (areas which cover 8% of South Africa's surface but supply 50% of runoff). The maps can be viewed here. Water-related impacts were estimated using freely available remote sensing products and our ensemble evapotranspiration model, validated using 14 flux tower stations nationwide.

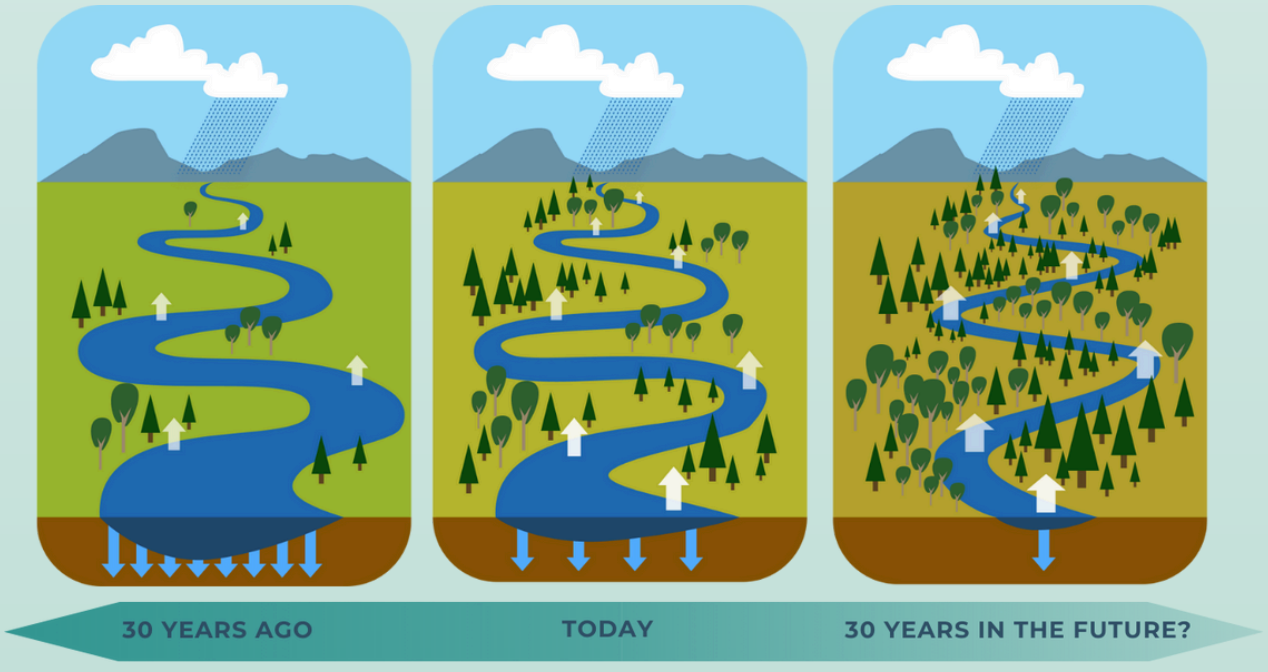

Figure 1: South Africa has long known that invasive alien trees threaten our water resources. The Working for Water Programme began in 1996 to stop their spread and reduce water loss. Yet, nearly 30 years later the problem is growing, underscoring the need for upscaling investment and maintenance. We now face a choice: allow further invasion and impact, or act to restore our ecosystems.

MAPWAPS
MAPPING WOODY INVASIVE ALIEN PLANT SPECIES

Urgency: We cannot afford to delay invasive alien tree clearing efforts

There is an urgent need to tackle the problem of invasive alien trees. With elevated CO_2 in the atmosphere, alien tree invasion is only going to be getting worse in the future (Figure 1). This is exacerbated by poor fire regimes (e.g. fire suppression), the loss of herbivores from many systems or over-grazing/poor grazing management in others, as well as high numbers of alien seeds in the soil.

