The distribution, impacts and identification of exotic stipoid grasses in Australia

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Abstract
Exotic stipoid grasses are one of the most significant issues affecting grazing industries and threatening nationally important remnant grasslands in Australia. This paper documents their distribution, impacts and identification. It also discusses how these grasses are coming into Australia and makes recommendations on how this could be addressed.

Introduction
South-eastern Australian indigenous grasslands are now regarded as one of Australia's most threatened ecosystems. Only half of one percent (10 000 hectares) of the original two million hectares of lowland grasslands now remain in near natural condition, and they contain the greatest number of species facing extinction (Marriott and Marriott 1998). Since European settlement, native grasslands have been rapidly transformed due to land clearance, urbanization, grazing by introduced ungulates (e.g., sheep, cattle, horses) and large scale agricultural production (cropping and grazing using introduced grasses and wide-scale addition of superphosphate). Introduced pests such as rabbits and weeds have added additional pressures to these remnant grasslands. At the same time, sheep and beef production have become some of Australia's most important rural industries. For many years Australia's economy was said to 'live off the sheep's back'. This paper examines the impacts caused by exotic stipoid grasses to agriculture and the environment and how we can recognize these serious weeds.

The Stipeae are strongly tussock forming, mostly perennial grasses that generally have narrow, inrolled leaves. The ligule (a small flap at the junction of the leaf blade and leaf sheath) is often short, membranous and fringed. Auricles (paired projections either side of the ligule) are glabrous or fringed. The inflorescence (flowering stem) is a panicle which is rarely branched at the base or occasionally reduced to a few spikelets. Each spikelet has two glumes (leaf-like structures at the base of a spikelet) which are often purplish in colour, and one floret (in which the seed is formed). The floret consists of the lemma and palea. The lemma is usually terete (i.e. circular in cross section) or gibbous (i.e. asymmetric) and firmly membranous. The palea is enfolded and concealed by the lemma. Seed may be tipped by a callus of hairs (see Figure 1), and has an awn (a curved, bristle-like tail) at the opposite end.

The exotic stipoid grasses are one of the most significant threats facing grazing industries and indigenous grasslands in south-eastern Australia (McLaren *et al.* 1998). Eleven exotic stipoid grass species have naturalized in Australia (McLaren *et al.* 1998), whilst white tussock (*Nassella tenuissima* (Trin.) Barkworth) has been sold in Australia through the nursery trade (McLaren *et al.* 1999). The stipoid grasses come from the Poaceae Family that comprises approximately 9500 species and 650 genera worldwide (Walsh and Entwisle 1994). The Stipeae is a cosmopolitan tribe of approximately 450 species in 14 genera (Barkworth 1993, Reyna and Barkworth 1994, Jacobs and Everett 1996). There are six stipoid genera in Australia, of which five are of exotic origin. *Austrostipa* is the only indigenous Australian genus. The exotic genera include *Achnatherum, Jarava, Nassella, Piptochaetium* and *Piptatherum.* As rice millet (*Piptatherum miliaceum* (L.) Coss.) appears to be confined to urban settlements, in Victoria at least (Walsh and Entwisle 1994), it will not be considered in this paper. Species of the other genera are a cause for serious alarm from both an environmental and agricultural perspective.

Eleven exotic stipoid grass species are described in this paper, in the following order:

- Serrated tussock (*Nassella trichotoma* (Nees) Hack. ex Arechav.)
- White tussock (*N. tenuissima* (Trin.) Barkworth)
- Chilean needlegrass (*N. neesiana* Trin. & Rupr.)
- Cane needlegrass (*N. hyalina* Nees)
- Texas needlegrass (*N. leucotricha* Trin. & Rupr.)
- Lobed needlegrass (*N. charruana* Arechav.)
- Short-spined needlegrass (*N. megapotamia* Spreng. ex Trin.)
- Uruguayan ricegrass (*Piptochaetium montevidense* (Spreng.) Parodi)
- Broad-kernel espartillo (*Achnatherum caudatum* Trin.)
- Narrow-kernel espartillo (*A. brachychaetum* (Godr.) Barkworth) and
- Plumerillo (*Jarava plumosa* (Spreng.) S.W.L.Jacobs & J.Everett).

All of these species are proclaimed plants in South Australia, under the *Animal and Plant Control (Agricultural Protection and Other Purposes) Act, 1986*.

For each species, a summary has been produced of its:

- Distribution – known overseas distributions, current Australian distribution and potential distribution in Australia (based on its current distribution in Australia).
- Impacts – agricultural and environmental.
- Identification – vegetative and floral characteristics that help differentiate the species.

Serrated tussock, *Nassella trichotoma*
Distribution
Nassella trichotoma (syn. *Stipa trichotoma*) is a perennial, drought resistant species that is native to the pampas grasslands of Argentina, Uruguay, Chile and Peru (Parodi 1930, Rosengurtt *et al.* 1970) and it has been reported from Bolivia (Walsh and Entwisle 1994). It has also naturalized in Australia, New Zealand and South Africa, whilst small infestations also occur in England, France, Italy, Scotland (Campbell 1982, Stace 1997) and the United States (Westbrooks 1991, Westbrooks and Cross 1993).

