# WETLANDS

## Novel study looks at ecosystem services provided by palmiet wetlands

*An investment in palmiet wetlands is also an investment in the benefits society derives from these unique 'ecosystem engineers', according to new research.*
*Article by Jorisna Bonthuys.*

*All photographs courtesy Alanna Rebelo*

Dr Alanna Rebelo recently received a joint PhD degree from Stellenbosch University (SU) and the University of Antwerp in Belgium on this topic. Her thesis, titled 'Ecosystem services of Palmiet wetlands: The role of ecosystem composition and function', considered the benefits palmiet wetlands hold for ecosystems and people in South Africa. The research was funded by the National Research Foundation and the Department of Science and Technology, among others.

Of all ecosystems, wetlands are considered to be one of the richest in terms of ecosystem services provided, yet the complexity of wetland ecology has resulted in them being the least studied. These 'services' are defined as the benefits that humans derive from nature.

"Many people have heard of palmiet, but do not know what a valuable wetland plant it is and what ecosystem services it supplies to society," says Dr Rebelo.

Currently, South African wetlands and associated river systems are in a critical state, with over 65% reported to be damaged, and 50% estimated to have been destroyed. There is also increasing concern about wetland loss and degradation. Despite the inherent value of palmiet wetlands and their threatened status, there is no comprehensive understanding of where they remain and what the main drivers of change are.

Dr Rebelo's study involved a systematic literature review, fieldwork, mapping and remote-sensing techniques (using satellites). She selected three palmiet wetlands in different catchments for fieldwork: the Theewaterskloof and Goukou wetlands (Western Cape) and the Kromme wetland (Eastern Cape). Despite being situated as much as 470 km apart, these wetlands are remarkably similar in vegetation composition.

Some of her main findings can be summarised as follows:

- Palmiet wetlands have decreased by 31% since the 1940s.
- Severe channel erosion in palmiet wetlands has changed water and soil quality, and caused a shift in plant communities.
- Relative groundwater depth and soil pH are the only abiotic parameters that differ among different wetland plant communities.
- Functional groups and even species in palmiet wetlands appear to be spectrally distinct, and
- Palmiet wetlands provide valuable ecosystem services to society, particularly the sequestration of carbon, water purification and flood attenuation.

Palmiet wetlands are valuable natural assets because of several factors, the research shows.

**Valuable 'ecosystem engineers'**

Palmiet grows in two main habitats: bordering mountain streams and forming dense monocultures in valley-bottom wetlands. Here, these wetlands have formed on steep slopes that produce high energy runoff during flood seasons.

These wetlands are subject to extreme water stress caused by soil saturation, water table fluctuations, floods, droughts and fires. It occurs where it should be impossible, possibly due to physiological adaptations through which it provides ecosystem services to society. This includes dense rootstocks, high leaf surface area and clonal growth.

"The proposed ability to transform this stressful environment into a habitat beneficial to itself and other species is why palmiet is thought to be an ecosystem engineer," Dr Rebelo explains.

Palmiet is adapted to both fire (thick stems) and floods (long, thin leaves and flexible shoots). "These and other unique adaptations of palmiet translate into ecosystem services for society," she explains.

"The question is, how did these (palmiet) plants originally come to survive in these conditions? We know that when these wetlands are degraded and the vegetation lost or removed, it is extremely difficult to restore them. During the restoration of the Berg catchment, it has been almost impossible to try and get palmiet to re-establish in the degraded river channel. So how did these dense, valley-bottom wetlands come about?"

Dr Rebelo's novel research methods enabled her to spectrally discriminate palmiet wetland species and functional groups by using satellite techniques, among others. "I was surprised to find such strong correlations between palmiet wetland species and functional traits like leaf area and nitrogen content," she says.

In relation to the patchy appearance of palmiet wetlands as a result of different plant communities, Dr Rebelo identified soil pH and relative groundwater depth as the main environmental parameters explaining these patches. "This finding was surprising, seeing that I had expected major differences in soil structure and chemistry between these communities," she says.

Soil pH was higher for palmiet communities, whereas relative groundwater depth tended to be closer to the surface but more variable for fynbos communities, and deeper below the ground for palmiet. Yet, it is not clear whether these abiotic conditions are driving vegetation patterns, or whether the vegetation is causing these local differences through differences in transpiration and photosynthesis.

