Department of Planning and Environment

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

Section 4: NSW Southern Tablelands and Slopes

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Cover photo: Grasses in Kosciuszko National Park. 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].

[1] Centre for Sustainable Ecosystem Solutions, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong NSW

[2] NSW Department of Planning and Environment, Sydney NSW.

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, 4: NSW Southern Tablelands and Slopes*, NSW Department of Planning and Environment, Australia.

Published by:

Environment and Heritage Group
Department of Planning and Environment
Locked Bag 5022, Parramatta NSW 2124
Phone: +61 2 9995 5000 (switchboard)
Phone: 1300 361 967 (Environment and Heritage enquiries)
TTY users: phone 133 677, then ask for 1300 361 967
Speak and listen users: phone 1300 555 727, then ask for 1300 361 967
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ISBN 978-1-922840-61-5
EHG 2022/0312
August 2022

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Acknowledgments

We acknowledge the Traditional Custodians of Country throughout New South Wales and their connection to land, sea and community. Field surveys were conducted on the traditional lands of Ngarigo, Ngunawal, Gundungurra, Wiradjuri and Dharug peoples. We pay our respects to their Elders past and present and extend our respect to all Aboriginal and Torres Strait Islander peoples today.

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 (this document)**
5. NSW South Coast

Introduction

The Southern Tablelands and Slopes region includes the area covered by Riverina Local Land Services (LLS) region, the Australian Capital Territory (ACT) and most of the western areas of the South East LLS region (Figure 1). Part of the South East LLS region, the South Coast, is treated separately (see Section 5 of this report) due to the difference in climate and land use influencing the exotic perennial grasses (EPGs) that invade and the distribution of the threatened ecological communities (TECs) that were surveyed.

Rain is dominant through spring and winter with high falls in the alpine regions, which decline quickly to the west (LLS no date). The winter snowfall and melt form an influential part of the hydrology, soil and ecology (LLS no date). The slopes, the central Monaro region and the tablelands are extensively cleared for agriculture and horticultural activities, while the subalpine and alpine areas comprise treeless plains and woodlands with significant areas in national parks.

Four threatened grassy communities were surveyed in this region, although the local land managers surveyed manage other communities in the region. Following the principles outlined in Section 1: Overview (see ‘Four-step approach to managing native communities’, below), we use field and land manager surveys to identify 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 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.

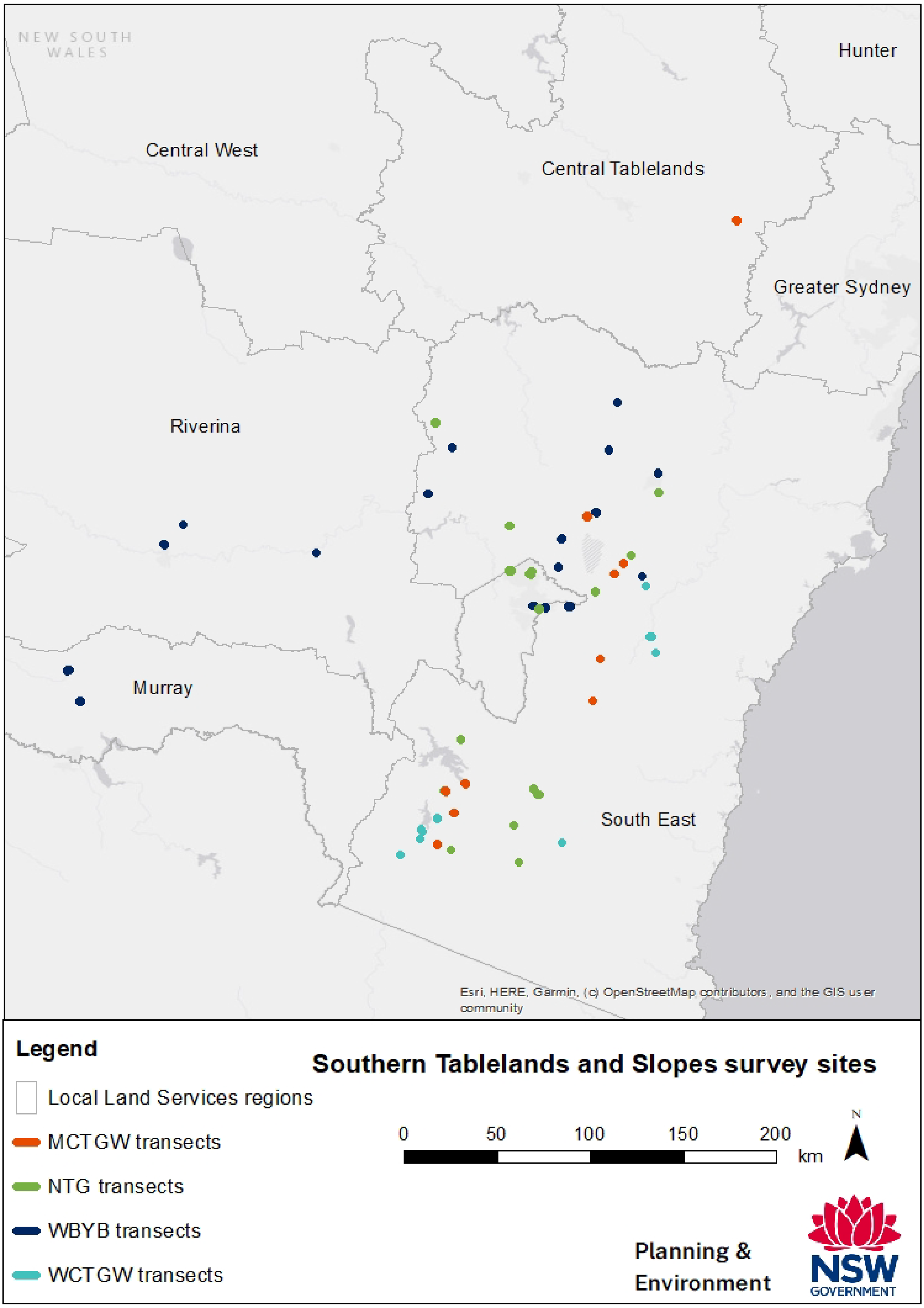

Figure 1 Southern Tablelands and Slopes field survey sites for the 4 threatened grassy communities

MCTGW: Monaro Tableland Cool Temperate Grassy Woodland, NTG: Natural Temperate Grassland, WBYB: White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland, WCTGW: Werriwa Tablelands Cool Temperate Grassy Woodland

1. Identify: grassy community field surveys

Four threatened communities were surveyed in the region representing 3 grassy woodlands and one grassland community. The highest proportion of survey participants were from this region (42%), working across threatened grassy woodlands, peatlands and swamps, hobby gardens and agricultural land. Across the field surveys 14 EPGs were recorded during 57 surveys.