Nassella trichotoma was probably introduced into Australia in the early 1900s but was not recorded in Australia until 1935 when a collection was made at Yass, 55 km north-east of Canberra (Campbell and Vere 1995). In 1977 it occupied 680 000 hectares (Campbell 1977) and now occupies more than 870 000 hectares in New South Wales with an estimated 2 000 000 hectares at risk of infestation (McGowan personal communication). In Victoria *N. trichotoma* was first collected in 1954 at Broadmeadows where infestations were then estimated at four hectares (Lane personal communication). By 1979 it had spread to occupy approximately 30 000 hectares (Lane *et al.* 1980) and by 1995 it occupied in excess of 130 000 hectares (Pest Management Information System, Department of Primary Industries (DPI) Frankston). The Victorian Government has recently increased *N. trichotoma*

control operations that have been facilitated by the Victorian Serrated Tussock Working Party. It has been estimated that in excess of 70 000 hectares of serrated tussock infestations have now been treated in Victoria (Boyle personal communication). *N. trichotoma* now occupies 82 000 hectares in Victoria, which is a 37% reduction from the 1995 infestation (Boyle 2003). *N. trichotoma* is also found in Tasmania where it was first recorded in 1956 (Parsons and Cuthbertson 1992) and is currently spread in scattered populations over an area of approximately 1000 hectares (Goninon personal communication). Its potential distribution in Australia, predicted from its current distribution in Australia, has been estimated at 32 million hectares (McLaren *et al.* 1998).

Impacts

Nassella trichotoma probably accounts for a greater reduction in pasture carrying capacity than any other weed in Australia (Parsons and Cuthbertson 1992). Its high fibre content and low protein content make it indigestible and stock will only attempt to eat it if nothing else is available. Heavily infested paddocks in NSW carry only 0.5 dry sheep equivalent (dse) per hectare compared to 7 to 15 dse on improved pasture without the weed (Parsons and Cuthbertson 1992). In 1988, *N. trichotoma* was estimated to be costing the Australian Wool Industry approximately $12.9 million annually (Sloane Cook and King Pty Ltd 1988). Aberdeen (1995) stated that Victoria could save approximately $35 million per year if it restricted the distribution of *N. trichotoma* to 200 000 hectares. A conservative figure for the cost of *N. trichotoma* in Victoria is $5 million per year (Nicholson *et al.* 1997) and for New South Wales $40 million per year (Jones and Vere 1998).

Carr *et al.* (1992) classified *N. trichotoma* as a very serious environmental weed that invades dry coastal vegetation, lowland grassland, grassy woodland, sclerophyll forest and woodland and rocky outcrop vegetation. In Victoria, *N. trichotoma* is either actively invading or has the potential to invade some of Australia's most endangered native grassland remnants.

N. trichotoma is also a significant fire risk. Its high fibre content makes it highly combustible and has reportedly extended the fire season by two months in the Geelong region of Victoria (Churnside personal communication).

N. trichotoma has been declared a Weed of National Significance in Australia (Thorp and Lynch 2000, Agriculture and Resource Management Council of Australia and New Zealand *et al.* 2001a).

Identification

Vegetative characters *Nassella trichotoma* forms a very dense tussock, to 50 cm high and 60 cm across, composed of numerous fine leaves. Leaves are tightly rolled and appear cylindrical when cut in cross section. Unlike Australian native grasses, *N. trichotoma* leaves, when rolled between the index finger and thumb, roll smoothly – like a needle. *N. trichotoma* leaves are rough to touch due to small serrations on their surfaces and these are easily felt when drawn between the fingers. Mature plants have drooping leaves. Flowering stems emerge in spring and grow to a length of 95 cm, twice as long as the leaves. They are initially erect but droop at maturity. They are much branched and usually break off at the base after seed set. The ligule is about 1 mm long, rounded, membranous and glabrous.

Floral characters The general floral characteristics of the Genus *Nassella* are: Lemma – strongly convolute (i.e. inrolled margins, as in *Austrostipa*). Corona – present (sometimes evident only on dissection.). Palea – reduced, usually glabrous (i.e. hairless), unveined. For all the exotic stipoid grasses, the easiest time for identification is at flowering during spring and summer.

In *N. trichotoma* the inflorescence is an open branched panicle up to 35 cm long. Major branches are in pairs that break into numerous branchlets where the florets develop. The panicle readily detaches at maturity. Glumes are strongly purplish. The lemma is obovoid and truncate at its apex, measuring 1.5–3 mm long. The corona is only evident on dissection and is very small (*ca.* 0.1 mm long). The awn is 25–35 mm long, attaching obliquely to the lemma (Figure 1). *N. trichotoma* can be easily mistaken for *N. tenuissima*. Distinguishing features are a shorter awn (25–35 mm compared to 50–90 mm for *N. tenuissima*) and the oblique attachment of the awn to the lemma.

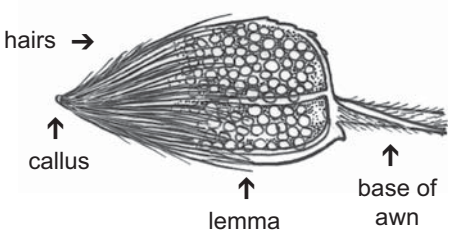

Figure 1. *Nassella trichotoma* seed.

