Biological Invasion Threat to Wetlands in Urban Areas of White River, Mbombela in Mpumalanga Province, South Africa: A Case Study

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Keywords
Wetlands, Alien Invasive, Assets, Clearing, Urban Area.

Article History
Received on 28th November 2022
Accepted on 25th December 2022
Published on 17th January 2023

Cite this article
Mafuwane, H. C., & Muchie, M. (2023). Biological Invasion Threat to Wetlands in Urban Areas of White River, Mbombela in Mpumalanga Province, South Africa: A Case Study. *International Journal of Students' Research in Technology & Management*, *11*(1), 01-10. https://doi.org/10.18510/ijsrtm.2023.1111

Abstract

Purpose: Wetlands are assets in the country, and they help make cities lockable and attractive. The study aims to assess the spread of alien invasive plants that affect the wetlands and construct a policy framework that could be used to preserve and conserve groundwater resources (Wetlands) in urban areas of Mpumalanga Province, specifically White River. This research will answer why alien invasives are a threat to wetlands.

Methodology: The study was conducted in White River on Longtom Street. A single observer conducted fixed-width line transect surveys to investigate species richness and abundance for all the untreated species detected next to the wetland. Three transects per habitat type were visited twice through twice per week.

Main Findings: During the survey, seven different alien invasive species were observed. The leading species was *Solanum mauritianum*, followed by *Chromolaena odorata* species; the third most dominant species was *Lantana camara* and *Tecoma stans*. Most species observed were illegally dumped by the residents that stay closer to the wetland, and no awareness, information, and training about the importance of wetlands were provided to the residents.

Implications: The framework can do more to help local communities manage urban wetlands, identifying opportunities for mapping and functional assessment to improve restoration and protection efforts. It can facilitate research and peer-to-peer exchange on innovative funding and financing methods for nature-based projects.

Novelty: Findings and recommendations resulting from this study will be summarized into a strategic guide by the end of 2023. It is recommended that all alien invasive plants in the wetland be eradicated. Wetlands must be protected to improve human health and well-being.

INTRODUCTION

South Africa is a water-scarce country, and approximately two billion people worldwide rely on groundwater for their water supply, irrigation for agriculture, and more. But a growing global population combined with climate change, pollution, and insufficient groundwater recharge leads to declining groundwater levels (Seward, Xu & Turton, 2015). South Africa has approximately 300,000 wetlands remaining, making up only 2.4% of South Africa's area. Of South Africa's 791 wetland ecosystem types, 48% are critically endangered, 12% are endangered, 5% are vulnerable, and 35% are least threatened to make wetlands the most threatened ecosystems in South Africa. Roughly 2.5 per cent of the earth's water resources are fresh water, and 30 per cent of the freshwater is present as groundwater (USEPA, 1993).

Regrettably, this small percentage of fresh water, especially groundwater, is threatened due to the rapid growth of population, increasing urbanization and unsustainable water consumption in domestic, industrial, and agricultural sectors (Mafuwane, 2019). Invasive plants are plants that humans intentionally or accidentally introduce into areas outside their natural habitat. Invasive plants are controlled by the National Environmental Management Biodiversity Act – Alien and Invasive Species regulations, which were gazette on 1 August 2014 and became law on 1st October 2014. (NEMBA Act, 2004). Under these regulations, invasive alien plants are divided into four categories: Category 1a Invasive species, which must be combatted and eradicated. Any trade or planting is strictly prohibited; category 1b Invasive species must be controlled and, wherever possible, removed and destroyed. Any form of trade or planting is strictly prohibited. Category 2 Invasive species, or species deemed to be potentially invasive, in which a permit is required to carry out a restricted activity. Category 2 species include commercially important species such as pine, wattle and gum trees and Category 3 Invasive species, which may remain in prescribed areas or provinces, such as jacaranda trees in urban centers.

Further planting, propagation, or trade is prohibited. These species can spread rapidly with negative significance for biological species. (www.invasives.org.za).

