



Australian Government

**Department of Agriculture,
Water and the Environment**

**Threat abatement plan to reduce the impacts on northern
Australia's biodiversity by the five listed grasses**

Review 2012-2021

EXECUTIVE SUMMARY

This review assesses the progress and effectiveness of the 2012 *Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses* (TAP). This is the first review since the TAP's inception. The TAP's listed grasses are gamba grass (*Andropogon gayanus*), para grass (*Urochloa mutica*), olive hymenachne (*Hymenachne amplexicaulis*), mission grass (*Cenchrus polystachion* – formerly *Pennisetum polystachion*) and annual mission grass (*Cenchrus pedicellatum* – formerly *Pennisetum pedicellatum*), all of which pose a threat to the biosecurity of northern Australia. These grasses were introduced as fodder crops for livestock but have escaped beyond the paddock boundaries and become invasive. Thus far, they are more of a concern within northern Queensland and the Top End of the Northern Territory, than they are in northern Western Australia.

There is evidence to suggest that current control efforts are not adequate in controlling the spread of the listed grasses, nor abating the threat to northern Australia's biodiversity that they pose. The TAP's purpose is to be a high-level document that can help shape the way that these grasses can be controlled, however, despite many on the ground efforts, this is not occurring. General feedback that was received whilst researching current control efforts was that there aren't enough monetary and boots-on-the-ground resources available to conduct the intensive actions that are needed to control the grasses. There is also a call for biological control agents to be developed, and the CSIRO is putting forth a bid to develop a biocontrol agent for gamba grass.

When conducting research for this review, stakeholders from across federal and state government departments, NRMs, conservancy groups, scientists and the NFF were approached via email to contribute their knowledge to the review, with 27 stakeholders responding. Research was also conducted using publicly accessible documents online. While this review spoke to a comprehensive cross-section of environmental stakeholders, agricultural stakeholders weren't as forthcoming, thus this review lacks direct knowledge from this sector.

The majority of the case studies and reference sources for this review are from the Northern Territory and Queensland, as that is where the bulk of the infestations currently present in the Top End and Cape York.

Objective one focuses on developing an understanding of the extent and spread pathways of infestation by the five listed grasses. This objective has been half met, with an understanding of the spread pathways firmly established, however, genetic studies to further inform how the grasses spread need to be prioritised. Individual land managers have their own mapping systems, however the existing mapping systems supported by the department (Atlas of Living Australia – MERIT) are not fully representative of the existing grassy weed incursions and do not allow landholders to upload maps or information about the grasses on their land.

Objective two focuses on supporting and facilitating coordinated management strategies through the design of tools, systems and guidelines. There is still a lot of work that needs to be done in the research fields to find more efficient means of controlling these grasses, and nothing has been achieved towards encouraging complementary weed status for the five listed grasses in the TAP across all jurisdictions, with the exception of gamba grass and olive hymenachne, which were declared as WoNS before the publication of the TAP. The

timeframes aren't all that relevant to these objectives, given the ever-changing nature of key assets, available and cost-effective control methods, and management plans. Hygiene protocols for general weed control have been developed and are promoted to stakeholders, although due to their costly and time-consuming nature, the uptake of thorough hygiene measures is insufficient.

Objective three aims to identify and prioritise key assets and areas for strategic management. Management zones are outlined in plans for public landholdings and institutions e.g., universities to manage the relevant weeds. On private landholdings identifying management areas for monitoring and control is less formalised or published, but the same principle applies of identifying key assets and prioritising their protection and preventing the grasses' spread. Stakeholders who are involved in managing the listed five grasses have identified the key assets for priority protection on the ground that they are responsible for. Ongoing monitoring of these assets and the grasses that threaten them is an important part of their management plans, and resources are focused strategically to make the most out of the available time, money and manpower resources.

Objective four aims to build capacity and raise awareness among stakeholders. The review found that the TAP itself isn't promoted to affected communities, but many of its objectives are promoted through extension materials. Awareness of the issues that these grasses create, however, have not been adequately disseminated to tourists and the general public

Objective five is to implement coordinated, cost-effective on-ground management strategies in high-priority areas. We can see by examining the progress made on each action that this is occurring, however, efforts are hindered by lack of funding and resources, as well as by the lack of a complementary weed status for all five listed species across northern Australia. This objective also reiterated the point from action 2.6 that stakeholders' land rehabilitation programs for high-priority areas consist of active planting of native grasses to choke out invasive seedlings and planting native species to shade out seedlings, however, many stakeholders choose to not revegetate the cleared area, opting to let native grasses germinate from the soil seed bank, unless the site in question is a watercourse, then it is hoped that no grasses will grow back, as they choke up the waterway and degrade aquatic species' habitats.

Objective six focuses on monitoring, evaluating and reporting on the effectiveness of management programs. Monitoring and evaluation is evident in national park management plans but is also informally undertaken by private land holdings. It was found that publicly available management plans do link with threatened species recovery plans, however, it is a tenuous link. Reporting on management programs does occur and can take the form of reporting to the funding body and there are often internal reports conducted for the interests of the land managers.

It is concluded that the issues and the objectives raised in the 2012 TAP are still valid in 2021 and likely to remain so into the future, however, the TAP could be revised to reflect the present priorities and include the amendments suggested by the review. The recommended revisions include changing the timeframes for 'completed' actions to a fluid timeframe, to encourage land managers that have already established these practices to maintain and build upon their actions; add grader, aleman and thatch grasses to the TAP, focus on wider community-based control programs; add an action that develops communication strategies for tourists and the general public; undertake research into best practice control methods including biological controls; and develop economic models into the costings of

controlling/eradicating the grasses where possible and understand the costings of the impact of the listed grasses if current control efforts are not improved.

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PURPOSE OF THE REVIEW

Section 279 (2) of the *Environment Protection and Biodiversity Conservation Act 1999*, the Minister must review each threat abatement plan at intervals of no longer than five years and consider whether a variation of the plan is necessary. The threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses was made by the Minister in 2012.

Reviewing threat abatement plans, at least every five years, allows for an assessment of whether the threat has been abated or, if not, what progress has been made towards abating the threat. The review provides a snapshot of current efforts in grassy weed management in northern Australia and highlights successes and failures of the plan in guiding and facilitating action on the listed weeds and their impact. It takes into account threat abatement actions funded by the Australian Government as well as work by the state and territory governments, natural resources management groups and other local organisations.

Background

In 2009 the Australian Government listed 'Ecosystem degradation, habitat loss and species decline due to invasion of northern Australia by introduced gamba grass (*Andropogon gayanus*), para grass (*Urochloa mutica*), olive hymenachne (*Hymenachne amplexicaulis*), mission grass (*Pennisetum¹ polystachion*) and annual mission grass (*Pennisetum pedicellatum*)' as a key threatening process (KTP) under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). This initiated the development of the Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses (TAP) (DSEWPC, 2012a). A threat abatement plan is enforceable on federal land, but for it to work comprehensively across privately owned, state and local government land, the plan relies on stakeholders to engage with it and act on the outlined actions within the plan.

The five grasses were introduced into northern Australia as feed grasses for livestock. Gamba grass, para grass, mission and annual mission grasses were all introduced into Australia from Africa, whilst olive hymenachne was introduced from Central and South America (DSEWPC, 2012b).

Gamba grass was introduced by the Council for Scientific and Industrial Research (CSIR) Division of Land Research in 1931 but was not widely used as a pasture grass until 1983. Perennial mission grass was introduced into Australia in the 1930s, and it is not clear if this introduction was deliberate or an accident. It appears predominately in the Top End of the Northern Territory and in northern Queensland, with the first sighting of the weed reported in the Northern Territory in the 1970s. Annual mission grass was imported into northern Australia in the 1940s as a pasture grass and olive hymenachne is native to tropical and sub-tropical South and Central America and was introduced into Australia by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in the early 1970s but wasn't approved to be released as a poned pasture species until 1988 (Waltham et al. 2019) (DSEWPC, 2012b).

¹ Now *Cenchrus polystachion* and *Cenchrus pedicellatum*.

These invasive grasses are high-biomass species that increase fuel loads and/or alter nitrogen cycling and water availability within systems, resulting in ecosystem degradation, habitat loss and biodiversity decline. These grasses, and particularly gamba grass is responsible for hotter fires during the bushfire seasons in the areas that they grow. These grasses are taller and more dense than native grasses and are responsible for thrusting the flames of hot fires up into the tree canopy, effectively killing the trees, whereas a native grass fire tends to be cooler due to the lower biomass and those fires aren't as destructive as those fuelled by invasive grasses (Beaumont et al. 2018).

The Northern Territory has reported an increase in the cost of fighting bushfires fuelled by gamba grass. In areas where the grass is dense, including around Batchelor and Darwin, fire managers have had to adapt and introduce new and expensive fire management measures, which are more typical of temperate forest fire management. These measures include assigning more staff, upgrading firefighting vehicles to provide more protection from fire and using water bombing aircraft. This contrasts with the resources which were on standby in the area in 2007, where two staff members and a 4-wheel drive fitted with firefighting equipment were adequate for rapid response to bushfires fuelled by native grasses with less biomass. The cost per day to be on standby to fight the gamba grass fuelled bushfires during periods of severe weather warning has increased by up to 9 times higher in the Batchelor region (Beaumont et al. 2018).

Gamba grass and olive hymenachne are both Weeds of National Significance (WoNS) whilst para, mission and annual mission grasses are not. All five of the grasses are valued to varying degrees by the pastoral industry due to their high production and economic value and, when appropriately managed and contained for cattle feed purposes do not necessarily contribute to the decline of the environmental assets in northern Australia (DSEWPC, 2012a) (Linnegar, 2011). It is noted that para grass and olive hymenachne also provide habitat support for some terrestrial invertebrate species, dependent on the surrounding environment (Grice et al. 2013).

REVIEW OF THE OBJECTIVE OF THE THREAT ABATEMENT PLAN

This threat abatement plan provides a coordinated national approach to management, research and education to increase awareness and provide strategic options of grassy weed control. This TAP's goal is to minimise the adverse impacts of the five listed grasses on affected native species and ecological communities. To achieve this goal, the TAP has six main objectives that were developed in consultation with experts in relevant jurisdictions.

Objective 1 – Develop an understanding of the extent and spread pathways of infestation by the five listed grasses

The goal of this objective is to gain information in the short term about where the grasses are and where and how they are likely to spread, which will help to inform the planning of control and surveillance activities.

