TECHNICAL BRIEF

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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

The unintended consequences of various alien plant removal methods on riparian ecosystems

A Water Research Commission (WRC) study has been completed on assessing the impacts of selected methods on removal of invasive alien and invasive plants in the Western Cape.

Study overview and rationale

Management of alien invasive plants are a major challenge in South Africa, especially in the fynbos biome. Riparian environments are especially vulnerable as the linear nature of these ecosystems make invasion more prevalent, and also make management more challenging due to the dynamic nature of flowing waters.

Various approaches to clearing and managing subsequent biomass accumulation are practiced, however, the nature of these interventions may in itself impact negatively on ecosystems. An example is herbicide application, which, in various contexts has led to altered soil microbial population.

Another example is removal of dead biomass through combustion of stacked slash (slash piles). Burning of slash piles have been shown to lead to scars that remain in the landscape for long periods, as well as altered soil physicochemical properties.

Loss of soil seedbanks which are destroyed during high intensity fires may be one reason for the lack of recovery of burn scars, while the altered physico-chemical properties of the soil may be another factor that may hinder the establishment of the vegetation.

Furthermore, removal of biomass off-site may also impact riparian ecology in terms of nutrients lost in woody and foliar biomass (the latter may be suspended and removed by floods following hacking of invasive trees). The result is that the recovery could be uneven, or delays may occur in the recovery of native vegetation following removal. There have been many reports detailing strategies to prioritise alien invasive clearance that details the impacts of alien species on water resources and the recovery for example, the streamflow post-clearance as well as many different studies on methods and protocols for alien clearance, both in terrestrial and riparian ecosystems.

These latter studies usually focus on the most effective ways to clear, remove and restore ecosystem properties such as plant species composition and structure, but less so on ecosystem functioning and processes. Little is known about the responses of soils and soil biota to invasion and clearing in South Africa, or, indeed whether these ecosystem processes also recover spontaneously following clearing or with active restoration.

Without a detailed understanding of the ecology of riparian zones and the consequences of various interventions including clearing and subsequent actions, desired outcomes for restoration may not be achieved. The overall aim of this study was to understand the impacts of clearing methods on soil processes, including biota changes, chemistry or nutrient status on selected Western Cape rivers.

Study area

Four ***in situ*** sites were selected, two of which were dominated by ***Acacia mearnsii*** and the other two by ***Eucalyptus camaldulensis*** along the catchments of the Breede River and Wit River in the Western Cape. The areas chosen for experimentation consisted of dense stands of ***A. mearnsii*** and ***E. camaldulensis.***

This meant that the soil samples taken were representative of soils invaded by ***A. mearnsii*** or ***E. camaldulensis*** and not of an uninvaded soil where only native plant species were present. Additionally, the sites had to be within the vicinity of a river, but at the same time not too close to the river so that herbicide spillage into the river could be prevented.

Other experiments were conducted *ex-situ*, in the university gardens.

Results

Soil available nitrogen is important in riparian fynbos as it is especially limited in the soil-matrix. Indigenous fynbos plant species have adopted specialised mechanisms for acquiring this limited nutrient in a form that is soluble and ready for uptake

Total available N for soils before and after herbicide treatment took place at the Alfalfa A site. The soil available nitrogen is shown across the three different herbicide concentrations (0% and 100% of the recommended WfW concentration). The point represent the mean and the whisker the standard error.

The soils subjected to treatment of Glyphosate and Triclopyr at the Alfalfa A site displayed no significant effect of the herbicide on the total soil available N (One-way ANOVA: F=0.40 and p=0.68 and F=0.05 and p=0.96). The total N in the soil remained fairly stable from pre-treatment to post-treatment, and ranged between 12 and 24 N-µg g^{-1}. There is a slight increase in the total N when applying the Fluroxypyr and Picloram herbicide at a 100 % concentration.

The excess AIP biomass should be sold or used on secondary markets such as bio-energy and timber. Alternatively, when there is no secondary market or the site is inaccessible, the excess biomass may be burnt on site, often through the process of burning of slash piles. This process might be effective in destroying IAP biomass, however, it also exposes the soil and surrounding environment to higher temperatures than those of natural wildfires, leading to short, medium or long term changes in soil chemical, physical and biological properties and thus the inability of the surface soil to establish and support vegetation.

The level of damage to soil depends on fire severity, which is influenced by several factors, including microclimatic conditions and the amount of wet or dry fuel available. Fire would have its greatest impact on the soil surface and less impact as distance into the soil profile increases.

Mean values are shown by different point symbols and vertical bars indicate ± 95% confidence intervals. Letters indicate significant differences between means (Bonferroni tests, p<0.05).

