Department of Planning and Environment

Abating the threat of exotic perennial grasses in native grassy communities in eastern NSW

Section 5: NSW South Coast

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Cover photo: Themeda Grassland on Seacliffs on the South Coast. Julia Rayment/UOW

Authorship and citation: The authors assert the right to be attributed as authors of the original material. This document has been prepared by Julia T Rayment[1], Morgan H Brading[2] & Kris French[1].

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This document should be cited as: Rayment J, Brading M & French K (2022), *Abating the threat of exotic perennial grasses in native grassy communities in eastern NSW, 5: NSW South Coast*, NSW Department of Planning and Environment, Australia.

Published by:

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ISBN 978-1-922840-62-2
EHG 2022/0313
August 2022

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Acknowledgments

We acknowledge the Traditional Custodians of Country throughout New South Wales, where this report was completed, and their connection to land, sea and community. We pay our respects to their Elders past and present and extend our respect to all Aboriginal and Torres Strait Islander peoples today.

We thank Jackie Miles for sharing data from her field work.

Thank you to the participants of the survey who took time out of their busy schedules to provide important information and feedback.

This report is in 5 sections. Each is available as a separate document for download:

1. Overview
2. NSW North Coast
3. NSW Northern Tablelands and Slopes
4. NSW Southern Tablelands and Slopes
5. **NSW South Coast (this document)**

Introduction

The South Coast region lies within the South East Local Land Services (LLS) area, and, for this report, extends north into Greater Sydney and from Newcastle to Eden and inland 50 km. The South East LLS area was divided into 2 regions in this report to account for climatic and land use differences.

This section presents information from the coastal region (see Section 4 for information on communities further inland). The South Coast experiences milder temperatures, higher rainfall and greater fragmentation from densely populated urban cities.

The region receives consistently high rainfall annually of 746–960 mm (Climate-Data.org no date). There are about 638,000 ha of national parks and reserves, including many wetlands of significance, and about 325,000 ha of state forests. Dairy, forestry, and fisheries form significant industries away from the metropolitan areas.

Three threatened grassy communities were surveyed although the local land managers manage a range of other communities. Following the principles outline in the Section 1: Overview (see 'Four-step approach to managing native communities' below), we use field and land manager surveys to identify exotic perennial grasses (EPGs) in the region.

We then combine this information with the risk assessment tool (see Section 1: Overview) to suggest which EPG species to prioritise for the grassy communities that we surveyed.

The risk assessment tool identifies the species most at risk of invading native communities, based on plant characteristics (Rayment and French 2021).

Lastly, we provide resources to help identify advantages and disadvantages of control techniques available for the species identified as high priority. We hope this information facilitates the management of this region, particularly the native grassy communities.

The information outlined here could also be useful for other communities of interest. EPG invasion will vary over time in response to rainfall and drought periods. We suggest starting with surveys to ensure you prioritise relevant EPGs and understand your management area.

Four-step approach to managing native communities

1 Identify

A quantitative survey of the area will identify the EPGs and their levels of invasion. *Monitoring Manual for Invasive and Native Flora* (Watson et al. 2021) sets out methods to do this in a rigorous manner. Training may be important to ensure grass identification is accurate.

2 Prioritise species for management

Based on the field surveys, identify the species with greatest invasion risk using the risk assessment tool (Section 1). Use other resources such as regional or national priorities to help prioritise your control. Some species might be rare in your community but have a high-risk score, leading to the need to prioritise the removal of the species from sites and an increase in the prioritisation score.

3 Control

Key to this action is the development of a management plan. Preventative weed control is a key tool in preventing EPG invasion. The NSW Department of Planning and Environment has developed hygiene guidelines to reduce the risks of introducing invasive plants.

Management options and resources are included in this document, but thinking about the biology of the species you are managing may help you to consider other control options too. The risk assessment tool provides information on the biology of species. The use of multiple control techniques (integrated weed management [IWM]) will be important in conserving these native communities. IWM is particularly useful to avoid plants adapting or improving their resilience to any single control method. Collaboration with a pooling of resources across land managers will be more effective, aiming to control a common area of land or common plant. Weed control is rarely short term: native regeneration is slow and EPG control is required continuously.

4 Monitor

Monitoring is critical to assess the success of control and identify new emerging threats, and will improve our understanding of management efficacy and native recovery. It also provides capacity to alter control strategies for long-term success. We recommend using the Monitoring Manual for Invasive and Native Flora and implementing monitoring as a key requirement of managing EPGs.

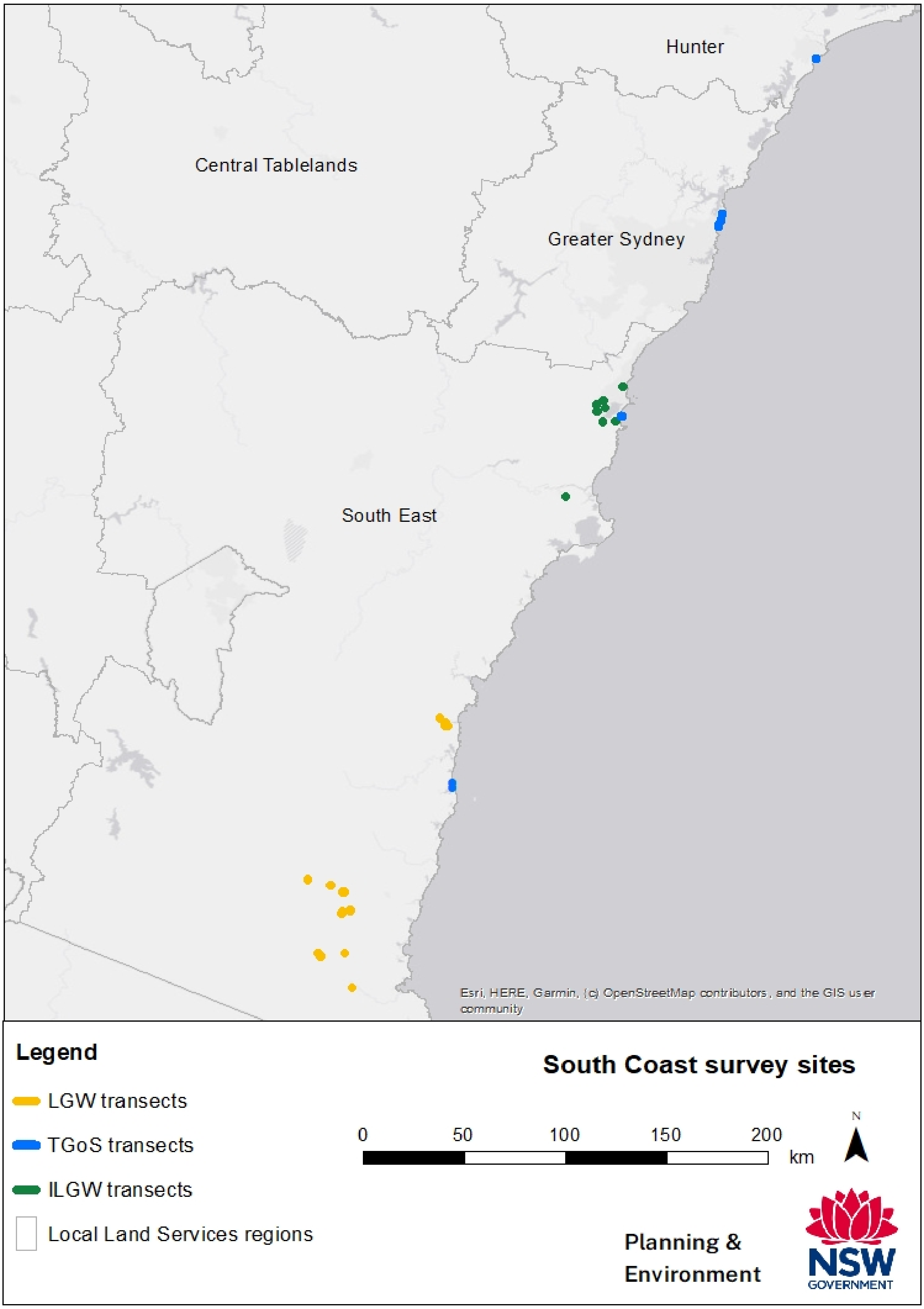

Figure 1 South Coast field survey sites for the 3 threatened grassy communities

TGoS: Themeda Grassland on Seacliffs and Coastal Headlands, ILGW: Illawarra Lowlands Grassy Woodland, LGW: Lowland Grassy Woodland

1. Identify: grassy community field surveys

Three threatened grassy communities were surveyed in the region: 2 grassy woodlands and one grassland. Across the 3 surveys 18 EPGs were recorded: 3 EPGs were identified as widespread across the region: *Sporobolus* spp. (23 sites), common paspalum (22 sites), Kikuyu (20 sites). Two other EPGs occurred in all 3 communities: slender pigeon grass (13 sites), which was characteristic within Illawarra Lowlands Grassy Woodland, and panic veldtgrass (11 sites).

African lovegrass was absent from the grassland community and was an important invader in Lowland Grassy Woodland (8 sites). Rhodes grass occurred in 5 sites each for Illawarra Lowlands Grassy Woodland and Themeda Grassland on Seacliffs and Coastal Headlands.

For the land manager survey, 22% of participants were from the South Coast region managing grasslands, grassy woodlands, rainforests, shrublands and woodlands. Parramatta grass (*S. africanus)* is one of several exotic *Sporobolus* species in Australia. Due to its genetic and morphological similarity to the other *Sporobolus* species and their ability to hybridise readily, they are collectively referred as the weedy *Sporobolus* grasses.

Trade-off species

Some EPGs were intentionally introduced for use in pasture and garden plantings. Several species are still frequently used in agriculture today and are often referred to as 'trade-off', or contentious species. These species provide economic benefit but are detrimental in native communities and cause environmental losses. Issues arise in the management of these grasses as they may spread into areas of conservation more easily, and may be modified for improved use in pasture, which also improves their invasive ability. High propagule pressure and differences in the management of economically useful grass species greatly increases the likelihood of spread into native areas.

Grassy communities are often surrounded by areas of land where trade-off species are planted and can experience stock movement and grazing pressure.