The following actions come under the first objective:

Actions

- 1.1 Undertake mapping of the five listed grasses at a scale that allows for appropriate planning and an adaptive management approach*
- 1.2 Develop a better understanding of spread pathways*

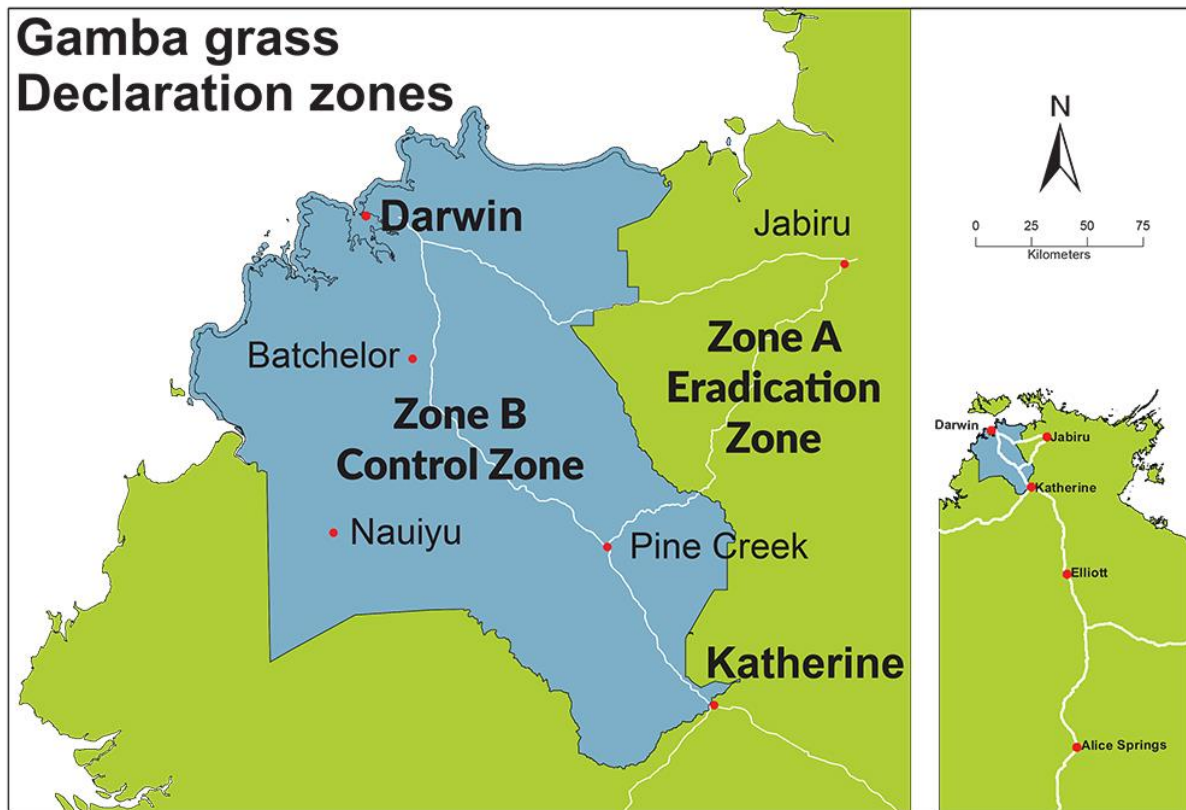
Action 1.1 Outcome/output

- Nationally agreed mapping guidelines used by all affected jurisdictions
- Website identified or developed and used to upload maps

Both actions within Objective one is classified as high priority with a 1-3-year timeframe to be completed. At the time of publication of the TAP, some mapping had been completed but not at a scale that allowed for the development of management plans at 'property level.' The rationale behind action 1.1 is that regularly updated and detailed maps would allow identification of spread pathways and tracking of un-infested areas that are at risk of invasion, as well as to provide a means of monitoring new incursions and determining the effectiveness of the management program.

Under the Northern Territory's Weed Management Plan for Gamba Grass (declared under the *Weeds Management Act 2001*), the Northern Territory is divided into three zones to differentiate where gamba grass is to be controlled and where it should be eradicated. Zone B – Control Zone contains Darwin, Batchelor, Litchfield National Park, Nauiyu and Pine Creek. Zone B contains most of the territory's gamba grass, which is deemed to not be eradicable, whereas Zone A covers the rest of the Northern Territory. Within Zone A, there are minimal gamba grass infestations, and thus it is deemed eradicable. Zone C covers both Zone A and B

and determines that no new gamba grass plants are to be introduced into the Northern Territory (Weed Management Branch and Snappy Gum Consulting 2020).



(NT Gov 2018)

Landholders within these zones must comply with the legislative requirements of these zones in relation to gamba grass control (Weed Management Branch and Snappy Gum Consulting 2020). To identify where landholders are situated within these zones, the online resource Natural Resource (NR) Maps may be used, which demonstrates the general areas where gamba grass is present within the territory (Department of Environment, Parks and Water Security 2021).

There is mixed success with mapping of the five listed grasses. The Weeds Australia website redirects to the Atlas of Living Australia online portal which contains profiles on each of the grasses and a map of the general distribution of each of them (Weeds Australia 2020a, b; Weeds Australia 2021a, b, c). It is important to note that these maps indicate the general area that the infestation occurs and does not contain coordinates of the specific area of infestation. The Atlas of Living Australia also has an ‘Occurrence Records’ function where the occurrence of the listed grasses can be inputted (Atlas of Living Australia 2021a).

The MERIT system as developed and hosted by the Atlas of Living Australia (ALA) does have a map for each grass, but it maps out where Australian government funded projects have taken place that have reported that they have implemented control measures against these listed grasses. It is not a comprehensive map of the current infestations (Atlas of Living Australia 2021b). These projects have received grant funds from the Department of

Agriculture, Water and the Environment, and as a part of their reporting requirements, they identify where the projects took place; and departmental employees update the ALA map accordingly.

There is no current website that has been identified or developed that every stakeholder uses to upload maps of grassy weed infestations and the known distribution maps that Weeds Australia redirects to are not up to date. Further, there is no current nationally agreed mapping guidelines that must be used by all affected jurisdictions.

Through the research component of this review, it has been found that individual landholders, councils and organisations do conduct mapping of the listed species, however, it is a very individual approach. Mapping on a property level is undertaken at the discretion of the landholder for their own management purposes, and, on a broader level, it may be undertaken as part of a grant funded weed control project, or it may be mapped when researchers are embarking on their own research in-field that may not be dedicated to the listed grasses (Weed Management Branch, Northern Territory Government 2021, pers. comm., 8 January). Western Australian residents have access to MyPestGuide™ where community members can report a sighting of a pest, or absence of one, including weeds (PIRD 2020a).

Here are case study examples of how different stakeholders are mapping the listed grasses on their landholdings.



Case Study 1.2

On the ground weed mapping

The Department of Agriculture, Water and the Environment leases land around the Ranger mine site, which is separate to, but surrounded by Kakadu National Park. Within this land, the department's Supervising Scientist's branch conduct extensive environmental monitoring programs to ensure that uranium mining activities from Ranger mine haven't impacted the surrounding national park. Weed mapping by the department was undertaken in conjunction with the 2016 annual weed spraying and measured weed composition and density at 145 sample locations across the lease.

General ground observations near the former Nabarlek mine site in 2018-19 indicated a reduction in the density para grass and the apparent elimination of mission grass from the former evaporation pond region. Further weed mapping was undertaken in January 2019, which is currently being assessed to evaluate the effectiveness of the ongoing weed management program.

During 2019-20 DevEx Resources (mine site owner company) intended to evaluate the use of residual herbicides to selectively target the prevalent incursion of mission grass in the open areas on-site. Due to the COVID-19 outbreak, these trials have been delayed until 2020-21.

In May 2019 and July 2020, the Supervising Scientists branch inspected the facility with representatives from Parks Australia. A build-up of grass-related fuel load around the perimeter of the facility which posed a risk to the revegetation efforts was noted during this inspection. An expanded weed spraying program and continuation of a program of late wet season/early dry season low intensity burns to reduce mission grass fuel load and to protect monitoring equipment was recommended from this inspection (DAWE 2020).

Bush Heritage (pers. comm., 28 January 2021) confirmed that the organisation's protocol for mapping new weed infestations was universal for all weeds of relevance to the individual property, and not just for any of the listed five grasses. Monitoring is ground based using all-terrain vehicles or spray backpacks. When a new infestation is found, it is sprayed, and its' location is logged on GPS.

Parks Australia are going to commence collecting data around Kakadu National Park on iPads on a range of aspects, including weeds. Parks Australia hope that the iPads can be used by other non-departmental stakeholders of the park, such as Indigenous ranger groups and researchers to help facilitate a coordinated approach to data collation in Kakadu National Park, which could help influence management programs.

Case Study 1.3 Using drones for mapping

In Kakadu National Park, Bininj/Mungguy Traditional Owners, Parks Australia, National Environmental Science Program, Charles Darwin University and the University of Western Australia are working with CSIRO to use drones to monitor and control para grass, which is impacting the magpie geese habitat within the park. These drones are powered by Microsoft AI for Earth and are being used to monitor the park's wetlands and to identify the areas of infestation, so that they can be targeted in weed control programs. Traditional Owners identify aspects that indicate the health of Kakadu, and this knowledge is used in conjunction with the science and data generated by the drones to monitor and evaluate if and how natural resource management objectives within the park are being met. This is an ongoing project (NESP n.d.[a]).

Drones are also being used by the department's Supervising Scientists branch, who discussed on 2 February 2021 (Department of Agriculture, Water and the Environment) that drone imagery was taken of mission grass at the Narbarleck mine site within Ranger mine, as well as being used to collect data and monitor water quality, feral animal numbers and the impact of fire in the Alligator Rivers area. The advantage of using drones to detect the listed grasses is that they can be used to create spectral images on both clear and overcast days, whereas satellite imagery can only be used on cloud-free days so that the resulting images aren't compromised. Using drones for identification of weed infestations is also less labour intensive and more cost effective than on-the-ground weed mapping. Drones also enable surveillance of areas that are difficult to get to on the ground or using light aircraft. Currently, drones are being used to identify the location of the weeds, but it is hoped that the next wave of drone technology used in the area will be able to deliver herbicide to the listed species on detection (Bardon 2015).

Action 1.2 Outcome/output

- Spread pathways identified and preliminary information made available as soon as possible
- Information publicised within four years of the publication of this TAP

We have a good understanding of how these invasive grasses spread, a sentiment echoed by a representative from the University of Western Australia (pers. comm., 18 December 2020) about her research with gamba grass. The TAP outlined that identifying the spread pathways and making the preliminary information publicly available was to be completed within four years of its publication. Each listed grass has a profile on the Weeds Australia website, summarising how each weed spreads (Weeds Australia 2020a, b; Weeds Australia 2021a, b, c). The information for these weed species' profiles was provided by the Council of Heads of Australasian Herbaria (CHAH) to the Department of Sustainability, Environment, Water, Population and Communities in August 2017 and was updated in December 2011 for gamba grass (*Andropogon gayanus* Knuth), olive hymenachne (*Hymenachne amplexicaulis*), mission grass (*Cenchrus polystachion*) and annual mission grass (*Cenchrus pedicellatum*) and in December 2013 for para grass (*Urochloa mutica*) (Weeds Australia 2020a,b; Weeds Australia 2021a, b, c).

Outside of the Weeds Australia profiles for the grasses, the Queensland, Western Australian and Northern Territory websites each have webpages giving a description of the grasses and mention possibly spread pathways.

Olive hymenachne reproduces by seed and vegetatively broken stem fragments. Seed is transported downstream during annual flooding and can also be spread in mud that is attached to animals, the tread of boots and vehicles. For a stem fragment to sprout, a small piece of mature grass is required with a minimum of two nodes placed in shallow water or planted in mud (AABR 2003). When speaking with stakeholders, it was found that there is anecdotal evidence that Magpie Geese (*Anseranas semipalmata*) spreading the seed either in their droppings or transport it in their feathers, however there is no scientific evidence to support this claim and some stakeholders questioned the validity of the argument. Seeds can also be transported in contaminated agricultural products, including hay (Weeds Australia 2021b). Para grass spreads in a similar way to olive hymenachne, by reproducing via seed, but also via broken stem pieces that can root again and produce a new plant. These stem pieces can be moved downstream by water during floods (Business Queensland 2020; Weeds Australia 2020a). The Weeds Australia (2020a) profile for para grass also reports that the stem pieces can occasionally be moved by birds.