CATCHMENTS

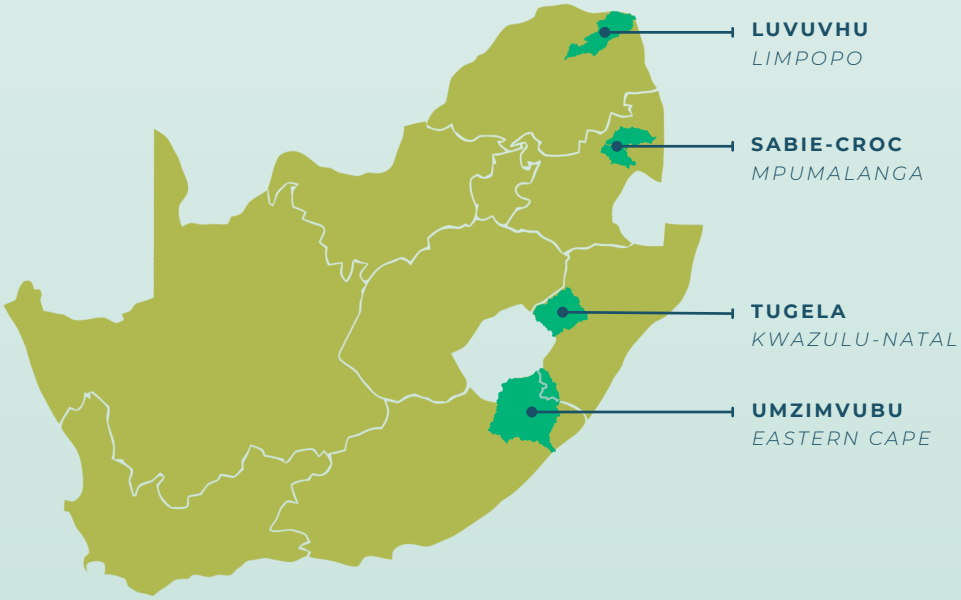

Figure 2: Map of South Africa with the MAPWAPS study catchments indicated.

STATEMENT 1

Clearing invasive alien trees in strategic water source area catchments has major water benefits

Clearing woody invasive alien plants (hereafter "alien trees") in all four of the study catchments could release over 100 mm per annum if they are restored to a native treeless ecosystem, such as grasslands, shrublands or wetlands (Figure 3). Even restoring to a treed ecosystem, such as a forest (where appropriate) produces **water gains** compared to alien tree invasions of wattle, pine, gum and poplar (by ~20 mm per annum).

ALIENS	NATIVE ECOSYSTEM: GRASSLAND	FOREST	WETLAND
WATTLE	**76**	**17**	**68**
GUM	**134**	**24**	**118**
PINE	**113**	**16**	**114**
POPLAR	**-**	**8**	**27**
BUGWEED	**141**	**-**	**-**
LANTANA	**111**	**-**	**-**

Figure 3: Amount of water released in mm/annum when restoring native ecosystems by clearing alien tree invasions (note: mm represents depth over an area; for example, 1 mm = 10 m³/ha/year).

If we cleared all the gum, pine and wattle invasions (not including plantations) in each of the four study catchments and restored these areas to native ecosystems, we would be able to free up approximately 110 million m³ of water overall (Figure 4). This equates to water for over 770 thousand households each year (based on 100 L per person, and four people per household).