Five EPGs were widespread across the region: serrated tussock (16 sites), phalaris (15 sites), cocksfoot (15 sites), sweet vernal grass (15 sites), and common paspalum (15 sites). African lovegrass was identified as an important invader in the grassland community, occurring rarely in the grassy woodland communities.

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 White Box – Yellow Box Grassy Woodland

Figure 2 White Box – Yellow Box Grassy Woodland. Photo: Jackie Miles/DPE

White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland (WBYB) is a Commonwealth- and State-listed TEC. This woodland has been extensively cleared, with the remaining community highly fragmented. Surveys were undertaken at 20 sites in the region, primarily on travelling stock reserves (TSRs), with the remaining sites scattered over cemeteries and nature reserves.

Two trade-off species, cocksfoot and phalaris, were the most prevalent, recorded at 10 sites (Figure 3) and when present at a site were both recorded in 21% of quadrats (Rayment et al. 2022). Both common paspalum and serrated tussock were recorded at 33% of sites, and occupied 28% and 38% of quadrats, on average, at these sites.

This was the only community where Chilean needle grass was recorded during surveys in the region. However, survey participants identified serrated tussock, Chilean needle grass and phalaris as EPGs of concern but did not consider other species that were dominant in surveys as being important. African lovegrass was also identified by survey participants as important although this species was recorded only in 2 sites in field surveys.

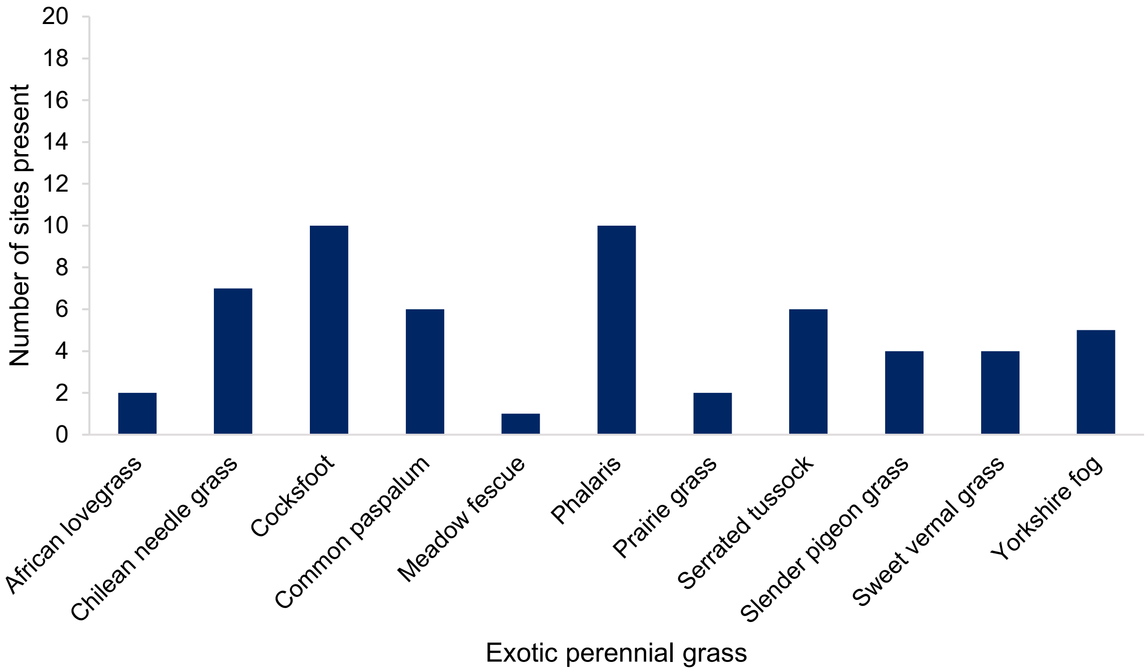

Figure 3 Number of sites where each EPG was recorded during field surveys of White Box – Yellow Box Grassy Woodland (WBYB) (n = 20)

1.2 Monaro Tableland Cool Temperate Grassy Woodland

Figure 4 Monaro Tableland Cool Temperate Grassy Woodland. Photo: Rob Armstrong/DPE

Monaro Tableland Cool Temperate Grassy Woodland (MCTGW) is characterised by a sparse to very sparse tree layer and dominant grassy groundcover. Three of the 10 sites where surveys were undertaken had no EPGs, highlighting the ability of the threatened communities to resist invasion.

In the remaining 7 sites, sweet vernal grass was the most prevalent, occurring in 44% of sites and occupying on average 51% of quadrats in those sites (Figure 5, Rayment et al. 2022). African lovegrass was not recorded, but serrated tussock, when present, occupied 38% of quadrats at sites.