1.1 Illawarra Lowlands Grassy Woodlands

Figure 2 Illawarra Lowlands Grassy Woodland. Photo: Jedda Lemmon/DPE

The Illawarra Lowlands Grassy Woodland (ILGW) community is the most range-restricted of the 9 communities surveyed and was the community with the highest levels of invasion of EPGs. There were 18 EPG species recorded across 8 sites and with high occurrence in quadrats within sites (Figure 3). ILGW sites occur in highly fragmented patches surrounded by urban and peri-urban areas.

Most sites had invasions of common paspalum (occurring in 24% of quadrats), weedy *Sporobolus* grasses (occurring in 20% of quadrats), Kikuyu (occurring in 24% of quadrats), pigeon grass (occurring in 26% of quadrats) and Rhodes grass (occurring in 28% of quadrats) (Rayment et al. 2022). While panic veldtgrass invaded fewer sites, where it occurred it had very high invasion rates, occurring in, on average, 55% of quadrats.

Notably, one site was dominated by Rhodes grass with over 70% of the ground cover with Rhodes grass monocultures and edge invasions noted at several other sites (J Rayment, personal communication). Survey participants involved with ILGW identified a different suite of species as of concern, including Chilean needle grass, African lovegrass, Coolatai and serrated tussock.

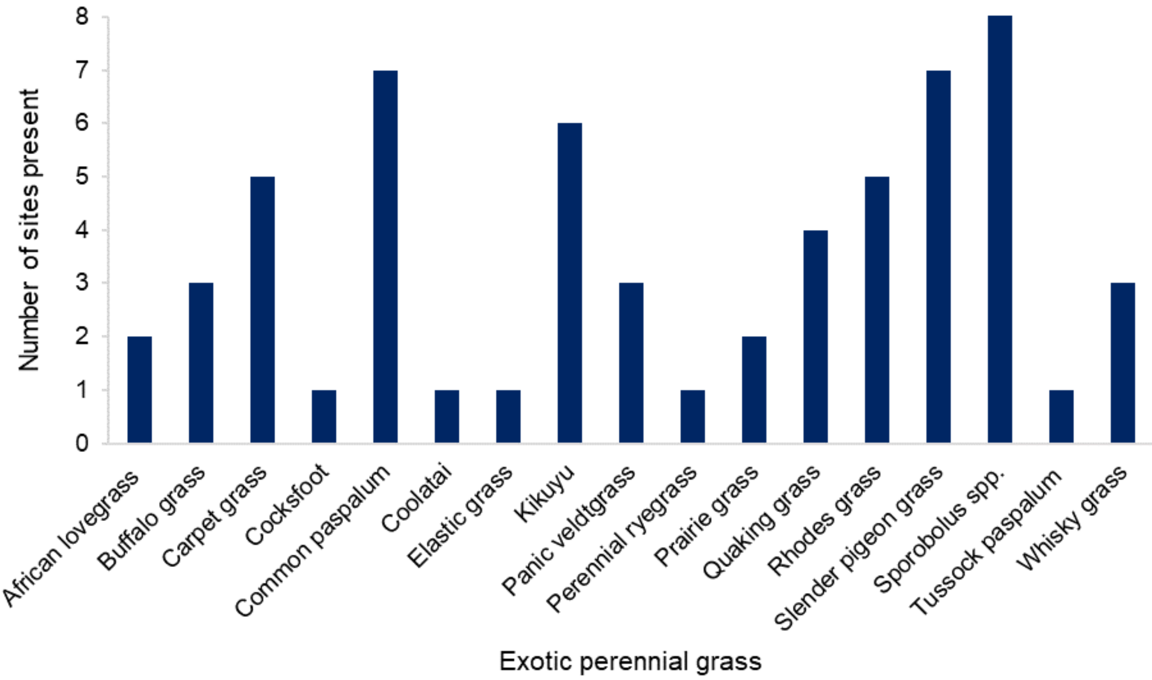

Figure 3 Number of sites where each EPG was recorded during field surveys of Illawarra Lowlands Grassy Woodland (ILGW) (n = 8)

1.2 Lowland Grassy Woodland

Figure 4 Fence line showing differences in ground cover of Lowland Grassy Woodland without (L) and with (R) management. Photo: Jackie Miles

Lowland Grassy Woodland (LGW) occurs in rain-shadow areas of the South Coast and hinterland, with representative sites in the Bega Valley, Eurobodalla and Palerang local government areas. Community remnants occur in travelling stock reserves (TSRs), cemeteries, significant roadside areas, reserves and on pastureland. Across the 14 sites surveyed, 15 EPGs were recorded (Figure 5). Weedy *Sporobolus* grasses, common paspalum, and Kikuyu were all prevalent across the community with significant invasions of African lovegrass.

African lovegrass occurred at 57% of sites and was, on average, recorded in 65% of the quadrats at sites (Rayment et al. 2022). Common paspalum, weedy *Sporobolus* grasses, panic veldtgrass and Kikuyu were in at least a third of the quadrats at surveyed sites (Rayment et al. 2022). LGW sites contained several areas where highly modified exotic-dominated sites had been transformed into well-managed areas of high conservation value.

One reserve, previously grazing land, experienced high native ground cover regeneration through only tree planting and mosaic burns, while legacy effects of previously enriched areas had Kikuyu invasion (Bemboka Landcare Group 2017; J Miles, personal communication).

Another site had been transformed from exotic improved pasture into high conservation value native pasture (D Lewis, personal communication).

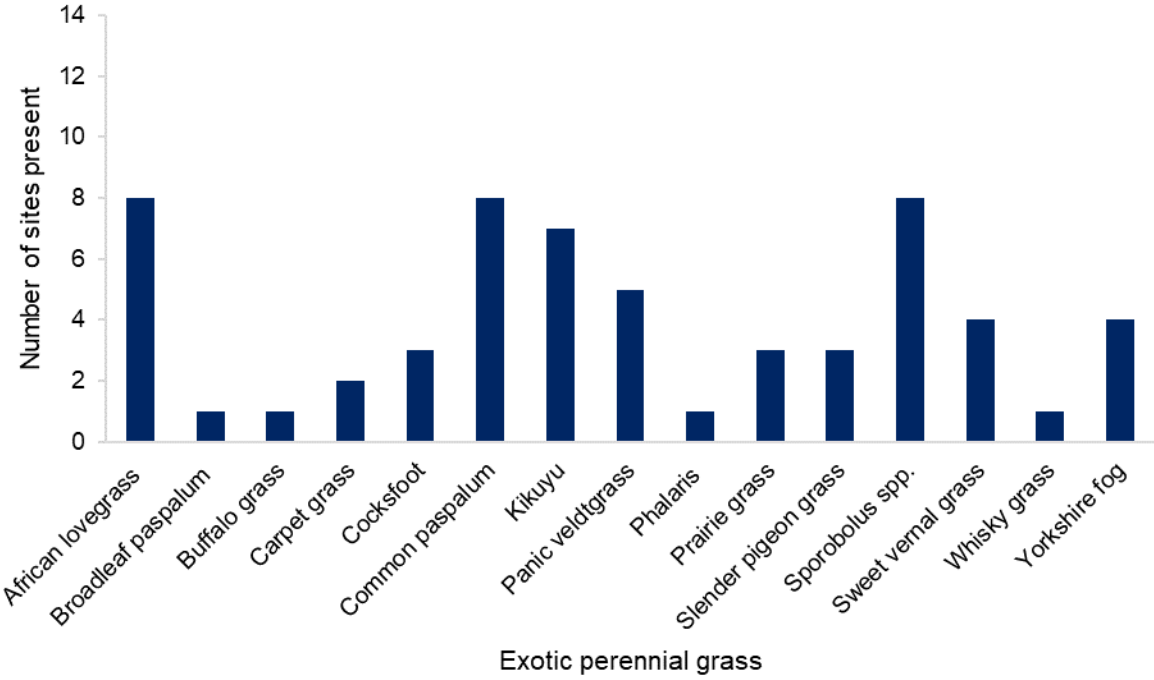

Figure 5 Number of sites where each EPG was recorded during field surveys of Lowland Grassy Woodland (LGW) (n = 14)

1.3 Themeda Grassland on Seacliffs

Figure 6 *Themeda triandra* on a Themeda Grassland site (Windang Island). Photo: Julia Rayment/UOW

Themeda Grassland on Seacliffs and Coastal Headlands (TGoS) occurs in small, highly fragmented areas on the South Coast from Newcastle, Sydney, Illawarra and Eurobodalla, as well as on the North Coast. The community is threatened by clearing of native vegetation, shrub encroachment, weeds, and human-mediated disturbance (OEH 2021). The communities are highly fragmented and are frequented by humans, disturbing sites and spreading seed on footwear and clothing. Sites occur naturally in exposed areas with heavy winds, full sun, and salt spray, so invading EPGs must have high environmental tolerance to establish (Adam et al. 1989).

We surveyed 8 sites which had significant invasions of common paspalum and Kikuyu. These species occurred at most sites, occupying at least 40% of the quadrats surveyed within sites (Rayment et al. 2022). Significant invasions of weedy *Sporobolus* grasses (63% of sites with 31% of quadrats invaded), Rhodes grass (63% of sites with 18% of quadrats invaded) and panic veldtgrass (38% of sites with 40% of quadrats invaded) were also noteworthy (Rayment et al. 2022). A total of 11 EPGs were recorded in the grassland community (Figure 7). Kikuyu and panic veldtgrass were identified by survey participants as being species of concern.