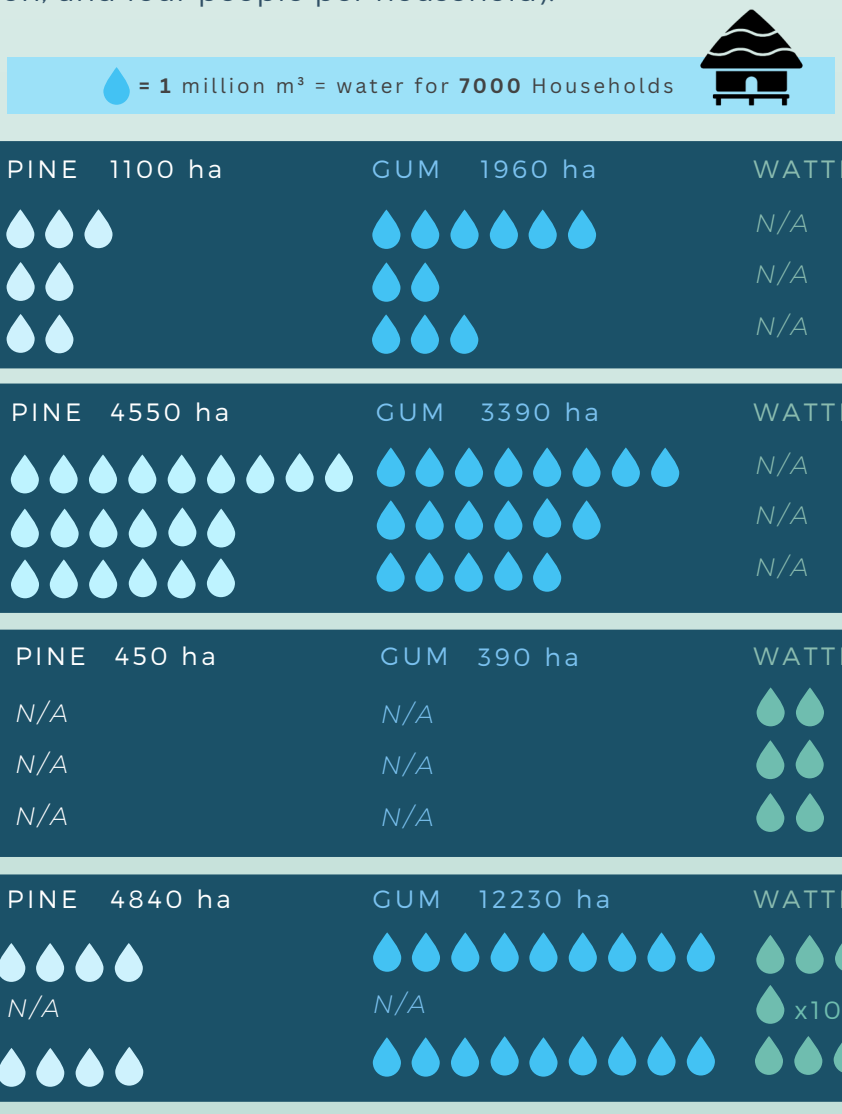

Figure 4: The volume of water (in million m³) that would be made available clearing invasive alien trees from each of the four strategic water source area study catchments in South Africa.

STATEMENT 2

Sustainable investment is the key

This research has shown that **alien trees** have **invaded between 1% to 5%** of catchments within strategic water source areas (Figure 5). A recent publication has shown that the investment in alien tree clearing over the last 25 years in South Africa has not resulted in the desired reduction of invasion, Although the programme slowed the spread of alien trees, why was it not more successful?

Part of the reason, according to the experts engaged, is that investment has been insufficient (despite being substantial), as well as intermittent. This has made running alien tree clearing programmes challenging. Permanence and security of jobs has been a major short-coming, and has had socio-economic consequences.

Sustainable investment into invasive alien tree clearing is critical. There needs to be a **long-term, strategic** vision, with buy-in and collaboration of all stakeholders. We recommend planning on a 50-year time frame.

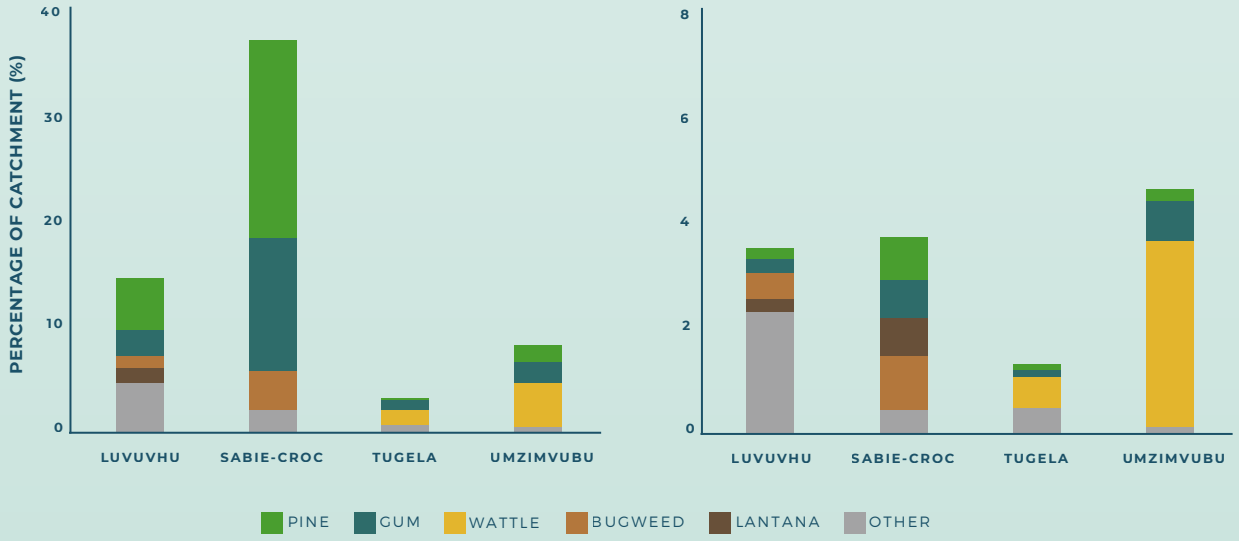

Figure 5: Percentage of alien trees invading catchments: (LHS) invasions + plantations, (RHS) invasions only

Warning: Ignore the emergent weeds at your peril!