Both annual and perennial mission grass seeds are light and fluffy, which can attach and be transported by animals, humans, vehicles and machinery, water and wind. Seeds can also be transported by contaminated grains and hay (Weeds Australia 2021a). Weeds Australia 2020b). Annual mission grass doesn't tend to be as prolific in its spread as the other listed grasses. The botanists in the department's North Australian Quarantine Strategy branch have confirmed (North Australian Quarantine Strategy branch 2020, pers. comm., 14 December) that annual mission grass tends to die out when it is growing in undisturbed sites and doesn't tend to compete against the established native grasses as well as the other weeds.

Gamba grass reproduces from seeds, with a single plant capable of producing 240,000 seeds per year with seed viability of about 65%. Seeds do lose their viability over time, with seeds a few years old being unlikely to germinate, meaning that the soil bank is not long-lived. Gamba grass seeds spread via wind and water and attach to machinery and vehicles, animals, and humans through mud (Weeds Australia 2021c).

All of these grasses have been found to spread rapidly throughout disturbed ground, including in areas disturbed by fire, roadside slashing, cultivation, gravel pits and mine sites. (Weeds Australia 2021c; Luck et al. 2019). Olive hymenachne can spread through wetland areas that are disturbed by livestock, and in disturbed cane-land stream channels (Wearne et al. 2010; Parks and Wildlife Commission of the Northern Territory 2017).

Pastoral leases that maintain populations of these grasses for cattle feed can also be sources of infestation, if not properly managed. In the Northern Territory, freehold and crown lands show the greatest increase in known gamba grass records from 2010-2018. This is partly due to increased survey efforts, but it also parallels a rapid increase in the density and size of the infestations. Nearly 95% of gamba grass records in the NT occur on 11 properties, and all but one is in Control Zone B. These properties show increase in gamba since 2011, however, due to increased notification or pre-existing gamba infestations and a lack of repeat surveys this increase cannot be reliably calculated. Transport corridors, specifically roads, have been found to be a primary pathway for gamba grass spread, with records in the Northern Territory

showing that infestations have doubled since 2015 in both Zone A and Zone B (Beaumont and Seabrook 2020).

Infestations of the listed grasses in Western Australia are minimal, with notable discrete gamba grass and olive hymenachne incursions in the East Kimberley region, that are under active eradication programs. Mission grass is widespread around Kununurra however the Western Australian Department of Biodiversity, Conservation and Attractions aren't actively involved in controlling it, nor are they involved in any para grass control programs (Western Australia Department of Biodiversity, Conservation and Attractions 2021, pers. comm., 15 February).

Genetic study

When interviewed on 11 February 2021 CSIRO spoke about a project in Queensland that is researching the morphology of gamba grass to understand why the weed grows prolifically in the northern areas of Cape York, yet its spread is limited in the southern areas of the Cape. There is currently not a lot of information on the genetic variability of gamba grass. The CSIRO hopes that the outcomes of this research will provide data that will inform management plans of the grass and potentially identify a genetic weak link that could be exploited for management purposes. Cape York NRM (2021 pers. com., 10 February) has the same observation on the morphology of gamba grass, observing that it is less problematic on the southern cape and is much easier to control, and that it grows taller and with a denser number of stems further North in the Cape than it does in the southern regions of Queensland's tropics.

Summary

- Nationally agreed mapping guidelines used by all affected jurisdictions have failed to be formulated.
- Individual stakeholders have their own mapping systems.
- The Northern Territory has been divided into zones where gamba grass has been deemed to require either controlling or eradicating.
- Atlas of Living Australia and the MERIT system have mapping capabilities, but they are limited by only showing general areas of infestations and where government funded control programs have taken place.
- Spread pathways for all five listed grasses have been identified and information has been made publicly available on the Weeds Australia website, as well as individual state and territory government websites.

Conclusions and recommendations

In conclusion, Objective one has been half met, with an understanding of the spread pathways firmly established, however, genetic studies to further inform how the grasses spread needs to be prioritised. The existing mapping systems supported by the department are not fully representative of the existing grassy weed incursions, and do not allow landholders to upload maps of the grasses on their properties. It is recommend that a system like <http://www.feralscan.org.au> (Centre for Invasive Species 2021) or Western Australia's

MyPestGuide™ could be a tool to be used by stakeholders nationwide to identify and upload the GPS coordinates of grass incursions in real time, thus providing a more accurate picture of where these grasses occur.

Objective 2 – Support and facilitate coordinated management strategies through the design of tools, systems and guidelines.

A number of tools, guidelines and protocols are required for the successful coordinated management of the five listed grasses. Some of these already exist for some of the grasses and for some of the situation in which they occur, and land management groups are continually refining the techniques available. Noting that the grasses vary in their habitat, biology and economic function, the rationale behind these actions is to identify gaps and to use and adapt existing tools, guidelines and management strategies to cover the five listed grasses. Ensuring that land management plans include consideration of these grasses is an important step in reducing the impacts they can have.

The following actions come under the second objective.

Actions

2.1 Encourage complementary weed status for the five listed grasses across all jurisdictions to which the TAP applies

2.2 Develop best-practice guidelines for use and/or management of the five listed grasses in agricultural and conservation contexts, and encourage their implementation

2.3 Develop hygiene protocols, focusing on high-priority spread pathways

2.4 Further develop prioritisation tools to identify high-priority areas for monitoring and management actions

2.5 Include strategic management of the five listed grasses in management plans for all affected land tenures, giving priority to identified key assets

2.6 Improve and promote understanding of invasive grass control and land rehabilitation methods to maximise native vegetation restoration and minimise site damage

2.7 Facilitate collaborate applied research that can be used to inform or support improved management of the five listed grasses

Action 21. Outcome/output

- Jurisdictions working towards amending legislation to achieve complementary weed status.

Gamba grass and olive hymenachne have both been declared Weeds of National Significance (WoNS) and thus have complementary weed status across Western Australia, Northern Territory and Queensland, although gamba grass can still be planted as a pasture grass under

permit in Queensland (Australian Government/Weeds Australia n.d. [a]; Australian Government n.d. [b]).

Neither para grass nor annual mission grass are declared weeds in any jurisdiction in Australia (Weeds Australia 2020a; Weeds Australia 2021a). Perennial mission grass is declared a weed in Western Australia and the Northern Territory, but not in Queensland, despite the invasive grass occurring along the state's coastline (Weeds Australia 2020b).

The profile of gamba grass and olive hymenachne as weeds is higher than the mission grasses and para grass, with Weed Management Branch, Northern Territory Government (pers. comm., 8 January 2021) attributing this to their WoNS status. Mr Elliot believes that granting the mission grasses and para grass the status of 'Weed of National Significance' would benefit in heightening the status of these grasses and possibly encourage stakeholders to engage in more concerted control efforts.

Upon discussion with representatives from the Australian Wildlife Conservancy (AWC) (pers. comm., 4 February 2021), South Endeavour Trust (pers. comm., 5 February 2021) and Cape York NRM (pers. comm., 10 February 2021), there is consensus that weed management would benefit, if all five weeds had complementary status across the jurisdictions. There are, however, no efforts being made amongst the states and territory governments towards this, as these grasses are still considered valuable feed resources for the pastoral industry.

Action 2.2 Outcome/output

- Existing guidelines promoted and further guidelines developed where required, for management and control in agricultural/conservation contexts.

The five listed grasses in the TAP were introduced to Australia as feed grasses and are still used by graziers as a fodder crop for cattle.

When researching for this review, efforts were concentrated on environmental outcomes as that was the bulk of information that was available concerning the listed grasses. We approached the National Farmers Federation (NFF) to ask about how these grasses are still being used as fodder crops but did not receive a response.

When speaking with stakeholders, there was a lot of anecdotal evidence that graziers are still using all five grasses as feed crops, with gamba grass and olive hymenachne being highlighted as valuable pasture grasses. South Endeavour Trust (pers. comm., 5 February 2021) explained how one of their reserves has an olive hymenachne infested wetland. This wetland used to be grazed every year before the South Endeavour Trust purchased the property and didn't appear to have any olive hymenachne. Since the cattle have been taken off country, the grass has appeared throughout the wetland and has now intermixed with the native hymenachne variety. Herbicide has been used to try and control the infestation and prevent it from spreading downstream and to improve wet season access, however the control methods aren't keeping up with the grass' spread. The South Endeavour Trust is now thinking about putting cattle back into the wetland to control the weed. Greening Australia ([Greening Australia] 2021, pers. comm., 2 February) explained that there is no substitute for olive hymenachne for livestock feed in areas with deeper water, i.e., wetlands, and when asked if she believed that there is an alternative to para grass being used as a fodder pasture,

she suggested kangaroo grass or native hymenachne might be, but native grasses are limited in where they grow.

Treating these grasses at the optimal time, that being spring/summer is difficult, as the wet season means access to the infestations is restricted as many areas are inaccessible due to excessive rainfall and crocodile presence, thus land managers rely on the dry season and early wet season to implement control methods. This limits the effectiveness of herbicides and manual controls. A slow-release herbicide that can be distributed during the dry season and which activates during rainfall would be beneficial to combat the impediment of the wet season, however a suitable, slow-release herbicide is not yet available.

In June 2012, the Queensland Department of Agriculture, Fisheries and Forestry produced the Para grass risk assessment document outlining the risks of para grass, and also included a brief paragraph on its uses, advising that it is still used for grazing and cut fodder and can be useful for erosion control on waterways where rainfall and soil allows vigorous growth, however, the document does not provide guidelines on how to manage the grass if used for these purposes (DAF 2012).

Control guidelines for these grasses have been developed by different levels of government to help manage the listed species, and to encourage the public to act. The disseminated control guidelines from local, regional, state and federal jurisdictions overwhelmingly concentrate on how to manage these grasses from an environmental perspective. These jurisdictions recognise that these grasses are still used as a pasture resource, however, this use of the weeds is not encouraged, and control methods including herbicide and physical removal of the plants are advised over the use of cattle to keep the plants short and palatable.

The Cassowary Coast Regional Council's Local Area Biosecurity Plan 2019-2023 (Cassowary Coast Regional Council 2019) outlines general biosecurity obligations for graziers to ensure that invasive pasture grasses are contained to production areas and are managed so as to reduce any impact on neighbouring properties. The Plan stipulates that primary producers are required to control fodder crops outside of the production area as required, which involves keeping waterways clean and implementing codes of practice. Whether all primary producers adhere to this directive from their local council is unknown.

Evidence of how the agricultural industry uses annual mission grass and perennial mission grass is lacking, however, using the NFF's 2011 submission contribution to the formation of the TAP, they have outlined that neither mission grass has any pasture or production value, which may be why there is lacking evidence on how stakeholders manage these grasses appropriately in an agricultural/conservation context. This document also reports that para grass is useful in managing the spread of mimosa (*Mimosa pigra*) and prevents mimosa seedlings from emerging (NFF 2011), but this use of the grass has not been found to be an endorsed guideline by either the Queensland, Western Australian or Northern Territory governments.

Case study 2.1 Gamba and a peri-urban setting

South Endeavour Trust ([South Endeavour Trust] 2021, pers. comm., 5 February) highlighted that cattle graziers in North Queensland are reluctant to control the gamba on their properties because it is a valued pasture crop for their cattle. The grass then spreads from the properties, onto the roadside and into surrounding bushland. South Endeavour Trust believes that the hobby farmers and peri-urban residents near Cooktown don't understand how bad gamba grass can be and can be reluctant to control what they see as a useful grass. He also believes that the more serious broad acre graziers in the area don't want gamba at all and take more stringent measures to control the invasive grass than their peri-urban neighbours. There is also the suggestion that the fires from 2020 may have been worsened in the peri-urban area of Cooktown due to the gamba grass presence, but this has not been confirmed.