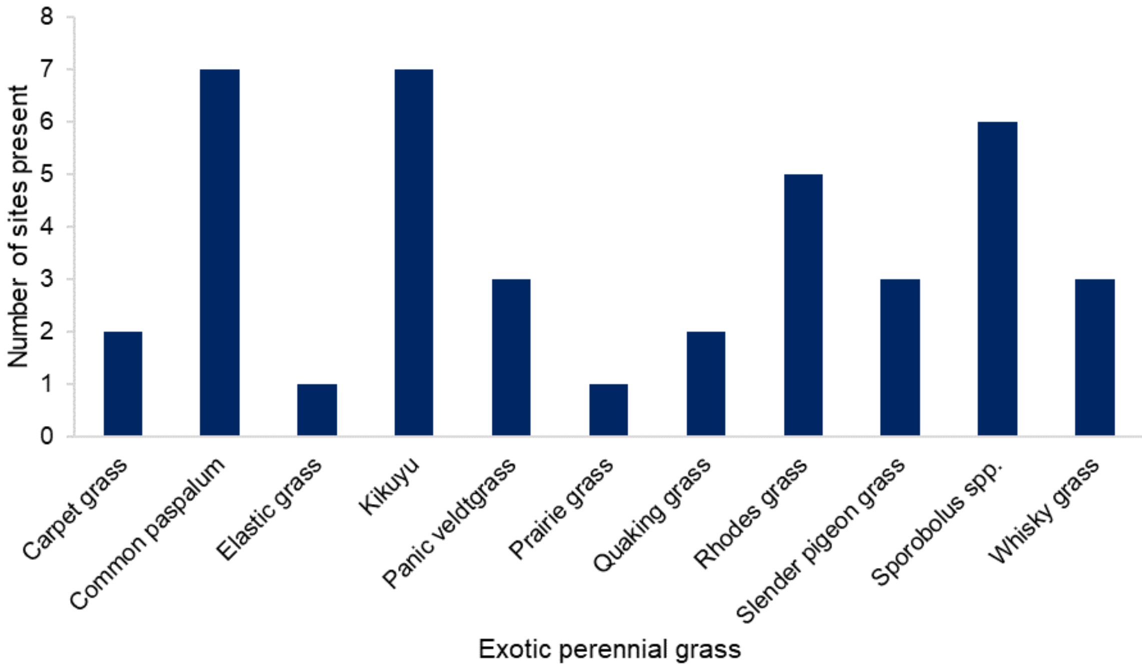

Figure 7 Number of sites where each EPG was recorded during field surveys of Themeda Grassland on Seacliffs (TGoS) (n = 8)

Figure 8 African lovegrass invasion on a farm in the Bega Valley; photo: Julia Rayment/UOW

1.4 Land manager survey results

Survey participants managed 13 communities in the region. African lovegrass was most commonly selected by participants as a species of concern (10 counts), followed by Kikuyu and panic veldtgrass (7 counts each) (Table 1).

These 3 EPGs represent regionally important species in both field surveys and land manager surveys. Despite a range of community types being represented, only 12 EPGs were mentioned by survey participants.

One key difference between what was recorded in field surveys and what was of concern to survey participants was concern over Chilean needle grass and serrated tussock, which were not recorded in field surveys.

Such a disparity may be due to a number of factors associated with these species being high-profile Weeds of National Significance. Low levels of occurrence at sites in the field surveys may also be associated with widespread adequate management of agricultural lands, with the spread into native communities being reduced.

Alternatively, these EPGs may invade agricultural areas, but are not particularly important in many native communities, or may respond to high rainfall periods (surveys were undertaken during a drought). Across similar community types (rainforests, grasslands, woodlands) there was little correlation between EPGs considered concerning.

Survey participants considered African lovegrass, panic veldtgrass and Kikuyu to have major negative impacts, frequently dominating sites and impacting native species. Participants were concerned about the threat of invasion from nearby sources such as agricultural areas.

Table 1 Results from the land manager survey in the South Coast region

Land managers were asked to list *up to* 3 EPGs they consider most damaging in the community they manage. The number of participants per community is given at the bottom. Communities with more than one participant may have EPG counts greater than 1.

Community names are abbreviated: BMSC: Blue Mountains Shale Cap Forest, BSF: Bangalay Sand Forest, BWVF: Brogo Wet Vine Forest, CPW: Cumberland Plain Woodland, CS: Coastal Saltmarsh, DF: Duffys Forest, DR: Dry Rainforest of the South East Forests, ESBS: Eastern Suburbs Banksia Scrub, ILGW: Illawarra Lowlands Grassy Woodland, LGW: Lowland Grassy Woodland, MTS: *Melaleuca Armillaris* Tall Shrubland, SGTF: Shale Gravel Transition Forest, TgoS: Themeda Grassland on Seacliffs

	BMSC	BSF	BWVF	CPW	CS	DF	DR	ESBS	ILGW	ISTRF	LGW	MTS	SGTF	TGoS	Total
African lovegrass	1		1	1		1		1	1	1	2		1		10
Chilean needle grass							1		2						3
Common paspalum											1				1
Coolatai					1	1	1		1						4
Elastic grass															
Kikuyu		1								1	3	1		1	7
Pampas grass					1	1									2
Panic veldtgrass				1				1		1	1	1	1	1	7
Rhodes grass											1	1			2
Serrated tussock	1		1						1						3
Sporobolus spp.							1		1						2
Whisky grass								1							1
Yorkshire fog	1														1
Number of participants	1	1	1	1	1	1	1	1	2	1	3	1	1	1	

2. Prioritise: EPGs of concern in native communities in the South Coast region

Using the field surveys in the 3 grassy threatened communities and land manager surveys who work across multiple native communities, we identified the following EPGs as of most concern to the region: weedy *Sporobolus* grasses, common paspalum, Kikuyu, panic veldtgrass, slender pigeon grass, Rhodes grass and African lovegrass. In this section we provide information on the biology of these species and use a 'triage table' (Table 2) to highlight our prioritisation.

Sporobolus africanus. Photo: Harry Rose

Common paspalum. Photo: Harry Rose

Kikuyu. Photo: Harry Rose

Panic veldtgrass. Photo: Harry Rose

Slender pigeon grass. Photo: Harry Rose

Rhodes grass. Photo: Harry Rose

African lovegrass. Photo: Harry Rose

Figure 9 EPGs most of concern in the South Coast region

2.1 Weedy Sporobolus grasses (*Sporobolus africanus, Sporobolus fertilis* and others)

The *Sporobolus* grasses are typically grouped together and referred to as 'Weedy *Sporobolus* grasses' (WSG). Five exotic *Sporobolus* species are present in New South Wales and are grouped into one complex due to their genetic and morphological similarity. Information on their ecology and biology has been reviewed in Rayment and French (supplementary material 2021), and a revised risk score of 15/32 was considered in Rayment et al. 2022.

Research priorities

There is low certainty relating to impact on native ecosystems. Increased research on resource competition and environmental tolerance in native communities is needed.

General biology and ecology

Giant Parramatta grass (*S. fertilis)* was less prevalent than Parramatta grass in surveys but identification among the suite of invasive species in this genus is difficult, especially when coupled with some hybridisation. According to mapping by NSW Department of Primary Industries (DPI) (DPI 2017) *Sporobolus* grasses are more abundant in the tablelands towards the border of New South Wales and Queensland.

The most invasive characteristics of *Sporobolus* spp. are their ability to inhabit a wide range of soil and climate types (Bray and Officer 2007; Ghasempour and Kianian 2007; Rana et al. 2012), coupled with highly prolific seed production (85,000 seeds/m^2: DAF 2018) and small seed size allowing good dispersal (Vogler and Bahnisch 2006).

As seeds can remain viable for up to 10 years, control of *Sporobolus* requires a large time investment to deplete the seed bank (Bray and Officer 2007). Weedy *Sporobolus* grasses establish best on disturbed ground and are more commonly found along roadsides or ecosystem edges.

They are prolific seeders, germinating year-round and quickly developing tough root systems to persist through stressful environmental conditions (Witt and McConnachie 2004; Bray and Officer 2007; Padilla et al. 2013). Weedy *Sporobolus* grasses appear to be better adapted to survive prolonged periods of drought than native counterparts. Yobo et al. (2009) describes *Sporobolus* spp. as opportunistic invaders, with the ability to spread when competition is low from drought.

Pasture

WSG are serious pastoral weeds (Bray and Officer 2007; DPI 2017). They reduce pasture production through low palatability, with competitive pastures needed to resist invasion (Bray and Officer 2007; Yobo et al. 2009).

Native communities

A participant managing ILGW commented on the ability of weedy *Sporobolus* grasses to outcompete native grasses once established. In field surveys, weedy *Sporobolus* grasses were observed as prevalent along trails and edges where disturbance and bare ground was highest (J Rayment, personal communication). Weedy *Sporobolus* grasses outcompete native species for space.

As with many invasive grasses, they germinate quickly, developing tough root systems in 5 weeks (Bray and Officer 2007) and have been observed to produce seed within 6 months of germinating (J Rayment, personal communication). Impact on native communities is not well-quantified but evidence from impact on agricultural areas, and these field and land manager surveys, indicates an ability to cause negative impact where they establish.

Figure 10 Invasion of *Sporobolus africanus* along a walking track on Themeda headlands. Photo: Julia Rayment/UOW

2.2 Common paspalum (*Paspalum dilatatum*)

Rayment and French (2021) classified common paspalum as having a very high risk of invasion and establishment (score 23.5/32). Common paspalum was found in significant invasions in all threatened ecological communities (TECs) in the field survey and was the second most frequently occurring EPG across the 3 communities.

Research priorities

As the fifth most risky species there is a need for research to improve the certainty of the assessment; we currently have poor knowledge of common paspalum's impact on ecosystems, competitive ability, and seed longevity.

General biology and ecology

This species is adapted to intermittent flooding and drought conditions, with germination improved with water availability (Vasellati et al. 2001; Cornaglia et al. 2005; Mollard et al. 2008). With a high seed output and sticky seeds, paspalum can spread through transport on fur, machinery and humans (Weeds of Australia 2016; Lawn Solutions Australia 2021). Paspalum prefers fertile soils and was described by one participant as 'able to dominate fertile alluvial soil in run-on zones'.

Paspalum is said to be adapted to the wetter areas of the coast and inland slopes and plains, growing prolifically in the summer months (DPI no date b). This establishes important information regarding when to be vigilant for paspalum invasions, influencing monitoring plans. Once established, paspalum can spread vegetatively, improving its abundance at a site (Henry, Yelverton et al. 2007) and has been suggested to have allelopathic potential improving competitive ability (Hassan and Mohamed 2020). Given its high risk score and limited attention by survey participants we consider paspalum requires more attention and concern in management.

Pasture

As a pasture species, common paspalum is tolerant to grazing and may outcompete less-competitive pasture species. With an ability to tolerate trampling, paspalum can persist in agricultural areas (Striker et al. 2006). Paspalum grows prolifically over summer and may spread from areas of intentional planting (DPI no date b). With highly fragmented landscapes along the coast, the propagule pressure associated with this trade-off specie increases likelihood of establishing in conservation areas.

