Options for Invasive Grass Management in the Nieuwoudtville Wildflower Reserve

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By

Simon Todd

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Background

The Nieuwoudtville Wildflower Reserve is heavily invaded by alien annual grass species, reducing the conservation and tourism value of the Reserve. Current management practices do not appear to have been effective in reducing the abundance of alien grasses despite the fact that management actions have been directed specifically at reducing these species. This report reviews the various management options that have been shown to reduce the abundance of alien grass species elsewhere, and discusses the likely potential and practicality of these various options for the Nieuwoudtville Wildflower Reserve.

Important Alien Grass Species within the Reserve

There are several vegetation types within the Reserve, which have been mapped and described in detail by Todd (2008). The majority of the different alien grass species present in the Reserve are ubiquitous and occur to a greater of lesser extent within all of the different vegetation types present. Currently, at least ten alien grass species have been identified, these are listed along with the environments they dominate in Table 1. On a whole, the most important species in descending order of importance are: *Avena fatua*, *Bromus diandrus*, *Lolium rigidum* and *Hordeum murinum*. Some of the other species present such as *Brachypodium distachyon and Vulpia myuros* are numerically equally abundant, but are smaller plants and do not appear to negatively impact the ecosystem to the extent of the larger species.

Snijman and Perry (1987), who conducted a complete botanical survey of the Reserve recorded only four of the species listed in Table 1. It is unclear whether the additional species listed here were not present in the Reserve at the time of the survey or if Snijman and Perry simply ignored these species as they were alien. This latter scenario seems unlikely given the comprehensive nature of the survey and the inclusion of the other alien species in their list. This suggests that the alien grass problem has become worse during the 20 years since the survey of Snijman and Perry and that additional species have invaded the area.

Table 1. The alien grass species that have been identified within the Nieuwoudtville Wildflower Reserve and the environments in which they are most commonly found.

Scientific Name	**Common Name**	**Distribution**
Avena fatua	Wild oats	Dominates dolerite plains and old lands. Common in Tillite Renosterveld in places.

Brachypodium distachyon	Stiff Brome	Dominant in places in the Dolerite Koppies. Common on Dolerite plains.
Bromus diandrus	Ripgut Brome/ Predikantsluis	Very Common in Tillite Renosterveld and Dolerite Koppies.
Bromus pectinatus	Japanese Brome	Occasional in all environments.
Bromus rigidus	Rigid Brome	Occasional in Dolerite Koppies.
Lolium rigidum/multiflorum	Annual Ryegrass	Dominant in wet areas between the Dolerite Koppies.
Hordeum murinum	Wild Barley	Dominant in disturbed places between the Dolerite Koppies.
Phalaris minor	Canary Grass	Occasionally dominant in moist places between the Dolerite Koppies.
Stipa capensis	Common Awn Grass	Occasional in the Dolerite Koppies.
Vulpia myuros	Rats Tail	Common in the Tillite Renosterveld and Dolerite Koppies.

Processes Driving the Dominance of Alien Grass Species

It is not possible to discuss the alien grass problem without addressing the root causes of the dominance of these species. Overwhelmingly, the dominance of alien grass species in the Reserve and the Nieuwoudtville area in general is related to current and past disturbance patterns. In the Reserve this pattern is clearly demonstrated by the dominance of alien grass species in those areas that have been ploughed previously as well as those areas that have experienced high animal activity such as old kraal sites and watering points. Nutrient enrichment associated with these sites appears to promote the long-term persistence of the grasses irrespective of current grazing practices.

The current management practice of grazing the Reserve annually with a large flock of sheep for approximately a month during late summer does not appear to have been very effective in decreasing the abundance of alien grass species. This failure appears to be driven by certain properties of the Reserve itself rather than an inherent flaw of the management practice. A single late summer grazing was successfully employed on Glen-Lyon to manage the small reserve area at the entrance to the farm which served as one of the main flower viewing areas. This area remains in good condition and is dominated by a diverse mix of indigenous shrubs, perennial grasses and geophytes. The failure of the same management practice in the Reserve can probably be ascribed to the fact that the Reserve is made up of several different veld types as well as to its size. The presence of widely different soil types as well as previously ploughed and fertilized areas has a large effect on the nutrient content of the vegetation in these different areas and consequently also affects the way that sheep utilise the area. As a result of these patterns it is likely that certain areas in the Reserve are very heavily utilised during grazing events, while other areas are little utilised. Similarly, sheep are highly selective foragers and hence will graze the more palatable species before moving onto the less palatable species and alien grasses. Extending the grazing period will not correct this problem as it will exacerbate the overgrazing problem in those areas that are heavily utilised, which appears to be those areas of natural vegetation. The selective use of the area by sheep also reinforces the patterns of nutrient loading and disturbance, promoting the dominance of alien species in these areas. An additional problem is that the heavily invaded areas of old lands serve as a seed source for alien species which are continuously dispersed by sheep and wind into the areas of natural vegetation.