Invasive plant species have an impact on the diversity of local species. They affect water availability and damage the quality of soil nutrients. Once an alien plant has invaded a habitat, it changes the conditions of that environment. It changes the infested patches' light, solar radiation, and temperature levels. The quality and availability of food, shelter, nest sites, relaxing sites and rest are changed for several animals. Invasive alien plants are known for extreme water consumption due to their high transpiration rates. This poses a significant threat to water security, particularly in water-scarce areas like Mpumalanga province. The impacts are distressing during drought, and this is a substantial threat to

irrigated agriculture and animal watering. Alien invasive plants are now a serious threat to our wetlands. South Africa's wetlands and water catchments are vulnerable to invasion by many aliens' invasive plants. South Africa is classified as a chronically water-stressed country, with between 500 and 1000 cubic meters of water available per person per year. Numerous studies have been conducted in South Africa to measure the amount of water taken up by invasive alien plants. Invasive alien plants, once established and often with no natural enemies, usually multiply exponentially to the disadvantage of the native plants. Invasive shrubs and trees often grow faster and taller than the surrounding natural vegetation, especially in fynbos and grassland. As a result, the indigenous vegetation is often swamped and dies out

A wetland is defined in the National Water Act (Act 36 of 1998) as the land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the. The ground surface is periodically covered with shallow water, which land in normal circumstances supports or would. Wetlands come in many different forms. The Ramsar Convention on Wetlands of International Importance (1971) defines wetlands as areas of marsh, fen, peatland, or water, whether natural or artificial, permanent, or temporary, with water that is static or flowing, fresh, brackish, or salt, including areas of marine water the depth of which at low tide does not exceed six meters.

Although wetlands are often wet, a wetland might not be wet year-round. Some of the most important wetlands are only seasonally wet. Wetlands are the link between the land and the water. Water resources are a precious commodity. The rarer the commodity and the higher the demand, the higher the price will become. Without water, nothing can survive. The availability of water ensures economic and agricultural development, which in turn leads to job creation, economic development, and empowerment. It is, therefore, essential that this precious commodity be protected and conserved. To develop management strategies for the sustainable use of our water resources, it's necessary to know the cost and financial implications for our economy. Since 2004, more than 800 wetlands have been rehabilitated at the expense of about R500 million. Wetlands seem to be especially vulnerable to invasions.

The study's overall objective was to construct a framework to ensure the proper Monitoring of Wetlands as one of the vital water resources in Ehlanzeni District municipalities of Mpumalanga Province. Wetlands are ecosystems characterized by their vegetation (aquatic plants), their soils (formed during anaerobic conditions caused by being flooded or saturated with standing water), and, of course, their state of being primarily saturated with water seasonally or permanently. Examples of natural wetlands include bogs, fens, marshes, and swamps. Humans can also construct wetlands to collect stormwater runoff from urban areas to reduce the risk of flooding and avoid overwhelming municipal sewer systems during large rainstorms. The study will answer a few questions: Why are wetlands not looked after, and which species are mostly found invading the wetland? The study will come up with a recommendation to ensure wetlands are safe and clean

Wetlands are the most threatened ecosystem on earth, and we are losing them steadily. Significant threats to wetlands include land development, pollution (agricultural and otherwise), and the introduction of invasive species. Wetlands are areas where water covers the soil or is present either at or near the surface of the earth all year or for varying periods during the year, including during the growing season. Water saturation (hydrology) largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favour the growth of specially adapted plants (hydrophytes) and promote the development of characteristic wetland (hydric) soils. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Indeed, wetlands are found from the tundra to the tropics and on every continent except Antarctica.

