NSW GOVERNMENT

Department of Planning and Environment

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

Section 2: NSW North Coast

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Cover photo: Themeda Grassland. Julia Rayment/UOW

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Acknowledgments

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

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

Introduction

The North Coast Local Land Services region covers an area of 32,051 km^2 (Figure 1), supporting the greatest diversity of native plant and animal species in the state and being home to over 370 threatened flora and fauna (NRC 2014). The region has a mix of temperate and subtropical climates with high rainfall, supporting a range of communities of conservation importance, including RAMSAR wetlands, rainforests, and grasslands (LLS no date). There are a range of natural resource-based industries, including cattle, grazing, intensive horticulture, fishing and aquaculture, timber production and tourism industries (LLS no date). The climate and varied land use of the region are associated with a high vulnerability to invasion of invasive plant species (NRC 2014). Transport corridors into and within the region all contribute to increased risk of weed spread.

There was only one threatened grassy community surveyed in the region: Themeda Grassland on Seacliffs (TGoS). 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 exotic perennial grasses (EPGs) in the region. We then combine this information with the risk assessment tool to suggest which EPG species to prioritise for the grassy community we surveyed. The risk assessment tool identifies the species most at risk of invading native communities, based on plant characteristics (Rayment and French 2021, Section 1). Lastly, we provide resources to help identify advantages and disadvantages to control techniques available for the species identified as high priority. We hope this information facilitates the management of this community and other native communities in the region. If there are other communities of interest, then similar approaches could be taken.

Four-step approach to management of 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* (Watson et al. 2021) and implementing monitoring as a key requirement of managing EPGs.