To answer this question Dr Rebelo developed three possible alternative theories for these vegetation dynamics, based on evidence from her thesis and work by other wetland scientists, including Prof Fred Ellery from Rhodes University. The first two theories are related to autogenic succession (competition for niche space), which suggests that palmiet plant communities change through time from a pioneer community to a climax one (through processes like competition). The third theory suggests that there is no succession, but rather that all communities within palmiet wetlands are mature plant communities.

"These theories also help us to understand how palmiet wetlands may have formed in such high-energy, steep catchments, and how they may be able to recolonise after natural rates, intensities and scales of repeated cut-and-fill cycles (gully erosion)," says Dr Rebelo. "However, once human impacts accelerate the rate, scale and intensity of these natural processes, it is clear that palmiet valley-bottom wetlands cannot cope, and soon collapse into another, less desirable, alternate stable state."

**Key natural assets**

The value of palmiet wetlands in terms of water purification (among other ecosystem services) has been overlooked in favour of their potential for food provision, says Dr Rebelo. Their position in strategic water-providing catchments, combined with their ability to accumulate peat, delivers key ecosystem services to society.

As peat forms, carbon is trapped from the atmosphere and stored in these wetlands. This is an ecosystem service of national or global importance, Dr Rebelo explains. "Although palmiet wetlands only make up a tiny percentage of the country's surface area, their restoration and protection are critical in terms of climate change mitigation. When these wetlands erode away entirely, we are talking about the loss of about 5 000 years' worth of carbon storage, which is certainly significant."

Palmiet wetlands perform functions that human-made infrastructure would find very hard to replicate, she says. Water leaving healthy palmiet wetlands is also of high quality. "Pristine wetlands provide about 16 times higher flood attenuation compared to degraded wetlands, according to estimates. These and other findings highlight the value of palmiet wetlands, making a case for their conservation and restoration."

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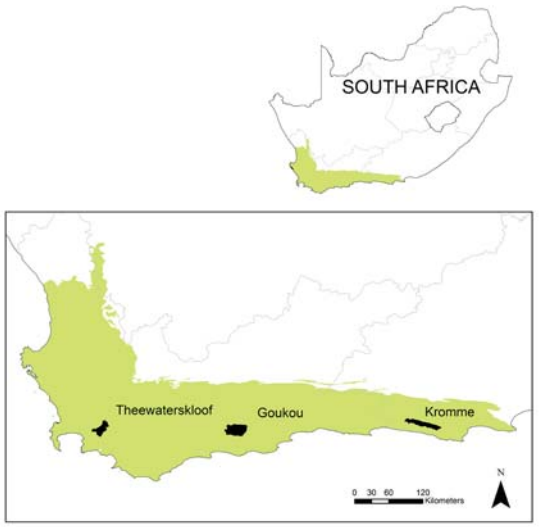


*The palmiet wetland areas included in the study.*

*"The proposed ability to transform this stressful environment into a habitat beneficial to itself and other species is why palmiet is thought to be an ecosystem engineer."*

Yet many of these palmiet wetlands have been ploughed up for agriculture, either for orchards or grazing. The remaining wetlands are threatened by a plethora of problems, including land-use change (for agriculture), pollution (from agricultural runoff), invasion by alien vegetation, extreme flood events (climate change), and inappropriate fire regimes.

"Using these wetlands for agriculture is not compatible with the supply of other ecosystem services, most notably clean water," Dr Rebelo says. "Ultimately, the resulting wetland degradation is neither beneficial to farmers nor downstream beneficiaries or stakeholders.

"When we consider the ecosystem services provided by South African palmiet wetlands, we need to ask ourselves: can we justify the true cost of development, in terms of continuously expanding and intensifying agriculture?

"No human-made infrastructure beats a palmiet wetland in terms of the services that it provides to society. How would we decrease flood force? How would we clean the water? All the 'traditional' solutions like dredging a channel and building water treatment plants are expensive and drastic (changing the hydrology of the catchment permanently) and require costly maintenance. However, we also cannot eat palmiet (or we can – traditionally, some South Africans did – but we don't use it as a food source today). There needs to be a compromise.

"Either we continue to destroy these wetlands and convert these small narrow valleys into agricultural landscapes with fields and canals and berms. Alternatively, we prioritise the protection of the wetlands, and only farm around the wetlands, away from the frequently flooded zone, making sure the agriculture is compatible with protecting the wetlands (low fertiliser and pesticide use). Given their value, it would make more sense to protect these water-providing systems, and focus our farming activities elsewhere more profitable, in less challenging and valuable landscapes."