Case study 2.2 Gamba grass research: using cattle as a method of control

Anecdotally it would seem that some graziers are taking advantage of the gamba infestations on their properties for cattle pasture, with Farm Weekly reporting that gamba is still valued among some northern livestock producers as it is said to be able to carry 40 times more cattle than native grasses (McLennan 2021). When gamba is grazed using a traditional method of set stocking it has been reported to grow rapidly and become too tall and unpalatable for cattle. Tim Schatz (2019) has reported that there is anecdotal evidence that intensive rotational grazing produces better livestock productivity and may be able to control the growth of the gamba grass, as well as reduce seed production, spread, and fire hazard. A trial at Douglas Daly Research Farm (DDRF) began in 2018 to test this theory and aimed to investigate how to use rotational grazing to control gamba grass and achieve good cattle production outcomes. The trial aimed to maintain the gamba grass at a short level so that it would remain palatable and nutritious to cattle and reduce the production of seed and spread. Results from the first wet season in 2018/19 showed that rotational grazing successfully kept the gamba grass short and palatable, and seeding was reduced. The growth of the cattle improved on the previous year's rate of growth. It is yet to be seen how the results of this research will inform gamba grass management guidelines.

Action 2.3 Outcome/output

- Hygiene protocols developed and provided to land managers, contractors and affected communities for implementation.

This action is a high priority with a timeframe between 2-4 years and concentrates on community access to information about best-practice hygiene and spread-prevention techniques. For this action, the review will identify the hygiene protocols that have been developed and provided to land managers, contractors and affected communities for implementation.

This review has found that the Queensland and Northern Territory governments have easily accessible information online for land managers, contractors and affected persons to easily access, whilst Western Australia's online resources regarding weed hygiene are limited. Individual NRMs have weed hygiene protocols that they enact and share knowledge of with the communities that they serve. This review has found that weed hygiene advice offered by all stakeholders is general in nature for all weeds and is not specific to the five listed grasses in the TAP.

Examples of available hygiene protocols that have been developed and disseminated by various organisations are demonstrated in the following case studies.

Case study 2.3 Government's dissemination of hygiene protocols

Queensland

The Queensland government has advice for farmers on its Business Queensland website on how to prevent the spread of weeds in general by implementing hygiene protocols, including 'Develop weed plans, protocols and procedures; Buy weed-free plant material' Keep vehicles and equipment clean; Manage your farm and livestock; and Dispose of weeds safely' (Business Queensland 2019). Under each of these categories, are strategies and procedures that can be implemented. This information is readily available on the internet for any stakeholder that is looking to access information on preventing weed spread. It is important to note that these guidelines are for farmers throughout Queensland and does not concentrate on the northern part of Queensland, unlike the focus of the weeds in the TAP.

Northern Territory

The Northern Territory also provides information on preventing general weed spread in the document 'Preventing weed spread is everybody's business' (DEPWS 2019) which was produced by the Department of Environment, Parks and Water Security and is available online. This document provides advice similar to that provided by the Queensland government except that it is targeted at all aspects of the general public, not just agriculture. It advises, in addition to the Queensland advice, that affected persons can 'use NR Maps to determine relevant declared weeds', 'map locations and densities of declared weeds through dedicated survey and send to Weed Management Branch', 'do not import or export contaminated materials including sand, gravel, rock and fill,' and 'work in collaboration with relevant government agencies and land holders, particularly those who have adjoining, overlapping or adjacent corridors.' This document provides general advice to be implemented by members of affected communities. It also highlights the need to adhere to relevant Statutory Weed Management Plans, of which there is one for gamba grass. The Weed Management Plan for Gamba Grass (*Andropogon gayanus*) focuses on the need for landowners and occupiers with gamba grass on their land to design and implement a weed spread prevention program that includes hygiene procedures and/or quarantine measures to prevent further spread in accordance with the 'Preventing weed spread is everybody's business' document (DENR 2018).

Western Australia

The listed grasses in the TAP aren't as prevalent in Western Australia as they are in the Northern Territory and Queensland. Online literature from the Western Australian government that discusses weeds, concentrates on public awareness of weeds and doesn't stipulate weed hygiene protocols (Western Australia State Weed Plan Steering Group 2001). The WA Department of Primary Industries and Regional Development does have the 'Pest and Disease Information Service (PaDIS) that can be contacted when seeking control advice for weeds of agricultural concern. They can then refer you to agricultural retailers, book and internet resources, industry bodies and agronomists for tailored control advice (PIRD 2020b).

Case Study 2.4 NRM hygiene protocols

Terrain NRM

The Terrain NRM in North Queensland has undertaken a project to develop a Regional Pest Management Plan that identifies environmental weeds that have the potential to invade and destroy ecosystems. While this project isn't concentrating on the five listed grasses in the TAP, it did produce a mobile clean down fully self-contained facility that can be taken anywhere by a regular vehicle. The sugar industry has used the facility during harvest in the area from Hinchinbrook shire to Daintree Shire and the Tablelands shires of Atherton and Malanda. While this unit is concentrating on cleaning machinery and vehicles of parthenium weed (*Parthenium hysterophorus*), giant rats tail grass (*Sporobolus pyramidalis*), Siam weed (*Chromolaena odorata*) and harungana (*Hypericaceae madagascariensis*), the listed grasses are also present in the Terrain NRM area, and by using this unit, one could inadvertently potentially be cleaning off and preventing the spread of the listed grasses (Terrain NRM n.d.). Action is taken in sugar farming regions as the listed weeds, particularly olive hymenachne and para grass have been known to block sugar cane drainage canals, impacting the productivity of the irrigation systems.

Wet Tropics NRM

Wet Tropics NRM, also in Queensland, has information available on its website about how the general public can help stop the advancement of all invasive species and lists suggestions of how anyone can prevent the spread of weeds. These suggestions come under three overarching protocols – 'Arrive clean, leave clean; Identify and learn about invasive pests' and Look after your property' (Wet Tropics NRM 2016).

Cape York NRM

Cape York NRM spreads community understanding of best-practice hygiene and spread-prevention techniques in a more targeted communication strategy than other NRMs that we've spoken to. Cape York NRM ([Cape York Natural Resource Management] 2021, pers. comm., 10 February) explained that the NRM supports individuals who undertake the ACDC (Weed Spraying) Licencing Course, where there is an element of weed hygiene training involved. Cape York NRM also reported that this course has proven to improve individual's job readiness.

When discussing weed hygiene with stakeholders, the most common protocol discussed is that vehicles are washed down after weed control measures are performed. The South Endeavour Trust have washdown facilities on each of the three tracks out of their reserve, and Kakadu National Park has reported that vehicle washdowns do occur in the Bowari Centre where the Ranger operations are located as they have their own washdown facility. It has been identified however, that there is a need for designated, strategically located washdown facilities to be installed in Kakadu National Park so that a more comprehensive hygiene station is available to people who travel in and out of the park for recreation, cattle trucks, military vehicles, and boats who do not currently adhere to weed hygiene practices ([DAWE] 2021, pers. comm., 21 January).

Another weed hygiene method that is in use is to forcibly blow the weed seeds from vehicles, as described by a DAWE representative in the East Alligator River region of the Northern Territory who has undertaken an eradication project of mission grass on the Sandstone River walk. To ensure the mission grass weeds weren't spread by those that were working on the

eradication project, electric blowers were used to remove all the seeds from the quad bikes and each worker cleaned the treads of their shoes ([Department of Agriculture, Water and the Environment] 2021, pers. comm., 09 February).

The Australian Wildlife Conservancy ([Australian Wildlife Conservancy] 2021, pers. comm., 4 February), have explained that there are hygiene protocols on their properties for weeds, but Australian Wildlife Conservancy wants to write these protocols into a management plan so that all property managers and staff are required to enforce them.

Hygiene protocols have been developed and are provided to land managers, contractors and affected communities for implementation, but it seems that this is either done on a need's basis by the interested stakeholders or is made available in an online format focusing on general weed hygiene, rather than specifically targeting the listed grasses in the TAP. Queensland currently has a program that actively educates people on their weed hygiene responsibilities ([Biosecurity Queensland] 2021, pers. comm., 18 February). While the information is publicly available, that doesn't mean that everyone adheres to it or is aware of their responsibilities. Tourists and the general public don't often know that the grass they are looking at and the seed that is under their vehicle is an invasive species, and they simply don't know to wash their vehicle down after driving in areas with weed incursion. Weed hygiene practices in industry are often not compliant due to the high financial and time cost associated with thoroughly washing down vehicles and machinery, e.g., a bulldozer can take a day or two to effectively clean ([Biosecurity Queensland] 2021, pers. comm., 18 February 2021).

Action 2.4 Outcome/output

- Appropriate prioritisation tools made available for use by land managers and others making decisions on the management of natural resources

Each land manager that has one or more of the listed grasses present on their property will have different objectives of which natural element within the boundary needs to be prioritised for weed control. Land managers make decisions on how they will embark on control methods depending on the size of the incursion, what control methods are available to them, ability to access the incursion during the right time to treat (access can be limited due to the wet season) and availability of time and monetary resources. Action 2.4 is deemed a high priority with a timeframe of 1-2 years. The TAP stipulates that tools and systems that allow evidence-based identification of high-risk and high-priority areas are necessary to maximise the efficient use of resources. These will help in identifying sites in which management will deliver the greatest benefits to biodiversity (DSEWPC 2012a).

Through this research process, the main inhibitor of further grassy weed control is lack of resources. Land managers are time poor and only have access to limited resources. The most effective and efficient tools have been traditionally available are herbicides [namely glyphosate in spray form and flupropanate in granular form (with limited success)] and fire. The use of fire is problematic though as it can cause further disruption to the ground and disperse the grass seed, thus causing further incursion ([South Endeavour Trust] 2021, pers. comm., 5 February). Research is being conducted to identify tools that can maximise the efficiency of weed control efforts, including the use of drones as described in Case Study 1.3,

which can be used to efficiently map, and -possibly one day- spray weeds, without tying up resources in labour intensive aerial and ground mapping efforts. These drones will be able to better map and identify high-priority areas for monitoring and management (NESP n.d.[a]).

This action also addresses identifying sites in which management will create the greatest benefits to biodiversity. All the listed grasses in the TAP enjoy varying degrees of a wet environment, which leads them to impact heavily on wetlands and savannas across northern Australia. Wetlands are a critical part of the Australian environment as they provide habitats for animals and plants and contain a wide diversity of life, as well as protect our shores from wave action, improve water quality, absorb pollutants, and reduce the impacts of floods (DAWE n.d.). The following case studies demonstrate how the land managers have prioritised tools that are available to them to implement weed control the key wetlands and savannas on their landholdings, which are highly valuable to the local biodiversity.

Case Study 2.5 Mary River National Park

The managers of Mary River National Park identify the practical weed control methods to be used by consulting the standards developed by Northern Territory Government experts to ensure that the park complies with the Weeds Management Act, including all associated statutory management plans. The concerns of Traditional Owners are also taken into consideration. The park has prioritised the management of olive hymenachne, mimosa, gamba grass and mission grass in priority order, as is advised by the Weed Management Branch of the Department of Land Resource Management, or other relevant government agency. All new weed incursions are assessed against legislative and statutory requirements, regional and park priorities before either new action is taken or altering existing priorities. Ensuring equipment is kept clean to avoid weed spread and mapping weed locations are tools that are prioritised by the park to ensure that they can monitor weed distribution and the effectiveness of control measures.