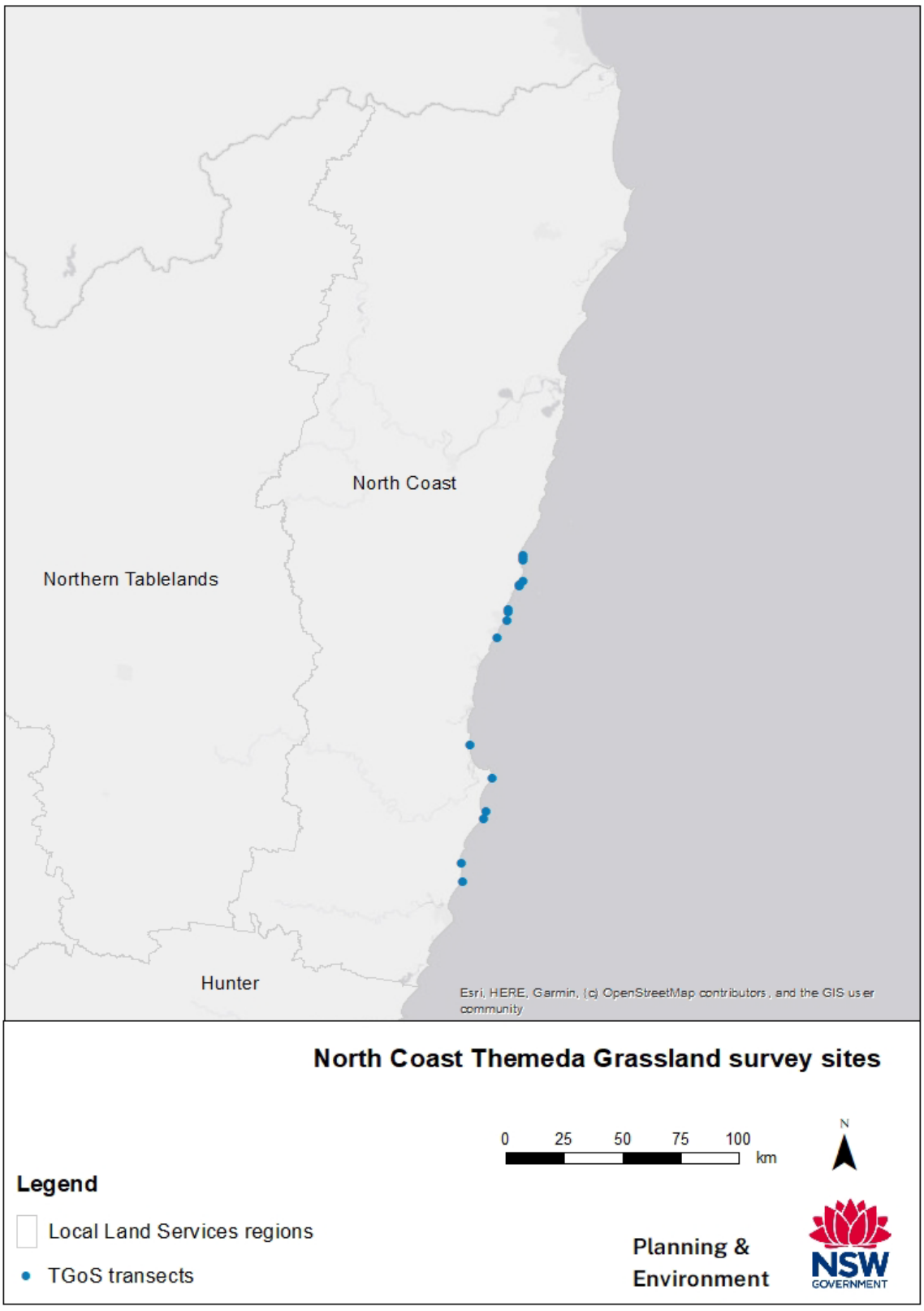

Figure 1 North Coast survey sites of Themeda Grassland on Seacliffs

1 Identify: grassy community field surveys

1.1 Themeda Grassland on Seacliffs

Figure 2 Themeda Grassland. Photo: Morgan Brading/DPE

Themeda Grassland on Seacliffs (TGoS) communities occur in small fragments on coastal headlands along the NSW east coast. In the North Coast region, the community is threatened by clearing of native vegetation, shrub encroachment, inappropriate fire regimes, weeds, and human-mediated disturbance (DPIE 2021). The communities are highly fragmented and are frequented by humans disturbing sites and spreading seed on footwear and clothing. Sites occur in conditions with heavy winds, full sun, and salt spray, so invading EPGs must have high environmental tolerance to become established (Adam et al. 1989). Some of the sites are within national parks, while others occur alongside urban developments and were a mosaic of natural grasslands and recreation headlands planted with turf grass (personal observations, Adam et al. 1989). Headlands can be difficult to access, with management sometimes limited to handheld techniques such as hand pulling, slashing, herbicide control or burning.

We surveyed 7 sites and used additional surveys by J Hunter (personal communications). In all, 16 sites were analysed. Twelve EPGs were recorded, including 3 paspalum species. Surveys identified common paspalum, broadleaf paspalum, vasey grass and weedy *Sporobolus* grasses as key invaders (Figure 2). Weedy *Sporobolus* grasses were the most prevalent, occurring in 43% of sites, followed by broadleaf paspalum (36%) and vasey grass (36%) (Rayment et al. 2022). 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. The invasion of *Sporobolus* spp. was frequently observed as heaviest along walking tracks where disturbance is high. Common paspalum, however, occurred in, on average, 78% of quadrats surveyed, while the weedy *Sporobolus* grasses occurred in, on average, 51% of quadrats at sites (Rayment et al. 2022). Vasey grass and broadleaf paspalum occurred only in the North Coast, and in the surveyed community occupied only an average of 14% and 5% of quadrats at sites. With the proximity to recreation land for some, or most, of the headland sites, disturbance through creation of informal paths, trampling of vegetation and pest animals also influences invasion (Abensperg-Traun et al. 1998; Lake and Leishman 2004). Rhodes grass was observed as more prominent in the shaded transition away from the grassland community and on average occurred in 30% of quadrats at sites.