Native communities

Paspalum will likely impact native recruitment and compete for resources such as space, light and nutrients. However, limited available research, particularly in native communities, limits our understanding in these areas. Its prevalence and dominance in many communities suggests it should be a focus of management as it can spread and invade without disturbance. Unpublished results from a greenhouse experiment have shown paspalum to effectively smother native species recruitment and have deeper, larger root systems, indicating the species grows faster and competes effectively for space, water and nutrients (J Rayment, personal communication).

2.3 Panic veldtgrass (*Ehrharta erecta*)

Figure 11 Seeds of panic veldtgrass (*Ehrarta erecta*). Photo: Julia Rayment/UOW

Panic veldtgrass was assessed to have a risk score of 19/32 (Rayment and French 2021). Panic veldtgrass is a characteristic invasive species in the South Coast region, present in all 3 field survey communities and identified as highly damaging in 7 communities by survey participants.

Indicative of its invasive potential is its presence across numerous communities, from woodlands, grassy woodlands and grasslands, to scrubs, shrublands and rainforests.

Research priorities

Research should focus on understanding seed output per plant to improve understanding of propagule pressure, as well as further understanding the impact on native communities where panic veldtgrass invades.

General biology and ecology

Panic veldtgrass exhibits a range of invasive characteristics, including high germination success and wide environmental tolerance, providing ability to rapidly invade nearby areas. Despite no information on seed output for panic veldtgrass, it is widely considered to be a prolific seeder; one survey participant suggested it can seed every 6 weeks (Ray 2016; Sydney Weeds Committees 2018).

The grass has near 100% germination (McIntyre and Ladiges 1985); once seeds or plants are present in the landscape an increase is inevitable. Panic veldtgrass grows in shaded or full sun (McIntyre and Ladiges 1985; Bidwell et al. 2006). Furthermore, it is tolerant of a wide range of environmental conditions.

In South Africa it grows from sea level to 2,100 m, with annual rainfall ranges from 600 to 1,875 mm (McIntyre and Ladiges 1985). McIntyre and Ladiges (1985) determined soil moisture was a limiting factor for panic veldtgrass establishment and persistence. Survey information for the Cumberland Plain Woodland community identified stormwater and run-off as a factor influencing invasion.

Pasture

There is limited information on the presence and impact of panic veldtgrass in agricultural communities.

Native communities

In Sydney's native Cumberland Plain Woodland communities, panic veldtgrass is a superior competitor under drought conditions, leading to reduced native species biomass and increased invasive spread as it captures free resources (Manea et al. 2016). In Melbourne, panic veldtgrass invades urban areas and impacts native ground cover through dense infestations (Bidwell et al. 2006).

Panic veldtgrass is also a strong competitor in California, where invasion leads to lower cover of native species (Ray 2016). As a grass with high rates of germination, a wide tolerance of environmental conditions, and an ability to form dense infestations that can outcompete native ground cover, panic veldtgrass is of high concern in the South Coast region. Control will be influenced by high fecundity.

Survey participant perceptions of panic veldt grass

‘Rapidly invades bush in poor to fair condition. Dense monocultures prevent native germination’ (Eastern Suburbs Banksia Scrub)

‘[Invades] from neighbouring properties … needs constant work to prevent spread’ (Lowland Grassy Woodland)

‘High seed set, hard to control, impacts recruitment of others’ (Melaleuca Tall Shrubland)

‘Excessive competition’ ‘Impacts revegetation’ (Shale Gravel Transition Forest, Themeda Grassland)

2.4 Kikuyu (*Cenchrus clandestinus*)

Kikuyu is a species of high risk in native grasslands as it was ranked second (27/32) in Rayment and French (2021). Plant characteristics are well-known although information on seed output would facilitate improved management. It was found to be a significant invader of the 3 grassy communities in the field survey, and was recorded in 5 communities by survey participants as highly damaging, including 3 participants in Lowland Grassy Woodland.

Research priorities

Research Kikuyu is heavily skewed towards its economic benefits. To fully appreciate the consequences of trade-off species, research is needed on their negative effects and the importance of management when planted intentionally and where invasive.

General biology and ecology

Kikuyu is a trade-off species, offering amenity value as lawn and turf grass in urban settings and offering feed value in some agricultural settings (Mears 1970). However, the same characteristics that have made it a desirable species are also key to its invasive ability (Mears 1970).

As a trade-off species, its propagule pressure is significantly improved, with increased opportunities to spread beyond its intended range into nearby native communities where it can impact biodiversity and ecosystem functioning. Arguably the most important invasive characteristic of Kikuyu is its vigorous vegetative spread, able to spread 1 m a year and create dense monocultures 1 m thick (Fullagar and Heyligers 2006).

Identified as having an extensive root system capable of sourcing water and nutrients from as deep as 5.5 m, this can provide Kikuyu with a competitive advantage over natives and exotic alike in capturing effective resources and surviving harsh conditions (Fraser et al. 2017). Kikuyu prefers high-fertility soils, which will impact its ability to establish and persist in many communities but underscore its ability to invade modified agricultural land, urban land and more fertile coastal communities.

Kikuyu is also known for its drought tolerance, although it grows best in moist conditions, particularly in coastal areas (IUCN Invasive Species Specialist Group 2010). Once established however, it can survive long periods of drought. Kikuyu is well-adapted to persist in Australian communities and impact native ecosystem functioning (Fraser et al. 2017). The traits identified emphasise the risk of Kikuyu to native communities in the South Coast region.

Pasture

There is a skew in research and information towards the economic benefits of Kikuyu (Rayment and French 2021). Kikuyu is available for commercial and agricultural purchase improving propagule pressure and ability to form dense turfs.

Native communities

Survey participants considered Kikuyu causes major negative impact in invaded native communities. Its ability to invade nearby communities through vegetative spread was echoed by participants from many communities, including shrubland and grassland communities who note the invasion front on the edges of communities.

Montague Island, an island offshore from the South Coast town of Narooma, was rapidly invaded by Kikuyu after the removal of feral goats, leading to the deterioration of breeding conditions for little penguins, and a subsequent eradication program to stop its impact (Fullagar and Heyligers 2006).

The spread of Kikuyu also allows it to colonise bare ground, limiting native recruitment (Mears 1970). Three participants from different communities mentioned the impact on native species recruitment and revegetation.

2.5 African lovegrass (*Eragrostis curvula*)

Figure 12 African lovegrass (*Eragrostis curvula*). Photo: Harry Rose/flickr

African lovegrass has the highest risk score (28/32) of the 29 EPGs assessed in Section 1: Overview (Rayment and French 2021). Its invasion characteristics are well-known, although a good understanding of seed longevity would facilitate management.

General biology and ecology

African lovegrass has plant traits indicative of a very successful invader, with traits that are well-suited to invasion and persistence in the South Coast region. These include tolerance of a range of environmental conditions, good seed production, and high competitive ability for both resource competition and interference competition (allelopathy) (Campbell 1983; Curhes et al. 2009; Firn 2009; Ghebrehiwot et al. 2014).

African lovegrass can persist in infertile soils and is able to tolerate, and even preferentially spread, during stress and drought. African lovegrass can also increase growth in response to fire, indicating a strong ability to persist through extreme environmental conditions common throughout the region (Bock and Bock 1992; Milberg and Lamont 1995). African lovegrass can employ vegetative spread in response to disturbance through tiller production (Campbell 1983, Masters and Britton 1990 in Firn 2009).

Pasture

Once a trade-off species, 7 varieties of African lovegrass have been introduced across Australia and cultivated for use as erosion control and in pastures (Queensland Government 2016; Firn et al. 2018). Although now commonly recognised as economically and environmentally damaging, its legacy as a pasture species has played a key role in its spread throughout Australia.

Native communities

The presence of African lovegrass is negatively correlated with native species richness and leads to ecosystem degradation (Bock and Bock 1992; Dorrough 2015; Godfree et al. 2017).

Survey participant perceptions of African lovegrass

'Dominates' (Brogo Wet Vine Forest)

'Rapidly invades … dense monocultures prevent native germination' (Eastern Suburbs Banksia Scrub)

'Forms dense patches, high competition, hard to control' (Illawarra Subtropical Rainforest)

'Change in fire severity and timing' 'Loss of plant diversity, modification of ground layer' 'Not yet present but approaching on road verges' (Lowland Grassy Woodland)

'On the peripherals' (Duffys Forest)

'Interacts with … fire regimes' (Cumberland Plain Woodland)

2.6 Rhodes grass (*Chloris gayana*)

Figure 13 Rhodes grass invasion in Illawarra Lowlands Grassy Woodland. Photo: Julia Rayment/UOW

In Rayment and French (2021), Rhodes grass was ranked third with a risk score of 26/32, suggesting it has the potential to invade easily and be highly invasive. Information on evidence for its high rank is available in supplementary material for Rayment and French 2021. Rhodes grass invasion was significant in ILGW and TGoS communities.

Research priorities

Further research is needed on seed biology and impact on ecosystems to provide certainty for this risk score.

General biology and ecology

The invasion potential of this species is due to its use as a trade-off species, tolerance to a range of conditions, vegetative spread and high competitive ability (Rayment and French 2021). Rhodes grass can spread through intentional plantings, vegetative growth, and high seed production (DAF 2016). As a pioneer species, Rhodes grass quickly establishes and dominates bare ground, leading to a reduction in native species (Watt and Whalley 1982; Huxtable et al. 2005). Rhodes grass has high environmental tolerance to salt and poor-quality soils but is not believed to be drought tolerant, making the wetter coastal regions suitable (Wehr et al. 2006; DAF 2016).

Pasture

Rhodes grass was used in pasture in New South Wales, with 10 varieties currently available (Lattimore and McCormick 2012; DAF 2016). As a useful pasture grass, invasion into nearby communities is possible through propagule pressure and improper weed hygiene facilitating seed spread.

Native communities

Rhodes grass has been documented for its ability to aggressively compete with natives and exotics alike (Huxtable et al. 2005; Lodge et al. 2009). While its competitive dominance impacts native communities, there is limited research quantifying its invasion and impact in native communities.

Its quick spread, through vegetative and sexual reproduction, was observed in field surveys where it dominated edges of sites, roadsides, and in one site of ILGW, was overwhelmingly the dominant ground cover, choking out native kangaroo grass (*Themeda triandra*) (J Rayment, personal communication).