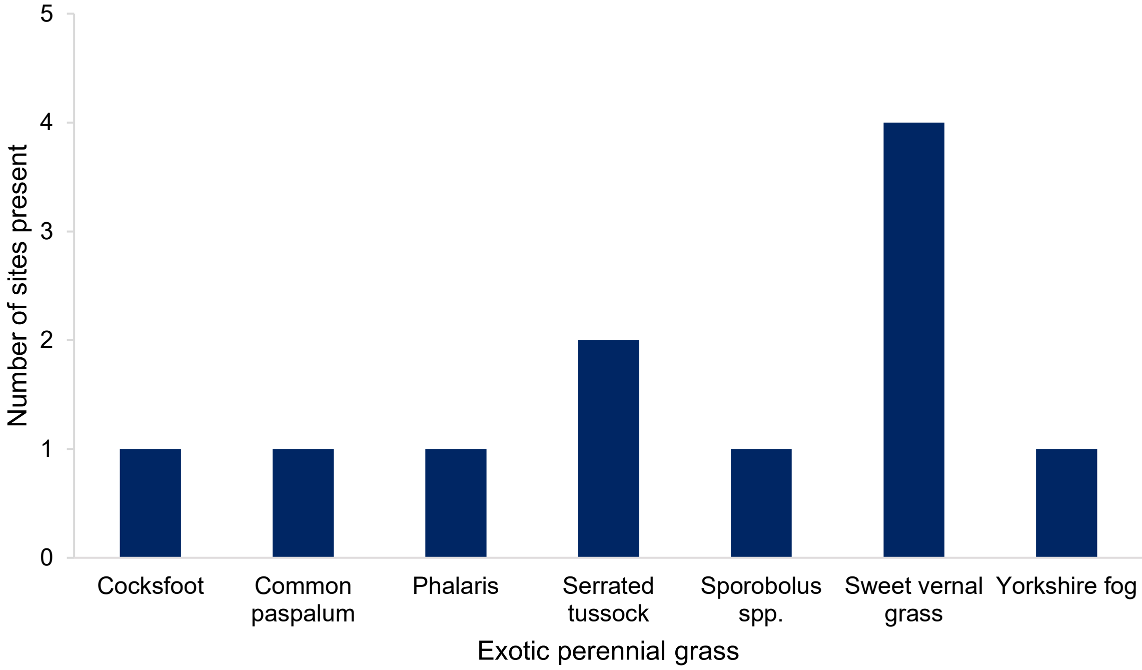

Figure 5 Number of sites where each EPG was recorded during field surveys of Monaro Tableland Cool Temperate Grassy Woodland (MCTGW) (n = 10)

1.3 Werriwa Tablelands Cool Temperate Grassy Woodland

Figure 6 Werriwa Tablelands Cool Temperate Grassy Woodland. Photo: Rob Armstrong/DPE

Werriwa Tablelands Cool Temperate Grassy Woodland (WCTGW) occurs in the same area as MCTGW but is differentiated by the tree canopy. The Werriwa community is dominated by *Eucalyptus pauciflora* with *E. rubida* sometimes as co-dominant (OEH 2019). Nine sites were surveyed but 2 sites had no EPGs present.

This community had the same main species of invaders as the Monaro Woodland, with sweet vernal grass as the most important invader which occurred in, on average, 46% of quadrats at a site (Rayment et al. 2022). There were only low levels of invasion by serrated tussock (Figure 7).

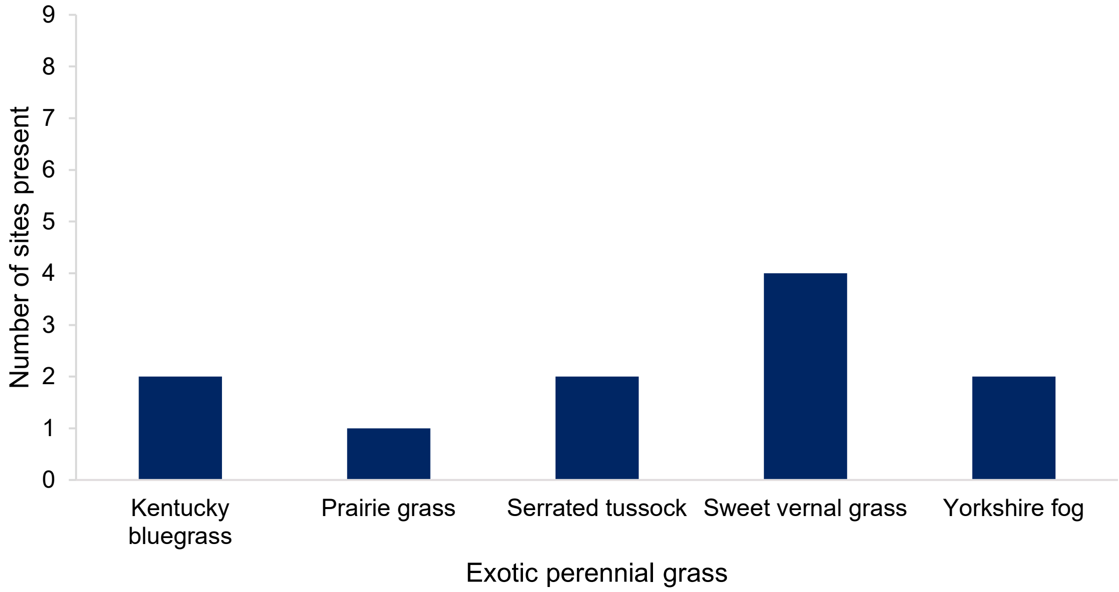

Figure 7 Number of sites where each EPG was recorded during field surveys of Werriwa Tablelands Cool Temperate Grassy Woodland (WCTGW) (n = 9)

1.4 Natural Temperate Grassland

Figure 8 Queanbeyan Nature Reserve. Photo: Libby Lindsay/DPE

Natural Temperate Grassland of the South Eastern Highlands (NTG) is a Commonwealth-listed critically endangered community, confined to the Southern Tablelands and supporting a range of unique and threatened species. Across the 18 sites surveyed, 10 EPG species were recorded (Figure 9).

African lovegrass and serrated tussock were recorded at over 30% of sites and, on average, were found in 28% and 24% of quadrats (Rayment et al. 2022). Three trade-off species (phalaris, cocksfoot and common paspalum) were recorded at 4 sites each and occupied about a third of the quadrats in those sites. Three sites had no EPGs.