Wetlands provide several ecosystem services, such as reducing erosion, recharging aquifers, and providing habitat for several wildlife species. Wetlands act as a natural sponge. When high rainfall events occur, surface water must go somewhere. Wetlands catch and slow down surface water flow and then slowly release the water, which significantly reduces the amount of flooding downstream. Since the water is slowed down, there is time for it to recharge groundwater and improve water quality because sediments fall out of the water column and nutrients are taken up by aquatic plants. Wetlands also act as bioremediation sites because they can remove pollutants from surface water. They are so good at this that they are sometimes used to treat wastewater. Wetlands do more than provide habitat for plants and animals in the watershed. When rivers overflow, wetlands help to absorb and slow floodwaters. This ability to control floods can alleviate property damage and loss and even save lives. Wetlands also absorb excess nutrients, sediment, and other pollutants before they reach rivers, lakes, and other water bodies. They are great spots for fishing, canoeing, hiking, and birdwatching, and they make excellent outdoor classrooms for people of all ages.

LITERATURE REVIEW

Groundwater is a critical renewable resource worldwide, valuable for human life and economic development. It constitutes a significant portion of the earth's hydrologic cycle and occurs in permeable geologic formations known as aquifers. These aquifers have a structure that can store and transmit water at rates fast enough to supply reasonable amounts of water-to-water wells. Groundwater's importance stems from its ability to act as an extensive reservoir of water, providing 'buffer storage' during periods of drought. In Kenya, all water resources are vested in the state. Water use is subject to approval, and permit issuing is controlled by the state However, groundwater is incorporated under broader water resource policy and institutional frameworks dealing with natural resources. According to the study

conducted by (Mumma, et. al. 2011), the different policy issues identified regarding the over-centralization of decision-making processes, inappropriate monitoring levels, and database were still present during the time of the assessment

Wetlands that encompass diverse and heterogeneous habitats ranging from lakes, estuaries, river flood plains, mangroves, coral reefs, and other related ecosystems seem particularly vulnerable to invasions. Even though 6% of the earth's land mass is wetland, 24% of the world's most invasive plants are wetland species (Zedler and Kercher, 2004). According to the United Nations' comprehensive Millennium Ecosystem Assessment, wetlands are one the most threatened ecosystems on earth. Because of the variety of harmful impacts that alien invasive species can have, the international theme for World Wetlands Day 2008, "Healthy Wetlands, Healthy People", seems unbelievable. According to one assessment of natural ecosystems, the dollar value of wetlands worldwide was estimated to be $14.9 trillion. (Costanza et al. 1997). This fact sheet summarizes some of the important ways in which wetlands contribute to the economy

Wetlands Ecosystem

Hernandez et al. (2015) provide a literature review on ecosystem services and carbon sequestration provided by wetlands. Two more authors supported the issue of ecosystem services (Mitsch, 2015). The papers aim at addressing the natural change in the wetlands landscape when accounting for soil carbon pools and fluxes. It can be noted that carbon confiscation in wetland ecosystems plays a vital role that benefits humans by mitigating climate change (Fisher & Turner 2008; Watanabe, 2011; Mitsch et al. 2013). However, using wetland as a tool to decrease climate change require quantification of this service.

According to studies conducted by (Costanza et al. 1997), wetlands are the most valuable parts of our landscape in ecosystem service assessments. The ecosystem unit estimators showed that wetlands, especially inland swamps and floodplains, were significantly more valuable than lakes and rivers, forests, and grasslands

A study conducted by Marois and Mitsch (2015) provides a literature review on the ecosystem services of coastal protection from tsunamis and cyclones provided by mangrove wetlands along tropical and subtropical coastlines of the world.

Wetland Communities and Ecosystems

Whittaker & Likens (1973) stated that the creation of oxidized root zones, and anaerobic respiration, allow wetland plants to remain productive under stressful conditions, making wetlands among the most productive ecosystems in the world. Because of the predominance of water and anaerobic conditions in wetlands, the organisms living there, especially rooted plants, often exhibit remarkable adaptations to deal with the stresses imposed by flooding. These adaptations include pressurized gas flow (Fig. 1). This high primary production, in turn, supports high secondary production rates that can exceed those of terrestrial ecosystems (Turner 1977).