White tussock, *Nassella tenuissima*

Distribution

Nassella tenuissima (syn. *Stipa tenuissima*) is native to Argentina, Chile, New Mexico and Texas (Jacobs *et al.* 1998). In 1996, *N. tenuissima* was found being sold at a nursery in Melbourne. Its potential distribution in Australia, predicted from its countries of origin, has been estimated at 14.2 million hectares (McLaren *et al.* 1999). *N. tenuissima* can potentially occupy six times the area predicted for *N. trichotoma* in Australia. The availability of *N. tenuissima* via the internet and other plant purchasing situations makes its entry and naturalization in Australia almost inevitable (McLaren *et al.* 1999).

Impacts

In Argentina *N. tenuissima* is regarded as an unpalatable grass (Moretto and Distel 1998). It has been classified as a non-preferred species that can become dominant under continual heavy grazing pressure with a low frequency of high intensity fire (Distel and Boo 1995). Similarly, it is regarded as a species that is rarely eaten by deer in Texas (Simons 1996). *N. tenuissima* is less palatable than serrated tussock in Argentina (Distel personal communication). *N. tenuissima* is climatically very well matched to Australian conditions and its taxonomic similarity to *N. trichotoma* makes this species a potential disaster for the Australian environment (McLaren *et al.* 1999). An economic assessment estimated that preventing *N. tenuissima* naturalizing in Australia would potentially save Australia $39 million over the next 60 years (Centre for International Economics 2001).

A national campaign to stop this weed has resulted in it being declared noxious in most States in Australia. The CRC for Australian Weed Management offered a reward of $100 to people returning *N. tenuissima* plants sold through the nursery trade. A number of plants were returned but many more have not. *N. tenuissima* is on the 'Weed Alert List' of the Commonwealth Department of Environment and Heritage. Its potential as an agricultural and environmental weed has seen it declared a State Prohibited Weed in Victoria.

Identification

Vegetative characters *Nassella tenuissima* forms a very densely tufted tussock to 70 cm high and 60–100 cm across, composed of numerous fine leaves. Culms (stems) grow to 70 cm high with 2–3 unthickened nodes. Culms are smooth, hairless and round in cross section between nodes. The flower-bearing section of the culm is 15–25 cm long and green or purplish in appearance. The lower section is

enclosed in a leaf-like sheath and, unlike *N. trichotoma,* the mature seed head does not always fully project and spread from this sheath. Ligules are membranous and glabrous. In general, *N. tenuissima* is very similar to, but grows more upright than, *N. trichotoma*.

Floral characters *Nassella tenuissima* has a single bisexual floret per spikelet, surrounded by two persistent bracts (glumes). Seed has an awn 50–90 mm long and it is not readily detached from the seed. The lemma is 2–3 mm long and its awn attaches centrally (Figure 2).

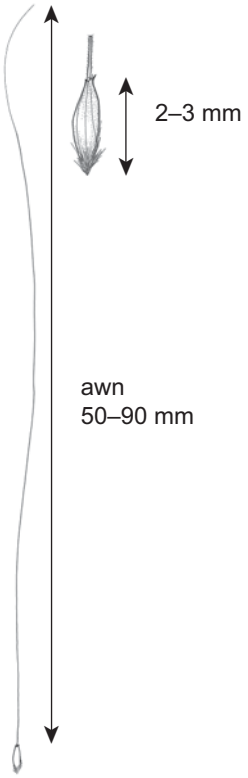

Figure 2. *Nassella tenuissima* seed.

Chilean needlegrass, *Nassella neesiana*

Distribution

Nassella neesiana (syn. *Stipa neesiana*) is a tufted perennial grass that is indigenous to Argentina, Bolivia, Chile, Ecuador, southern Brazil and Uruguay (Rosengurtt *et al.* 1970). This species is a serious weed in Australia (McLaren *et al.* 1998) and New Zealand (Bourdot and Hurrell 1992). It has also been recorded in south-east England (Stace 1997) and has been found in the USA on ballast dumps such as in Mobile, Alabama (US Department of Agriculture 1953), but there have been no recent records according to Barkworth (1993).

The first record of *N. neesiana* from Australia was in Victoria (Northcote) in 1934. It was later identified in NSW (Glen Innes on the New England Tablelands) in 1944 and is also naturalized in South Australia (Lucindale) (McLaren *et al.* 1998). A survey conducted in Victoria and NSW during 2002 estimated that *N. neesiana* was dispersed over an area of more than 4 million hectares (McLaren *et al.* 2002). Its potential distribution, predicted from its current distribution in Australia, has been estimated at 42 million hectares (McLaren *et al.* 1998).

Impacts

Nassella neesiana tolerates drought, heavy grazing and sites that are subject to seasonal waterlogging (McLaren *et al.* 1998). Its competitive ability and efficient reproductive mechanisms has enabled *N. neesiana* to dominate large areas of highly productive pastures on the Northern Tablelands of New South Wales and the Volcanic Plains of Victoria (Gardener 1998). During warmer months it produces large numbers of unpalatable flower stalks and very little leaf material, resulting in a severe reduction in summer stock carrying capacity. Conversely, a reasonable quantity of good feed is produced during the winter months on the New England Tablelands (Gardener 1998). *N. neesiana* seeds have very sharp points that reportedly penetrate and damage the fleece, skins and eyes of livestock (Bourdot and Ryde 1986).