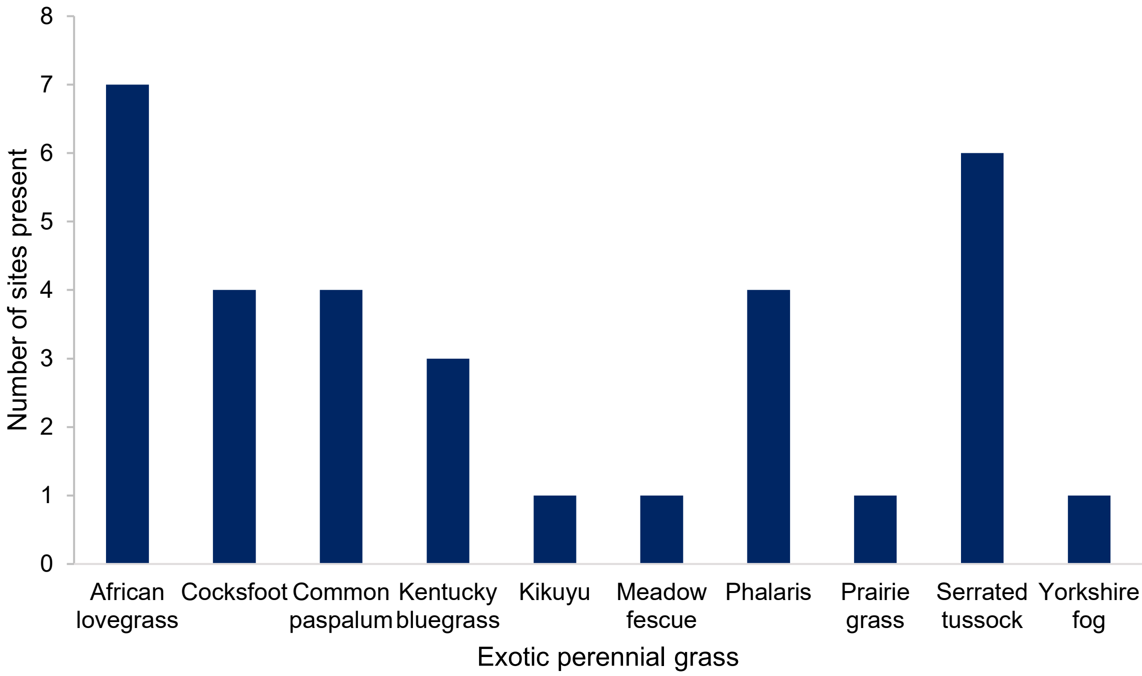

Figure 9 Number of sites where each EPG was recorded during field surveys of Natural Temperate Grassland (NTG) (n = 18)

1.5 Land manager survey results

Participants in the survey managed other communities in the region that were not threatened grassy communities. Participants identified 25 EPGs across 13 communities, with African lovegrass the most commonly identified (23) (Table 1). Of the EPGs, 17 were recorded only once.

While survey participants have common concerns about well-known EPGs such as African lovegrass and *Nassella* species, they also have a broader range of concerns about other species. Therefore, while this document discusses regionally important EPGs, the best outcomes for the region might focus on prioritisation at a community or site level. For example, the EPGs identified in the River-flat Eucalyptus community by a survey participant contain none of the regionally significant EPGs identified.

Table 1 Results from the land manager survey in the Southern Tablelands and Slopes 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: IGB: Inland Grey Box Woodland, MCTGW: Monaro Tableland Cool Temperate Grassy Woodland, MPS: Montane Peatlands and Swamps, NG: Natural Grasslands, NTG: Natural Temperate Grasslands, Other: TEC name not identified or native community not considered TEC, RFEF: River-flat Eucalyptus Forest, SENSW: South East NSW (represents a participant who likely works over multiple communities/areas or is involved with EPGs in another capacity in the region), WBYB: White Box – Yellow Box Grassy Woodland, WCTGW: Werriwa Tablelands Cool Temperate Grassy Woodland

	ACT Grassy Woodland	Farm land	Hobby garden	Pasture/ other	IGB	MCTGW	MPS	NG	NTG	Other	RFEF	SENSW	WBYB	WCTGW	Total
African lovegrass	1	1		1	1	4	1		5			1	9		23
Barley							1								1
Broadleaf paspalum											1				1
Buffalo grass										1					1
Cane needle grass													1		1
Chilean needle grass		1		1	1	1	1		4			1	7		16
Cocksfoot						1									1
Common couch						1									1
Common paspalum													1		1
Coolatai					1			1		1	1		2		6
False oat grass							1								1
Kikuyu			1	1						1					2

	ACT Grassy Woodland	Farm land	Hobby garden	Pasture/ other	IGB	MCTGW	MPS	NG	NTG	Other	RFEF	SENSW	WBYB	WCTGW	Total
Mexican feather grass						1							1		2
Pampas grass										1					1
Panic veldtgrass			1	1											1
Phalaris	1						2		3				6		12
Queensland blue couch										1					1
Red fescue						1									1
Serrated tussock	1	1		1		5			4			1	8		20
South African pigeon grass											1				1
Sporobolus spp.										1					1
Sweet vernal grass						1	2		1				1	1	6
Tall fescue													1		1
Timothy														1	1
Yorkshire fog														1	1
Number of participants	1	1	1	2	3	5	2	1	5	2	1	1	9	1	

Survey participants were involved in managing the 4 grassy communities: White Box – Yellow Box Grassy Woodland (9 participants), both Monaro (5 participants) and Werriwa Cool Temperate Grassland (1 participant), and Natural Temperate Grassland (5 participants).

Across these 4 communities, African lovegrass, serrated tussock, and Chilean needle grass were consistently identified by participants as EPGs of concern. While Chilean needle grass was only recorded in one field survey, participants frequently identified it as an EPG of concern. Low invasion in native communities by this species could be a result of community resistance to invasion by Chilean needle grass, or a result of a region-wide reduction in the prevalence of this species associated with management, or a result of the dry conditions at sites.

Participants were concerned by the ability of EPGs to outcompete native counterparts, reduce productivity on agricultural land, and spread and dominate without control. They overwhelmingly identified major negative impact.

One positive impact was recorded for phalaris by a land manager: as a trade-off species it is often planted to provide valuable feed, but it can have a negative impact on native communities.

Figure 10 Kuma Nature Reserve, a site containing Natural Temperate Grassland in Cooma. Photo: Julia Rayment/UOW

2. Prioritise: EPGs of concern in native communities in the Southern Tablelands and Slopes region

Using the field surveys in the 4 grassy threatened communities and surveys of land managers who work across multiple native communities, we identified the following EPGs as of most concern to the region: sweet vernal grass, phalaris, cocksfoot, serrated tussock, common paspalum, 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.

Sweet vernal grass. Photo: Harry Rose/flickr

Phalaris. Photo: Harry Rose/flickr

Cocksfoot. Photo: Paul Leyland/flickr

Serrated tussock. Photo Harry Rose/flickr

Common paspalum. Photo: Harry Rose/flickr

African lovegrass. Photo: Harry Rose/flickr

Figure 11 Six EPG priority species identified through field surveys and risk assessments

2.1 Sweet vernal grass (*Anthoxanthum odoratum*)

Sweet vernal grass scored 20/32 in the level of invasion risk the species poses (see Overview Section, Rayment and French 2021).

Research priority

Long-term viability of the seed bank and the capacity for competition with native species is poorly understood for this species and should be a focus for research. In particular, research is needed into its impact in an Australian context.