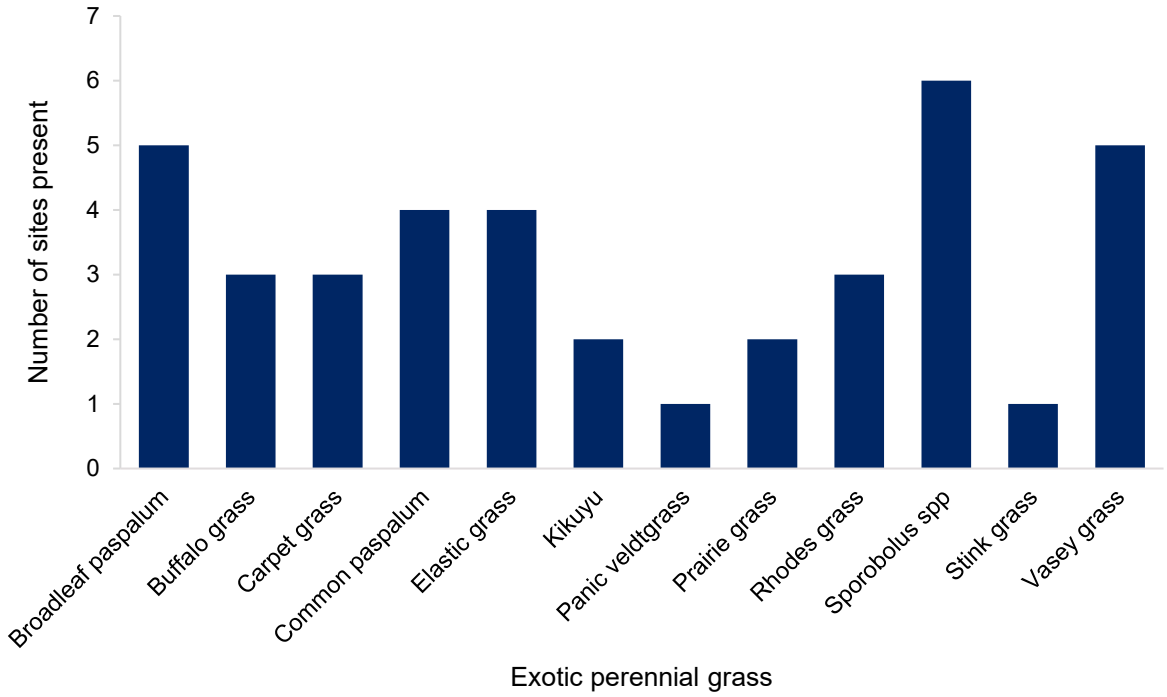

Figure 3 Number of sites where each EPG was recorded during field surveys of Themeda Grassland on Seacliffs (n = 16 sites)

1.2 Land manager survey results

Participants working across a range of communities in the North Coast identified a different suite of EPG species as 'of concern' (Table 1). Weedy *Sporobolus* grasses were identified as an EPG group of concern by 5 participants across 4 communities. South African pigeon grass was identified by 3 participants across 3 communities but was not recorded in field surveys in the 3 grassy communities. Two semi-aquatic species, para grass and torpedo grass, were perceived as high threat in the wetter rainforest and coastal floodplain communities. In the survey all participants indicated that EPGs have major negative impact on a range of communities, although one participant each for Kikuyu and weedy *Sporobolus* grasses scored impact to community as minor.

Table 1 Results from the land manager survey in the North 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: CCPF: Coastal Cypress Pine Forest, LRSTA: Lowland Rainforest, SCFF: Subtropical Coastal Floodplain, SSF: Swamp Sclerophyll Forest, TgoS: Themeda Grassland on Seacliffs.

EPG	CCPF	Farmland	LRSTA	SCFF	SSF	TGoS	Total
Broadleaf paspalum			1			1	2
Buffalo grass						1	1
Carpet grass				1			1
Common paspalum					1		1
Mollasses grass					1		1
Para grass				1			1
Rhodes grass	1					1	2
South African pigeon grass	1			1	1		3
Sporobolus spp	1	2	1			1	5
Torpedo grass			1				1
Number of participants	1	2	1	1	1	2	

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

Using the field surveys in one grassy threatened ecological community (TEC) and surveys of land managers that work across multiple native communities, we identified the following EPGs as of most concern to the region: paspalum species, weedy *Sporobolus* grasses, South African pigeon grass and Rhodes grass. Here we provide information on the biology of these species and use a 'triage table' (Table 2) to highlight our prioritisation. In the following management section, other trade-off species are discussed, and a brief note on semi-aquatic grasses is provided.