The park's floodplains are prioritised as areas of weed control as the presence of olive hymenachne and mimosa can exclude native flora and reduce wetland habitat diversity. Within the savanna woodland area of the park, gamba grass and mission grass control are prioritised due to their role in worsening the fuel intensity in late dry season bushfires which cause changes to vegetation structures by killing mature trees and removing groundcover. This in turn means these fire affected areas are susceptible to further disturbance from erosion and weed invasion. The park prioritises strategic collaboration with the partners of the park and its neighbours to overcome the difficulty of multiple unconnected land portions within the park that make access to weed infested areas difficult.

The park has identified less frequent, patchy cool burns during the late wet season and early dry season reduces the fuel load, and constructing fire breaks, as the best means to reduce the likelihood of large, intense fires fuelled by gamba and mission grasses (Northern Territory Government 2015). The prevention of bushfires requires collaboration with neighbouring landholders, informal and formal agreements, on-groundwork and regional planning developed between neighbouring pastoral, reserved and Aboriginal lands. To ensure that these measures are long-term, these relationships must be maintained. The focus for fire management goals is to focus on incorporating traditional burning practices, protecting sacred sites, avoiding catastrophic bushfires, increasing community education and collaboration with land managers (Northern Territory Government 2015).

These measures have been successful in Mary River National Park reducing the infestations of invasive grasses within the park.

Case Study 2.6 Kakadu floodplain

Para grass is prevalent within Kakadu National Park and the Australian native rice (*Oryza* spp.) has been identified as a high-risk natural resource and the locations that it occurs are high-priority areas. The park applies a multi-scale approach to examine the spatial dynamics and impact of para grass. First, they measured the overall displacement of different native vegetation communities across the floodplain from 1986-2006, and then used high spatial resolution satellite imagery with historical aerial-photo mapping to measure the inter-annual changes between successive dry seasons from 1990-2010. Para grass absence maps were also produced with an object-based machine-learning approach. And changes over time were tracked by relating maps of depth-habitat and inter-annual fire histories. It was found that para grass invasion and establishment patterns varied greatly and that the wild rice communities were the most frequently invaded. Para grass continues to expand its distribution and there is concern that the ongoing formation of larger, persistent patches of grass might lead to greater depletion of native plant seedbanks and valuable habitat areas will be further compromised. The data gathered by these tools can further inform the judicious use (or exclusion) of fire within different floodplain habitats as a tool against para grass. This data can also be useful in designing and coordinating future applied research for site-specific para grass control strategies and for other aquatic weeds that impact on the park's natural assets (Boydon et al. 2019).

Identifying and prioritising the tools that are available and are the most efficient to use for monitoring and managing weed control actions change depending on the circumstance, availability of resources and changing technology. While the review recognises that this action is high priority with a tight timeframe, we must consider the everchanging nature of control practices and environments. Having a fixed timeframe doesn't allow for this, so instead it is suggested having a fluid timeframe, so that land managers can accommodate ongoing changes to practices and identified sites as needed.

Action 2.5 Outcome/output

- In areas containing key assets, management plans that address the suppression of outlier infestations.
- Management plans across land tenures that include control of the five listed grasses

This research investigated NRM groups, private trusts, national parks (both federal and state/territory run) and private land holdings, all of whom have management plans to abate the weeds on their sites of responsibility. These plans often concentrated on the containment, and if possible, eradication of the listed species that they deemed were detrimental to the key assets and ecology of the land that they are managing. Land rehabilitation and integrated management of weeds are included in these plans, with considerations towards fire. Feral animals are also considered in some of the weed control plans that this review found. Most of the weed management plans that were produced by land managers don't just focus on the listed weeds, but also include other weeds that they deem to be detrimental to the biodiversity of their land. This review will include case studies of some of the management plans that were found.

Weed management plans are continually created and adjusted to account for changes in the ecology of the parcel of land that it pertains to, and due to change of ownership. Given that every land manager that we spoke to who has these grasses present on their land has a management plan in place, that incorporates both main infestations and outlying ones, one would deem this action completed.

Case Study 2.7 Kakadu National Park

There are various entities that work within Kakadu National Park that all have their own priorities and plans of management. This includes DAWE departments – Parks Australia (Jabiru), Supervising Scientists Branch for Ranger mine, Energy Resources Australia for the running of Ranger mine, and Traditional Owners and ranger groups that work outside of the Parks rangers, all of whom conduct their own weed works. In addition to the park ranger groups, there is also an Integrated Feral animals' team that also have their own designated weed team. There are also Territory NRM staff that come onto the park, targeting gamba grass in particular areas and there are research projects conducted and/or funded by different organisations, including NESP (NESP n.d.[b]; [Department of Agriculture, Water and the Environment] 2021, pers. comm., 21 January).

Gamba grass, olive hymenachne, para grass and mission grasses together with mimosa pigra and salvinia molesta are all species that pose a substantial and ongoing threat to floodplain and savanna environments within the park. The Kakadu National Park Management Plan 2016-2026 (2016) outlines the management priorities for the Parks Department within DAWE who are responsible for the overall running of the park and includes the strategy for how the department intends to contain the weed infestations present in the park. There is also a strategy for Kakadu National Park that aims to protect threatened ecological communities which details invasive grass management actions to reduce the incidence, extent and abundance of the grasses in areas where high priority threatened species reside (Woinarski & Winderlich 2014).

To manage weeds on the floodplains, para grass and olive hymenachne control is prioritised in key areas and the eradication of mimosa is still sought after. The management plan also outlines that feral animal numbers on the floodplains are to be reduced in priority areas. To control these grassy weeds, fire is to be used to replicate the traditional floodplain burning regime which will reduce cover of hymenachne, para grass and other weed species, and will promote the growth of *Eleocharis* and other native wetland species. By using fire to control the density of aquatic grasses, the extent of open water is increased which is favoured by native wetland animals and plant species, which in turn provides an increased abundance of animals to hunt, including magpie geese (Director of National Parks 2016).

On the lowlands region of the park, fire is managed to reduce the impact on the animal and plant habitats and the controlling the spread of gamba grass is prioritised, along with managing feral animal numbers (Director of National Parks 2016).

The management plan reports that the condition of rainforest environments is variable across the park with some degradation occurring as a result of a combination of buffalo and pigs and encroaching grassy weeds. Weed control is just one part of this integrated management plan that must account for the other parties involved with Kakadu, whilst maintaining conservation efforts (Director of National Parks 2016).

Case Study 2.8 Charles Darwin University

Charles Darwin University, in the Northern Territory, has identified the presence of listed grasses on two of its campuses. Each campus has a different weed management plan. The Casuarina campus weed plan has identified four priority weed species – gamba grass, mission grass, coffee bush and Guinea grass. The campus is divided into 5 management zones, each with a different method of dealing with the weeds in that zone. In Zone one, gamba grass is well established thus the focus was to eradicate the grass in the peripheral areas of Zones 1 and 2, creating a 50m buffer around less dense infestations, or a 30m buffer in areas with dense, well-established stands. The use of glyphosate proved to be more effective than expected (EcoScience NT & Little Falcon Consulting 2018). In other areas of the campus outlier infestations were suppressed during repeated rounds of control. Both perennial and annual mission grass are present on the university campus, and it was found that the mission grasses and the gamba grass tended co-occur and were mapped together as priority mixed grasses and treated with herbicide. The aim of the ongoing weed management plan for the Casuarina campus is eradication of the grassy weeds, by regular treatment, monitoring and mapping, and ensuring that the grasses don't spread (EcoScience NT & Little Falcon Consulting 2018).

The Palmerston campus is using an integrated strategic fire and weed management plan with the objective that grassy weed presence on campus is reduced to zero, or very close to zero. Thatch (*Hypparrhemoa rufa*), gamba, perennial and annual mission grasses, and snake weed (*Stachytarpheta sp.*) and hyptis (*Hyptis suaveolens*) were the focus plants of this plan. Targeted areas for control included where the weeds were present and ensuring that they didn't spread to further compromise key assets on site, including the drainage area line. Going forward the weed management plan for the Palmerston campus is to maintain the eradication of the targeted weeds and prevent any further spread. The plan also identifies potential causes of reinfestation, including unclean mowing and slasher equipment, neighbouring properties and plants that have survived the control efforts (these plants have been noted in the report) (Charles Darwin University 2019).

Case Study 2.9 El Questro management

There is a small infestation of gamba grass on El Questro station in the East Kimberley region of Western Australia and is the only infestation of gamba grass in the state. Western Australia is cognisant of how damaging gamba grass has been in the Northern Territory and Queensland, so an eradication program was put into place in 2006. It is a joint venture between El Questro, the Department of Biodiversity, Conservation and Attractions, Department of Primary Industries and Regional Development and Kimberley Rangelands Biosecurity Association. Independent contractors from the Northern Territory who have gamba grass specific experience were hired specifically to target the incursion, which has proved instrumental in the program's success thus far.

The program is tracking well towards eradication or control with only 23 plants found across 80 hectares in 2020, whereas in 2018 there were 3086 plants found across 430 hectares ([WA Department of Biodiversity, Conservation and Attractions] 2021, pers. comm., 15 February). Rangelands NRM, Department of Fire and Emergency Services and the Kimberley Rangelands Biosecurity Association and Rangelands NRM have all contributed funds, personnel, expertise and equipment as well in this collaborative eradication effort. To manage the gamba grass, aerial and foot surveys are used to map, treat and monitor the grass' habitat during March-July each year (PIRD 2018).

Case Study 2.10 Defence properties

The Australian Government Department of Defence has 16 sites in the Northern Territory that have mission and/or gamba grass on them. On all properties, glyphosate and/or residual herbicides were used on the infestations, and buffers of various widths have been installed to protect key assets from mission and gamba grass spread and grass fuelled fires. These key assets include internal woodlands, perimeters, track, quarries, firing ranges and roads. On all properties since control has begun, there has been a reduction in the density of the plants, and in some sites have been reduced or maintained to very low numbers. Each site is either a containment or eradication site. Infestations are monitored, with individual plants that have been missed in the spraying of herbicides, being noted ([Department of Defence] 2021, pers. comm., 21 January).

Case Study 2.11 Local government

Each local government has a Biosecurity Plan that includes how the council intends to manage weeds on their land, and oftentimes, how their rate payers can report infestations. In Queensland, under the Queensland *Biosecurity Act 2014* the responsibility for invasive biosecurity matter falls to the local governments, who have the authority to declare restricted species for their jurisdiction ([Biosecurity Queensland] 2021, pers. comm., 18 February 2021). It is the council's duty to notify its ratepayers and residents of their biosecurity obligations that are unique to the council area.

The Townsville City Council (TCC) is an example of a council that is proactive in gamba grass eradication. It has a specific gamba grass eradication program and outlines in its biosecurity plan the TCC plans on addressing the issue. In the management section of the plan, under best practice, the TCC will refer to Queensland Government, Business Queensland website for up-to-date information on how to control gamba grass. The TCC is focused on controlling the plants as they are identified in known locations; spread awareness and encourage ratepayers to report sightings of the species. The Biosecurity Plan also explains that the Council wants to work with ratepayers to solve biosecurity issues by monitoring known incursions, liaise with stakeholders, investigate reports of suspected sightings and maintain communication with neighbouring councils. The TCC also expects industry to maintain weed hygiene practices and liaise with council if they want to conduct a gamba grass burn, and to avoid growing gamba grass as a crop. Transport corridors are addressed, in that quarantine yards for incoming and outgoing stock are expected to be maintained; and dispersal caused by human activities is expected to be managed through implementation of coordinated strategies at local, regional, state, national and international levels (TCC 2020).