On average, *N. neesiana* costs from $64.50 to $118.75 per hectare to control on grazing lands, depending on whether the infestation is scattered or dense (McLaren *et al.* 2002). An economic assessment of *N. neesiana* in Victoria shows that without government investment in its coordinated treatment, under the worst-case scenario of weed spread rate, *N. neesiana* is likely to cost the Victorian community approximately $464 million in 30 years. Government investment in *N. neesiana* control under the base-case 'high' rate of spread scenario was assessed to deliver to Victoria a net present value (NPV) of about $82 million in terms of saving potential production losses and avoiding future control costs (Morfe *et al.* 2003).

Nassella neesiana has been described as potentially the worst environmental weed of indigenous grasslands in Victoria (McLaren *et al.* 1998). Carr *et al.* (1992) classified *N. neesiana* as a very serious environmental weed that invades lowland grassland, grassy woodland and rocky outcrop vegetation. *N. neesiana* has been declared a Weed of National Significance in Australia (Thorp and Lynch 2000, Agriculture and Resource Management Council of Australia and New Zealand *et al.* 2001b).

Identification

Vegetative characters When grazed *N. neesiana* will tiller profusely, producing many shoots from the base that develop into a wide, untidy tussock 30–60 cm across. However, the growth form is rather more like that of rye grass (*Lolium* spp.) or cocksfoot (*Dactylis glomerata* L.) than the very pronounced tussock growth of plants such as *N. trichotoma* and the common native tussock grass (*Poa labillardierei* Steud.). The leaves are flat or somewhat inrolled, to 30 cm long and 5 mm wide, and harsh to touch due to their strong ribs and short marginal hairs. The leaf surface is mostly glabrous and often bright green in colour. At the base of each leaf is a 3 mm long, glabrous, membranous ligule, which extends across the leaf base and is bordered by two small tufts of erect hairs either side (which are easily seen when the leaf is pulled away from the stem).

Floral characters *Nassella neesiana* flowers from spring to early summer but occasional plants can be found in flower until April. It produces both panicle seeds (cross-pollinating) and cleistogamous seeds (selfing, stem seeds). The panicles are loose, sometimes interrupted and up to 40 cm long. The glumes are 16–20 mm long and have a distinctive purplish colour. The lemma is 8–10 mm long, with a 1 mm long, terminal corona with slightly divergent apical spines 0.2–0.5 mm in length. The callus is 2–4 mm long and the awn is 60–90 mm long (Figure 3). When seeding, the awns of several seeds can become twisted together forming a tangled seed mass. *N. neesiana* also produces cleistogamous (stem) seeds within stems. Cleistogenes allow the plant to reproduce even if flowering has been inhibited.

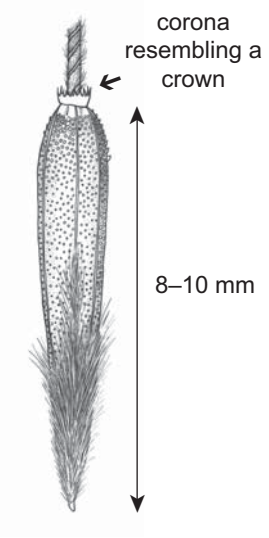

Figure 3. *Nassella neesiana* seed.

Cane needlegrass, *Nassella hyalina*

Distribution

Nassella hyalina is a tufted, perennial grass indigenous to Argentina, southern Brazil and Uruguay (Caro 1966, Rosengurtt *et al.* 1970). It was first recorded in Australia in central New South Wales (between Glen Innes and Inverell) in 1951 and was later recorded in Victoria (Woodstock) in 1964. Significant infestations are centered on the outer western suburbs of Melbourne and central Victoria (McLaren *et al.* 1998). Its potential distribution, predicted from its current distribution in Australia, has been estimated at 0.9 million hectares (McLaren *et al.* 1998).

Impacts

In Argentina, *N. hyalina* is reportedly palatable to stock (Rosengurtt *et al.* 1970) and is regarded as producing reasonable fodder. Carr *et al.* (1992) considered *N. hyalina* a serious risk as an environmental weed. It is primarily a weed of indigenous grasslands but has also been observed growing in areas subject to seasonal waterlogging and riparian vegetation (McLaren *et al.* 1998). *N. hyalina* is on the 'Weed Alert List' of the Commonwealth Department of Environment and Heritage.

Identification

Nassella hyalina can be confused with *N. leucotricha.* This confusion could be due to intraspecific variation of *N. hyalina* and/or *N. leucotricha*. Alternatively, what is currently called *N. hyalina* in Australia may in fact be another species (i.e. *N. formicarum*).

Vegetative characters *Nassella hyalina* forms a loosely tufted, sparse tussock of less than 30 cm across.

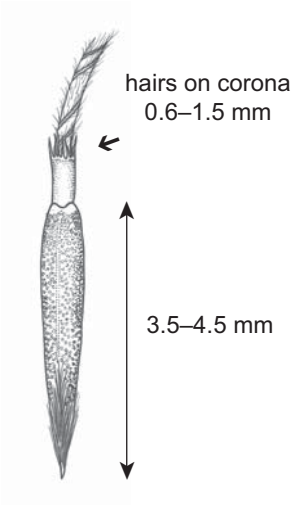

Figure 4. *Nassella hyalina* seed.