Managing 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 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.

2.1 Paspalum species (*Paspalum* spp.)

Three paspalum species were common invaders of the threatened community surveyed and were considered issues in a range of other non-grassland communities, reflecting their preference for temperate climates and wet conditions (Vélez-Gavilán 2017; DAF 2020).

Common paspalum

Common paspalum (*Paspalum dilatatum)* is present through most of New South Wales and has a high-risk score (23.5/32. Rayment and French 2021). It impacts communities through resource and potentially interference (allelopathy) competition, smothering native species and suppressing regeneration (Henry 2009; Vélez-Gavilán 2017; Hassan and Mohamed 2020). Paspalum is tolerant of intermittent flooding and drought (Vasellati et al. 2001) and disperses using sticky seeds that attach to humans, animals, machinery, or float in run-off (Lawn Solutions Australia 2021). Common paspalum is a contentious species, and its intentional presence on agricultural land is likely to be a significant source for invasion into nearby native communities or other nearby agricultural land. In agricultural land, paspalum is tolerant to grazing and may outcompete less competitive pasture species (Cornaglia et al. 2009; Lattimore and McCormick 2012). In native communities, paspalum will impact native recruitment and compete for resources such as space, light and nutrients (Henry 2009; Henry et al. 2009; Hassan and Mohamed 2020).

Broadleaf paspalum

Broadleaf paspalum (*Paspalum mandiocanum)* had a moderate risk score (16.5/32. Rayment and French 2021) but was considered by survey participants to have 'major

negative impacts' in communities. As its ranking was associated with a high degree of uncertainty in knowledge, its presence and mechanism of invasion is poorly understood. Broadleaf paspalum prefers high light conditions but can grow in shaded conditions as well (DAF 2020). Research is needed to confirm the pathways and competitive abilities of this species in a range of different communities.

Survey participant perceptions of broadleaf paspalum

'Invades rainforest understory and wet gullies' (Lowland Rainforest in NSW)

'Crowds out native plants and changes abiotic [conditions]' (Themeda Grassland on Seacliffs)

'Forms a dense monoculture' (Broad-leaved Paperbark – Swamp Oak)

Vasey grass

Vasey grass (*Paspalum urvillei)* had a risk score of 17.5/32 but limited knowledge was available in the literature to confirm this ranking (Rayment and French 2021). Its localised invasion in TGoS reflects its preference for full sun, its tolerance to drought, and its preference for moist soil (Rayment and French 2021, supplementary material). Growing taller than many of the native species on Themeda Grassland may allow it to shade-out other species and increase its spread. Reports of allelopathy indicate a competitive advantage with vegetative reproduction favouring its spread once established.

Common paspalum (*Paspalum dilatatum)*. Photo: Forest and Kim Starr

Broadleaf paspalum (*Paspalum mandiocanum)*, leaves are much broader than common paspalum. Photo: Harry Rose

Vasey grass *(Paspalum urvillei*). Photo: Harry Rose

Figure 4 Three invasive paspalum species are common invaders in the NSW North Coast

2.2 Weedy Sporobolus grasses (*S. africanus*, *S. 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 its 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). *Sporobolus*, particularly Parramatta grass, was the most prevalent grass in the field surveys and was identified in 4 communities by survey participants.

Research priorities

Despite its high occurrence, 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 weedy *Sporobolus* grasses will require long-term 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) describe *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) with survey participants noting they ‘spread [into] adjacent grazing land’ and cause ‘reduced productivity’. Unpalatable weedy *Sporobolus* grasses in pasture lead to overgrazing of more desirable species, creating a cycle that allows these grasses to increase in size and establish.

Native communities

Weedy *Sporobolus* grasses outcompete native species for space and resources. 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 observation). Impact on native communities is not well quantified but evidence from impact on agricultural areas, and these surveys, indicates an ability to cause negative impact where WSG establish.