Seed Biology of the Dominant Alien Grass Species

Before considering the different options that have commonly been used for the control of alien grass species, it is worth examining the seed biology of the dominant invasive grass species. The seed biology of the different species provides the background and context required to interpret the likely impact of the different potential control measures.

Bromus

Bromus species are among the most important weed species globally, in North America alone, *Bromus tectorum* occupies more than 40 million hectares and has had a profound impact on local ecosystems by increasing the fire frequency (Ditomaso 2000). Seed production can range from 600 to more than 3,000 seeds/plant. As the seeds are shed as they ripen and do not all ripen at once, this makes it difficult to control using physical methods. Seed will germinate over a wide range of temperature, so long as sufficient moisture is available. During dry seasons, germination may continue until as late as August (McGillion & Storrie 2006). Dormancy in the soil depends to some extent on the soil moisture conditions, with seed remaining viable for longer under dry soil conditions than under humid conditions. As much as 30% of the seed may be carried over from one year to the next.

Wild Oats

Wild oats is a weed associated with cereal cultivation in most parts of the world and it is difficult to control under these circumstances due its similarity to the crop species. Although a large number of herbicides have been developed to combat wild oats in croplands, resistance has developed numerous times, including South Africa and in some areas wild oats has become resistant to all of the commonly used herbicides (McGillion & Storrie 2006). Although seed production per plant is relatively low compared to some of the other invasive grass species, uncontrolled infestations can develop large seedbanks and up to 20 000 seeds per square meter may be produced by dense stands of wild oats. Wild oats seed has a staggered germination and although the main cohort of the season will germinate in autumn and early winter, small numbers continue to emerge until spring. This makes control using herbicides that do not have a residual effect problematic since plants germinating later will produce large amounts of seed, rapidly increasing the population again. The seed bank of wild oats is not long-lived, and 75% of the seed becomes depleted within 12 months, however, deep burial of wild oats seed increases the survival time. If further seed production can be prevented, then the seedbank can be depleted within 3-5 years (McGillion & Storrie 2006).

Lolium

Ryegrass is a strong competitor for nitrogen, and when it germinates early it has a competitive advantage over other species. However, if other species are already established, it is a poor competitor and is not able to reach similar levels of biomass and seed production. As a result, the best method to prevent ryegrass establishment is to maintain a healthy stand of desirable species which will be able to resist ryegrass invasion. As with Wild Oats, many populations of ryegrass have developed multiple herbicide resistance (McGillion & Storrie 2006). Once established, ryegrass can produce large amounts of seed with dense stands producing up to 45 000 seeds per square meter. Ryegrass seed is however relatively short lived and germinates readily, with less than 1% viable seed remaining after late winter. Seed burial and soil disturbance can however prolong seed life, and seed may remain viable in the soil for at least 4 years (McGillion & Storrie 2006).

Hordeum

Wild barley is a problem worldwide in both crops and natural vegetation. The long awns are especially a problem as they can cause injury to livestock by puncturing the mouth and throat and entering the skin and eyes as well as contaminating wool. There are few effective post-emergent herbicides effective against wild barley, and resistance to several of the effective herbicides has already developed. As with ryegrass, wild barley is especially a problem in nutrient enriched sites. In the Nieuwoudtville area this is clearly manifested as a high density of wild barley around watering points and kraal sites. Although grazing pressure can lead to increases in wild barley, on old lands heavy stocking rates (5 sheep/ha) can be used to reduce the density and seed set of wild barley. This must however be done before the plants start to flower, as once it reaches the flowering stage it is completely avoided. Wild Barley is highly effective at colonizing bare ground, which is one reason why it dominates on old lands. Germination is rapid, especially in response to autumn rains, allowing it to establish before other grasses such as ryegrass. The majority of seed germinates during the autumn and there is little seed that germinates afterwards during the winter or spring. Wild Barley does not produce long-lived seed banks and more than 99% of the seed germinates in the first year after seed set. As a result, effective control methods such as herbicides can be highly effective at reducing wild barley abundance, as little seed remains that can germinate the following year.