Wetland and People and its benefits

In their study, Balwan & Kour (2021), the authors claimed that wetlands offer benefits that no other ecosystem can, even though they are often weak, disease-ridden areas. These include chances for enjoyment and aesthetic appreciation, flood protection, coastline erosion prevention, natural water quality improvement, and free access to genuine items. Our safety and welfare can be protected by protecting wetlands. The advantages of wetlands include: (i) conserve our water and keep supplies available during dry spells. Wetlands may prevent flooding, replenish groundwater, (ii) store our water to maintain supply during dry periods, (iii) prevent floods, and (iv) assist in erosion control.

Wetland Impact Factors

The Ramsar Convention has categorized wetland effect factors into twelve categories, which can be further separated into natural elements and human influences Natural system modification, land area impacts, human settlement and transportation environmental impact, human invasion and disturbances, mining and energy production, and the impact of biodiversity, which includes invasive and other problematic species as well as overuse of biological resources, are the categories into which human activities factors fall. Climate change is a natural phenomenon. (Ramsar, 2015).

Table 1: Impact of Alien Invasive plants on wetlands

Economic Impacts	Reduction in agricultural productivity, Reduction in livestock productivity, Disruption of ecosystem services, Reduction in land values, and hamper transportation; wetlands contribute to the national and local economies by producing resources Enabling recreational activities and providing other benefits, such as pollution control and flood protection.
Environmental Impacts	Ecosystem functions Impairment of water quality Alteration in nutrient cycling Change in habitat morphology Alteration in water flow decrease in water retention ecosystem structure Local or regional species extinctions Loss of biodiversity and reduced ecosystem stability
Social Impacts	Decrease in value of public amenities (tourism, recreation) Deleterious effect on public health and safety

Diagram of wetland ecosystem

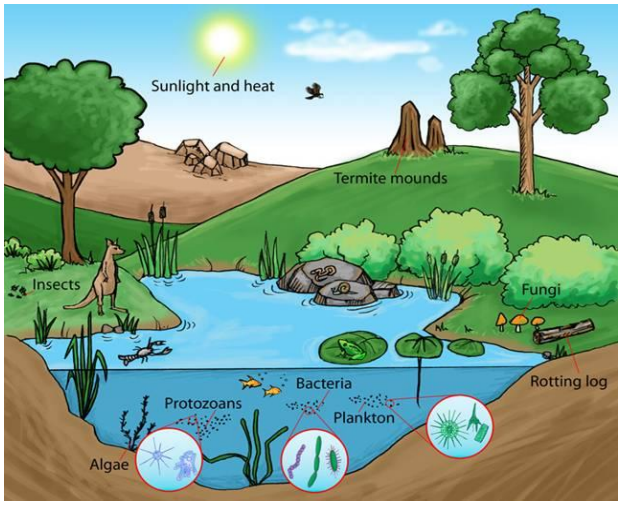

Figure 1: Drawing of ecosystem services (Yotova, 2018)

The concept of ecosystem services

M. E. A. (2005) divided ecosystem services into four categories: provisioning services (food, wood, fuel, water, and other tangible benefits, also known as goods), regulating services (regulation of biogeochemical cycles, including climate), supporting services (such as soil formation), and cultural services (aesthetics, cultural, recreational, and educational activities). Many fundamental services enabling individuals to live their lives include plants purifying the air and water, microbes breaking down pollutants, bees pollinating flowers, and tree roots stabilizing the soil to stop soil erosion.

MATERIALS AND METHODS

Study area

The study was conducted in White River on Longtom Street. Coordinates -25.3267580,31.0171970. White River is situated north of Nelspruit in Mpumalanga, South Africa. It is a trendy small town because it is 46 km from Hazyview, which is the most accessible access point to Kruger National Park. It has three dams and several nearby forests with many waterfalls are one of the largest Agricultural areas and produces tropical fruit, lowers and timber.

The wetland is situated in town next to the road from Nelspruit to Hazy view. Residents of White River use the wetland as their picnic area. In the present study, one (1) wetland less than 1 ha in size in White River Town is functional and healthy. The total extent of wetlands for the Wetlands occupies 1.4% of the geographical area of the town. Wetland area class >500 ha occupies a higher proportion. The study's overall objective was to construct a framework to ensure the proper Monitoring of Wetlands as one of the essential water resources in Ehlanzeni District municipalities of Mpumalanga Province.