Survey participant perceptions of weedy *Sporobolus* grasses

‘Degrades roads and tracks, spreads to adjacent grazing land’ (Lowland Rainforest in NSW)

‘Crowds out native themeda’ (Themeda Grassland on Seacliffs)

‘ … reduction in native species’ (Farmland)

Parramatta grass (*Sporobolus africanus*). Photo: Julia Rayment/UOW

Giant Parramatta grass (*Sporobolus fertilis*). Photo: Harry Rose

Figure 5 Two species of *Sporobolus* present throughout the North Coast region
Parramatta grass generally has a shorter growth form than Giant Parramatta grass but can be confused.

2.3 South African pigeon grass (*Setaria sphacelata*)

In Rayment and French (2021), this species was given a risk score of 16/32, suggesting a species of moderate risk.

Research priorities

Improved research into the ecology and biology of South African pigeon grass is considered an important aspect of its management given the current poor knowledge in many critical characteristics (Rayment and French 2021). Importantly, we lack basic information and lack an understanding of its impact on native communities.

General biology and ecology

Current information is reviewed in Rayment and French (supplementary material 2021). It was not recorded in Themeda Grassland on Seacliffs, however, this species was identified by land managers as invading 3 forest TECs. South African pigeon grass has been used as a pasture grass, with 4 varieties available. Information from DPI indicates the varieties are drought and frost tolerant with good growth in response to storms (DPI no date b). South African pigeon grass is known to prefer warm climates and areas with high rainfall, making the North Coast a highly suitable region for invasion. Information related to its use in pasture suggests South African pigeon grass tolerates frost, short-term waterlogging, and drought (Mushtaque et al. 2010; Lattimore and McCormick 2012).

Pasture

As a pasture species, research is focused on improving productivity. Information on seed production is limited to seed yield rather than seed numbers per plant (Hacker and Cuany 1997; Dwivedi et al. 1999; Jank et al. 2007), limiting our understanding of propagule pressure in native areas, however, seed production is said to be low (Loch no date; Hacker and Jones 1969). South African pigeon grass has a high requirement for potassium and nitrogen and may establish better in improved soils of agricultural land (Dwivedi et al. 1999; DPI no date b).

Native communities

One case study from research into fire and weeds describes South African pigeon grass as prolific in the North Coast and a problem in conservation and agricultural land (Rose 2016). It is thought to perform best on coastal lowlands with annual rainfall of 1000 mm, which may explain its high occurrence in the North Coast forest regions (NCC 2017). South African pigeon grass can outcompete surrounding ground cover and regenerate quickly in response to disturbance (NCC 2017). South African pigeon grass has been described as aggressively competitive against other weeds but there is limited research on its impact and competitive ability in native communities (Jiang et al. 2008; DPI no date b).

Survey participant perceptions of South African pigeon grass

'Supresses native species regeneration' (Subtropical Coastal Floodplain Forest, Swamp Sclerophyll Forest)

2.4 Rhodes grass (*Chloris gayana*)

In Rayment and French (2021) Rhodes grass was ranked third with a risk score of 26/32 suggesting it has the potential to be highly invasive. Information on evidence for its high rank is available in supplementary material for Rayment and French (2021). In Themeda Grassland on Seacliffs sites, Rhodes grass was present in 3 sites (21%) but was considered damaging by one participant who worked in these communities, as well as in Coastal Cypress Pine Forest.

Research priorities

Further research is needed on seed biology and impact on ecosystems to provide certainty for this risk score. Clearly Rhodes grass can establish and persist in sites, and given its ability to form a monoculture in at least one site, it is likely to have negative impact. Specific research into what impacts it has and how it achieves competitive dominance will improve risk assessment and management of this highly ranked species.

General biology and ecology

The invasion potential of this species is associated with its use as a trade-off species, apparent tolerance to a range of conditions, vegetative spread and high seed production (DAF 2016; Rayment and French 2021). Rhodes grass grows extensively in the NSW North Coast (Lattimore and McCormick 2012). 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, and has previously been tested for rehabilitation of old mine sites (DPI no date a; Huxtable et al. 2005; Lattimore and McCormick 2012). As a useful pasture grass, invasion into nearby communities is possible through propagule pressure and poor weed hygiene practices facilitating seed spread.