2.7 Slender pigeon grass (*Setaria parviflora*)

Slender pigeon grass scored 14.5/32 in the risk assessment. To understand the impact and risk of this grass, research and knowledge sharing is paramount. Slender pigeon grass was present in all 3 field surveys, and particularly in Illawarra Lowlands Grassy Woodland, and is likely to compete for space and impact native germination. Its higher presence in ILGW indicates it is more concerning at a community level.

General biology and ecology

Slender pigeon grass is said to have broad geographical and ecological distribution (Dekker 2003). It grows in areas with frequent disturbance, such as the grasslands of the flooding pampa, and in higher positions without flooding, indicating ability to tolerate a range of environmental conditions (Dekker 2003; Mollard and Insausti 2011).

Flooding can result in breaking of seed dormancy and improved germination of slender pigeon grass (Mollard and Insausti 2009, 2011). Slender pigeon grass has low seed output, with reports of 848 seeds/m^2 (Leguizamón et al. 2009) and online sources claiming a short-lived seed bank (Buddenhagen 2013). Slender pigeon grass can spread through rhizomatous growth (Buddenhagen 2013).

Research priorities

Despite being common across the South Coast sites, and prevalent across eastern New South Wales, there is limited information on slender pigeon grass for its biology, ecology, and potential impact and interaction with native species. This is reflected in an uncertainty (or confidence) score of 50% in the risk assessment.

Baseline data to better understand slender pigeon grass is important for effective management in the South Coast region. Information regarding resource competition and impact on ecosystems is scarce.

Table 2 Triage system for the risk and prioritisation of EPGs in the South Coast region

Red (HC) = highest concern, high priority for weed control (frequent, high risk), orange (MC) = moderate concern (e.g. high threat with moderate occurrence/ high uncertainty in information), blue (N) = notable species (e.g. trade-off species, high risk with low occurrence)

EPG	Risk score	Prevalence score %	Risk factors for invasion	Areas for concern	Other considerations
HC – *Sporobolus* spp.	15	Total: 73% ILGW: 88% LGW: 57% TGoS: 63%	High seed output, resistant to competition, tolerant of harsh environmental conditions.	Invades disturbed areas. Long-lived seed bank.	Control before seed set. Best practice manual available for pasture.
HC – Common paspalum	23.5	Total: 73% ILGW: 88% LGW: 57% TGoS: 50%	Tolerant of drought and flooding. Rainfall promotes growth and seed spread.	Grazing and mowing promote growth. Evidence for allelopathy.	Information needed for impact on natives and control.
HC – Panic veldtgrass	19	Total: 37% ILGW: 38% LGW: 36% TGoS: 38%	Quick to seed production, high viability of seeds. Grows well in shady and sunny positions.	Invades all communities but high risk in shaded areas. Responds quickly to rainfall.	IWM with a focus on removing seed heads and seeds from seed bank.
HC – Kikuyu	25	Total: 67% ILGW: 75% LGW: 50% TGoS: 88%	Trade-off species. Rapid vegetative spread and dense growth form.	Invasion from nearby intentional planting. Prefers fertile soil. Extensive roots for resource capture.	Contain spread where planted intentionally. Competitive groundcover required.
MC – African lovegrass	28	Total: 33% ILGW: 25% LGW: 57% TGoS: 0	Highly competitive. Adapted to drought, fire, and unfavourable conditions.	Multiple cultivars. Evidence of herbicide resistance.	Canopy cover reduces abundance. Research needed on biocontrol. Management guides for pasture available.
MC – Rhodes grass	26	Total: 33% ILGW: 62% LGW: 0	High seed output, tolerant to low soil fertility, salt, and metals. Highly competitive.	Prefers coastal conditions. Responds well to rain and defoliation. Pioneer species.	Potential to form dense stands if left unmanaged. Revegetation important. Increased research on control needed.

EPG	Risk score	Prevalence score %	Risk factors for invasion	Areas for concern	Other considerations
		TGoS: 63%			
N – Slender pigeon grass	14.5	Total: 43% ILGW: 88% LGW: 36% TGoS: 38%	Lack of information.	Similar to several species. Lack of information to determine potential impact.	Investigate biology, ecology and impact as per risk assessment advised.

3. Control: managing EPGs in the South Coast region

3.1 General management of EPGs

This document focuses on the grassy communities for which we have information from field and land manager surveys. Here we present a range of options for the management of the prioritised species that we consider might be important across the whole region. However, prioritisation decisions in other communities and at smaller scales may result in the inclusion of other priority species.

Despite this, the principles of the 4-step approach can still be applied and information on management provided in this document can be used. While setting up a robust monitoring design is essential, monitoring should also include the type of weed, the type of control, the level of infestation, who undertook the activities and where it was done.

This information provides valuable data to determine efficacy and the scale of the problem, and the free availability of such information will influence other activities in the region. Several survey participants commented on the costs of control, both financially and time wise.

Weed control can be an exhausting process, particularly for land managers. Engagement with community and organisations can help with sharing the loads associated with weed control, helping to implement a more efficient regional approach.

Managing trade-off species

Many sites in the region offer both agricultural and conservation benefits. A concerted and continued effort needs to be made to actively improve the native ground cover of threatened communities to increase resilience to invasion from trade-off species, and weeds more generally.

This may involve retiring, replanting, or limiting grazing of TSRs and other native communities while actively promoting native regeneration with the aim of creating communities able to resist invasion and, in the future, provide intermittent grazing benefits (Baer et al. 2009).

While many primary producers employ weed hygiene and farm biosecurity to prevent unwanted weeds, pests or diseases entering their farm, these measures can also be used to prevent trade-off species spreading beyond the farm. Abating the threat of EPGs in these communities requires acknowledging, and changing, the relationship between agriculture and the decline of threatened communities.

Current control strategies

Control of EPG species should, where possible, involve community-wide coordination to facilitate the most impactful management and education. Communities throughout the South Coast assist in weed management, including several Landcare groups and councils, the Far South Coast Conservation Management Network, Sydney Weeds Network, universities and government organisations (see Resources section).

Survey participants provided survey information on 4 of the EPGs determined to be of special concern. Control of African lovegrass overwhelmingly led to a lowered abundance, while panic veldtgrass and Kikuyu had more varied results. The response of surrounding ground cover to control of the target EPG was varied for all species although all, except weedy *Sporobolus* grasses, had at least one instance of increase in surrounding ground cover.

In the South Coast, the mosaic of major urban cities with agricultural land provides ample opportunities for weeds to spread into conservation areas through disturbance, urban run-off, and spread through humans and vehicles.

Preventative control will be important, with a focus on promoting resilient native communities with native ground cover and reducing the presence of invasive propagules on roadsides, in agriculture, and in amenity landscapes. Management techniques that may facilitate spread, such as roadside slashing or mowing, or weed spread through stock movement, require special consideration.

Where limited information and resources are available on appropriate control methods and appropriate herbicide regimes, use caution, plan well, and monitor the response of target EPGs and surrounding ground cover. Best practice manuals are available for weedy *Sporobolus* grasses, and weed management guides are available for African lovegrass (see Resources section).

Weeds of National Significance

Two Weeds of National Significance (WoNS) were identified by survey participants (Chilean needle grass and serrated tussock). These weeds are economically and ecologically damaging in native and agricultural communities with high potential for spread.

As WoNS, extensive research has been conducted into their invasiveness and management strategies (see Resources section).

These grasses are examples of the serious threat EPGs pose to Australia and New South Wales, and provide evidence of the coordinated management needed for accurate risk assessment and effective control.

Our priority species list doesn’t include these 2 species as they were not recorded during surveys, however, these should be controlled if present at sites.

In Table 3, we outline suggested strategies for the EPGs of concern in the region. These were current at the time of publication, but as new research is undertaken, best practice management may change over time. Following this we provide further information for each species.

Table 3 Management options for the main EPG species of concern in the South Coast region

Note: best practice uses more than one control strategy. Grazing strategies should be considered only on native pasture communities where allowed.

	Manual	Mechanical	Chemical	Fire	Biocontrol	Grazing
General rules	**Weed hygiene** **Bag seed heads** **Work from most to least invaded areas**	**Weed hygiene**	**Avoid herbicide resistance, use DPI handbook**	**Best as IWM**	**Use where available**	**Consider stock movement, competitive pasture planting, use of native pasture species. Restrict use in native communities.**
Sporobolus spp.	Suitable for small infestations	Suitable for IWM, weed hygiene important	Susceptible to herbicide	Fire will reduce biomass	Currently being researched	Unpalatable. Pasture competition recommended, using native species. Weed hygiene important
Common paspalum	Suitable for small infestations	Regrowth in response to mowing, however, this may help through limiting seed production	Follow Queensland guides and seek advice. Information needed for NSW	Role of fire in management unknown	N/A	Trade-off species. Avoid spread into new areas. Weed hygiene important
Panic veldtgrass	Suitable for small infestations	Weakened by mowing	Susceptible to herbicide	Resprouts, enhances seed production	N/A	Weakened by heavy grazing
Kikuyu	Rapid vegetative spread, ensure whole plant is removed	High capacity for regrowth, broken fragments can act as spread pathway	Susceptible to herbicide	Regenerates from rhizomes	N/A	Trade-off species. Avoid spread into new areas. Weed hygiene important
African lovegrass	Suitable for small infestations. Tough root system	High capacity for regrowth	Suitable but herbicide resistance possible	Can withstand frequent fire and resprout after fire	N/A	Graze heavily when young, weed hygiene important. Competitive pastures

Rhodes grass	Suitable for small infestations	Information needed. Weed hygiene important	Susceptible but other species in genus are herbicide resistant	Tolerant of fire, recovers well	N/A	Trade-off species. Avoid spread into new areas. Weed hygiene important
Slender pigeon grass	Suitable for small infestations	Information needed	Information needed	Information needed	N/A	Information needed

The following provides current information to help you make educated decisions for management in native communities.

3.2 Weedy Sporobolus grasses (*Sporobolus africanus*, *Sporobolus fertilis* and others)

Due to the impact Weedy *Sporobolus* grasses have been causing in northern New South Wales and Queensland, several resources are available for the best practice management of these grasses. These can be found in the Resources section, and we recommend consulting these to aid management. However, these manuals have a focus on agricultural land, and actions may not be applicable to native communities.

