Rethinking the management of serrated tussock, our worst perennial grass weed

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Abstract
Serrated Tussock (*Nassella trichotoma*) is Australia's worst perennial grass weed that now infests over 1 million ha of southeastern Australia. The main problems with this introduction from Argentina are in non-arable grazing lands that are characterised by lower soil fertility and lower rainfall. The benefits of control are marginal in this case as sowing competitive pastures species such as phalaris are expensive or not feasible. Regular spraying with effective herbicides also has negative impacts on desirable species. This paper investigates the factors associated with managing the competition from desirable native perennial grasses that often are still present even when these grasslands are degraded. Evidence supports the view that C4 grasses are more competitive under low fertility conditions than C3 species. However, grazing practices may need to change to exclude livestock during the period when C4 species can be most competitive. This may not result in a major change in total annual carrying capacity if appropriate grazing practices are employed. Future management of these grasslands needs to consider the very real possibility that serrated tussock will continue to invade unless a more competitive environment is maintained.

Keywords
Serrated tussock, *Nassella trichotoma*, Native Grasses, Competition, C4 grasses

Introduction

Serrated tussock (*Nassella trichotoma*) is a highly invasive weed and is considered the worst perennial grass weed in Australia. Serrated tussock, a *stipoid* grass native to Argentina, is now well established in Australia since its introduction over 100 years ago. It currently infests over 1 million ha of pastoral land across southeastern Australia (12, 14). The area of serrated tussock is increasing annually as current control techniques have failed to reduce its spread. Using climatic data, it has been estimated that 32 million hectares is potentially at risk of invasion within Australia (14). Although it is unlikely that the weed will reach its potential distribution, there is opportunity for a large-scale increase in the area of land affected.

Serrated tussock is a highly unpalatable plant and rarely eaten by livestock. Adult plants have a very low crude protein content (4.1% (5)) and a very high fibre content (86% neutral detergent, (6)). As a result selective grazing by livestock of other more palatable species in a pasture is a major problem. This reduces the ability of palatable species to effectively compete with serrated tussock and increases the conditions that serrated tussock require to establish. Mature serrated tussock plants produce an extremely large amount of seed, estimated by Taylor (17) to exceed 140 000 seeds/plant/year. They are very efficiently dispersed by wind and have been documented travelling up to 16 km (10). Serrated tussock seed often dominates the seedbank with Joubert (13) reporting that the seedbank under a serrated tussock infestation contained 34% serrated tussock seed, while other Poaceae only represented 1%. A combination of all of these factors ensure that serrated tussock quickly becomes dominant in a pasture.

In New South Wales serrated tussock is found in the areas associated with the 21°C isotherm of mean January temperatures and rainfall from 500 – 900mm (3), but it has been found growing successfully in areas of the Monaro where the annual rainfall is less than 450 mm (4). Neither soil type nor fertility appears to affect the distribution of serrated tussock (7, 10) and the state of the grassland appears to have a larger bearing on where the weed invades. Grasslands that are healthy and are not over grazed are not as susceptible to invasion as pastures that are heavily grazed or have been disturbed in other ways.

Current Control in Native Vegetation

Degraded native pastures are commonly infested with serrated tussock. In this type of vegetation flupropanate, which is long-lived and soil active herbicide, is predominately used to control serrated tussock. It is not appropriate, however, for use in most native pastures where the majority of the species present are C3 species i.e. wallaby grass (*Austrodanthonia* spp.), Weeping grass (*Microlaena stipiodes)*, and Spear grass

(*Austrostipa* spp.). These C3 native grasses are very susceptible to flupropanate with the result that total groundcover is substantially reduced by its application. A consequence of this non-selective impact is that no competitive species are retained to prevent the re-establishment of serrated tussock seedlings. A less stable mixture of broadleaf weeds and annual grasses invade while the chemical is still active. Once the chemical has degraded or leached out of the root zone, serrated tussock seedlings rapidly re-colonise into the large areas of disturbed bare ground (personal observation). This means that repeat herbicide applications are likely to favour serrated tussock. It enlarges the seedbank relative to that of the native species leading to re-establish at higher densities eventually forming a serrated tussock monoculture.

This highlights the need for control practices to focus not only on the eradication of adult plants but must also prevent the re-establishment of seedlings. Pasture establishment with an introduced pasture based on *Phalaris aquatica* has predominately being used to control seeding re-establishment. However, this may not be economically viable (18) or sustainable (11) in many low fertility, low rainfall or inaccessible areas. In these areas new solutions have to be examined that not only control adult serrated tussock but also prevent recruitment of serrated tussock seedlings. If the cover of native grasses could be retained as a competitive base while adult plants are controlled there would be a greater chance of preventing serrated tussock from re-invading. To date minimal work has been done on developing management practices for native vegetation that strengthen the competitive ability of native grasses against serrated tussock.

Competition from Native Grasses

Whether native grasses can compete with serrated tussock is subject to contention. Species often small in stature, such as *Austrodanthoinia* sp. are unlikely to offer substantial competition to mature serrated tussock plants. However, a well-managed pasture that is dominated by *Austrodanthonia* sp. may be able to resist invasion from serrated tussock seedlings. Serrated tussock seedlings have a very low vigour (7), but the plant compensates for this by producing extremely large amounts of seed that is very efficiently dispersed by wind. Therefore the species relies on the large number of seeds it produces to find a suitable establishment site rather then on a few more competitive seedlings. As this species evolved, opportunities for establishment were probably rare. As disturbance has increased with human activity, however, the opportunity for serrated tussock to establish has increased. It has become a serious weed in countries such as Australia, New Zealand and South Africa where many of the native species are not well adapted to these conditions.