Native communities

Rhodes grass has been documented as an aggressive competitor of both natives and exotics (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.

Figure 6 Rhodes grass. Photo: Julia Rayment/UOW

Table 2 Triage system for the risk and prioritisation of EPGs in the North 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 at sites (%)	Risk factors for invasion	Areas for concern	Other considerations
HC – Broadleaf paspalum	16.5	31%	Information needed e.g., impact in native areas. Thought to be like *P. dilatatum*.	Known to be problematic in Queensland. Prefers high rainfall areas.	Increased research, control according to Queensland risk assessment.
HC – Common paspalum	23.5	25%	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.
HC – *Sporobolus* spp.	15	38%	High seed output, resistant to competition, prefers low fertility soils. Invades disturbed areas.	Prefers sunny areas. Long lived seed bank. Invasion likely in disturbed areas and along edges.	Focus control on limiting seed set.
MC – Vasey grass	17.5	31%	High seed output. Competes for space and light. Prefers full sun.	Limited knowledge of impact on native communities and competitive ability.	Research needed on invasion and control. Use control guides from other states.
MC – South African pigeon grass	16	N/A	Vegetative spread and similarity to other *Setaria* species.	Lack of information. Has been intentionally planted in agricultural areas.	Research needed on impact on native ecosystems, seed output and evidence that burning and herbicide are effective.
MC – Rhodes grass	26	19%	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.
N – Other trade-off species	25	14–21%	Quick vegetative spread. Increased propagule pressure.	Cultivars may be adapted to tolerate harsh conditions.	Care should be taken to avoid spread into unwanted areas.
N – Semi-aquatic grasses	11–11.5	N/A	Harmful in wetter communities. Vegetative spread can form dense stands.	Para grass high fuel loads, spread facilitated by fire. Torpedo grass resistant to herbicide.	Increased research into local impact needed. Prevent spread.

3. Control: managing EPGs in the North Coast region

3.1 General management of EPGs

This document focuses on the on the Themeda Grassland on Seacliffs community, 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 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 ground cover 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 Travelling Stock Routes (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 controls can also be implemented 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. North Coast LLS has a Regional Strategic Weed Management Plan with 11 statutory regional weed communities made up of local control authorities, public and private land managers, and community members. Other groups in the North Coast assisting in coordinated weed control include North Coast Weeds (NCWAC no date) and Landcare at various councils in the North Coast region (North Coast Regional Landcare 2017). We recommend facilitating discussions with these groups to improve management of key EPG species.

We asked survey participants to identify the impact of control on the target EPG and the surrounding ground cover, with most control leading to lowered abundance of the target species and increased native ground cover. Active regeneration after control will often be needed to build resilience in the community post-invasion. For some of the EPG species, limited information and resources are available on what control methods and herbicide regimes are appropriate. The ability to understand the effectiveness of the outcome of control is sometimes lacking, indicating that a monitoring program to inform management in native communities is a high priority.

Research priorities for improved control are outlined for each species where necessary. We advise following the method set out in *Monitoring Manual for Invasive and Native Flora* (Watson et al. 2021) as an integral part of weed management. 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 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 the community and organisations can help with sharing the load associated with weed control, helping to implement a more efficient regional approach.

If unsure, contact your local weeds officer for information on recommended control regimes. Collaboration with organisations to share resources will improve understanding and education about best practice management options.

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.

Vasey grass invasion at a Themeda Grassland site. Photo: Julia Rayment/UOW

Rhodes grass grows above kangaroo grass at a Themeda Grassland site. Photo: Julia Rayment/UOW

Figure 7 Vasey grass and Rhodes grass invasions

Table 3 Management options for the main EPG species of concern in the North Coast 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.