Case Study 2.12 Litchfield National Park

Within Litchfield National Park, Northern Territory, there are numerous key assets that the managers want to protect from the five grasses and their effects. Areas of the park that are most at risk from bushfires harming the biodiversity of the area are the sandstone plateaus, melaleuca woodlands and the lowland and alluvial plains, and visitor assets including the park infrastructure, sacred sites, art sites, Blyth Homestead, Bamboo Creek tin mine and the Magnetic Termite Mounds site. Visitor enjoyment and safety are also put at risk by the gamba grass and the resulting bushfires fuelled by the grass (Royal Commission into National Natural Disaster Arrangements 2020; Parks and Wildlife Commission of the Northern Territory 2017).

To manage the threat of fire to the Magnetic Termite Mounds, a fuel buffer is maintained around the termite mounds to protect them from the effects of fire (Parks and Wildlife Commission of the Northern Territory 2017). For the other assets of the park conservation objectives have been established including:

- Wildfire: No more than 20% of the Park burnt by high intensity wildfire per year
- Gamba grass: The spread of gamba grass across the Table Top is less than or equal to 2014 aerial survey estimates
- Inappropriate fire regime: Habitat fire regime targets are met
- Arson: The estimated number of arsons caused ignitions are lower than the number of illegal ignitions in 2014
- Mission Grass: The spread of Mission grass is contained to the western portion of the Park is less than or equal to 2014 aerial survey estimates (Royal Commission into National Natural Disaster Arrangements 2020)

The plan also describes how olive hymenachne, paired with mimosa and humidicola (*Urochloa humidicola*) are impacting the biodiversity of the park's wetlands, and has conservation objectives for these weeds including maintaining the spread of olive hymenachne to less than or equal to 2014 aerial survey estimates. Feral animal conservation objectives are also included in the plan which are imperative to improving and maintaining the biodiversity of the park. The plan outlines high, medium and low priority strategies against each of the objectives that are outlined in the document to form a cohesive and integrated management plan. These actions include monitoring the values identified in the plan using surveys, mapping, ranger field estimates and remote sensing technology. The plan also outlines weed control actions and when and how they will be deployed to control the main infestations and to record and control or eradicate outlying infestations, in line with legislative requirements and weed priority matrix. The plan has stated that it will be reviewed and adapted to suit the ever-changing nature of the park (Royal Commission into National Natural Disaster Arrangements 2020).

Outside of Litchfield national park's weed management plan, there are other groups who work in the vicinity on projects regarding gamba grass control, that complement the existing plan including the use of the 'Gamba Army' as commissioned by the Northern Territory government and implemented by Territory NRM (Territory NRM n.d.[a]). The Territory NRM has also facilitated plans in collaboration with primary stakeholders for every region of the Northern Territory to provide an integrated and collaborative approach for sustainable management of Territory's environmental assets.

Action 2.6 Outcome/output

- Guidelines identified and modified or developed for distribution to land managers

This action focuses on the management practices that are employed to ensure best practice for native vegetation restoration, particularly in areas containing key assets. After completing the research component of this review, the land rehabilitation technique that most stakeholders prefer is to remove the grassy weed, and then let nature take its course and rehabilitate itself. In wetland areas where olive hymenachne and para grass grow, grassy vegetation isn't wanted in those areas to begin with, and in areas that gamba grass, mission grass and annual mission grass are removed from, land managers let native grasses grow back into the vacated area. In some instances, where the land managers deem it an appropriate method of rehabilitation and further weed control, they may choose to plant samplings that will grow to shade out any potential weed growth. Dr Lynise Wearne et al.'s (2010) report discusses past experiments that used spraying and artificial and natural shade to decrease the biomass of olive hymenachne over time as being a successful control and rehabilitation option but did say that further information is required on the effects of the shade and competing vegetation for longer term control of the weed. Choosing whether to actively rehabilitate the land or use a passive approach by letting native grasses regrow in cleared areas is an individual choice made by land managers and doesn't necessarily rely on government distributed guidelines. The Australian Association of Bush Regenerators (2003) has identified a guideline in its Olive Hymenachne 'Weed Management Guide' that shading by tall vegetation could be a way of reducing the amount of olive hymenachne plant material from infesting waterways, and that it could be a long-term, cost-effective control method that is ecologically friendly. It does stipulate though, that tall vegetation is unlikely to establish in seasonally inundated floodplains and could have its own impact on the system.

Case Study 2.13 Revegetation practices

Greening Australia

Greening Australia ([Greening Australia] 2021, pers. comm., 2 February 2021; Greening Australia 2018) explained for their work with the Mungalla wetlands and Crooked waterhole that revegetating areas where water weeds are removed (namely olive hymenachne and para grass), the aim was to create more open water ways, to remove the vegetation and not replace it. But in the instance of the Mungalla wetlands restoration project, more revegetation work has occurred with the planting melaleucas and native grasses in the riparian edges of the site. Greening Australia also found in previous projects that if plants that are planted for revegetation purposes grow to be at least 1m tall, they can choke out para grass. Greening Australia plants stems in high numbers in their revegetation projects, approximately 10,000 stems per hectare.

Terrain NRM

Terrain NRM has announced a new project focusing on improving the condition of upstream wetland and nursery areas for fish. Terrain NRM will work with local partners to remove the barriers that exclude juvenile fish from moving from spawning areas in the estuaries to nursery areas upstream (Terrain NRM 2020), and will also work on managing weeds, including olive hymenachne and para grass, and manage feral pigs and improve management of drains and farm creeks. Terrain NRM ([Terrain NRM] 2021, pers. comm., 3 February 2021) has said that weed control will be strategic, to mitigate its impact and spread in the important wetlands of the area and improve waterhole connectivity. Direct herbicide will be used, and then the watercourses will be revegetated with native plants, shading out the weed species. The project is looking to use wet rainforest species for its revegetation efforts, and Terrain NRM mentioned that they are looking at planting *syzygiums* as they are particularly good for providing canopy cover for shading. Fire management will follow. This project has just begun, with no results yet available.

Case Study 2.14 No action required

When speaking with the Australian Wildlife Conservancy ([Australian Wildlife Conservancy] 2021, pers. comm., 4 February), they stipulated that when they pull out olive hymenachne, they find that other natives and exotic species take over the newly bare area. Australian Wildlife Conservancy also reported that managers of AWC's properties sometimes use a boom spray to distribute glyphosate onto the newly bare earth to prevent seedlings of the targeted weed from emerging and reinfesting the area.

The South Endeavour Trust ([South Endeavour Trust] 2021, pers. comm., 5 February) also opts to let nature take its course once gamba and mission grasses have been removed, although along the tropical river flats on one reserve there is forestry. The Trust focuses on replanting tropical monsoon rainforest species in the area with the aim of shading out both sicklepod (*Senna obtusifolia*) and the small gamba grass infestations, to prevent them from having access to the space and sunlight that these species need to thrive. By planting these local rainforest species, the Trust also helped to ensure habitat continuity for other flora and fauna native to the area. In order to plant these species, the Trust had to develop its own nursery to germinate the plants that they needed. It was acknowledged that this form of revegetation would not work in an agricultural setting, due to the amount of productive land that would be lost.

Action 2.7 Outcome/output

- Collaborative applied research projects undertaken to test and improve management of the five listed grasses

Action 2.7 is a high priority with a 2-5-year timeframe where joint/collaborative research to inform and update knowledge of ecology, impact and effective management techniques was to have taken place. Again, like previous actions, it seems odd that a very specific timeframe has been applied to it, given the ever-changing nature of research. Once a project unlocks a key piece of information about these grasses, further research must be conducted to understand how to use this information against the invasive species in Australia. It is an ongoing process, that is likely to continue while these grasses remain a threat to northern Australia's biodiversity. This action was given a high priority, and should remain so, but the timeframe should be removed. The research regarding timing of herbicide application, grass selective herbicides, biological control options and fire response is still ongoing, or is yet to start, but not for lack of trying by scientists and research organisations.

Here are examples of the research that has been conducted and information on how Australia is addressing the need for a biological control agent. Please note that aspects of case studies 1.1, 1.2, 1.3 and 2.2 also apply to this action.

Case study 2.15 Grass selective herbicide research

CSIRO and NESP have been working on a project in association with the Queensland Government to see if there are any alternative herbicides to glyphosate that don't have large off-target effects when spraying gamba grass.

Field trials were conducted just outside the edges of a national park in the tablelands around Atherton, and on roadsides near Weipa. Biosecurity Queensland is also working alongside this project, who have been running a pot trial, using 10 different herbicides and 10 native species to see what impact they have on gamba and what the off-target effects would be on other co-occurring species. Field trials were used to detect the target effects, although this was difficult due to dry season die-back.

Unfortunately, the trial hasn't been successful in finding an alternative to glyphosate that is as effective. Some of the other herbicides that were tested had limited success on the gamba grass, but not enough to deem them an alternative to glyphosate. Fluproponate was found to be moderately effective, but only at very high rates, making it a non-economical option, and being very resource heavy ([Commonwealth Scientific and Industrial Research Organisation] 2021, pers. comm., 11 February). Fluproponate was also found to be an undesirable option where are non-target plants due to the effects from the herbicide load.

The final report for this research will be released in 2021.

Cast study 2.16 Biocontrol research

Due to the large area that gamba grass covers; biocontrol is seen by many stakeholders as the only effective, long-term solution to control the grass over a broad expanse.

The CSIRO has begun the process of looking into what the biocontrol agent could be to manage gamba grass. The CSIRO, through the Queensland government, is putting forward a nomination to the Environment and Invasives Committee (EIC) to work on developing a biocontrol option under the *Biological Control Act 1984*. The option that CSIRO are hoping to find would be an agent that would cause gamba grass' standing columns to either not grow as tall as they are capable of doing in northern Australia or find an insect that would cause the grass to weaken at the stems and fall down. Either option would reduce the height of gamba and thus reduce its capacity to thrust fire into the canopy of trees, and generally decrease the available biomass. Having shorter gamba grass would also make it more palatable to cattle, and they would be able to eat more of it, thus providing a secondary means of control ([Commonwealth Scientific and Industrial Research Organisation] 2021, pers. comm., 6 January; AgForce 2021).

The EIC has not made a decision yet regarding the nomination (as of February 2021).

Case study 2.17 Use of fire to control mission grass

A representative from DAWE has been working with the East Alligator River weed crew in the East Alligator River region to eradicate mission grass from spreading along the 6 km walking track known as the Sandstone River Walk, which had been closed to prevent tourists and animals from spreading the grass to other areas of the region.

In April 2019 the weed crew began trialling ways to eradicate mission grass during the dry season. Early burning can help spread mission grass as it is still green when the native grasses dry out and are ready to burn. Only the bottom of the mission grass plant burns, leaving the seed heads intact and ready to spread into areas where the native grasses have burned out. Recognising this, the weed crew tried flattening the mission grass onto the ground using quad bikes and then spraying with glyphosate. Once the grass had dried it was burned in the cool of the afternoon. The following year, mainly native grasses had grown back, and the mission grass had been reduced to 10% of its infestation size.