Arguably, one of the most pressing threats to palmiet wetlands is gully and channel erosion due to headcuts that undermine existing peat beds. Any disturbance to wetland vegetation, such as vegetation removal for agriculture, a road or railway crossing intersecting the wetland, can cause a knick-point whereupon erosion acts. These headcuts can be 3-5 metres deep and several metres wide in places. This represents a substantial amount of sediment loss that cannot be replaced.

"These systems are extremely flashy, meaning that a huge amount of water moves through the valley-bottom during flood events, providing a great deal of energy for erosion," says Dr Rebelo. "It is important to note that this erosion is a natural process. It is even thought that gully erosion plays an important role in palmiet wetland development. However, it is the acceleration of this natural process by anthropogenic activities that becomes problematic.

"It is hard to halt, it decreases water quality, causes sedimentation of dams and may result in a lowering of the water table," Dr Rebelo explains. "This perpetuates the cycle of degradation and can render adjacent agricultural land unusable."

The food versus water, carbon and biodiversity trade-off is something that policymakers and land-use planners need to consider. This is especially in light of the new research on strategic water source areas by the CSIR, she points out. These strategic water source areas are the main sources of the water that feeds our major rivers and urban hubs. They make up only 8% of the country, but capture and supply 50% of our runoff. Palmiet wetlands fall into these critical areas. Some are situated upstream of important dams for large cities, including the Theewaterskloof and Churchill Dams, which provide water for Cape Town and Port Elizabeth.

Dr Rebelo recommends that policy mechanisms change to support landowners who are currently incentivised to produce one ecosystem service (mainly food production) to optimise other ecosystem services, including water provision, purification and carbon sequestration.

*"Municipalities could save millions of Rand spent on water purification each year if farmers were not damaging the upstream wetlands."*

With a decline in governmental support for conservation within and outside protected areas, more pressure is also needed to create innovative solutions for endorsing and financing conservation, she argues. "Landowners cannot afford to simply not farm," she says. "It is clear they would need financial support to provide other ecosystem services, to become landscape managers, and thereby protect palmiet wetlands, our critical ecological infrastructure.

"The remaining palmiet wetlands should be bought out (and placed in nature reserves), or payments for ecosystem services schemes should be set up. Such plans could enable farmers to become managers of ecosystem services and to be paid to maximise (or 'farm') these ecosystem services. These options would be appropriate in different situations and depend on factors like landowner willingness and the state of the wetland."

An example could be water purification and sediment retention. Polluted water and sedimentation are two of the most significant threats to dams (water impoundments) in South Africa. With agriculture destroying these wetlands, especially in the Kromme (Churchill Dam), there is increased sedimentation that reduces the lifetime of the dam, as well as a decline in water quality that costs the municipality millions of Rands monthly to treat.

There is the potential for working together in water-providing catchments. Ecological engineering ('soft' solutions) can also be used rather than constantly turning to expensive 'hard' solutions (like chemicals to improve water quality and dredging). At the very least, wetland management should complement traditional engineering solutions (municipal dams, water treatment works), the research highlights.

"Municipalities could save millions of Rand spent on water purification each year if farmers were not damaging the upstream wetlands," Dr Rebelo says. "This is not to mention the cost once the dam is full of sediment."

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**More about palmiet wetlands**

- Palmiet wetlands get their name from a wetland species called 'palmiet', ***Prionium serratum***.
- Palmiet is a peat-forming plant with unique properties enabling it to survive in high-stress valley-bottom environments throughout the Cape Floristic Region.
- Palmiet wetlands provide many essential ecosystem services to society, particularly water regulation, water purification and climate regulation.
- Palmiet wetlands that have high-quality peat are usually almost permanently wet, and decomposition cannot take place, or takes place very slowly, leading to $CO_2$ being trapped. As palmiet wetlands become degraded, peat dries out, and its quality decreases as decomposition take place.
- Agricultural practices threaten many palmiet wetlands, yet agriculture in these wetlands is marginal due to the challenges of farming a system that experiences severe floods and droughts.

One successful example of this strategy highlighted in her study is that of the Catskill catchment in New York, where holistic farm planning was developed as an attempt to decrease pollution of the watershed. In this system, farmers were incentivised to pollute less by having their operational and capital costs of investment into pollution control covered by the City of New York. Through collaboration, cost efficiency was achieved, and private as well as social benefits realised.

"Prevention is always better than cure, and in the case of damage to palmiet wetlands, the cure – ecological restoration – is extremely expensive," she concludes.