Serrated tussock is often found in many low fertility areas, although it may not prefer these conditions. Serrated tussock can dominate in grazed grasslands under these conditions not because of its suitability but because other native species suffer heavier utilisation which limits their ability to compete with serrated tussock. There is evidence to suggest that when grazing is removed or limited there are certain native grasses that can be more competitive with serrated tussock. Serrated tussock evolved in the semi-arid, Calden region of Argentina where soil fertility was relatively high but rainfall was low (approximately 400mm). The mechanisms that the plant developed to deal with the low rainfall environment include, slow growth rates, retention of senescent leaf material and low palatability (8). This has also given the plant the ability to persist in areas of low soil fertility and to respond with substantially higher growth rates at more fertile sites.

Under low fertility conditions it is likely that some native grasses, in particular C4 (summer growing) perennial grasses will be able to grow more vigorously than serrated tussock. In general C4 grasses use nutrients in the soil, especially nitrogen, to lower levels then those required by many C3 species (19, 20). Serrated tussock is a C3 species and it is suspected that at low soil fertility levels C4 native perennial grasses will be better able to out-compete it. There is evidence to support this notion that C4 species are more competitive then C3 species. Michalk *et al.* (15) suggested that well managed native pastures dominated by redgrass (*Bothriochloa macra*) tended to resist invasion from serrated tussock. Hocking (9) also found that areas that had been previously dominated by serrated tussock had no significant re-invasion four years after kangaroo grass (*Themeda australis*) had been established on the site. In a survey of the infested areas within New South Wales, Badgery *et al.* (2) found that there was a negative association between C4 native grasses and serrated tussock. One perceived problem of basing management practices on these observations is the belief that C4 grasses are not sufficiently abundant in areas that are infested by serrated tussock to become a competitive force. However, in different rainfall and soil fertility environments in New South Wales, Badgery (unpublished data) found that C4 grasses were not present at only 2 out of 10 sites being invaded by serrated tussock.

C4 grasses not only have the capacity to use nutrients more efficiently then serrated tussock, but their growth patterns may also help them to dominate serrated tussock seedlings. Most serrated tussock seedlings establish in autumn, after the 'autumn break', although seedlings have been found to germinate at any time of the year (7). C4 grasses grow most actively over the summer/early autumn months and it is likely that they are still actively growing at the time when serrated tussock seedlings are germinating. C3 native species and exotic annual grasses do not grow as actively at this time of year and provide larger gaps in grassland cover for the establishment of serrated tussock. This growth pattern of native grasses may explain why serrated tussock has not substantially invaded the northern areas of New South Wales where the summer dominant rainfall maintains a higher proportion of C4 grasses. It could also be that large amounts of seed are not present in these areas and higher awareness and control programs have led to the control of the weed before the infestations have gained hold.

Management of Native Grasses

If C4 native grasses can be competitive with serrated tussock, it is critical to define what management practices are required to encourage this. Over grazing of C4 native grasses is a major factor in preventing them from being competitive with serrated tussock. Many of these species such as kangaroo grass are sensitive to heavy grazing (16). Grazing pressure must therefore be reduced to increase the competitive ability of C4 grasses. Badgery *et al.* (1) found that in a naturalised pasture, which contained C3 and C4 native species as well as serrated tussock, the proportion of serrated tussock increased substantially under continuous grazing at average district stocking rate or higher. However, areas that were rested from grazing had a slightly lower proportion of serrated tussock and higher levels of C4 native grasses. The higher the initial proportion of C4 native grasses, the larger the impact that was found on serrated tussock. Limiting grazing when C4 grasses were actively growing provided them greater opportunity to compete with serrated tussock. Grazing not only has a direct physical effect on the plants, it also affects nutrient cycling. When grazing is removed the amount of available N is decreased due to slower recycling. These conditions benefit C4 perennial grasses, providing them with a competitive advantage over C3 perennial grass species.

To promote the competition of C4 native grasses current management practice will need to be changed. One way of doing this could be to introduce a rotational grazing system. Areas with serrated tussock problems may receive longer rest periods over the summer months when the C4 native grasses are actively growing. On properties that are conventionally grazed a simple summer rest may have a substantial effect on increasing the competitiveness of these species. Initially, grazing may have to be significantly reduced to increase the proportion of C4 grasses, but as these species increase and bare ground is reduced then grazing may be able to be increased returning these areas to moderate production.

It is unlikely that such techniques will have a large affect on established adult tussocks that are in clumps within a time period that would be acceptable to most managers. Rather, the benefit of this technique would be to reduce seedling establishment, thereby halting the invasion by serrated tussock. If serrated tussock is no longer rapidly encroaching on pastoral land, the urgency for control is reduced. At this point, established techniques such as spot spraying could be used to control the remaining adult tussock. This may mean that weed inspectors have to take a longer-term view of control in areas where this technique is possible. It is unlikely that any grazing technique will completely remove all the opportunities for serrated tussock to establish and therefore spraying or chipping will still be required.

There are many examples of farmers who have lived in serrated tussock infested areas for a long period of time and have learnt to control the problem. These farmers maintain ground cover predominately by applying sub clover and super while also maintaining production. In less productive areas of their property managing C4 native grasses may be a more cost-effective approach to controlling serrated tussock. In the control of serrated tussock action has often been reactive, dealing with the problem once the weed has invaded. Greater emphasis needs to be placed on pasture management to maintain ground cover at a level sufficient to prevent the weed from invading. Control of serrated tussock can be achieved in native vegetation but it is not easy and will require careful pasture management.

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