Control Options for Invasive Grass Management

Remarkably few studies have addressed the impacts or management of alien grass species within South Africa (Milton 2004, Musil et al. 2005). As a result, most the information on the management of these species must be drawn from other ecosystems around the world.

Control of alien annual grass species either directly or indirectly revolves around seed production. Since annual plants must regenerate from seed each year, the abundance of seed in the soil largely determines the abundance of the grasses and long-term effective control must focus on reducing seed input and reserves in the soil. In general terms, there are only four management actions that can be used to reduce the abundance of alien grass species these are mowing, fire, herbicide application and grazing. However, in practice management options are complicated by the fact that these can be applied at different times of the year as well as in combination, thereby giving rise to many possible treatments.

Fire

Fire is commonly used in cropping systems to control weeds. This practice is most effective when the chaff is placed in rows or heaps and then burned as this generates higher temperatures, destroying a larger proportion of weed seeds. This practice has been shown to be particularly effective for annual ryegrass where over 90% of the seed may be destroyed (McGillion & Storrie 2006). However, certain species such as Wild Oats (*Avena*) and Rats Tail (*Vulpia*) may be stimulated by fire and increased germination can occur (Nietschke et al 1996). This can obviously be problem if burning is the only treatment, but if followed up by herbicide treatments, this can be turned into an advantage since a greater proportion of the seed bank can be depleted.

However, within the context of reducing the abundance of alien grasses within natural vegetation, fire may not be ideal as apart from stimulating the recruitment of certain alien grass species, it has been shown to reduce the recruitment of geophytes (Musil et al. 2005). Furthermore, although fire is considered a natural element of Renosterveld in some areas, in more arid Renosterveld there is little evidence that fire is a natural phenomenon or has a beneficial effect. In the Nieuwoudtville area, fire appears to encourage alien species such as medic and *Erodium* and Renosterveld that has been burnt repeatedly is dominated by undesirable species such as *Merxmeullera* and *Elytropappus*.

Mowing

Mowing has been used both in cropping systems as well as in natural vegetation to reduce annual grasses. In cropping systems the residue is usually used as mulch or is made into hay or silage. The effectiveness of mowing in natural vegetation relies to some extent on a height difference between the invasive species and the indigenous species. Where the indigenous and alien species are of similar height, mowing will also have a negative effect on the indigenous species unless they have a different phenology. Mowing treatments usually need to be repeated several times before an effect becomes apparent. Wilson and Clark (2001) were able to convert a prairie dominated by the alien grass *Arrhenatherum* into to a prairie dominated by native grasses through mowing at 15cm in late spring for four years. When using mowing as a treatment, timing is also important since if it is performed too early in the season, the grasses will still produce seed and if it is performed too late, a lot of viable seed may already have been produced. The correct stage is when the seed is in the so-called milky dough stage.

Grasses often dominate in nutrient enriched sites and these species have superior competitive advantage under these conditions. However, because these species have a nigh nitrogen requirement, they become inferior competitors under low nutrient conditions. Thus manipulating the soil nutrient status can shift the competitive balance in favour of indigenous species. The simplest method to reduce the nitrogen content of the soil is to mow and remove the plant biomass repeatedly. In such nutrient enriched sites mowing and biomass removal can promote indigenous forbs and greatly reduce alien grasses (Maron and Jefferies 2001). However, this practice needs to be maintained for several years, even after an apparent recovery of the vegetation because the increase in perennial plants prevents further nitrogen depletion of the soil, with the consequence that alien species will quickly re-establish if mowing ceases.

Herbicide Treatment

Herbicide treatment, especially with selective herbicides can be a very effective method of controlling alien grass species. This is often the only practical method for some situations and species which cannot be easily controlled by other physical means. However, herbicide application is not as promising as it may at first sound, as there are several potential pitfalls associated with it. Firstly, if herbicides are used repeatedly, then it is highly likely that resistance will develop as has commonly occurred in South Africa as well as elsewhere (McGillion & Storrie 2006). Secondly, although the selective herbicides may reduce alien grasses, a side effect may be that alien forb species increase in their place (Cox and Allen 2008). This is to some extent visible in the herbicide treated areas in the Flower Reserve, where medic has increased substantially in some locations apparently as a result of competitive release from the alien grasses. Thirdly, despite their selective nature, most herbicides nevertheless still have some negative effects on non-target species. Timing of herbicide application is also important to achieve good results. If it is applied too early, more grass seeds may germinate later in the season, and if applied too late then an effective level of control may not be achieved. This is a particular problem with alien grass species which have a long or staggered germination period, such as wild oats.