Management of WSG infestations in native areas should focus on limiting seed set, preventing or removing seeds from seed bank, and encouraging competitive native ground cover to increase resilience. In native ecosystems this may involve a focus on preventing seed set and using weed cleaning stations, educational signs and farm biosecurity to limit spread.

Small infestations may be removed through manual control (Bray and Officer 2007). Padilla et al. 2013 investigated strategies for reducing grassland degradation by WSG invasion: actively sowing native species to promote recolonisation led to infestation reduction from 52% to 5%, with cover of desired species increasing from 20% to 89%.

Although intensive, active management can overcome issues of slow native recovery and reinvasion from weeds in response to control.

Plant choice should prioritise native species able to compete against *Sporobolus* spp., species adapted to the area or competitive pasture species (Bray and Officer 2007).

While burning of plants was suggested as unlikely to kill the plant, it may reduce the seed bank and, if used alongside herbicide, can be an effective management strategy (Bray and Officer 2007). Research is underway for more biocontrol options.

3.3 Common paspalum (*Paspalum dilatatum*)

Figure 14 Common paspalum. Photo: Harry Rose/ flickr

Research priorities

Limited information is available on how paspalum will respond to control techniques as it has not been a focus to date, despite a serious invasion across the region. More research and information on successful techniques are badly needed.

In native communities, management should focus on limiting lateral spread of paspalum to prevent crowding out native seedlings. To minimise off-target damage, timing of control and control techniques that promote native regeneration are important.

Mechanical removal has mixed reports with reductions in lateral spread achieved through close mowing (Henry, Burton et al. 2007) while defoliation has been shown to promote establishment of paspalum species (Cornaglia et al. 2005).

While no chemical rates are available for paspalum, chemical control is suggested throughout Australia (PIPWE 2019; DAF 2020). In response to fire on themeda headlands, Nature Conservation Council (NCC) (2017) says paspalum is severely reduced such that the addition of targeted control (e.g. herbicide or mechanical) will be more effective.

3.4 Panic veldtgrass (*Ehrharta erecta*)

Public awareness may form an important part of management, as panic veldtgrass can be easily hand pulled by volunteers, thanks to its weak and fibrous root system, but can be misidentified as a native (Popay 2013). Low-cost management with long-term dedication is likely to lead to good control of panic veldtgrass but frequent attention is required.

Effective control through physical removal was achieved by Ray (2016) with McIntyre and Ladiges (1985) suggesting at least 2 years is needed to limit panic veldtgrass seed banks. One Illawarra Lowlands Grassy Woodland site has Bushcare volunteers that meet once a fortnight to remove panic veldtgrass and other notable weeds.

Through consistent hand removal for over 8 years, infestations of panic veldtgrass were localised and passive regeneration of kangaroo grass occurred. The aim was to remove weeds in small manageable areas within a site. Veldtgrasses are said to be weakened by heavy grazing and mowing (Murphy 2022). Flaming plants can be effective on small infestations and may be helpful as part of IWM (DiTomaso and Kyser 2013).

Herbicide is an effective control but should be undertaken by people with good grass ID skills as panic veldtgrass can appear similar to native weeping grass (Ray 2016).

Integrated management of panic veldtgrass was described by one survey participant who had contractors bag and remove seed before applying herbicide. This participant noted frequent management is required due to the quick seed production. Agricultural and native control practices are likely to be similar (DiTomaso and Kyser 2013).

Figure 15 Panic veldtgrass invasion in a site of Illawarra Lowlands Grassy Woodland. Photo: Julia Rayment/UOW

3.5 Kikuyu (*Cenchrus clandestinus*)

Figure 16 Kikuyu runner (left) and ground cover (right). Photos: Harry Rose/flickr

As Kikuyu heavily relies on vegetative spread and can regenerate from broken fragments, control needs to be more specialised and considerate of this. Unless the entire infestation of above- and below-ground parts can be confidently removed, a labour-intensive effort, physical removal is likely to lead to reinfestation.

In Bangalay Sand Forest, mowing was said to exacerbate the invasion, with other online sources also suggesting Kikuyu is tolerant to mowing (HerbiGuide no date). Mulching may help suppress re-emergence of Kikuyu (Earthco 2019). In Pambula, control of Kikuyu grass is being achieved through steam weeding (Reardon 2021).

If mechanical control is done where Kikuyu is present, weed hygiene is paramount to remove broken fragments that may act as invasive propagules. Kikuyu is described as fire resistant, with DPI describing it as one of the first colonisers following post-fire rainfall (DPI no date a). Sources overwhelmingly suggest herbicide as the most effective control against invasions (HerbiGuide no date; Mears 1970; Parker 2008). Kikuyu incursion on Montague Island was eradicated effectively using herbicide (Fullagar and Heyligers 2006).

Active competition from surrounding ground cover will be important to limit spread, and regeneration may be useful in creating resilient ecosystems. Integrated control of Kikuyu was employed by one participant with the use of occasional spot spraying, burning the encroaching main front every 1 to 3 years and hand-pulling runners when close to the surface. Any research or success should be communicated with other end users.

3.6 African lovegrass (*Eragrostis curvula*)

Strategies for African lovegrass management in relation to grazing and agricultural practices for the region are available in the Resources section. Management strategies on conservation land are less reported on but should integrate practices that limit spread (i.e. hygiene practices), strategies to reduce infestation (e.g. mechanical, chemical and fire where applicable), and strategies that improve active and passive regeneration of native species (e.g. planting trees and shrubs where applicable, sowing natives or using enclosure fences, etc.).

African lovegrass can be manually removed but this is best reserved for small infestations. Many participants had been battling infestations for over 10 years, emphasising the impact and invasives of this grass and the challenges of containing its spread. To avoid African lovegrass becoming well-established, one survey participant has been clipping and safely disposing of seed heads annually for 10 years.

African lovegrass increases growth in response to mowing (Johnston and Shoemark 1997; Firn et al. 2010). Weed hygiene and appropriate timing to limit weed spread are important to consider if using mechanical control.

African lovegrass control can be effective using herbicide. However, herbicide resistance has been identified in the Southern Tablelands so reliance on herbicide alone should be avoided (Michael 2021). Three participants employed similar tactics involving hand weeding of small infestations, herbicide spray, and use of fire to reduce biomass and stimulate native plant regeneration. In one case mowing was also used to prevent seed set until the invasion could be treated appropriately. One participant also combined their integrated control with careful livestock management.

In native communities, active regeneration of shrub and tree cover may be necessary, as invasion is reduced under canopy cover (Firn et al. 2018). Native resilience is possible but a threshold abundance of least 33% is required (Firn et al. 2018).

Where kangaroo or other faunal grazing is high, enclosure fences to promote native recovery may be one way to protect palatable native species and encourage grazing of less-palatable African lovegrass (Lindsay and Cunningham 2011). One participant successfully reduces African lovegrass through increased tree cover where herbicide control isn't feasible or appropriate, such as riparian zones.

African lovegrass can spread rapidly in response to fire. Fire may be more useful in IWM where it can reduce biomass before secondary control or to limit seed set. As it has a higher fuel load than natives, careful planning is required. One survey participant, who used herbicide in burnt areas where African lovegrass was invading, emphasised the importance of rapid response within 6 weeks to prevent seed set.

Once controlled, the hardest task is restoring the native ground cover and community (Sanders and Chapple 2016). Successful use of fire as part of IWM has been recorded in the Cumberland Plain in Sydney (Sanders and Chapple 2016).

While cover remained high after using fire only as a control method, when combined with herbicide spray either before or after fire, cover was halved and was near zero for the treatment 'herbicide + fire + herbicide' (Sanders and Chapple 2016; NCC 2017). In the Bega Valley, African lovegrass is targeted with a fire followed by a raised roller wiper that reaches the taller exotic species, protecting species such as the shorter native weeping grass (*Microlaena stipoides*).

3.7 Rhodes grass (*Chloris gayana*)

Research priority

Most information is available for *Chloris virgata,* feathertop Rhodes grass. It is unclear how similar these 2 species are in their susceptibility to control. Control of Rhodes grass would benefit from greater certainty in the feasibility of control mechanisms.

Rhodes grass is highly competitive and can spread through runners, therefore increasing native ground cover to reduce bare ground available for colonisation is important. Seed production can occur quickly, particularly in response to rainfall, so control may focus on reducing biomass to limit seed set.

Manual removal should ensure the entire plant and all runners are removed. Mowing can promote growth and spread without proper weed hygiene and timing considerations in place. Rhodes grass is believed to be susceptible to herbicides, with information on rates available through a Queensland assessment (DAF 2016). Rhodes grass can survive fire (Moore 2018).

3.8 Slender pigeon grass (*Setaria parviflora*)

Figure 17 Slender pigeon grass flower head (left) and whole plant (right). Photos: Harry Rose/flickr

Information for prevention and control of slender pigeon grass invasion is scarce. It is unclear whether management techniques for other *Setaria* species have the same efficacy therefore careful monitoring of control techniques, and sharing of knowledge, is recommended.

Slender pigeon grass appears to be susceptible to herbicides (Buddenhagen 2013) and manual removal is likely to be suitable for small infestations, however, no other information on control could be sourced. Controlling this species requires careful monitoring of methods and results and will benefit from sharing findings to improve control in invaded communities.

4. Monitor

Monitoring is critical to assess success of control, identify new emerging threats, and to improve our understanding of management efficacy and native recovery. It also provides an opportunity to reflect on current control strategies and how we might alter future control strategies for long-term success.

Monitoring is also necessary to provide clear information on outcomes of management programs. Using standard monitoring practices supports consistent data collection and improve transdisciplinary communication and integration.

We recommend using the *Monitoring Manual for Invasive and Native Flora* (Watson et al. 2021) and implementing monitoring as a key requirement of EPG management.