All of these mega invaders, like pine, gum and wattle, started somewhere. While this study focused on invasive alien trees that cover large areas and can easily be detected using satellite imagery, there are many other emergent invaders that are likely to become tomorrow's problem. **Supporting and funding early detection programmes is critical**. Prevention is better than cure (and cheaper!).

STATEMENT 3

Clearing invasive alien trees within a restoration framework, leads to water-related co-benefits

Clearing invasive alien trees followed by restoration to a native ecosystem, not only makes more water available (**water provision** or **yield**), but also assists with **water regulation**. **Infiltration** is higher under native ecosystems like grasslands or fynbos, than under invasive alien trees or plantations (Figure 6).

This infiltration allows soil water stores to replenish, and in some cases also for aquifers to recharge (i.e. the "**sponge effect**"). **Slowing the movement** of water through the landscape means that this additional water doesn't rush from the surface all at once, preventing flooding downstream (**flood attenuation**) as well as **reducing drought risk**. Therefore invasive alien tree clearing within a restoration framework is a very important strategy for South Africa to consider in terms of **climate change adaptation**.

Clearing invasive alien trees with restoration helps to build **resilience** back into our ecosystems. Resilience means the ability of an ecosystem to recover after a shock, like a flood, fire or drought. The implication of all these benefits, is that invasive alien tree clearing and restoration can contribute to securing the **strategic water source areas** in South Africa.

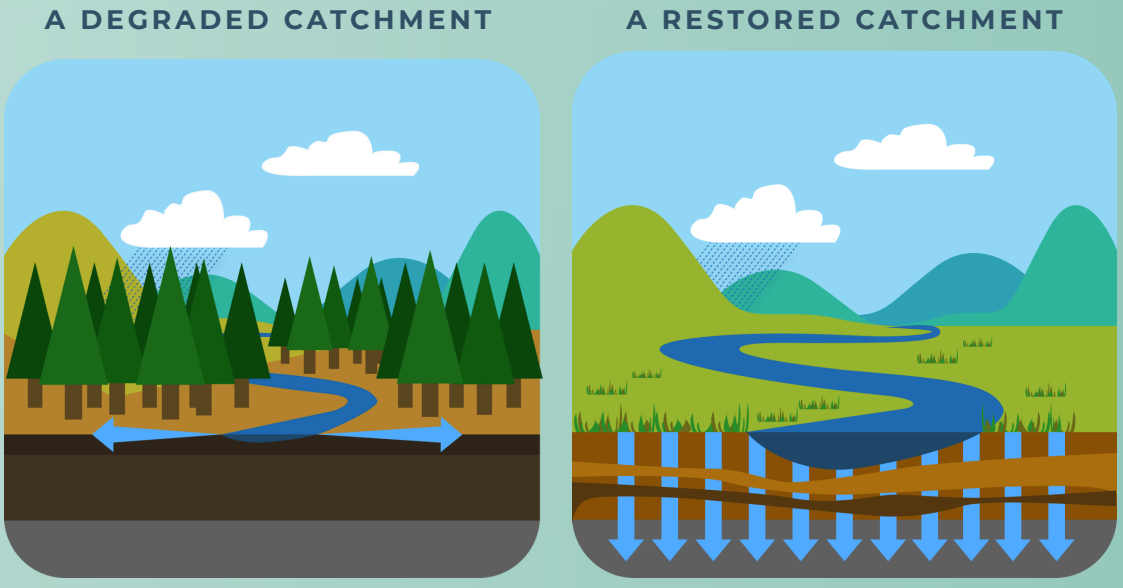

Figure 6: Invasive alien trees deplete surface water and groundwater reserves due to increased evapotranspiration (water-use). Restoration to native ecosystems, e.g. grasslands, provide water regulation ecosystem services, such as slowing the movement of water through the landscape (the "sponge effect") and thereby replenishing soil water and groundwater reserves and storing them for when they are needed the most (e.g. the dry season), as well as improving flood attenuation due to the catchment being less "flashy".

STATEMENT 4

Relative water impact of invasive alien trees is consistent inside and outside strategic water source areas

Our research has shown that inside strategic water source areas invasive alien trees use more water but so does the native vegetation. This means that relatively speaking, the water impact of alien tree invasion, or clearing, **is the same** inside compared to outside strategic water source areas.

It is important to note that we didn't consider **groundwater** strategic water source areas, only surface water ones. It is possible that where invasive alien trees have access to a source of water that is not available to native vegetation (e.g. trees tapping groundwater that grasses with shorter roots cannot access), such as groundwater, that invasive alien trees will use proportionally more water relative to native vegetation.