General biology and ecology

Sweet vernal grass appears to be a coloniser of disturbed sites and indicative of low soil fertility (Van Den Bergh and Elberse 1962). With 100% survival of emergent seedlings recorded, establishment could quickly lead to persistent communities and an increased spread in native areas (Van Den Bergh and Elberse 1962; Roach 1987; Fransen et al. 2001). Its roots are highly effective at capturing nutrients, which may allow it to outcompete surrounding groundcover.

In the field surveys, sweet vernal grass had high abundance in most sites but particularly in disturbed areas such as cemeteries and roadsides (J Rayment, personal observation). On-ground monitoring in invasion sites and research into competitive ability will improve understanding. Sweet vernal grass also has allelopathic properties, which may enhance its ability to impact biodiversity and the health of invaded ecosystems (Yamamoto 1995).

Pasture

Sweet vernal grass can spread in contaminated agricultural produce, but information about its impact on agricultural areas is scarce (Weeds of Australia 2016a).

Native communities

Several websites note its competitive ability and threat to threatened communities and flora (Popay 2013; Brown and Bettink 2019a; Agriculture Victoria 2020). One website claimed that sweet vernal grass occurs in several conservation areas in the Southern Tablelands, including sites occupied by threatened flora (Weeds of Australia 2016a).

Figure 12 Sweet vernal grass. Photos: (left) Briantspuddle/flickr, (right) Andreas Rockstein

Survey participant perceptions of sweet vernal grass

‘Extremely competitive coloniser … difficult to control in myriad of native grasses’ (Montane Peatland and Swamps, Monaro Tableland Cool Temperate Grassy Woodland)

‘Dominates large areas of Kosciusko National Park, excluding and outcompeting native flora’ (Montane Peatland and Swamps)

2.2 Phalaris (*Phalaris aquatica*)

Figure 13 *Phalaris aquatica*; photo: Harry Rose/flickr

Research priorities

Phalaris is a trade-off species with a risk score for invasion into native communities of 19.5/32, however, there is a paucity of knowledge (45% uncertainty, see Section 1: Overview; Rayment and French 2021). Low confidence is attributed to a focus on productivity and stocking rates for pasture, with little to no information available regarding competitive ability against native species and impact on native ecosystems, as well as a lack of information on seed biology and longevity. This identifies areas for future research for more accurate risk assessment and better management.

General biology and ecology

Phalaris is particularly problematic in wetter, more fertile areas of invaded communities, such as along creek flats. Phalaris can accumulate biomass if unmanaged. This can limit surrounding recruitment and produce higher fuel loads, which can be 3 times higher than native kangaroo grass (Stoner et al. 2004). Oram et al. (2009) describes phalaris as a hardy plant in drought with an ability to resprout through reproductive tillers. These characteristics improve competitive ability and persistence.

Pasture

Exotic pasture species improvement has given rise to grazing-tolerant and disturbance-adapted exotics that influence ecosystem functioning even after pastureland is retired (Low 1997; Keith 2017).

In most cases these grasses have been modified to improve their use in production systems, increasing their potential for major negative impact in threatened native communities and increasing their likelihood of establishing and persisting.

Several studies have clearly shown that weed invasion is more prevalent in fragments that have been grazed by livestock (Scougall et al. 1993; Abensperg-Traun et al. 1998, 2000; in Hobbs 2001).

One survey participant considered the impact of phalaris positive, reflecting its economic benefit. This positive impact was explained as providing high-quality feed that increases carrying capacity, but its ability to proliferate where unmanaged and ‘choke out the EEC’ [endangered ecological community] was also noted by some.

Native communities

One of the biggest risks and complexities is its intentional planting in agricultural areas. This leads to increases in propagule pressure in the region, enhancing invasion in nearby native communities.

Phalaris has been observed to germinate faster, and colonise and accumulate biomass faster than native counterparts, which may hinder native biodiversity and survival (J Rayment unpublished).

Survey participant perceptions of phalaris

‘Cover much the previously grazed lands … would be good to replace the phalaris with native grasses’ (ACT)

‘Outcompetes native grasses and forbs’ (Montane Peatlands and Swamps)

‘Established and major problem along more fertile parts of property on creek flats’ ‘Difficult to control … Dominates other species’ ‘Smothers and replaces native grasses and forbs’ (Natural Temperate Grassland)

‘Can proliferate where it is not managed … increases the risk of fire’ ‘Outcompetes native species and contributes significantly to build-up of thatch’ (White Box – Yellow Box Grassy Woodland)

2.3 Cocksfoot (*Dactylis glomerata*)

Figure 14 Cocksfoot. Photo: Harry Rose/flickr

Cocksfoot is a trade-off species with a risk score for invasion into native communities of 20.5/32 and in the top 10 of the ranking list (see Section 1: Overview; Rayment and French 2021). Several studies have shown that weed invasion is more prevalent in fragments that have been grazed by livestock (Scougall et al. 1993; Abensperg-Traun et al. 1998, 2000; in Hobbs 2001). In the Southern Tablelands and Slopes significant invasions were evident in WBYB, NTG and MCTGW.

Research priorities

Research aimed at filling current knowledge gaps concerning seed biology and its ability to compete with native species is a priority for this species (uncertainty score 22.5%, see Section 1: Overview).

General biology and ecology

As a trade-off species, new cultivars in Australia have improved drought tolerance and adaptation to the Australian climate (Lolicato and Rumball 1994). Volaire and Lelièvre (2001) found low mortality of cocksfoot under drought associated with dehydration tolerance and an ability to extract water. This tolerance provides an opportunity for it to outcompete less-tolerant native and non-native counterparts.

One participant described the distribution of cocksfoot as less extensive but having the potential to compete with natives. Williamson and Harrison (2002) recorded cocksfoot spreading into 2 adjoining ecosystems with spread limited by disturbance and seed supply. Increased invasion is seen on fertile soils. The invasion of cocksfoot was negatively correlated with species richness indicating the ability to compete for resources (Williamson and Harrison 2002).

Pasture

Cocksfoot is intentionally planted across New South Wales and requires as little as 450 mm rainfall annually for development (DPI no date a). With several varieties available, all adapted to the Southern Tablelands, there is higher propagule pressure as a trade-off species promoting spread and establishment outside its planted range and into native communities.

Native communities

Although its invasion throughout the Southern Tablelands is concerning, there is little information regarding the impact of cocksfoot as an invasive species in native communities. What is available suggests that cocksfoot has a competitive advantage due to to potential for drought tolerance and may outcompete native species (Muyt 2001; Volaire and Lelièvre 2001).