Grazing

Grazing is commonly used to control alien plants, however, in the majority of cases that have reported some success these are broadleaved forbs that are acceptable or preferred by sheep or goats (Ditomaso 2000). Intensive livestock grazing during or just before flowering can be used to reduce alien grasses. However, grazing management to reduce alien annual grasses is complex since grazing can increase as well as decrease the abundance of alien species. This appears to be contingent on stocking rate, time of the year, and the species composition of the vegetation. While grasses such as Wild Barley may be reasonably palatable when in the leafy stage, they become unpalatable when in flower (McGillion & Storrie 2006). Livestock may also spread the seed of alien grasses, and so livestock should not be moved from areas of high infestation to areas of low infestation, but rather the other way around.

Recommended Management Options in the Context of the Nieuwoudtville Flower Reserve

Numerous studies have demonstrated that no single control method is effective for long-term alien grass control. All successful weed control programs stress the need for and integrated approach to weed management. Problem plant control must form an integrated part of the whole production system rather than being viewed as an isolated problem to be dealt with alone. Furthermore, most weedy species have substantial seedbanks that take several years to deplete. As a result, there is no quick-fix for alien plants, and short-term solutions such as the use of pesticides often result in an increase in other pest species. Solutions that take longer to have an effect may actually be more effective in the long term as they enable the natural vegetation to recover during the process, thereby creating an inherent ability in the vegetation to resist re-invasion. Annual grasses tend to be poor competitors and healthy stands of indigenous species or desirable crops are able to significantly reduce the biomass and seed production of invasive grass species, sometimes by over 50% (Lemerle et al. 2001, Walker et al. 2002).

Although herbicides offer an effective short-term solution to the alien grass problem, they are costly and require a lot of machinery to apply efficiently. Although mowing does not require herbicides, it nevertheless also requires some machinery which may be relatively costly to operate. Furthermore, as both mowing and herbicide application require the use of heavy tractors, they can cause compaction of the soil which may be undesirable. Since mowing needs to done repeatedly in order to be effective, this is a negative side effect that needs to be considered when using this treatment. Furthermore, the use of such machinery is restricted to relatively even ground, limiting where such treatments can actually be used.

Grazing management may be effective at reducing alien grasses in cultivated pasture where there is little perennial plant material present, since stocking rates can be adjusted to achieve the desired effect, without undue negative effects on other components of the pasture. However, in natural vegetation, the high stocking rates required to impact alien grasses also necessarily impact indigenous species, and may create open space that can be colonized by alien species. Grazing is however the most environmentally friendly and the most cost effective option for alien grass management since it can generate income rather than require large funds to hire or run equipment. However, it is also the most complex to manage and may require several years of treatment for an effect to become apparent. Since grazing animals recycle rather than remove nutrients from a system, livestock grazing cannot easily be used to solve the problems of alien grass dominance associated with nutrient enrichment. The potential and practicality of using grazing to control alien grasses in the flower reserve is also limited under the current conditions. Livestock preference for certain areas and certain species prevents grazing from being an effective strategy in the Flower Reserve. Greatly improved grazing management could be achieved by dividing the Reserve into four sections, namely the Dolerite Koppies, the Dolerite Plains, the Tillite Plains and the Old Lands. Grazing each habitat type individually would allow the grazing impact to be varied between the different units and would also result in a much more even distribution of impact within each unit. Perhaps the biggest advantage of doing this would be that certain sections could be grazed during the winter months to retard the growth of the alien grasses. Such a division could be relatively easily achieved through the use of portable electrified fencing, although additional watering points would also need to be provided. If such a division was applied, then the animals would need to be rotated first through the Tillite Plains, then onto the Dolerite Plains, the Dolerite Koppies and finally onto the old lands. Such a rotation would ensure that little alien grass seed is moved from one habitat to another and would also promote the dispersal of indigenous species from the Koppies to the old lands. This would also allow heavy grazing pressure to be applied to the old lands without concern for damaging the other areas of indigenous vegetation.

Nutrient enriched sites in the Reserve contain very dense stands of alien grasses and it is unlikely that these can be effectively reduced using livestock grazing. The best solution for these sites would be to mow them and bale the residue for livestock fodder as this would gradually deplete the nitrogen stocks in the soil, switching the competitive balance in favour of indigenous species, as well as reduce the seed input of these species.

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