More research on invasive alien tree impact on water resources in groundwater strategic water source areas should be an urgent priority, as it may advise priority areas for invasive alien tree clearing, where investment can have a larger impact on water availability.

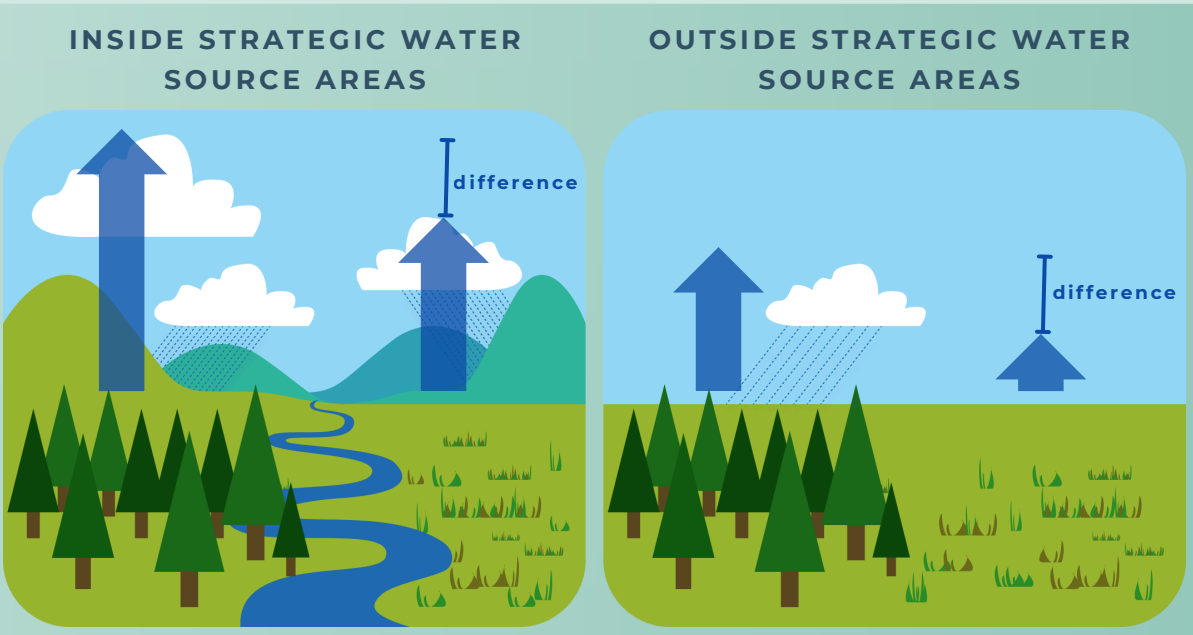

Figure 7: Invasive alien trees inside strategic water source areas use more water compared to those outside them, however so does the native vegetation. Therefore the relative amount of water freed up when clearing invasive alien trees and restoring to native ecosystems is the same, whether inside or outside of a strategic water source area.

Note: There are many other benefits!

This particular study focussed only on **water**, however there are many other benefits of invasive alien tree clearing within a restoration framework, and these include **biodiversity** benefits (alien trees reduce biodiversity), improved **carbon sequestration** in natural ecosystems (alien trees results in loss of organic carbon from soils), reducing the risk of severe and unmanageable **wildfires** (alien trees result in more dangerous fires) amongst other benefits. Therefore when we consider the benefits of invasive alien tree clearing, we should look at **"bundles" of ecosystem services** (e.g. water, biodiversity, carbon, and fire) to avoid the risk of perverse incentives.

For example, if the focus is purely releasing water from the ecosystem, it would be better to clear alien trees and manage the landscape as bare soil, and not restore to a native ecosystem. However this will compound many other issues linked to degradation, such as erosion, loss of biodiversity, carbon emissions, and reduced infiltration (more droughts and floods). Therefore in order to derive maximum benefit from ecosystems without causing unintended harm, we should consider **"bundles" of benefits** (ecosystem services) when securing buy-in.

STATEMENT 5

Forestry in strategic water source areas trades economic gains for significant water costs

Having plantations within strategic water source area catchments presents a **trade-off**: these plantations have economic benefits, but they also have a major water cost relative to native ecosystems that they replace (even indigenous forest). In certain strategic water source areas, **rezoning** of land-use activities could be beneficial to protect water sources. Considering actions such as the **restriction** of any further water use licences for plantation forestry in water-stressed catchments as well as strategic water source areas could be beneficial in terms of water resource management. Forestry companies wishing to reduce their water footprint could also consider **genus swapping** to taxa that consume less water within their specific bioclimate. Read the report for more information.