Figure 18 Illawarra Lowlands Grassy Woodland (Mount Brown, Wollongong). Photo: Julia Rayment/UOW

Resources

4.1 General

Greater Sydney Regional Strategic Weed Management Plan 2017–2022 – Greater Sydney LLS

South East Regional Strategic Weed Management Plan 2017–2022 – South East LLS

4.2 Landcare

Far South Coast Landcare Association – Far South Coast Landcare

Shoalhaven Landcare – Shoalhaven Landcare

Illawarra Landcare – Illawarra Landcare

Greater Sydney Landcare – Greater Sydney Landcare Network

4.3 Councils

Weed Management – Bega Valley Shire Council

Illawarra District Weeds Authority – Illawarra Shoalhaven Joint Organisation

Weeds – Far South Coast Conservation Management Network

Grass Weeds – Sydney Weeds Network

Weed Control Programs – Eurobodalla Shire Council

4.4 Government

Weeds – DPI

4.5 African lovegrass

Managing African Lovegrass, Information Sheet 1 – Far South Coast Landcare

Managing African Lovegrass, Information Sheet 2: Roller Wiping – Far South Coast Landcare

Managing African Lovegrass, Information Sheet 3: Lowland Grassy Woodlands – Far South Coast Landcare

Managing Weeds on the Far South Coast of NSW: African Lovegrass – Southern Rivers Catchment Management Authority (CMA)

NSW WeedWise: African lovegrass (Eragrostis curvula) – DPI

Molonglo Catchment Group Weed Fact Sheet: African lovegrass – Molonglo Catchment Group

African lovegrass management – DPI

African lovegrass – 3D weed management

Using fire to manage priority weeds in Cumberland Plain vegetation: African lovegrass – Nature Conservation Council (NCC)

African Lovegrass – Upper Snowy Landcare

4.6 Sporobolus

Giant rat's tail grass (Sporobolus pyramidalis) – NSW WeedWise, DPI

Giant Parramatta grass (Sporobolus fertilis) – NSW WeedWise, DPI

Strategic management of weedy Sporobolus grasses – MLA

Weed Management Guide – Weedy Sporobolus Grasses, Technical Report 2011 – Australian Government Department of Agriculture and Fisheries

Weedy Sporobolus grasses: Best practice manual – Queensland Department of Primary Industries and Fisheries

4.7 Weeds of National Significance

Chilean needle grass

Chilean needle grass – 3D weed management

Integrated control of Chilean needle grass – Meat & Livestock Australia (MLA)

Developing whole farm Integrated Management programs for Unpalatable grasses – (including Chilean needle grass and serrated tussock) – MLA and DPI Victoria

Chilean needle grass case studies (Farmers managing Chilean needle grass in grazing systems) – 3D weed management

Nassella neesiana (Trin. & Rupr.), Chilean needle grass – Weeds Australia – Profiles

Weed Management Guide: Chilean needle grass (Nassella neesiana) – Natural Heritage Trust

Serrated tussock

NSW WeedWise: Serrated tussock (Nassella trichotoma) – DPI

Serrated Tussock Management and Control in NSW and ACT – DPI

National Best Practice Management Manual: Serrated Tussock – National Serrated Tussock Management Group

Regional Local Weed Management Plan: Serrated tussock – Central Tablelands and Central West LLS

Serrated tussock – 3D weed management

Integrated Management Strategies for the Control of Serrated Tussock in Inaccessible Native Pastures – MLA

Weeds Australia – Profiles: Nassella trichotoma – Atlas of Living Australia (ALA)

Managing Weeds on the Far South Coast of NSW: Serrated Tussock – Southern Rivers Catchment Management Authority (CMA)

Serrated tussock – NRM South and Southern Tasmanian Councils Authority

More information

- Hygiene guidelines
- Monitoring Manual for Invasive and Native Flora

References

Adam P et al. (1989), 'The vegetation of seacliffs and headlands in New South Wales, Australia', *Australian Journal of Ecology* 14(4): 515–545, Wiley Online Library.

Baer SG et al. (2009), 'Vulnerability of Rehabilitated Agricultural Production Systems to Invasion by Nontarget Plant Species', *Environmental Management* 43: 189–196. doi: 10.1007/s00267-008-9167-6.

Bemboka Landcare Group (2017), *Bemboka River Reserve Project*, NSW Landcare Gateway website, https://landcare.nsw.gov.au/groups/bemboka-landcare-group/projects/bemboka-river-reserve-project/. Accessed: 15 September 2021.

Bidwell S, Attiwill PM and Adams MA (2006), 'Nitrogen availability and weed invasion in a remnant native woodland in urban Melbourne', *Austral Ecology* 31(2): 262–270. doi: 10.1111/j.1442-9993.2006.01575.x.

Bock JH and Bock CE (1992), 'Vegetation responses to wildfire in native versus exotic Arizona grassland', *Journal of Vegetation Science* 3(4): 439–446.

Bray S and Officer D (2007), *Weedy Sporobolus grasses: best practice manual*, 3rd edn, Queensland Department of Primary Industries and Fisheries, https://futurebeef.com.au/wp-content/uploads/2011/09/Weedy_sporobolus_manual.pdf.

Buddenhagen C (2013), *Setaria parviflora (knotroot foxtail),* Invasive Species Compendium website, CABI, https://www.cabi.org/isc/datasheet/49768. Accessed: 7 September 2021.

Campbell M (1983), 'Area, distribution and weed potential of *Eragrostis curvula* (Schrad.) Nees in New South Wales', *Australian Weeds (Australia)* (2)3: 107–112.

Climate-Data.org (no date), *Climate: South Coast (New South Wales)*, Climate-Data.org website, AM Online Projects, https://en.climate-data.org/oceania/australia/south-coast-new-south-wales-10236/. Accessed: 9 May 2021.

Cornaglia PS et al. (2005), 'Emergence of dallisgrass as affected by soil water availability', *Rangeland Ecology & Management* 58(1): 35–40, Elsevier.

Curhes S, Leigh C and Walton C (2009), *Weed risk assessment: African lovegrass Eragrostis curvula*, Biosecurity Queensland, Queensland Primary Industries and Fisheries.

DAF (2016), *Rhodes grass: Chloris gayana*, Queensland Department of Agriculture and Fisheries, https://www.daf.qld.gov.au/__data/assets/pdf_file/0014/51512/IPA-Rhodes-Grass-PP91.pdf. Accessed: 3 February 2019.

DAF (2018), *Rat's tail grasses*, Queensland Department of Agriculture and Fisheries.

DAF (2020), *Broad-leafed paspalum*, Queensland Department of Agriculture and Fisheries, https://www.daf.qld.gov.au/__data/assets/pdf_file/0008/65429/broad-leafed-paspalum.pdf.

Dekker J (2003), 'The foxtail (Setaria) species-group', *Weed Science* 51(5): 641–656, Cambridge University Press.

DiTomaso JM and Kyser G (2013), *Weed control in Natural Areas in the Western United State*s, University of California, https://wric.ucdavis.edu/information/natural areas/wr_E/Ehrharta.pdf.

Dorrough J (2015), 'African Lovegrass and endangered grassy ecosystems on private land – trends and risks, record of talk given at 'Grass half full or grass half empty? Valuing native grassy landscapes' Friends of Grasslands' Forum 30 October – 1 November 2014.

DPI (2012), Nigrospora crown rot for biocontrol of giant Parramatta grass, NSW Department of Primary Industries.

DPI (2017), *Giant rat's tail grass (Sporobolus pyramidalis)*, NSW Department of Primary Industries website, https://weeds.dpi.nsw.gov.au/Weeds/GiantRatsTailGrass. Accessed: 8 March 2019.

DPI (no date a), *Kikuyu*, NSW Department of Primary Industries website, https://www.dpi.nsw.gov.au/agriculture/pastures-and-rangelands/species-varieties/kikuyu. Accessed: 16 September 2021.

DPI (no date b), *Paspalum*, NSW Department of Primary Industries website, https://www.dpi.nsw.gov.au/agriculture/pastures-and-rangelands/species-varieties/paspalum. Accessed: 30 August 2020.

Earthco (2019), *Earthco's Best Practices: Management of Kikuyu Grass*, Earthco website, https://earthcompany.org/earthcos-best-practices-management-of-kikuyu-grass/. Accessed: 16 September 2021.

Firn J (2009), 'African lovegrass in Australia: A valuable pasture species or embarrassing invader?', *Tropical Grasslands* 43(2): 86–97.

Firn J, House APN and Buckley YM (2010), 'Alternative states models provide an effective framework for invasive species control and restoration of native communities', *Journal of Applied Ecology* 47(1): 96–105, doi: doi:10.1111/j.1365-2664.2009.01741.x.

Firn J, Ladouceur E and Dorrough J (2018), 'Integrating local knowledge and research to refine the management of an invasive non-native grass in critically endangered grassy woodlands', *Journal of Applied Ecology* 55(1): 321–330.

Fraser D et al. (2017), 'Abiotic stress tolerance of kikuyu (*Cenchrus clandestinus*) and some related grasses and potential of kikuyu for agricultural and urban environments', *Crop and Pasture Science* 68(3): 285–296, CSIRO Publishing, doi: 10.1071/CP15380.

Fullagar P and Heyligers P (2006), 'Shearwater colonies on Montague Island; are they being affected by encroaching Kikuyu Grass?', *Aust. Zool.* 33(4): 476–479, doi: 10.7882/az.2006.020.

Ghasempour HR and Kianian J (2007), 'NThe Study of Desiccation-Tolerance in Drying Leaves of the Desiccation-Tolerant Grass Sporobolus elongatus and the Desiccation-Sensitive Grass Sporobolus pyramidalis', *Pakistan Journal of Biological Sciences* 10(5): 797–801, http://www.docsdrive.com/pdfs/ansinet/pjbs/2007/797-801.pdf.

Ghebrehiwot HM, Aremu AO and Van Staden J (2014), 'Evaluation of the allelopathic potential of five South African mesic grassland species', *Plant Growth Regulation* 72(2): 155–162, doi: 10.1007/s10725-013-9847-y.

Godfree R et al. (2017), 'Why non-native grasses pose a critical emerging threat to biodiversity conservation, habitat connectivity and agricultural production in multifunctional rural landscapes', *Landscape Ecology* 32(6): 1219–1242.

Hassan MO and Mohamed HY (2020), 'Allelopathic interference of the exotic naturalized Paspalum dilatatum Poir. threatens diversity of native plants in urban gardens', *Flora* 266: 151593, Elsevier.

Henry GM, Burton MG and Yelverton FH (2007), 'Effect of mowing on lateral spread and rhizome growth of troublesome Paspalum species', *Weed Science* 55(5): 486–490, BioOne.

Henry GM, Yelverton FH and Burton MG (2007), 'Dallisgrass (*Paspalum dilatatum)* control with foramsulfuron in bermudagrass turf', *Weed Technology* 21(3): 759–762, BioOne.