2.4 Serrated tussock (*Nassella trichotoma*)

Serrated tussock plant. Photo: Julia Rayment/UOW

Serrated tussock inflorescence. Photo: Harry Rose/flickr

Figure 15 Serrated tussock

As a Weed of National Significance, serrated tussock is recognised for its invasive ability and major impact to native communities and the agriculture sector. Serrated tussock has been established in the region since 1926 with severe drought in 1981–83 facilitating its spread through preferential overgrazing of more favourable grasses (Klepeis et al. 2009). It has a risk score of 17/32, moderate risk, but there is limited information on some key life history traits related to invasion of native communities, e.g. seed biology, impact on native species and ecosystem effects.

General biology and ecology

Serrated tussock spreads through high propagule pressure and long-lived seed banks. Seed establishment is linked to rainfall (Badgery et al. 2008). Serrated tussock persists in areas of drought and low fertility soils (Badgery et al. 2005). Badgery et al. (2005) attribute the success of serrated tussock to its ability to grow quickly early, even in areas of low fertility, with an ability to monopolise nutrients. Its spread and establishment is exacerbated by dry conditions (Michelmore 2003).

Pasture

In areas of primary productivity, animals are known to avoid serrated tussock and graze more palatable species (Vere and Campbell 1984; Laffan 2006). This was echoed by participants who described livestock avoiding the EPG due to unpalatability, instead 'seeking any alternative' to serrated tussock.

Native communities

Once established in native communities, serrated tussock can spread through seed carried by wind and reduces biodiversity values in the invaded community (ARMCANZ 2000). Land managers described the ability of serrated tussock to compete with natives, leading to negative ecosystem impact.

Survey participant perceptions of serrated tussock

'Prevents native grasses re-colonising bare areas following overgrazing by kangaroos after long droughts' (Monaro Tableland Cool Temperate Grassy Woodland, White Box – Yellow Box Grassy Woodland)

'Rapid spread … tendency to grow under eucalypts making treatment potentially hazardous' (Monaro Tableland Cool Temperate Grassy Woodland)

'Created monoculture' 'Control to ensure it does not expand or dominate and outcompete native grasses and forbs' (Natural Temperate Grassland)

'Highly invasive and unpalatable, invades country and displaces native tussock grasses' 'Smothers native grasses and regeneration of shrubs and trees' (White Box – Yellow Box Grassy Woodland)

2.5 Common paspalum (*Paspalum dilatatum*)

Figure 16 Common paspalum. Photo: Harry Rose/flickr

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 TECs in the field survey and was the second most frequently occurring EPG across the 4 communities.

Research priorities

As the fifth most risky species there is a need for more research to improve the certainty of the risk score; we currently have poor knowledge of its impact to the ecosystem, 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 2016b; 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 in the Southern Tablelands and Slopes, the propagule pressure associated with this trade-off specie increases likelihood of establishing in high conservation native 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: 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).

2.6 African lovegrass (*Eragrostis curvula*)

Figure 17 African lovegrass. Photo: Harry Rose/flickr

African lovegrass has the highest risk score of the 29 EPGs assessed in Section 1: Overview (28/32, Rayment & French 2021). Information about its invasion characteristics is well-known, although a good understanding of seed longevity would facilitate management. This species was very prevalent in Lowland Grassy Woodland (see Section 5: South Coast).

General biology and ecology

African lovegrass has plant traits that are indicative of a very successful invader, with traits that are well-suited to invasion and persistence in the Southern Tablelands and Slopes region. These include tolerance of a range of environmental conditions, high seed production, and 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, seven 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

‘Can cover large areas containing native grasses if allowed to spread’ (ACT)

‘Rapid spread and gradual development of a monoculture’ ‘Catastrophic nearby’ (Monaro Tableland Cool Temperate Grassy Woodland)

‘Outcompetes native grasses and forbs’ (Montane Peatlands and Swamps)

‘Smothers and replaces ground story’ ‘Creates monoculture almost impossible to contain or control’ (Natural Temperate Grassland)

‘Transformer weed’ ‘Invades low fertility sites … ongoing threat’ ‘Spread down nearby roadsides dramatically and is invading adjoining grass ecosystems’ ‘Becoming more prolific’ ‘Outcompetes native species’ (White Box – Yellow Box Grassy Woodland)

Table 2 Triage system for the risk and prioritisation of EPGs in the Southern Tablelands and Slopes 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)

	Risk score	Prevalence score %	Risk factors for invasion	Areas for concern	Other considerations
HC – Sweet vernal grass	20	Total: 21% WBYB: 0 MCTGW: 40% WCTGW: 44% NTG: 20%	Good pioneer species, prevents native establishment. Good competitor for soil moisture and nutrients.	Invasion likely along roadsides and in response to disturbance. High seedling survival, will compete with native recruitment.	Research into control methods needed. Herbicide control feasible. Be aware of colonisation after disturbances.
HC – Phalaris	19.5	Total:26% WBYB: 50% MCTGW:10% WCTGW: 0 NTG: 22%	Trade-off species. Drought tolerant. Invades where soil moisture is high.	Information skewed towards productivity. Alters fire regime. High biomass accumulation.	More research into phalaris as an invasive species needed. Weed hygiene to prevent spread from pastures important.
HC – Serrated tussock	17	Total: 28% WBYB: 30% MCTGW: 20% WCTGW: 22% NTG: 33%	High propagule pressure and preference for low-fertility soils and dry periods. Monopolises nutrients. Similar to natives.	Impacts productivity on pastures and can gain competitive advantage in native communities through selective grazing.	Follow WoNS best practice manual for in-depth approved control advice. Cross tenure weed control important for best success.
MC – Cocksfoot	20.5	Total: 26% WBYB: 50% MCTGW: 10% WCTGW: 0 NTG: 22%	Trade-off species. Drought tolerant. Competitive.	Reduces native species richness. Limited information on impact in Australia.	Limit seed bank – no seed dormancy. Research needed into impact in NSW.
MC – Common paspalum	23.5	Total: 26% WBYB: 30% MCTGW: 10%	Tolerant of drought and flooding. Rainfall promotes growth and seed spread.	Grazing and mowing promote growth. Evidence for allelopathy.	Information needed for impact to natives and control.