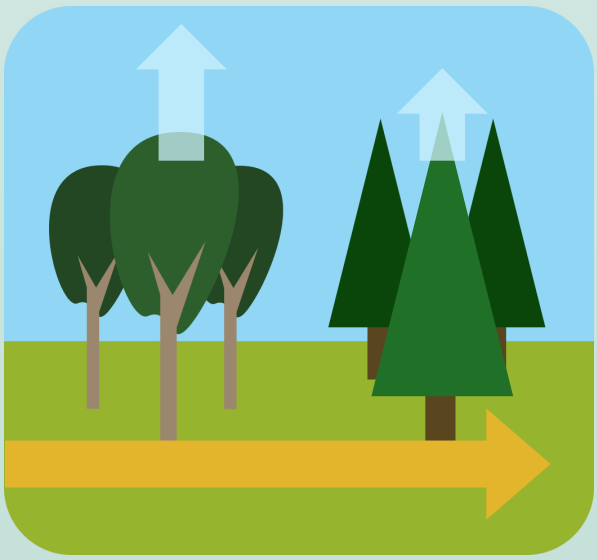

Figure 8: Genus swapping, from taxa that are higher water users (e.g. LHS) to those which use less water (e.g. RHS) might be an option in water-stressed areas to improve water security without requiring a change in land-use.

STATEMENT 6

Many alien tree invasions are a legacy of forestry

This study demonstrates that alien tree invasions are most severe in areas surrounding plantations and decline with increasing distance from them. Given that plantation forestry is a major driver of these invasions, the forestry sector should bear **responsibility** for managing and controlling their spread. It is imperative that this issue is addressed by all entities within the sector, including both private companies and state-owned enterprises.

It is ethically indefensible for the citizens of South Africa to bear the financial burden of clearing invasive alien trees or suffer the resulting loss of ecosystem services, while forestry operations continue to profit **without internalizing** the environmental costs they impose. Forestry companies must incorporate the costs of alien tree invasions into their pricing structures. If the true cost of forestry — including the ecological and economic impacts of invasions — were accurately accounted for, the sector's profitability might be significantly reduced. Holding the forestry sector accountable for restoring the ecological degradation it has caused **could incentivize more responsible practices**. This includes increased private-sector investment in solutions such as the development of sterile cultivars and the advancement of biological control measures.

We recommend that the legislation around accountability for spread of invasive alien trees be urgently strengthened. Companies and landowners should be legally required to clear alien trees that have spread from their plantations, regardless of how far they have dispersed, and to actively restore the affected ecosystems. In the longer term, we recommend the government consider **bans** on the planting of tree species known to be major invaders — species that have **cost the country billions of Rands in damages and hundreds of millions annually over the past 25 years in clearing efforts.**

Such measures could be implemented through **stronger wording and penalties** in the National Environmental Management: Biodiversity Act (Act No. 10 of 2004), and subsequent revisions, as well as improved enforcement. The approaches we have developed could also assist government with **monitoring and compliance**.

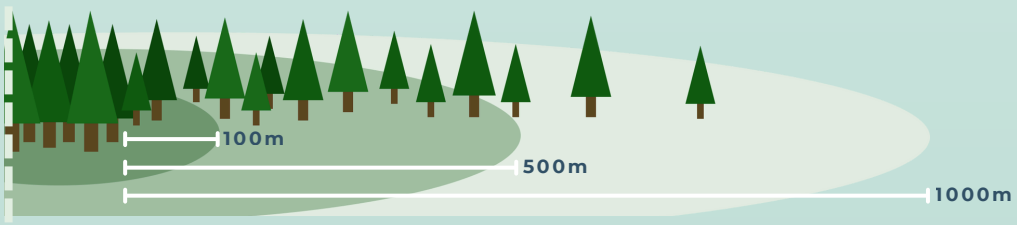

Figure 9: This research showed that alien tree invasions are most severe adjacent to plantations and decline with distance away, implying that forestry should be more involved with interventions.

STATEMENT 7

The water-related impacts of plantation forestry non-compliance

Our study found widespread alien tree invasions **within riparian zones** (areas alongside rivers) across all four study catchments. These invasions are of particular concern, as invasive alien trees in riparian areas are known to have disproportionate impacts on water availability. Notably, we also observed that many commercial plantations are located within these sensitive zones, in direct violation of environmental regulations. According to national legislation, forestry operations are required to maintain a 20-meter **buffer** from the edges of rivers and wetlands.