For the second trial, the weed crew found a patch of mission grass that had already gone to seed and thus, too late to burn, so they decided to flatten it, clear it away from under the trees and blew the seeds with blowers from the tree line into the flattened grass. Half of this trial area was cool-burned, and the other half unburned to see the difference in subsequent growth of the flattened grass. Late in the Dry season, a hot fire came through the area and burned the whole site. Where the site had been cool burned earlier in the season, 60% of the mission grass was gone, but where the hot fire had come through, 99% of the mission grass was gone.

These findings will be written into a report later this year, 2021 ([Department of Agriculture, Water and the Environment] 2021, pers. comm., 09 February).

Case study 2.18 Salt water and manual removal

Greening Australia has worked with local land managers, local government and private enterprise to remove olive hymenachne and other aquatic weeds from Mungalla Wetlands and Crooked Waterhole in northern Queensland and to improve the overall biodiversity of these key areas.

In Crooked Waterhole, an amphibious excavator was used to mechanically remove olive hymenachne that had formed large weed masses in the water. Foliar herbicide spraying of olive hymenachne, water lettuce, water hyacinth and *Salvinia molesta* followed manual removal. This was performed from both the waterhole bank, from a boat and an amphibious Argo ATV. Aerial weed control was also undertaken in the Pink Lily Lagoon at a later stage. Greening Australia developed several approaches to contain and control the aquatic weeds including floating bunding, and the surrounding riparian zone was subjected to on-going weed treatment of snake weed, Chinese apple, raintree, coffee bush and pasture grasses. These efforts included spraying and removing the weed, and revegetation efforts.

In the Mungalla wetland, feral pig management was undertaken, and areas of the wetland were refenced for more efficient rotational grazing to control olive hymenachne and aleman grass. Greening Australia also installed three production-size groundwater bores to access a high-yielding saltwater so that salinity could be introduced into the wetland, which was found to very beneficial in controlling the olive hymenachne, and thus reduce the need to use chemical control. Using saltwater bores allows one to control where the salt water is used and when (Greening Australia 2019).

The controls that were trialled in this project succeeded in clearing the waterways and aquatic flora and fauna returned to the sites, however, weed management has not been upkept since the end of the project, and much of the sites have reverted to their near original states ([Greening Australia] 2021, pers. comm., 2 February).

Case study 2.19 Residual Herbicide Research

Current management strategies of gamba grass concentrate on the use of herbicide and fire, although the use of fire and its ability to manage gamba grass is up for debate. Research is finding that invasive grass species like disturbed ground to move into, which result from fire (Luck et al. 2019). Re-establishment of the invasive grasses from the soil seed bank after the use of herbicide and fire remains a major challenge to eradication efforts. This study focused on soil seed bank treatments on gamba grass on a mine site in northern Australia. The adult grass plants were killed with glyphosate to exclude resource competition; and then chemical, physical and biological treatments were applied, and the subsequent gamba grass seed emergence and survival was quantified. The research found that dalapon and sulfometuron herbicides reduced emergence by 90% compared to standard glyphosate treatment. These residual herbicide treatments reduced seedling emergence for at least 5 months after emergence. The physical (ground scarification with a hand-operated rotary hoe) and biological treatments (leaf litter coverage) that were tested didn't have a significant effect on seedling emergence. After 5 months the trial ended (Luck et al. 2019).

Acacia species have been found to affect grass seedling establishment through allelopathy (production of biochemicals by the plant to inhibit the growth of other plants), with the allelopathic properties of *A. holosericea* leaf litter being especially effective against the listed mission grasses. Leaf litter was applied in this trial at 0.5cm depth and 90% cover. It was found that to cover just one hectare at optimal depth, over 2000 trees would have to be denuded of their leaves to provide the litter. This technique of seedling control is impractical on a large scale but may be of use for localised application in areas sensitive to chemical treatments (Luck et al. 2019).

Summary

- Action 2.1 for complementary weed status has not been completed. Except for olive hymenachne and gamba grass which are WoNS, the other listed grasses in the TAP still have different classifications across WA, QLD and the NT. There is no action being taken to encourage complementary weed status.
- Action 2.2 is a medium priority that calls for the development of best-practice guidelines for use and/or management of the five listed grasses in both agricultural and conservation contexts. There are guidelines widely available for a conservation context, but agricultural guidelines, apart from the general biosecurity directive to control existing occurrences that are being used as pasture, are lacking. These guidelines are provided by local governments, state governments, federal government, NRMs and community action groups.
- Action 2.3 focuses on the development of hygiene protocols and spread pathways. There are no specific protocols or unusual spread pathways for the listed grasses that are any different to general weed protocols, except the anecdotal theory that magpie geese may be spreading olive hymenachne seeds. Weed hygiene practices including washing down of vehicles and equipment is not being undertaken as thoroughly as protocols dictate, due to the cost and time pressure on industry. Tourists and the general public also don't know to enact these practices due to lack of knowledge about these weeds and how their movements can affect the biodiversity of northern Australia. This is an area that needs more focus on communication and education, and in some areas facilities to enable action.
- Action 2.4 seeks further development of prioritisation tools to identify high-priority areas for monitoring and management actions. Land managers have identified the areas that are prioritised, and often work to control weeds with the means that are available to them. When speaking with stakeholders, we found that financial resources are lacking across the board, thus hindering effective weed control efforts.
- Action 2.5 found that every land manager has a form of a management plan for weed control for the weeds that they deem important to manage. These plans can either be formally written and published by governments and private businesses, or they are informal and developed on an *ad hoc*. basis by private landholders.
- Action 2.6 found that revegetation is sometime conducted to prevent further infestation when using vegetation to shade out the listed weeds, otherwise, the cleared areas are left to revegetate themselves, as the cleared area allows the native grass seeds in the soil seed bank to grow.
- Action 2.7 has seen that research has found that saltwater incursions help to control olive hymenachne, the use of fire may be more detrimental to weed control than beneficial, except in the instance of the East Alligator River mission grass eradication program. Timing of herbicide application is important, but research has not yet been able to find a grass selective herbicide with low off-target effects. Biocontrol options for gamba grass have not been explored yet, however, a nomination is being prepared to go to the Environment and Invasives Committee prior to beginning research in this field.

Conclusions and recommendations

There is still a lot of work that needs to be done in the research fields to find more efficient means of controlling these grasses, and nothing has happened to encourage complementary weed status for the five listed grasses across all jurisdictions, except for the olive hymenachne and gamba grass being declared WoNS in 2012. Work also need to be done to encourage the adoption of hygiene protocols.

The timeframes aren't all that relevant to these objectives, given the ever-changing nature of management plans, what is considered a key asset and the prioritisation of available weed control tools. These could be considered completed, except for the perceived lack of resources that is preventing land managers from enacting further efficient grassy weed control measures.

Objective 3 – Identify and prioritise key assets and areas for strategic management

The key purpose of this TAP is to address the key threatening process 'Ecosystem degradation, habitat loss and species decline due to invasion of northern Australia by introduced gamba grass (*Andropogon gayanus*), para grass (*Urochloa mutica*), olive hymenachne (*Hymenachne amplexicaulis*), mission grass (*Cenchrus polystachion*) and annual mission grass (*Cenchrus pedicellatum*)'. Actions resulting from the TAP must work to reduce ecosystem degradation, habitat loss and species decline cause by the five listed grasses. It is necessary to identify the important ecosystems, habitats and species that may need protecting. For the purposes of the Australian Government, these are the EPBC Act listed assets. There are also state, regional, and local assets that have been identified to help prioritise management activities on the grass-roots level. In areas of invasion or potential invasion, identified assets need to be prioritised for monitoring and management activities in order to best use limited resources

Actions

3.1 Identify key assets for priority protection

3.2 Identify areas at risk of invasion, prioritise for monitoring and determine appropriate management actions

Action 3.1 Outcome/output

This action is a high priority with a timeframe of 1-2 years. This action encourages land managers to identify key assets and prioritise their protection from these grasses.

Through this review, nearly all people have identified what they believe to be are the key assets in their jurisdictions. These assets include cultural sites and resources, wetlands, carbon farming sites, flora and fauna, and physical structures. In many instances, key assets are identified as areas where a tangible weed control outcome can be obtained. Bush Heritage Australia (2021, pers. comm., 28 January) stated that the ecological priorities as key assets

for each property the conservation agency purchases are identified before the acquisition of the property.

The following case studies will provide examples of these identified key assets and how land managers have strategically focused their resources to gain maximum benefit. It is important to note that in many instances it is not possible to eradicate these grasses in all areas, thus techniques for control are implemented. For more examples of key assets that have been prioritised for protecting and the actions that have taken place, see the previous case studies in this review, as all of the examples covered in this document have been determined to be key assets by those who have vested interests in the areas.

Case study 3.1 Carbon farming

The TAP does not discuss how the listed grasses may affect carbon farming throughout northern Australian tropical savannas, yet, since its inception, this has become a very real concern (ICIN n.d).

The presence of gamba grass excludes land from being able to be counted in carbon farming programs. Indigenous communities rely on the income from carbon farming; thus, the presence of gamba grass not only jeopardises the biodiversity of their land, but also puts their income at risk (NESP n.d.[c]).

NESP have done research in the Darwin and Daly region to see how gamba grass infestations and fires affect carbon stocks, particularly soil carbon which is the largest store of carbon in terrestrial ecosystems. The research team mapped gamba invasion within priority areas and determined the rate of invasion and effectiveness of the existing weed control techniques used in the area. The baseline quantity of carbon stocks in native vegetation and the change following invasion was determined and the resulting data was integrated into a decision-support tool to determine a cost-effective management solution for gamba grass at a regional scale. This research can help Traditional Owners strategically focus their resources to prevent gamba grass and other invasive grasses from impeding on the land designated for carbon farming (NESP n.d.[c]).

Case study 3.2 Conserving biodiversity and Indigenous bush tucker and cultural sites

This case study covers two important Indigenous assets that have been identified as key areas to protect from invasive grasses. It is important to note that what is deemed to be a key asset and which ones are to be prioritised are on a case-by-case basis, and each ranger group will have different primary issues.

The first asset is Indigenous rock art and cultural sites throughout the Top End in the Northern Territory. Wallabies carry mission grass seeds close the rocks of the sites; thus, they grow against the site and when a fire comes through, the biomass of the mission grass will increase the heat and ferocity of the fire. This causes the paint in the rock art site to peel away, thus the preservation of rock art is a priority ([Territory NRM] 2021, pers. comm., 28 January).

The second asset is the floodplain biodiversity and the bush tucker that is available there within Kakadu National Park. Both key priorities are at risk from olive hymenachne and para grass which form monocultures and displace the diverse mosaic of native vegetation. The floodplains provide the local Indigenous population with a vital source for food and cultural practices with social and economic benefits. These include including hunting magpie geese and turtles, fishing and gathering native plants. A study was done by Adams et al. (2018) that focused on modelling and predicting management scenarios that could work at strategically containing and controlling the existing infestations using resources available to the rangers. This study also produced a comprehensive map of bush tucker sites within the Magela Creek, West Alligator and South Alligator floodplains. The resulting management scenarios involved a mix of ground control methods and identifying containment boundaries that reflect the natural barriers to the weeds (Adams et al. 2018).

Action 3.2 Outcome/output

The TAP deems that preventing the spread of the listed grasses into ‘clean’ areas is the most cost-effective management approach. Management zones can be developed to help prioritise and plan for monitoring and management actions.