Floral characters The panicle of *N. hyalina* is contracted, to 25 cm long. Glumes are 6–12 mm long (6–8 mm in Caro 1966). The lemma is 3.5–4.5 mm long (Figure 4). The corona is 0.5–1 mm long with apical hairs or slender spines 0.6–1.5 mm long. The callus is 1–3 mm long and awn 35–40 mm long. When flowering the seed heads are erect and contracted (like a cane). *N. hyalina* also produces cleistogamous seeds within the basal crown and within the stems.

Texas needlegrass, *Nassella leucotricha*

Distribution

Nassella leucotricha (syn. *Stipa leucotricha*) is a tufted perennial grass indigenous to Oklahoma, Texas and central Mexico (Leithead *et al.* 1971, Reyna and Barkworth 1994). It was first found in Victoria (Northcote) in 1934 and has since spread through the northern and western suburbs of Melbourne and into central Victoria (McLaren *et al.* 1998). It is also naturalized in South Australia. The potential distribution of *N. leucotricha*, predicted from its current Australian distribution, has been estimated at 4.8 million hectares (McLaren *et al.* 1998).

Impacts

In North America, the species is known either as Texas needlegrass or Texas wintergrass. It is readily grazed by livestock and apparently of significant value for early spring or winter grazing (Leithead *et al.* 1971, Gould 1978). In its indigenous habitat, *N. leucotricha* thrives under conditions of moderate disturbance and is frequently abundant on roadsides, in open grassland sites and heavily grazed pastures (Leithead *et al.* 1971). To date no information is available about its fodder value in Australia. In Victoria, *N. leucotricha* invades native pasture and native grasslands. Seeds become readily attached to the hair and wool of grazing animals and can cause injury to stock (Leithead *et al.* 1971).

Identification

Vegetative characters Stems of *N. leucotricha* are erect, to 1–1.5 m high, unbranched and mostly hairless. Leaves are approximately 30 cm long and 5 cm wide. The blades are flat or slightly inrolled. The ligule is 0.5–1 mm long and hairless. (Pennhall *et al.* 2000)

Floral characters The panicle of *N. leucotricha* is contracted or more or less loose to 25 cm long. Glumes are 11–15 mm long (12–21 mm long in Barkworth 1993). The lemma is 6–10 mm long. The corona is *ca.*1 mm long, with erect, apical hairs or slender spines 0.6–1.5 mm long. The callus is 1–3 mm long (Figure 5). The awn is bent twice and is 35–60 mm long, with 10–20 mm to the first bend (Pennhall *et al.*2000).

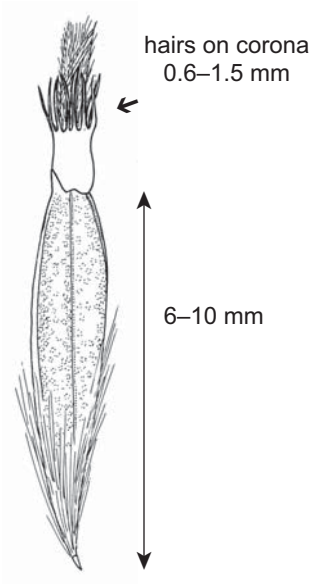

Figure 5. *Nassella leucotricha* seed.

Lobed needlegrass, *Nassella charruana*

Distribution

Nassella charruana (syn. *Stipa charruana*) is a perennial tussock grass that is indigenous to Uruguay, Argentina and south-east Brazil (Rosengurtt *et al.* 1970). It is becoming a serious weed in Australia (McLaren *et al.* 1998). To date it has only naturalized in Victoria and was first collected in 1995 at Thomastown, just north of Melbourne (McLaren *et al.* 1998). The potential distribution of *N. charruana,* predicted from its Australian distribution, has been estimated at 0.6 million hectares (McLaren *et al.* 1998).

Impacts

A personal observation by Mark Gardner in Argentina showed that *N. charruana* was regarded as very poor fodder and, unlike *N. trichotoma* and *N. neesiana,* it was considered an extremely damaging noxious weed due to its invasiveness, competitiveness, unpalatability and very sharp and clinging seeds (McLaren *et al.* 1998). In contrast, Rosengurtt *et al.* (1970) says it provides productive winter fodder but its seeds can penetrate the fur and skin of stock. The potential of *N. charruana* as an agricultural and environmental weed has seen it declared a State Prohibited Weed in Victoria. The Victorian Department of Primary Industries has recently commenced an eradication program. *N. charruana* is on the 'Weed Alert List' of the Commonwealth Department of Environment and Heritage.