Sampling method

A single observer conducted line transect surveys to investigate species richness and abundance for all the untreated species detected next to the wetland. The line transects run parallel to the other side of the stream channel that flows to the wetland for 500m and is conducted with fixed width sampling that extends for 50m on each side of the transect line to ensure independence. Line transects are frequently applied to assess abundance, distribution patterns and habitat preference. For this study, we used a fixed-width line transect because the sampling method was appropriate for surveying the narrow linear habitat of the riparian zone. Three transects per habitat type were visited twice through twice per week.

Technological inputs for Biodiversity data collection (Research Instruments)

For this study, Handheld GPS and Cell phones were used. The site survey notebook and pen were used to write about different species observed growing in and around the wetland. Binoculars were used for distant viewing and identification of mainly avian species found in and around the wetland. During the field survey, a sweep net was used for surface-dwelling species and quadrats for terrestrial floral and faunal species.

Species Distribution Data

The following section includes a table related to the impact, mode of spread, and growth form of invasive alien species within the White River wetland. It should be noted that the absence of a particular species in Table 2 (see after the reference list) does not necessarily signify the lack of species from that area. The data presented is according to records at this stage, which may be particularly weak from several species that may have recently invaded the area and therefore have not been recorded on the database list.

FINDINGS

The leading species was *Solanum mauritianum*, followed by *Chromolaena odorata* species; the third most dominant species was *Lantana camara* and *Tecoma stans*. During the study, we noticed that most species observed were illegally dumped by residents who stayed closer to the wetland. It has been proven that the residents did not receive awareness, information, and training about the importance of wetlands. The issues and the seriousness of wetland invasion and their consequences to wetlands, people and biodiversity were not addressed to the residents; hence people are still doing illegal dumping.

It is necessary to strengthen the public's awareness of wetland resources protection and resource distress through education, enhance the awareness of wetland protection among global citizens, and expand wetland protection to the global scope. We have noted that municipal by-laws are not implemented in White River since there is a lot of illegal dumping and pollution next to the wetland.

RESULTS AND DISCUSSION

Currently, a total number of 7 different alien invasive species found in the catchment of the wetland were recorded for this study. All alien invasive plants recorded were untreated. The number of *Solanum mauritianum* plants counted was 56, the number of *Tecoma stans* counted was 46, the number of *Ricinus communis* plants counted was 13, several *Lantana camara*, garden 22 plants mother-in-law tongue plants 23. The most dominant species was *Solanum mauritianum*, where 32 plants matured, and 24 plants were young.

Municipalities and Governments department should recognize the severe impact of Invasive alien species in the country and the issue of water shortage and have control plans for alien invasive plants in the wetland as wetlands serve as assets to the country. The NEMBA regulation states that landowners must be responsible for managing their land. Governance involves much more than the ensemble of government frameworks. It includes multiple and overlapping governance systems, with the private sector, civil society, and sub-national and local levels all engaged in making decisions about their interests.

There is a widespread assumption that governments are the central actors in governance. Still, a more profound look shows that government is often an instrument, both of its own and others' interests, rather than playing the role of objective arbitrator.

The theoretical framework of the study

The study's theoretical framework is based on the study conducted by Hatfield and Dold (2019), who conducted a similar study. The regulatory framework for ensuring the proper monitoring of wetlands as an essential water resource was assessed using a composite index developed by Hatfield and Dold (2019). The framework has been adapted to the South African situation to ensure relevance to the study.

The framework considers the need to address all relevant technical requirements. Based on findings obtained from the study, the following framework has been constructed to ensure the protection of the Wetland in White River, Ehlanzeni District municipalities. The framework is inspired by the research work done by (Gleeson, et.al. 2012). The framework is suitable for the needs of White River and the City of Mbombela.