	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.**
Broadleaf and 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
Vasey grass	Suitable for small infestations but labour intensive	Effective, particularly in IWM	Effective but no information for rates in NSW, seek and share advice	Information limited	N/A	If present on grazing land can be grazed, considerations required
Sporobolus spp.	Suitable for small infestations	Suitable for IWM, weed hygiene important	Susceptible to herbicide	Fire will reduce biomass	Biocontrol under research	Unpalatable; pasture competition recommended; weed hygiene important
South African pigeon grass	Suitable. Vegetative spread: complete removal necessary	Limited information but may promote spread	Achieves good control	Burning as part of IWM suitable, see resource guide	N/A	Trade-off species; avoid spread into new areas
Rhodes grass	Suitable for small infestations	Information needed, weed hygiene important	Susceptible but other species in genus are herbicide resistant	Can survive burns, information needed for IWM	N/A	Trade-off species; avoid spread into new areas; weed hygiene important

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

3.2 Common paspalum (*Paspalum dilatatum*) and broadleaf paspalum (*Paspalum mandicocanum*)

There is significantly less information about control of common paspalum, but it is suggested it will respond to control techniques similarly to broadleaf paspalum, therefore, they have been combined in this section. More research and information on successful techniques are a high priority. 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 is important. Mechanical removal has mixed reports with reductions in lateral spread achieved through close mowing (Henry et al. 2007) while defoliation has been shown to promote establishment of paspalum species (Cornaglia et al. 2005). Chemical control is suggested throughout Australia with chemical rates available for broadleaf paspalum (PIPWE 2019; DAF 2020). In response to fire on Themeda headlands, NCC (2017) says paspalum is severely reduced such that the addition of targeted control (e.g. herbicide or mechanical) will be more effective.

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.

For control of broadleaf paspalum, one user described integrated control methods of 'wick-wipe with glyphosate and hand weed ... at least twice in the first season [and] follow-up annually.'

3.3 Vasey grass (*Paspalum urvillei*)

Manual control may be suitable for small occurrences of vasey grass. For a larger grass the root system is likely to be tough and removal may be labour intensive. In native communities, particularly in Themeda Grassland, vasey grass is taller and occupies more space compared to native counterparts (e.g. *Themeda triandra*) which can lead to competitive advantage. Control techniques should focus on reducing biomass to promote native competition. Mowing can control vasey grass, particularly when used in conjunction with herbicide application (Jeffries et al. 2017) but may not be appropriate in native communities. Herbicide will control vasey grass infestations and will work best as part of IWM with considerations for reinvasion or secondary invasion. Information on grazing to control vasey grass is scarce and not provided in an Australian context. We suggest avoiding grazing, but where it is considered, please keep records and monitor for effectiveness to share knowledge with other landholders and managers. Do not graze if the grass is in seed.

In a Victorian impact assessment, vasey grass is reported as able to withstand fire (reference). If using fire, we suggest monitoring to improve knowledge as fire may be a less effective control technique for vasey grass. If using fire, we suggest monitoring to improve knowledge about controlling vasey grass. As part of IWM, fire may act to reduce biomass and allow herbicide to be more effective, but currently there is no evidence to confirm this.

Research priorities

Chemical control rates could not be found online for vasey grass. If using chemical control, speak to your local weeds officer for advice.

Control programs may benefit from understanding the potential role of fire in vasey grass management, particularly as fire is an important part of community health for many native communities in the North Coast, including Themeda Grasslands.

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

Due to the impact weedy *Sporobolus* grasses have been causing in northern NSW and Queensland, several resources are available for 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 may not be applicable to native communities.

Management of weedy *Sporobolus* grass infestations in native areas should focus on limiting seed set, preventing or removing seeds from the seed bank, and encouraging competitive ground cover to increase resilience to competition from weedy *Sporobolus* grasses. In native ecosystems in the North Coast region that may be frequented by humans, such as the headlands in Themeda Grassland, control should aim to limit human-mediated spread. This may involve preventing seed set of weedy *Sporobolus* grasses, setting up weed cleaning stations and educational signs and manipulating paths to limit spread of *Sporobolus*. Small infestations may be removed through manual control (Bray and Officer 2007).

While burning of weedy *Sporobolus* grasses 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).