Identification

Vegetative characters *Nassella charruana* forms large, densely tufted tussocks with

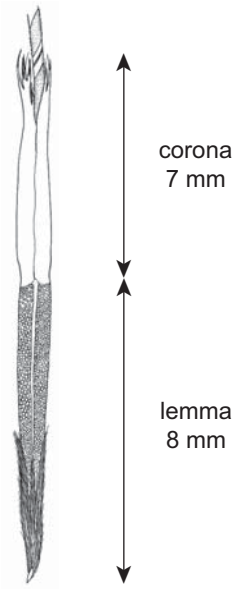

Figure 6. *Nassella charruana* seed.

mature plants being greater than 30 cm in diameter and 0.5–1.0 m high. Leaves have a tough, leathery feel and grow up to 50 cm long. They are narrow, rolled inwards and have a short, membranous, glabrous ligule. Auricles have short hair tufts.

Floral Characters *Nassella charruana* has a very distinctive seed with large, apical lemma lobes (Rosengurtt *et al.* 1970). The panicle is contracted. Glumes are purplish, shiny and longer than the floret (excluding the awn). The lemma is unmistakable with long corona lobes. The lemma is at least 8 mm long and relatively slender (Figure 6). The corona is approximately 7 mm long with lobes forming a collar of firm tissue surrounding the base of the awn. The corona is divided at its end into 0.5–1.9 mm long 'fingers', in turn divided into fine 0.5 mm long hairs. The awn is 45–85 mm long and is not readily detached from the seed (Faithful 1999).

Short-spined needlegrass, *Nassella megapotamia*

Distribution

Nassella megapotamia (syn. *Stipa megapotamia*) is indigenous to Argentina and southern Brazil (Rosengurtt *et al.* 1970). The first collection in Australia was made in 1961 at the CSIRO site at Black Mountain, Canberra and it appears to be confined entirely to this area. No collections have been lodged at the New South Wales and Canberra herbaria since the 1960s but it was still thought to be surviving at Black Mountain during the 1980s (S. Jacobs personal communication). It was apparently an escapee from the CSIRO plant introduction plots (Pullen personal communication).

Impacts

In its country of origin, *N. megapotamia* inhabits undisturbed areas and is rarely found on grazed land. It is considered rare, palatable and of low to medium productive potential. The seeds of *N. megapotamia* are considered innocuous (Rosengurtt *et al.* 1970). The environmental weed status of this species is unknown in Australia. However, *N. megapotamia* could be considered a potential environmental weed (M. Lazarides personal communication).

Identification

Vegetative characters Ligules of *N. megapotamia* are membranous, glabrous and truncate, to 0.7 mm long. Auricles have hair tufts.

Floral characters The panicle of *N. megapotamia* is contracted and 25–35 cm long. Glumes are 8–10 mm long. The lemma is 5.5–6 mm long, with lobes 0.1–0.2 mm long. The corona is 0.5–0.8 mm long with spines on its upper margin. The callus is 2–2.5 mm long and the awn *ca.* 50 mm long.

Uruguayan ricegrass, *Piptochaetium montevidense*

Distribution

Piptochaetium montevidense is indigenous to Argentina, Bolivia, southern Brazil, Paraguay, Uruguay and Chile (Roig 1978). It was first recorded in 1988 from Cherry Lake, Altona, Victoria (Carr personal communication). Its potential distribution in Australia, predicted from its current distribution in Australia, has been estimated at 0.6 million hectares (McLaren *et al.* 1998). However, several recent visits to its recorded location have failed to locate any remaining specimens. It appears that since 1988, the Altona site has been covered by approximately 5 metres of soil/landfill.

Impacts

This grass is uncommon in Argentina and is a small perennial that produces many seeds. Its stock food value is unknown, its seeds cause no problems to stock and have low weed potential (Gardener personal communication). *P. montevidense* has been observed as a component of an overgrazed cattle pasture on the pampas in Argentina where unpalatable grasses dominated (McLaren personal observation). Its impact as an agricultural or environmental weed is unknown. *P. montevidense* is on the 'Weed Alert List' of the Commonwealth Department of Environment and Heritage.

Identification

Vegetative characters *Piptochaetium montevidense* forms dense tussocks to about 0.5 m high. Leaf blades are about 0.5 mm in diameter and are almost the same length as the stems, which are jointed. Leaf blades are hairless but are covered with fine projections, whilst the leaf sheath may have scattered hairs. The ligule is 1–2 mm in length and hairless.

Floral characters *Piptochaetium montevidense* has dense, branched panicles to 10 cm long. The seed is about 2 mm long, whilst the awn is about 10 mm long. The glumes are up to 3.5 mm long and are purplish in colour when young.

Broad-kernel espartillo, *Achnatherum caudatum*

Distribution

Achnatherum caudatum (syn. *Stipa caudata*) is a perennial, densely tufted grass indigenous to Chile and Argentina (Rosengurtt 1970, Caro and Sanchez 1971). The earliest known collection in Australia was made in the Cootamundra district of New South Wales in 1959 and it has since spread to the Deniliquin area in New South Wales (Parsons and Cuthbertson 1992). In Victoria it was first observed near Dunnolly in 1984. It has also been collected from Cambells Creek near Castlemaine and found invading riparian vegetation along Edgars Creek, Coburg. According to McPhee and May (1992), *A. caudatum* was first introduced to Clunes in gravel, possibly during the 1970s. It was recorded on Flinders Island in 1979 (Parsons and Cuthbertson 1992) and on mainland Tasmania at Bridgewater and is declared a noxious, prohibited species in that state. Its potential distribution in Australia, predicted from its current distribution in Australia, has been estimated at 12.9 million hectares (McLaren *et al.* 1998).