Despite this obligation, our findings reveal frequent non-compliance, with numerous plantations extending directly into riparian zones and wetlands. If these areas were restored and companies brought into compliance, **substantial volumes of water could be recovered**. For example in the Sabie-Crocodile catchments, 18.7 million cubic meters of water would be made available each year, if plantations and alien tree invasions were removed from the riparian buffer zones (see Figure 10).

We recommend that plantations should stay out of riparian zones and floodplains (e.g. above 10-20 year flood lines). To facilitate this, government should strengthen inspection and enforcement mechanisms and enhance oversight of the Forest Stewardship Council certification process in South Africa.

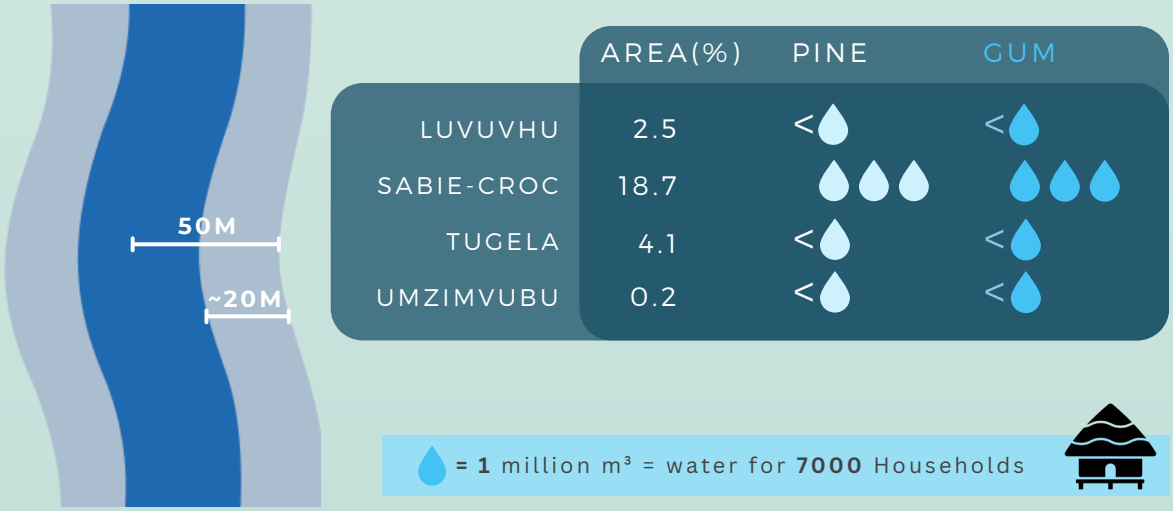

Figure 10: Volume (mcm) of water made available with removal of pine and gum trees from the riparian zone (defined in this study as a buffer of 50m from the centre of the river) within the MAPWAPS study catchments, which fall within strategic water source areas of South Africa.

STATEMENT 8

Up-to-date invasive alien tree maps are needed

Effective management of invasive alien trees requires accurate knowledge of their locations. Given the rapid rate at which these invasions spread, regularly updated maps are essential for timely and effective intervention. This highlights the need for a mapping approach that is both **easily updatable** and therefore readily **repeatable**. The MAPWAPS approach has been developed for this purpose and has achieved good accuracy results (Figure 11).

Investment in such a mapping process —and the resulting outputs— is critical not only for **on-the-ground management**, but also for **fulfilling national and international reporting obligations**, such as the National Biodiversity Assessment and commitments under the Global Biodiversity Framework.

The method developed in this project offers a practical solution by providing a repeatable approach for generating regularly updated, national-scale maps of invasive alien trees. We strongly recommend that **ecological expertise be a core requirement** in the development and interpretation of these maps to ensure their accuracy and relevance.