HerbiGuide (no date), *Kikuyu grass*, HerbiGuide website, http://www.herbiguide.com.au/Descriptions/hg_Kikuyu_Grass.htm. Accessed: 16 September 2021.

Huxtable CHA, Koen TB and Waterhouse D (2005), 'Establishment of native and exotic grasses on mine overburden and topsoil in the Hunter Valley, New South Wales', *Rangeland Journal* 27(2): 73–88, doi: 10.1071/RJ05006.

IUCN Invasive Species Specialist Group (2010), *Cenchrus clandestinus (grass)*, Global Invasive Species Database, http://issg.org/database/species/ecology.asp?si=183&fr=1&sts=sss&lang=EN. Accessed: 24 August 2020.

Johnston WH and Shoemark VF (1997), 'Establishment and persistence of palatable taxa of Eragrostis curvula complex in southern New South Wales', *Australian Journal of Experimental Agriculture* 37(1): 55–65, doi: 10.1071/EA96025.

Lattimore MA and McCormick L (2012), *Pasture varieties used in New South Wales 2012–13*, NSW Department of Primary Industries and the Grassland Society of NSW Inc.

Lawn Solutions Australia (2021), *Paspalum (Paspalum dilatatum)*, Lawn Solutions Australia website, https://lawnsolutionsaustralia.com.au/lawn-care/paspalum-paspalum-dilatatum/. Accessed: 4 May 2020.

Leguizamón ES et al. (2009), 'Modelling the emergence pattern of six summer annual weed grasses under no tillage systems in Argentina', *Weed Research* 49(1): 98–106, Wiley Online Library.

Lindsay EA and Cunningham SA (2011), 'Native grass establishment in grassy woodlands with nutrient enriched soil and exotic grass invasion', *Restoration Ecology* 19(101): 131–140, Wiley Online Library.

Lodge GM, Boschma SP and Harden S (2009), 'Replacement series studies of competition between tropical perennial and annual grasses and perennial grass mixtures in northern New South Wales', *Crop and Pasture Science* 60(6): 526–531, https://doi.org/10.1071/CP08374.

Manea A, Sloane DR and Leishman MR (2016), 'Reductions in native grass biomass associated with drought facilitates the invasion of an exotic grass into a model grassland system', *Oecologia* 181(1): 175–183, doi: 10.1007/s00442-016-3553-1.

Masters RA and Britton CM (1990), 'Ermelo weeping lovegrass response to clipping, fertilization, and watering', *Rangeland Ecology & Management / Journal of Range Management Archives* 43(5): 461–465.

McIntyre S and Ladiges PY (1985), 'Aspects of the biology of Ehrharta erecta Lam', *Weed Research* 25(1): 21–32, doi: 10.1111/j.1365-3180.1985.tb00613.x.

Mears PE (1970), 'Kikuyu (Pennisetum clandestinum) as a pasture grass', *Tropical Grasslands* 4(2): 139, Tropical Grassland Society of Australia.

Michael D (2021), *Survey identifies herbicide resistant African Lovegrass on the Monaro*, Local Land Services website, https://www.lls.nsw.gov.au/regions/south-east/latest-news-and-newsletters/se-news/2021/survey-identifies-herbicide-resistant-african-lovegrass-on-the-monaro. Accessed: 1 July 2020.

Milberg P and Lamont BB (1995), 'Fire enhances weed invasion of roadside vegetation in southwestern Australia', *Biological Conservation* 73(1): 45–49.

Mollard FPO et al. (2008), 'Flooding tolerance of *Paspalum dilatatum* (Poaceae: Paniceae) from upland and lowland positions in a natural grassland', *Flora – Morphology, Distribution, Functional Ecology of Plants* 203(7): 548–556, doi: https://doi.org/10.1016/j.flora.2007.10.003.

Mollard FPO and Insausti P (2009), 'Breaking *Setaria parviflora* seed dormancy by nitrates and light is part of a mechanism that detects a drawdown period after flooding', *Aquatic Botany* 91(1): 57–60, Elsevier.

Mollard FPO and Insausti P (2011), 'Geographic variation in the flood-induced fluctuating temperature requirement for germination in Setaria parviflora seeds', *Plant Biology* 13(4): 660–666, Wiley Online Library.

Moore G (2018), *Rhodes grass in southern Western Australia*, Department of Primary Industries and Regional Development website, Government of Western Australia, https://www.agric.wa.gov.au/pasture-species/rhodes-grass-southern-western-australia. Accessed: 14 August 2021.

Murphy S (2022), *Trouble from the Veldt*, Recreating the Country website, https://www.recreatingthecountry.com.au/blog/trouble-from-the-veldt. Accessed 7 June 2022.

NCC (2017), *Hotspots Fire Project: Managing Fire on Your Property*, Nature Conservation Council and NSW Rural Fire Service, https://nrmregionsaustralia.com.au/wp-content/uploads/2020/01/fire-and-weeds-landholders-bookletfinallr.pdf.

OEH (2021), Themeda Grassland on Seacliffs and Coastal Headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions – profile, Office of Environment and Heritage website, NSW Government, https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20042.

Padilla C et al. (2013), 'Strategies for controlling the degradation of grasslands invaded by sporobolus indicus (L) R. Br.', *Cuban Journal of Agricultural Science* 47(2): 113–117.

Parker C (2008), *Pennisetum clandestinum (Kikuyu grass)*, Invasive Species Compendium website, CABI, https://www.cabi.org/isc/datasheet/39765. Accessed: 16 September 2021.

PIPWE (2019), *Herbicides for Paspalum Control*, Tasmanian Department of Primary Industries Parks Water and Environment website, https://dpipwe.tas.gov.au/invasive-species/weeds/weeds-index/non-declared-weeds-index/paspalum/paspalum-herbicides-for-control. Accessed: 8 March 2021.

Popay I (2013), *Ehrharta erecta (panic veldtgrass)*, Invasive Species Compendium website, CABI, https://www.cabi.org/isc/datasheet/114038. Accessed: 16 September 2021.

Queensland Government (2016), *Eragrostis curvula*, Weeds of Australia website, Biosecurity Queensland Editions, https://keyserver.lucidcentral.org/weeds/data/media/Html/eragrostis_curvula.htm. Accessed: 4 July 2018.

Rana N et al. (2012), 'Effects of environmental factors on seed germination and emergence of smutgrass (Sporobolus indicus) varieties', *Weed Science*, 60(4): 558–563, Cambridge University Press.

Ray CA (2016), Invading coastal California's forests: Impacts and best management practices for the perennial grass, Ehrharta erecta, UC Santa Cruz.

Rayment JT and French K (2021), 'Uncertainty in research about key invasion characteristics limits the evaluation of exotic perennial grasses in natural systems in New South Wales, Australia', *Ecological Management & Restoration* 22(1): 53–63, Wiley Online Library.

Rayment, Julia, Kris French, and Michael Bedward. "Understanding patterns and pathways of exotic perennial grass invasion in South-eastern Australian grassy communities." Diversity and Distributions 28.5 (2022): 1136-1150.

Reardon A (2021), *Bushfire-affected Eurobodalla residents struggle to manage 'relentless' weeds bolstered by downpours*, ABC News 6 April, https://www.abc.net.au/news/2021-04-06/bushfire-properties-battle-weed-growth-eurobodalla-shire/100045346.

Sanders J and Chapple S (2016), *Using Fire to Manage Priority Weeds in Cumberland Plain vegetation: African lovegrass*, Using Fire as a Restoration Tool in Cumberland Plain

Vegetation project, Nature Conservation Council of NSW, https://www.nature.org.au/media/213734/cumberland_african-lovegrass_web_jan2016.pdf.

Striker GG et al. (2006), 'Root strength and trampling tolerance in the grass Paspalum dilatatum and the dicot Lotus glaber in flooded soil', *Functional Ecology* 20(1): 4–10, Wiley Online Library.

Sutton GF et al. (2019), 'Grasses as suitable targets for classical weed biological control', *BioControl* 64(6): 605–622, doi: 10.1007/s10526-019-09968-8.

Sydney Weeds Committees (2018), *Grass Weeds; Panic Veldt Grass*, Sydney Weeds Committees website, http://sydneyweeds.org.au/wp-cms/weed/panic-veldt-grass/. Accessed: 3 July 2018.

Vasellati V et al. (2001), 'Effects of flooding and drought on the anatomy of *Paspalum dilatatum*', *Annals of Botany* 88(3): 355–360, Elsevier.

Vogler WD and Bahnisch LM (2006), 'Effect of growing site, moisture stress and seed size on viability and dormancy of *Sporobolus pyramidalis* (giant rats tail grass) seed', *Australian Journal of Experimental Agriculture* 46(11): 1473–1479, CSIRO.

Watson GM, French KO, Burley AL, Brading MB and Hamilton MA (2021), *Monitoring Manual for Invasive and Native Flora*, NSW Department of Planning, Industry and Environment, https://www.environment.nsw.gov.au/research-and-publications/publications-search/monitoring-manual-for-invasive-and-native-flora.

Watt LA and Whalley RDB (1982), 'Establishment of small-seeded perennial grasses on black clay soils in north-western New South Wales', *Australian Journal of Botany* 30(6): 611–623, doi: 10.1071/BT9820611.

Weeds of Australia (2016), *Paspalum dilatatum*, Weeds of Australia website, https://keyserver.lucidcentral.org/weeds/data/media/Html/paspalum_dilatatum.htm. Accessed: 8 March 2019.

Wehr JB, Fulton I and Menzies NW (2006), 'Revegetation strategies for bauxite refinery residue: A case study of Alcan Gove in Northern Territory, Australia', *Environmental Management* 37(3): 297–306, doi: 10.1007/s00267-004-0385-2.

Witt ABR and McConnachie AJ (2004), 'The potential for classical biological control of invasive grass species with special reference to invasive *Sporobolus* spp.(Poaceae) in Australia', in Cullen J et al. (eds), *XI International Symposium on Biological Control of Weeds* p. 198, CSIRO, Canberra.

Yobo KS et al. (2009), 'Evaluation of Ustilagosporoboli-indici as a classical biological control agent for invasive Sporobolus grasses in Australia', *Biological Control* 50(1): 7–12, doi: 10.1016/j.biocontrol.2009.01.006.