Impacts

Achnatherum caudatum and the closely related species *A. brachychaetum* have been identified as problem weeds in lucerne crops in both Argentina and California (Parsons and Cuthbertson 1992). In Chile and Argentina *A. caudatum* and *A. brachychaetum* are considered to have little to no fodder value but their seeds are not harmful to stock. They inhabit fertile areas and are considered aggressive plants on fallow lands of calcareous soils (Rosengurtt *et al.* 1970).

In New South Wales, *A. caudatum* is becoming a serious weed invading pasture, particularly after cultivation. It invades re-sown pasture and becomes prominent by the third year. In native pasture it is limited to areas of disturbance and along fence lines. *A. caudatum* poses a serious threat to grazing production near Clunes in Victoria. It is a poor fodder plant but starving stock will feed on young plants that are still vigorous under heavy grazing pressure (McPhee and May 1992). At Maryborough, Victoria, cattle were

feeding on *A. caudatum* where little or no other pasture species remained (V. Stajsic, E. Bruzzese personal observation).

Achnatherum caudatum is reportedly spread by water, particularly after flooding and by stock along stock routes (J. Cherry personal communication, McPhee and May 1992). It is also spread by slashing, mowing and soil disturbance by machinery along roadsides in the Maryborough, Talbot and Clunes areas (V. Stajsic personal observation, McPhee and May 1992). *A. caudatum* has been observed invading riparian vegetation in central Victoria and in Melbourne (McLaren *et al.* 1998).

Identification

Vegetative characters *Achnatherum caudatum* forms large, dense tussocks to 1.5 m high and 1 m across. The erect stems of mature plants can stand 60–100 cm tall with 2–4 nodes. The sheath-like leaves are tightly adpressed to the stems, and loosen as they grow upwards. The stiff leaf blades are strongly ribbed on both sides and may be flattened or rolled (Parsons and Cuthbertson 1992). The leaf blades are tightly whorled to give stiff spikelet tips and, to the open hand of an observer, the plant feels spiny. It has been suggested that this is a mechanism to protect the basal leaf sheaths of the plant that harbour seeds (Bonnici 2000).

Floral characters Terminal panicle stems of *A. caudatum* are 15–35 cm in length and much branched. The lemma (5-6 mm in length) has a short coma 0.2–1 mm long and is membranous to papery (not thickened or leathery as in *Austrostipa*). The seed does not have a corona or callus. The awn is 10–15 mm long. The species produces abundant, hard, awnless, 'nut-like' cleistogenes at the base of the leaf sheaths and within the stems. The tussocks are spiny at the crown that may serve to protect the basal sheaths containing the cleistogenes (McPhee and May 1992).

Narrow-kernel espartillo, *Achnatherum brachychaetum*

Distribution

Achnatherum brachychaetum (syn. *Stipa brachychaeta*) is native to Uruguay, Chile and central Argentina (Rosengurtt *et al.* 1970). The earliest Australian record comes from Merriwa, New South Wales in 1955. It has been difficult to obtain reliable data on this species in New South Wales due its close resemblance to *A. caudatum*. Its potential distribution in Australia, predicted from its current distribution in Australia, has been estimated at 0.6 million hectares (McLaren *et al.* 1998).

Impacts

Achnatherum brachychaetum is listed by the Federal Government of the United States as a noxious weed. It was collected from ballast near Portland, Oregon and occurs in California (USA Department of Agriculture 1953, Barkworth 1993).

Identification

Same as *A. caudatum,* except the seed kernel is narrower.

Plumerillo, *Jarava plumosa*

Distribution

Jarava plumosa (syn. *Stipa papposa*) is indigenous to southern Brazil, Uruguay, Argentina and Chile (Roig 1978). This species has been recorded in Catalonia in Spain (Casasayas *et al.* 1985) and was also found at Berkley, California in 1983 but has not persisted (Barkworth 1993). Its potential distribution in Australia, predicted from its current distribution in Australia, has been estimated at 1.8 million hectares (McLaren *et al.* 1998). *J. plumosa* was first introduced as a potential pasture plant by the Waite Agricultural Research Institute, Adelaide, South Australia, probably in the early 1940s and the first herbarium record came from a cultivated glasshouse specimen in 1941 (Gardner *et al.* 1996). It has since been found naturalized in the vicinity of the Waite Institute but populations are grubbed out on an ongoing basis (Gardner *et al.* 1996).

Impacts

Jarava plumosa is reportedly of little value for fodder and its seed is irritable to stock (Rosengurtt *et al.* 1970).

Identification

Vegetative characters *Jarava plumosa* is a tufted perennial, 25–80 cm high and is sometimes branched at lower nodes. Its growth form resembles *Austrodanthonia.*

Floral characters The seed of *J. plumosa* has an apical pappus and is the only exotic stipoid species in Australia that has seed adapted for wind dispersal (Jacobs and Everett 1996). The glumes are usually shorter than the lemma. The lemma is 6–7.5 mm long, with no coma or corona. The callus is 1–1.5 mm long. The palea is *ca.* 20% the length of lemma and hyaline. The awn is 15–30 mm long, with basal, pappus-like hairs 4–8 mm long.