At all study areas, available N was not immediately affected by burning of slash piles. Contrary to findings of this study, available N has been reported to increase after fire which has been attributed to increased N mineralisation resulting from fire-induced changes in soil temperature, soil pH and microbial activity.

On occasion, available N (NH_4^+-N) has been shown not to significantly change on burnt soils However, at Rawsonville (*Acacia*-invaded) within 6 months after burning, available N levels within the burn scar became higher than the non-burn treatment sites and continued to increase towards the end of sampling.

Conclusions and Recommendations

Programmes such as the Working for Water programme and other aligned programmes have, with the help of a large ecological research effort, managed to go some way towards addressing the challenge of woody alien invasive plants in terrestrial and riparian ecosystems in South Africa.

Though alien invasive trees are still spreading at an alarming rate, the strategic intervention of the WfW programme in catchments has prevented to loss of water associated with stands of alien invasive trees, and has also allowed rural people to attain a certain dignity that comes with being employed and earning an income, as opposed to grinding poverty that lack of employment confine South Africa's poor and vulnerable population to.

The benefits of the WfW and its approaches to removing and managing alien invasive trees are obvious. However, literature suggest that use of herbicides, fire and removal of biomass may have some consequences for ecosystem functioning. Application of herbicides to cut stumps ***in situ*** and to soils ***ex situ*** changed soil pH significantly, with major declines seen at levels typically applied in the field, and stronger declines seen with increasing concentrations. In addition, soil nitrogen levels increased significantly with the application of Glyphosate.

Soil microbial populations were not affected in a major way, however, as has been shown in several studies, alterations to soil pH may ultimately impact soil microbial populations, and also processes supported by soil microbes. In addition, the study covered soil microbial community responses in the short term, and these results cannot be extrapolated to longer-term microbial responses to herbicide applications. Soil pH was also one of the main soil properties that changed following burning of slash piles in riparian soils. Surprisingly, soil pH did not return to pre-fire levels even up to one year after the fire. Other impacts were also seen, notably in terms of soil pH and cations, which increased following fire, but returned to pre-fire levels one year after the fire.

No major differences were evident when comparing the riparian sites to a terrestrial site. Interestingly, soil available N was unaffected by the fire, until some months afterwards, when scars where ***Acacia mearnsii*** slash was burned showed high available N compared to non-burned areas. This implied that P levels are more available initially, but that N levels in burned areas may only become more available over time, and then only in burn scars where ***Acacia*** biomass was burned.

It may be possible the difference between the two categories (***Acacia*** and ***Eucalyptus*** slash plies may be related to the size of the pile and the size of the main members, which may induce hotter fires in the case of ***Eucalyptus camaldulensis***, however, this was not determined in the study.

This may also be the reason why the study showed that burning of slash piles of ***Eucalyptus*** biomass has a more profound impact on the microbial diversity and community structure than burning of slash piles of ***Acacia mearnsii*** biomass. All the sites indicated a microbial community shift after the effect of fire, which may be directly due to mortality of microbial population and a lag phase in recover, as well as indirectly due to altered soil properties such as pH and soil phosphorus.

These alterations in physicochemical and microbial dynamics may also influence regeneration and survival of seedling established on the burn scars. The invasive species ***E. camaldulensis*** responded very fast in terms of germination when planted in burned soil, but soil nutrient deficiencies or toxicity may affect survival of species growing in burned soil during the seedlings phase. While some information is available on slash and burn of alien invasive trees in relation to regeneration post fire, it is the first time that a study has specifically investigated the soil chemical and microbiological changes subsequent to burning of slash piles, hence suggestion that the negative impact of this practice need to be carefully traded off against other benefits.

The alternative to biomass management though burning in the form of stacks on site is removal of whole wood or chips that are removed to local or international destinations. Several models were developed that can be used to determine which nutrients are exported and in what quantities, and different models were derived for free-standing trees and trees in dense stands. These models are the first to be developed for biomass and nutrients stocks in invasive stands of ***A. mearnsii*** and ***E. camaldulensis***.

Some suggested further studies are recommended before the impacts of different AIP control methods can be changed, such as:

- The medium to longer term fate of soils within burn scars should be investigated given the potential impact on soil microbial and soil functioning.
- Improving our understanding of competitive interactions between native and invasive seedlings in cleared landscapes and how these are affected by altered soil chemical and microbial properties could also be a good topic for future research.

Related project:
Assessing the impacts of selected methods on removal of invasive alien plants in the Western Cape (**WRC Project No. K5/2343**). Contact Publications at Tel: (012) 761 9300;
Email: orders@wrc.org.za or Visit: www.wrc.org.za.