Land managers surveyed used multiple control techniques, including herbicide spray, crown rot fungus and mechanical control. Two participants described the use of a selective herbicide (e.g. flupropanate) once a year per growing season with appropriate follow-up. One participant used a non-selective herbicide (e.g. glyphosate) via wick wiping.

Land managers controlling *Sporobolus* in the North Coast advocated the use of Nigrospora crown rot, a local native fungus that was considered as a biocontrol for Giant Parramatta Grass (GPG). Participants used this fungus in conjunction with herbicide and, on pastureland, mechanical control. Due to legally enforceable restrictions imposed by the APVMA, Nigrospora is no longer considered an effective biocontrol treatment. Research is still being conducted to identify new biocontrol agents for *Sporobolus*.

3.5 South African pigeon grass (*Setaria sphacelata*)

Originally introduced as a pasture plant, South African pigeon grass is adapted to heavy grazing (DPI no date b; Mushtaque et al. 2010), suggesting slashing or mowing is likely to promote growth. As its invasion into native communities is a result of spread outside agricultural areas, we suggest avoiding the use of this species in pasture. Information is scarce regarding manual removal, but for small infestations this may be feasible. Ensure the entire plant is dug out as some sources have suggested it can spread vegetatively. Information suggests IWM using fire and herbicide can lower invasion and improve native species richness. South African pigeon grass can increase fire risk, but fire has been used effectively as a management tool in the North Coast LLS region as part of IWM. In forested wetlands in northern NSW, South African pigeon grass infestations were managed using a combination of herbicide spray and Indigenous cultural burning. Although initial reinfestation

after burning was worse, subsequent herbicide application allowed natives to regenerate, and more-selective spot spraying provided better results than the unburned site (Firesticks 2014; NCC 2017). Native regeneration on the site was highly successful leading to similar trials at nearby Indigenous protected areas and properties.

3.6 Rhodes grass (*Chloris gayana*)

Rhodes grass is highly competitive and can spread through runners. Increasing native ground cover is important in its management, to reduce bare ground available for colonisation by Rhodes grass. 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. Rhodes grass is believed to be susceptible to herbicides; information regarding suggested chemicals is available for other states but not in New South Wales (DAF 2016). Rhodes grass can survive fire (Moore 2018).

Research priority

Most information is skewed towards *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.

3.7 Other trade-off EPGs

Kikuyu (*Cenchrus clandestinus)* and buffalo grass (*Stenotaphrum secundatum)* were present at a few sites in the North Coast. If undertaking control, care should be taken as they can spread through stolons or rhizomes. Complete removal and/or follow-up control will be necessary. Where possible we recommend planting native counterparts instead of exotic plants. If planted intentionally, monitoring is recommended to ensure these EPGs do not spread beyond their desired space. Planting with native species or less impactful pasture species is recommended.

3.8 Semi-aquatic grasses: Torpedo grass (*Panicum repens*) and Para grass (*Urochloa mutica*)

Two semi-aquatic EPGs were recorded by participants across 2 communities in the survey that were not recorded in the field survey. These grasses scored low in the risk assessment (Rayment and French 2021) however, their invasive capability may be higher in wetland communities specifically. Both grasses are not currently widespread throughout New South Wales with both using stoloniferous runners that can float on water, forming dense mats. Control of these species is not considered a priority across the region, however, at a local community scale, they may be more important (Langeland et al. 1998; Hannan-Jones and Csurhes 2012; University of Florida 2018).

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 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 8 Themeda Grassland on Seacliffs in the North Coast. Photo: Julia Rayment/UOW

5. Resources

General

North Coast Regional Strategic Weed Management Plan 2017–2022, Version 2 – North Coast LLS

Grasses – North Coast Weeds Advisory Committee (NCWAC)

North Coast Regional Landcare Network – NSW Landcare Gateway

Grasses fact sheets – Clarence Landcare

A Resource Kit for Rural Landholders in the Northern Rivers Region of NSW – Clarence Landcare

Regional Plans and Strategies – NCWAC

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 – Meat & Livestock Australia (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

6. More information

- Hygiene guidelines
- Monitoring Manual for Invasive and Native Flora

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