Discussion

The combined effects of introduced exotic stipoid grasses on grazing industries and native grasslands in Australia are considerable. Their significance as weeds can be seen by the fact that two exotic stipoids (*N. trichotoma* and *N. neesiana*) are Weeds of National Significance (Thorp and Lynch 2000). Similarly, four exotic stipoids (*N. tenuissima, N. charruana, N. hyalina* and *P. montevidense*) have been identified as a priority weeds for control on the 'National Environmental Weed Alert List' out of twenty-eight weed species nominated across Australia (Department of Environment and Heritage 2004).

The exotic stipoid grasses are having a significant impact on grazing industries in Australia. *N. trichotoma* has been described as causing a greater reduction in pasture carrying capacity than any other weed in Australia (Parsons and Cuthbertson 1992). None of the exotic stipoid grasses are wholly useful pasture species. Some, such as *N. neesiana*, may be palatable at certain times of the year (Gardener 1998), but farmers would overwhelmingly prefer to be rid of this species (McLaren *et al.* 2002). In particular, these grasses threaten the wool industry through contamination of wool, reductions in animal condition and physical damage from their sharp-pointed seeds penetrating the fleece, skins and eyes of livestock.

Impacts by exotic stipoid grasses on threatened species within endangered grasslands are now becoming particularly serious. In Victoria, there is now less than half of one percent of relatively 'pristine' grasslands remaining with six nationally recognized, critically-endangered grassland remnants being listed in Victoria alone (Craigie 1999). Within these remnants, flora such as the Sunshine spider orchid (*Diuris fragrantissima*) and the plains rice flower (*Pimelea spinescens*) and fauna such as the grassland earless dragon (*Tympanocryptis pinguicolla*), the grassland growling frog (*Litoria raniformis*) and the plains-wanderer *(Pedionomus torquatus*) are critically endangered. *N. neesiana* in particular, is invading these remnants and rapidly degrading their integrity.

Efforts to manage these exotic stipoid grasses are resulting in increased herbicide use, rock clearing, cultivation, soil fertility and replacement of native pastures with exotic pastures. In addition, afforestation is being increasingly used in grasslands for management of grass weeds such as *N. trichotoma* (Campbell and Vere 1995). The exotic stipoid grasses are causing wholesale changes in land management from grazing to cropping and from sheep to beef, resulting in significant impacts to both land managers and the environment. These exotic grasses are also affecting fire frequency and intensity with unknown consequences. All these factors combined are placing severe pressures on native grasslands to the point where our capacity to harvest seed of native species such as kangaroo grass (*Themeda triandra* Forssk.) for rehabilitation purposes is diminishing.

Another critically important issue is how these grasses are being introduced into Australia. The northern suburbs of Melbourne appear to be the epicentre of stipoid introductions into Australia. Our only hint on how this may have occurred is that *N. leucotricha* was locally called Tatlow grass, after a local trotting

identity called Edgar Tatlow. The grass was thought to have originated from Edgar Tatlow's trotting stables in Epping, east of Darebin creek (Haberfield personal communication). Perhaps horses and hay came in from South America from where these weeds have spread.

Plant 'hunters' have been roaming the planet for centuries, transporting plants for ornamental and commercial uses to new countries. This practice continues today and new material is continually entering Australia. Fads and fashion drive the nursery trade with customers demanding new and exciting plants, resulting in a great deal of pressure on nurseries and garden centres to seasonally provide new lines of plants. Novel plants are usually first obtained legally but sometimes plant collectors, gardeners and some smaller nursery operators have brought in material without approval from the Australian Quarantine Inspection Service (AQIS).

During the past decade, native grasses have become very popular as ornamental plantings in Australia. In many capital and regional cities, native grasses such as tussock grass (*Poa labillardierei* Steud.) are being used extensively as a low maintenance, attractive groundcover along road and freeway verges. The popularity of grasses in urban areas has resulted in rare plant nurseries taking an increased interest in importing new, attractive, hardy, easily grown species. The resemblance of these exotic stipoid species to indigenous *Austrostipa* species has meant that they are easily overlooked as weeds, increasing the likelihood that they will successfully naturalize. Many gardening books and magazines are advertising these exotic grasses, creating a demand.

The increased use of the internet for global trading has made plants more accessible to a much wider range of customers and has undoubtedly increased the rate of illegal plant introductions coming into Australia. *N. tenuissima* has been sold through nurseries in Victoria and NSW (McLaren *et al.* 1999) but to date it has not naturalized in Australia. It has now been declared a State Prohibited weed in Victoria that should end any future trade with this species.

Recommendations

1. That a blanket ban be placed on exotic grasses being introduced into Australia unless strict weed risk assessments have been conducted that can reduce the likelihood of further ecological and agricultural disasters.
2. That introduction of cultivars of exotic grass species already in Australia only be permitted after strict weed risk assessment that can assure their safety.
3. That an investigation of grass plant collectors be undertaken to determine whether any illegal importations have taken place.
4. That governments and industry support biological control of exotic stipoid species that are beyond expiration.
5. That efforts to eradicate or suppress *N. tenuissima, N. charruana, N. megapotamia, P. montevidense, J. plumosa, A. caudatum* and *A. brachychaetum* continue.

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