	Risk score	Prevalence score %	Risk factors for invasion	Areas for concern	Other considerations
		WCTGW: 0 NTG: 22%			
MC – African lovegrass	28	Total: 16% WBYB: 10% MCTGW: 0 WCTGW: 0 NTG: 39%	Highly competitive. Adapted to drought, fire and unfavourable conditions.	Multiple cultivars. Evidence for herbicide resistance.	Canopy cover linked with reduced abundance. Research into biocontrol needed. Management guides for pasture available.
N – Chilean needle grass	21	Total: 12% WBYB: 35% MCTGW:0 WCTGW:0 NTG: 0	Similar to native grasses. Quickly invades communities in poor condition.	Can cause damage to wool and hide industries. Outcompetes natives.	Follow WoNS best practice manual for in-depth approved control advice. Cross tenure weed control important for best success.

3. Control: managing EPGs in the Southern Tablelands and Slopes region

3.1 General management of EPGs

This document focuses on the grassy communities for which we have information from field and land managers 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 a different set of 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.

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 groundcover of threatened communities to increase resilience to invasion from trade-off species, and weeds more generally. This may involve retiring, replanning, 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. The Southern Tablelands and Slopes region has a range of community organisations that facilitate community weed management and transdisciplinary management. This includes organisations such as Local Land Services, NSW Department of Primary Industries, NSW Department of Planning and Environment and NSW National Parks and Wildlife Service, universities, Friends of Grassland, Kosciuszko to Coast, and Local Landcare.

Examples of coordinated management include Kosciuszko to Coast: a project involving 14 partners that aims to deliver improved natural resource management and environment services to facilitate transdisciplinary weed research and management (K2C 2017). Upper Snowy Landcare works with farmers and the University of Sydney to research African lovegrass and improve management practices (Upper Snowy Landcare 2021).

Figure 18 Sign acknowledging the presence of significant vegetation (WBYB) and coordinated control from council and organisations. Photo: Julia Rayment/UOW

Participants were asked to rate the response of the target EPG to their control methods. Overwhelmingly, the use of control led to lowered abundance of the target weed for all species. Responses were varied for African lovegrass and Chilean needle grass; some recorded reinvasion while others recorded no change. Generally, control of African lovegrass improved ground cover. However, for Chilean needle grass the recovery was more mixed. Similarly, control of sweet vernal grass often resulted in reinvasion. Control of phalaris and serrated tussock usually resulted in a lower abundance but resulted in reinvasion. The variation is responses indicates that, while most control leads to lowered abundance of the EPG, the ground cover will not automatically recover.

Active regeneration after control is needed to build resilience in the community post-invasion. The ability to understand the effectiveness of the outcome of control was lacking for many participants, indicating that a monitoring program to inform management in native communities is a high priority (see Section 4 in this document: Monitoring). We advise using the method set out in *Monitoring Manual for Invasive and Native Flora* (Watson et al. 2021) as an integral part of weed management. Examples of good monitoring are evident in the ACT where, for the past 6 years, monitoring of weed control has been conducted and is accessible online (ACT Government 2021). 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. 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 load associated with weed control, helping to implement a more efficient regional approach.

In the Southern Tablelands and Slopes particular importance should be placed on the potential spread through agricultural land and fragmented native communities. These 2 often intersect in TSRs or in significant roadside environments. Management techniques that may facilitate spread, such as roadside slashing or mowing, or weed spread through stock movement, require special consideration.

3.2 Weeds of National Significance

Two Weeds of National Significance were identified by survey participants (Chilean needle grass, serrated tussock). Extensive research has been conducted into their invasiveness and management strategies. This can be accessed through the Resource 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 only included one of these 2 species, as Chilean needle grass was not recorded during surveys, however, this 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 managing each species.

Table 3 Management options for the main EPG species of concern in the Southern Tablelands and Slopes region

Note: Best practice management uses more than one control strategy. Grazing strategies should be considered only on native pasture communities where allowed.
N/A: not available.

Control option	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.**
Sweet vernal grass	Suitable for small infestations	Capacity for regrowth. Not suitable in areas of high moisture	Susceptible but limited information on rates in NSW	Limited information	None	Unclear, research needed
Phalaris	Suitable but requires follow-up throughout the year	Regular mowing limits spread	Suitable but limited information	Suppresses growth but higher fuel loads with natives	N/A	Trade-off species. Avoid spread into new areas. Weed hygiene important.
Cocksfoot	Suitable but ensure crown is removed	Suitable to limit seed set	Suitable but will require follow-up treatments	Limited information. Unaffected by fire in the United States	N/A	Trade-off species. Avoid spread into new areas. 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. Defoliation improves competitiveness. Weed hygiene important.

Control option	Manual	Mechanical	Chemical	Fire	Biocontrol	Grazing
Serrated tussock	Suitable for small infestations	Suitable to limit seed set	Can be used but be careful of herbicide resistance. Best used as part of IWM	Good to reduce biomass	N/A	See best practice manual (in Resources) for control on pastureland
African lovegrass	Suitable for small infestations. Tough root system	High capacity for regrowth	Suitable but herbicide resistance possible	Can withstand and resprout after fire	N/A	Graze heavily when young, weed hygiene important. Competitive pastures.

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

3.3 Sweet vernal grass (*Anthoxanthum odoratum*)

Figure 19 Sweet vernal grass in Goulburn. Photo: Harry Rose/flickr

Research priorities

There is limited information regarding control of sweet vernal grass. Information about successful activities should be shared to help develop best practice management.

Germination success and survival of seedlings is high for this species, so limiting seed set is critical. Manual removal is likely to be suitable for small infestations, but follow-up control and monitoring will be required. Good water availability may improve growth (Popay 2013), so mechanical control may be most beneficial during drier months. Good native groundcover may reduce the capacity for establishment at sites, suggesting native groundcover improvement may be a useful option, although sweet vernal grass may be competitively dominant at times.

No information was found regarding the use of fire, but an increase in density of sweet vernal grass was noted in Kosciuszko National Park in response to the 2020 fires (J Rayment, personal communication). Both selective and non-selective herbicides are identified as suitable for control of sweet vernal grass (DiTomaso and Kyser 2013; Brown and Bettink 2019a). As limited information for New South Wales exists for sweet vernal grass, monitoring and record keeping will improve understanding of control efficacy. No biocontrol is available for sweet vernal grass.

3.4 Phalaris (*Phalaris aquatica*)

Research priority

As a valuable pasture species there is limited information on control techniques for phalaris. Monitoring is important to better understand suitable control techniques for phalaris.