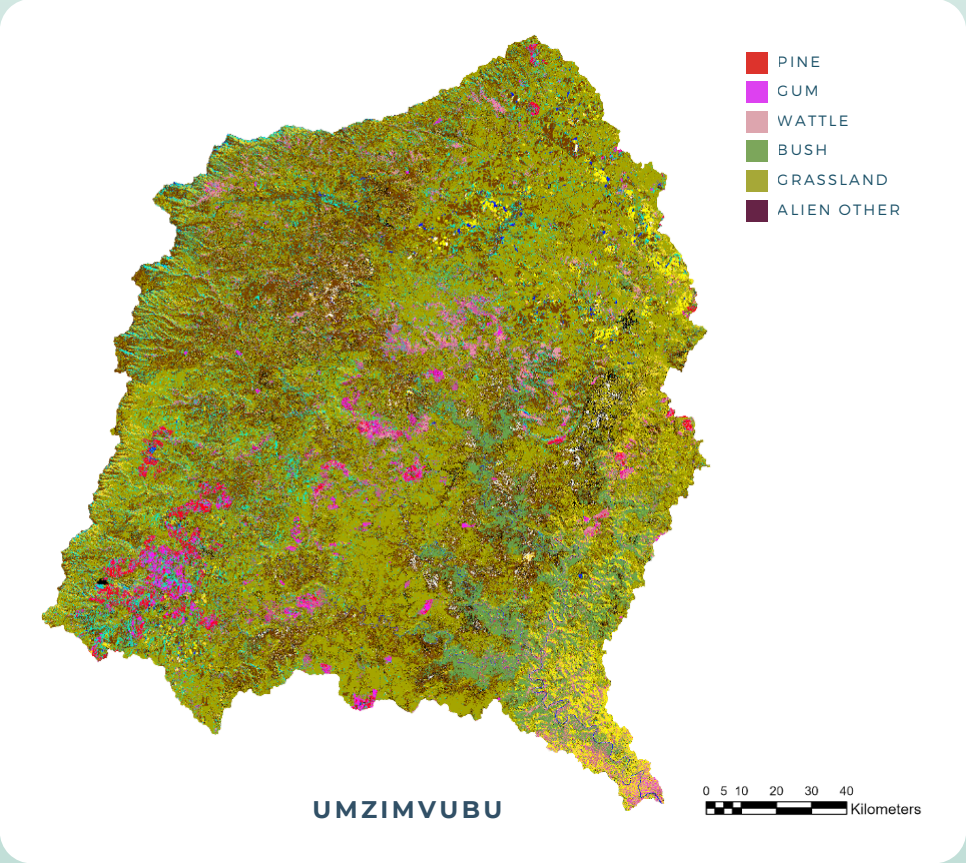

Figure 11: An invasive alien tree map of the uMzimvubu Catchment scored an overall invasive alien tree accuracy of 97%, and 94% for telling alien tree taxa apart.

STATEMENT 9

A water-use calculator is needed to calculate benefits of clearing invasive alien trees

We recommend investment into the development of **a tool to enhance estimates of the water-use impacts of invasive alien tree clearing**, using satellite remote sensing products as demonstrated in this study. Such a tool could play a vital role in supporting evidence-based decision-making and ongoing monitoring in water resource management.

Currently, the most widely used tool focuses solely on streamflow changes, based on the streamflow reduction curve concept. In contrast, our MAPWAPS approach captures comprehensive changes in water availability, including **both surface and groundwater** (Figure 12). This represents a significant advancement over existing methods and makes strategic use of freely available satellite imagery to improve water management.

Furthermore, this approach aligns with the government's priorities for digital transformation within the environmental and water sectors.

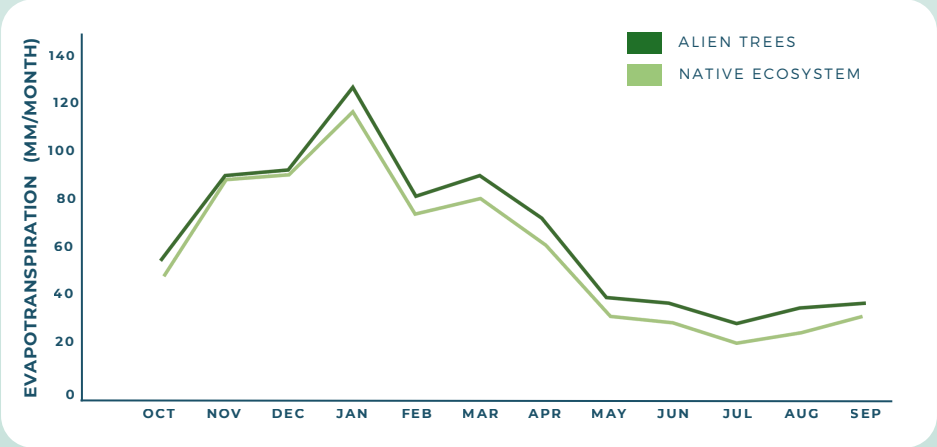

Figure 12: The difference in evapotranspiration (water-use) between alien trees and a native ecosystem (in this case a grassland) in the Tugela Catchment, South Africa for one year, 2023. Water use is similar over the summer rainfall season (Oct-Dec), but in the dry winter, when the grasslands are dormant, is when the differences in evapotranspiration are most apparent.