Based on results obtained from the study, the following 7-point framework or guideline is recommended to residents of White River Mbombela and local municipalities to preserve and conserve water resources at Ehlanzeni District municipalities.

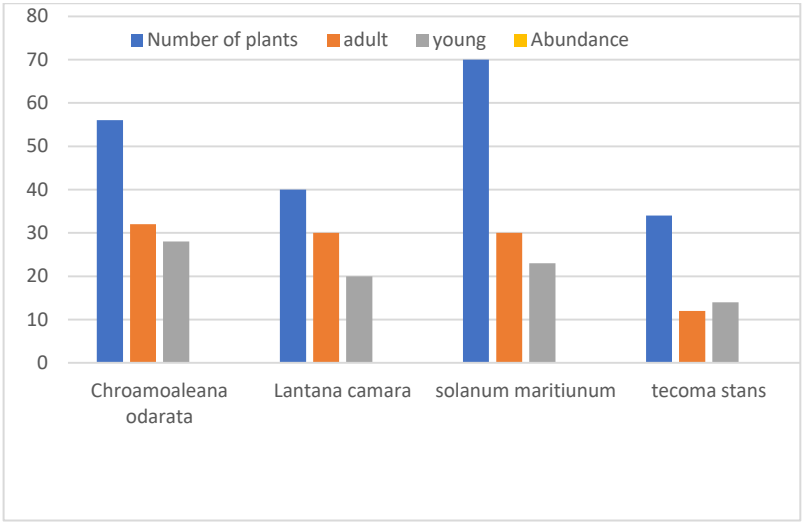

Figure 2: Diagram showing the number of species per class Identified at White River wetland

Regulatory Framework

Figure 3: Regulatory Framework (developed by author)

Management of alien invasive plants in White River wetland

There are several control methods for alien invasive plants: Mechanical Control, Chemical control, and biological control. Fire can be another method to suppress the spread of alien invasive plants. There is a need for the municipality to appoint a clearing team to tackle the alien invasive plants that occur in the wetland since they have an impact on water consumption and the impact of spreading fire. The density estimation of alien invasive plants in White River areas dumped is 70 per cent. Some species have reached maturity, while others are at the seedling stage. The challenge that the wetland has been exposed to is that it is impacted by the Invasive alien plants (ornamentals) that residents are dumping.

RECOMMENDATIONS

Based on findings from the study, the following recommendations are made to the Ehlanzeni Municipality to improve the viability and value of Wetlands in White River in Mpumalanga Province. The recommendations can potentially improve the value of wetlands in the region. It is recommended that a clearing team be appointed to do continuous follow-up clearing of all the alien invasive plants in the upper stream and surrounding the wetland. Awareness should be raised among the residents of White River to ensure every member knows the impacts of alien plants on wetlands. If municipalities are to succeed in the future, more emphasis and effort will need to be spent on issues relating to biological invasions.

Any program's long-term success or failure will require long-term sustainability, both ecological and economical. Careful integration of the most appropriate control methods will be needed to ensure that invasive species management is integrated into protected area management as one of the critical issues. Municipal By-laws should be implemented within the Mbombela municipality. It is also recommended that municipal officials do all continuous monitoring to check if all alien invasive plants are eradicated and that no illegal dumping is done in the wetland. Scientific research on wetland protection and restoration is still lacking and should be encouraged and developed. Scientific research can improve wetland management and protection to a higher level. Scientific research on critical wetland protection and restoration technologies should be carried out to serve large-scale ecological restoration projects of wetlands.

Research and monitoring for identifying the underlying mechanisms responsible for invasiveness and invisibility. The departments responsible for alien invasive management must ensure that they write scientific papers about alien invaders impacting the wetlands. Prediction and Quarantine, developing a predictive framework for potential invaders to prevent and limit their spread. Policies and Legislation their developed and implemented for the management of biological invasions. Launch wetland protection activities on World Wetland Day, Bird Week, Wildlife Protection Month, etc. Publicize wetland protection awareness through the media; establish a wetland science education base in the wetland reserve and add relevant knowledge of wetland protection to primary school textbooks.