Phalaris appears tolerant to herbicides when controlling other EPGs in a phalaris pasture, but limited information is available on control where phalaris invades (Campbell and Ridings 1988). Any techniques that reduce growth and limit seed spread should be employed to prevent phalaris from invading into native areas. Monitoring and early control may be necessary in native areas that are close to pastures, such as roadsides. As with the other EPG species, manual control is suitable for small infestations of phalaris. There is limited information on the response of phalaris to mechanical control, but as a pasture plant it is likely to survive defoliation and mowing. Information from the United States suggests mowing phalaris is an effective way to reduce vigour biomass for improved efficacy when sprayed with herbicide (DiTomaso and Kyser 2013). Burning may suppress growth, and, when used before herbicide, can improve the efficacy of herbicide control (Popay 2015b).

Research from Department of Environment, Land, Water and Planning (DELP) Victoria, on an annual herbicide program in a native grassland, shows control of phalaris was achieved with annual application but emphasises the process takes many years as native grasslands are slow to recover and regenerate. Suggestions for herbicide rates and application timing are available online (HerbiGuide no date b).

Survey participants had variable IWM strategies based on infestation levels, the land, and resources available. One participant completed burning in winter followed by herbicide in spring. For large-scale infestations one participant employed methods to starve nutrients from phalaris and sowed native grasses wherever bare soil occurred, as well actively planting native trees and shrubs to improve ground cover and reduce EPG cover. Other sources suggest burning and herbicide as good integrated control for phalaris while also encouraging shrub and tree revegetation (HerbiGuide no date b; DiTomaso and Kyser 2013).

3.5 Serrated tussock (*Nassella trichotoma*)

A serrated tussock national best practice management manual and other resources are available for management advice.

Manual control can be used for small infestations and mechanical control can be useful to limit seed set and biomass if the plants aren't seeding. The best practice management guides provide advice for control based on different native community structure, and include integrating multiple techniques. In native areas, strategies such as fencing and windbreaks may help promote native recovery and limit serrated tussock spread. Fire can be used to reduce biomass, and herbicide is an effective control, although serrated tussock has the potential to develop resistance. One survey participant suggested winter as the best time to spot spray to reduce off-target damage as other grasses are dormant. Serrated tussock was sprayed twice a year by managers who used only herbicide.

IWM strategies employed by survey participants included mowing appropriate areas, only after native grass seeds had released, and spot spraying and chipping in inaccessible areas. Surrounding ground cover recovery was slow, indicative of the time needed for effective control and native regeneration in grassy communities. One participant employed an intensive rotational regime to promote the grazing of serrated tussock by livestock, integrated with spot spraying, noting good success. Common integrated methods for smaller infestations include hand pulling and spot spraying.

3.6 Cocksfoot (*Dactylis glomerata*)

Figure 20 Cocksfoot on a roadside. Photo: Harry Rose/flickr

Research priority

As a pasture plant with limited recognition of its negative environmental impact, information on control strategies is limited. A greater understanding of the impact of cocksfoot in native environments, and how to control it, is urgently needed.

Information provided for cocksfoot uses internet resources of unknown or mixed reliability. Monitoring of native areas near roads or agricultural areas is important as propagule pressure is high and early eradication is needed. Where cocksfoot is established, reducing its competitive ability and promoting native establishment is recommended.

Cocksfoot plants can be removed via manual control, but regrowth is possible so the entire crown must be removed (Muyt 2001; Popay 2015a). Information suggests mechanical control such as slashing can be employed to limit seed production and that close mowing can eliminate the grass (Muyt 2001; Popay 2015a). Close mowing may not be relevant for conservation sites but may be useful on roadside infestations.

As a trade-off species, weed hygiene in native pastures to prevent its spread into surrounding areas is important. Information from North America suggests cocksfoot will be unaffected or increase in response to fire (FEIS no date). Chemical control is said to be effective but will require follow-up treatments (HerbiGuide no date a; Muyt 2001; Popay 2015a). Some sources consider IWM strategies including a slash, burn, herbicide regime (Brown and Bettink 2019b).

3.7 Common paspalum (*Paspalum dilatatum*)

Research priority

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. Research and information on successful techniques is a high priority.

In native communities, management should focus on limiting lateral spread of paspalum to prevent crowding out native germination. 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).

One participant controlling paspalum described chipping as time-consuming but leading to considerable reduction in collateral damage risk. As paspalum is responsive to flooding, monitoring and control should be increased after high rainfall.

3.8 African lovegrass (*Eragrostis curvula*)

Figure 21 African lovegrass on a roadside. Photo: Harry Rose/flickr

Strategies for African lovegrass management in relation to grazing and agricultural practices in the region are available in the Resources section. African lovegrass can be manually removed but this is best used for small infestations.

One participant in the ACT discussed the variation of control techniques for African lovegrass based on personal skill. Volunteers preferred manual removal, leaving more involved methods like herbicide spraying to contractors. This participant also discussed the ease with which manual removal could be applied, during daily walks by volunteers trained in ID. 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). Participants using herbicides on African lovegrass often used both glyphosate and flupropanate by spraying at least once a year, but commonly twice.

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 in riparian zones.

African lovegrass can spread rapidly in response to fire. Fire may be more useful in IWM where it could 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 groundcover 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.

Similar integrated control was used by a survey participant who undertook burning in winter and spraying in summer, with seed heads removed before herbicide use. More complex IWM was described by one participant who employed manual removal, herbicide, mowing to reduce seed spread, and restricting use of vehicles to tracks. Another participant integrated herbicide with longer term techniques to improve fertility and targeted grazing practices to limit African lovegrass persistence.

The success of variable IWM reinforces that integration depends on a variety of factors and there are multiple ways to achieve control. 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.).

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 improves 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 22 TSRs are often TECs. Photo: Julia Rayment/UOW

Resources

Managing grassy woodlands

A Guide to Managing Box Gum Grassy Woodlands – Department of the Environment, Water, Heritage and the Arts (DEWHA)

2005 ACT Lowland Native Grassland Conservation Strategy – ACT Government

Grassy Ecosystems Management Kit – ACT Government

Protecting and Connecting ACT Woodlands – Greening Australia

Exotic perennial grass

African lovegrass

NSW WeedWise: African lovegrass (Eragrostis curvula) – DPI

Molonglo Catchment Group Weed Fact Sheet: African lovegrass

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

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

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

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