CONCLUSION

The study's overall objective was to construct a framework that could ensure the proper monitoring of Wetlands as one of the essential water resources in Ehlanzeni District municipalities of Mpumalanga Province. This wetland is on the inventory database of the City of Mbombela, which was collected and stored last year to give information on the wetlands found in Mbombela and their use. For continuous planning and management, it is necessary to assess the changes in the water bodies from time to time and monitor the species that grow along and inside the wetland.

More research about the wetland ecosystem and the impact of alien invasive on the wetland must be conducted. Remote sensing and GIS techniques allow natural resource inventories to be completed promptly with greater accuracy and provide a database for storing, manipulating, and displaying spatial data often missing in traditional inventories. Future studies applying technology must be conducted to check further challenges affecting wetlands' function. Data on alien

invasive plants in the White River wetland will be stored in SAPIA. Finally, a new science, Wetland Science, can be developed in universities or scientific research institutions in the regions where wetland science research is relatively backwards or lacking, attracting more scholars to participate in wetland conservation research.

There is a need for Limnological studies to be conducted. Water samples were collected from White River wetlands during the survey to be analyzed for water quality like pH, color, alkalinity, and magnesium. Chloride calcium, heavy metal and the mean were calculated for another research.

ACKNOWLEDGEMENTS

The authors are grateful to (i) The Tshwane University of Technology, Industrial Engineering Division, and (ii) NRF funding for sustained support for ecological research.

CONFLICT OF INTEREST

The authors declare no conflict of interest in any aspect of data collection, analysis, or the preparation of this paper.

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Table 2: Impact, mode of spread, and growth form of invasive alien species within the White River wetland

Name of species	Growth form	Category	Place of Origin	Mode of spread	Family	Impact
Campuloclinium macrocephalum (Less.) DC	multi-stemmed shrub	1b	Tropical Americas, in Argentina and Honduras	Birds, Wind, people	Asteraceae	The plant is a serious threat to the conservation of grasslands in South Africa. This invader causes serious degradation of the veld, lowering the biodiversity and reducing the grazing capacity by

						being unpalatable to large herbivores. Infestations: become conspicuous when the plants are in flower between December and March, transforming the veld from green to pink.
Tecoma stans	Shrub	1b	Southern USA, Mexico, the Caribbean, Peru, and Ecuador	Birds, Wind, people	Bignoniaceae	It invades forestry, Roadsides, and conservation
Lantana Camara	Shrub	2	Native to Mexico, Central America, the Caribbean and tropical South America	Birds, Wind, people	Verbenaceae	Lantana camera reduces the biodiversity of natural ecosystems. Dense stands in plantations obstruct access and utilization. This plant is poisonous to humans and animals and responsible for livestock mortalities that amount to millions of Rands annually in South Africa. It also reduces the grazing potential of the land.
Solanum mauritianum	Shrub	1b	Native to South America (Brazil, Uruguay, and northern Argentina	Birds, Wind, people	Solanaceae	This invader also competes with young trees on plantations, mainly pines and black wattle, inhibiting growth and causing stem deformation.
Chromolaena odorata	Multi-stemmed shrub	1b	South-eastern USA, Mexico, the Caribbean and tropical South America	Birds, Wind, people	Asteraceae	Chromolaena odorata likes disturbed areas; it can also invade natural habitats subject to minimal disturbance. It causes fire due to its leaves.
Eichhorniacrassipes		1b	native to the Amazon River basin of South America	Birds, Wind, people	Pontederiaceae	Water hyacinth is one of the world's worst aquatics weeds due to its invasive potential and negative impact. On aquatic ecosystems, and

						the high rate of costs to control it. This invader forms dense mats that cover entirely dams' water surface, leading to altered water chemistry and composition to the detriment of other organisms. Adverse effects associated with water hyacinth infestation include the destruction of local aquatic biodiversity, the blockade of river flows which may aggravate flooding and interference with water utilization for activities like recreation or irrigation