When researching this project, several different examples were found where the land area of concern is split into zones to monitor and manage the grasses. The research also found that in many instances these zones are formed around key physical assets and the weed of concern within the area. Individual landholders and conservancy groups have their own approaches to designating zones within their property boundaries to monitor and control these grasses, and to prevent them from spreading into clean areas. Their management zones are prioritised and planned for monitoring and management actions, depending on the key assets within the landholding, and the level of infestation of the invasive grasses. Management zones can also consist of working on the public roadside along their properties where there are incursions, to prevent further spread by vehicles along the road, or from the grasses growing across the property boundary ([South Endeavour Trust] 2021, pers. comm., 5 February).

Charles Darwin University’s Palmerston campus has split up its management zones based on grass weed density, with each zone separated by a road or path. Within each of these zones,

management action was tailored to the specific grass and its density, and the university's monitoring of weeds is also split up and recorded against these specified zones (CDU 2019). Charles Darwin University's Casuarina campus management zones are broken into 5 zones along the western section of the campus that each have a different vegetative makeup. Field surveys and mapping were undertaken and recorded for each zone, with individual patches of weeds and larger infestations noted, along with their density. An individual action plan is made for each zone, to control the current infestations, and to prevent spread into clean areas of the campus. Management objectives and the subsequent results are included in the report as of 2017/18 for each target species within each management zone; and a plan of action for identifying and managing isolated plants and outbreaks has also been included in the report (EcoScience NT & Little Falcon Consulting 2018).

Litchfield National Park's management strategy is different from CDU's, in that the park is separated into Key Values within the park that are interconnected. The four key natural values are the Sandstone Plateaus, Monsoon rainforest, Melaleuca woodlands and the Lowland woodland and alluvial plains; and the one key contemporary value being Visitor safety, Visitor, Cultural and Heritage Assets. Management actions for all matters of conservation (research, preservation, and monitoring of native species, weed and feral animal control) and threatening processes are tailored to these key values. Litchfield National Park falls within the broader Northern Territory's Zone B – Control zone, thus the park is required to undertake management actions to control the gamba grass within the park prevent its spread to clean areas (Parks and Wildlife Commission of the Northern Territory 2017; Royal Commission into National Natural Disaster Arrangements 2020). Unfortunately, the core infestation of gamba grass along the north-eastern floodplains is deemed unaffordable to manage (Parks and Wildlife Commission of the Northern Territory 2017).

On a large scale, the Northern Territory itself is divided into two clear zones that determine whether the gamba grass within each zone is to be controlled or eradicated. Most of the gamba grass presence in the territory is within Zone B - Control Zone, and includes Darwin, Batchelor, and Litchfield National Park. Any gamba grass outside of this area is to be eradicated, as per the legislative requirements of Zone A. A further Zone C applies to the whole Northern Territory and prohibits any new gamba grass plant material from being introduced into the jurisdiction. Landholders that are within these zones are legally responsible for controlling (monitoring and management) the grass on their property as per the requirements of the zone that the land is situated in (NT Gov 2018). Western Australia has seen the level of infestations in the Northern Territory and Queensland and has made a concerted effort to manage the known gamba grass infestation at El Questro station, to prevent incursions from growing to the scale of the grasses which are present in the other two jurisdictions.

Summary

- Stakeholders who are involved in managing the listed five grasses have identified the key assets for priority protection on the ground that they are responsible for. Ongoing monitoring of these assets and the grasses that threaten them is an important part of

their management plans, and resources are focused strategically to make the most out of the available time, money and human resources.

- Management zones are outlined in plans for public landholdings and institutions e.g., universities to manage the relevant weeds. These plans showcase the priorities, objectives and what action is being taken to achieve them. On private landholdings identifying management areas for monitoring and control is less formalised or published, but the same principle applies of identifying key assets and prioritising their protection and preventing the grasses' spread.

Conclusions and recommendations

Both actions within Objective 3 of the TAP are deemed to be high priority, with the plan calling for land managers to identify and prioritise key assets and use management zones as a cost-effective approach towards grassy weed management. Both actions have been achieved by stakeholders with management zones often coinciding with the identified key assets. The TAP should still mention the need for these actions, however, putting a timeframe on established work may no longer be necessary. Case study 3.1 discussed the impact of gamba grass on carbon farming – an issue that the TAP has not addressed. Introducing carbon farming as a consideration in the TAP going forward is highly advised, as it is a growing industry throughout northern Australia and within the potential range and habitat of the listed grasses.

Objective 4 – Build capacity and raise awareness among stakeholders

The rationale behind this objective is that raising awareness of the grasses and of their environmental impacts may improve the success of control efforts through increased support for implementing these management actions, alerting of new infestations, and complying with weed legislation. As Indigenous land managers may have limited access to available management tools and are often required to contribute to biodiversity conservation, an action to better assist the capacity of Indigenous land managers to participate in managing these grasses is included in the list.

Actions

4.1 Develop and deliver communication strategies to raise awareness of the threats posed by the five listed grasses

4.2 Better assist the capacity of Indigenous people to participate in the management of the five listed grasses

Action 4.1 Outcome/output

- TAP promoted in affected communities and extension materials developed and made available

- Community ownership of the issue and increased awareness among stakeholders of the importance of managing invasive grasses

When talking to stakeholders a common theme that came back to us was that many people hadn't heard of the TAP. Those that did know about it were heavily involved in research that is informed by the TAP, and those in government roles. Those that didn't know included some stakeholders within the department, conservancy groups and NRM representatives weren't aware of this high-policy document. The TAP is a high-level policy document that outlines actions that need to be taken by everyone to control the listed grasses, which doesn't provide any tangible directives on how to control these grasses or how to implement management plans. Higher level organisations including NRMs, state and territory governments and local governments are usually aware of the plan which can help them decide on how to structure their advice to their constituents. The plan also helps to inform how these organisations plan their own weed management initiatives.

Extension materials are provided to different areas of the community and are delivered in a way that fosters community ownership of the issue and increases awareness among stakeholders of the importance of managing invasive grasses. Different communication techniques are used for Indigenous communities, conservation agencies, pastoralists, and the general public.

This is a high priority action that has a timeframe of being delivered within 1-5 years of the TAP being published. This action has been achieved however, it is unlikely that awareness of the issues that these grasses create has been completely disseminated. From speaking with a wide variety of stakeholders (state and territory governments, NRMS, conservancy groups etc) it would appear that general communities who are impacted by and in regular contact with these grasses are aware of their biosecurity obligations (whether they act on the guidelines or not is a different matter), but there are also communities (i.e., tourists and the general public) that come into contact with the grasses but who are not directly impacted by them, that are ignorant of what they are and the environmental harm that they are causing.

Case Study 4.1

Awareness in Indigenous communities

The Indigenous ranger scheme across northern Australia is greatly beneficial for ecological work, including combatting weeds. NRMs and conservancy groups often work with Indigenous rangers and communities to implement weed control work, and by doing so, teaching them how to care for country by identifying invasive weeds, knowing the harm that they cause and how to mitigate the issue ([Territory NRM] 2021, pers comm., 28 January). By involving the community, knowledge is being passed on, which in turn builds community momentum to tackle the associated issues. By engaging Indigenous stakeholders, efficiencies in weed control work and mapping are also achieved.

The Territory NRM (TNRM) has held land management days with Indigenous communities across the Top End, including with communities from the Daly River region and in Arnhem Land. In the Daly River region, the Wangamaty Land Management have been aiding the broader Daly Community for over a decade. In 2015 TNRM provided funding for the group to continue threat abatement work against gamba grass and olive hymenachne in the region. They worked closely with the Malak Malak Rangers and regional landholders and stakeholders were invited to participate in a weeds information day, which provided an opportunity to discuss regional natural resource management issues including best practice management of these invasive grasses (MERIT 2015). In 2017 a two-day workshop was hosted by Jawoyn Rangers at Nitmiluk National Park in Arnhem Land where land managers discussed the threat of gamba grass and planned for joint action towards a gamba free future for the area. This workshop was a part of the ALFA NT ranger network end of season fire meeting (MERIT 2015).

Representatives from The University of Western Australia and Charles Darwin University ([The University of Western Australia], pers comm., 18 December) and ([Charles Darwin University], pers comm., 18 December) outlined how they and their research partners disseminate information to the local Indigenous communities by bringing Kimberley groups to Batchelor for training and demonstrate through the use of fire, the threat posed by gamba grass. They also aim to convey the impact that these invasive grasses have on the bush tucker supply and on other cultural values. An example of this is that olive hymenachne smothers wild rice which reduced the food source for magpie geese, which in turn reduces hunting opportunities for the local community. Rangers are also engaged in management practices from the beginning and are tasked with monitoring incursions and weed control ([The University of Western Australia], pers comm., 18 December 2020; [Charles Darwin University], pers comm., 18 December 2020; Boydon et al., 2019). By engaging these communities and conveying how these grasses will impact on essential life practices, one can foster community ownership and involve them in control efforts, thus enabling more efficient and participatory work.

Throughout northern Australia Indigenous communities are participating in the Australian government's Carbon farming scheme, where they burn vegetation to prevent hotter fires that would render the environment unable to absorb as much carbon as it is capable of. If gamba grass is present on sites designated for carbon farming, then they are excised from the scheme due to the hot and destructive fires that it generates, which are capable of killing trees. This means that there is strong community motivation to keep gamba grass out, but it can also lead to underreporting of the gamba present on land designated for carbon farming, for fear of loss of income. There is an annual savanna fire forum where community members can engage more with regulators and discuss how to manage gamba on the land and find the right scale of gamba of a few plants that can be managed, versus an incursion that would make the land parcel excised (NESP n.d.[c]; ([Territory NRM] 2021, pers. comm., 28 January).

Case Study 4.2 Awareness in Pastoralists and the general public

Pastoralists are required to adhere to their state/territory Biosecurity Acts regarding weeds and this information is widely accessible on the internet.

As stipulated by the Queensland *Biosecurity Act 2014* in Queensland each local government must have a biosecurity plan that covers invasive plants within its jurisdiction (DAF 2020a) and may include actions to be taken for certain species, some of which may be required under local laws. These plans and information are made available to rate payers and is publicly accessible online. Depending on the local laws, there may be fines for non-compliance.

The listed grasses have historically been used as pasture for cattle, and while these grasses may no longer be actively planted, anecdotally, existing incursions are still used for their primary purpose. The Department of Agriculture and Fisheries in Queensland advises that gamba grass should be grazed with enough stock to keep it below a height of 90cm so that seed production and potential spread is limited, and also advises that maintaining pastures in good condition with high foliage cover and crown will provide a level of resistance against the grass' spread. Physical control, cool burning early in the wet season and herbicide control are all advised to graziers on how to handle a gamba grass infestation (DAF 2020). The Queensland government has also generated an online fact sheet that advises graziers on how to utilise grazing, mechanical or physical control, fire and herbicides to control olive hymenachne and para grass (DAF 2020b; DAF 2020c).

The Northern Territory also disseminates information regarding invasive grasses to graziers through the Gamba Grass Roots action group and through government information resources which are available online (NT Gov 2020; DENR n.d.). These resources are also available to the general public. Constituents are informed about the importance of managing invasive grasses and are encouraged to undertake mapping, monitoring and control actions, particularly for gamba and para grasses, and olive hymenachne infestations, on their properties. Through the Gamba Action Program all Territorians can access free herbicide, spray equipment loans and weed management advice from the Northern Territory Government to help control gamba grass. The Territory NRM also produces natural resource management plans which are available online and contain information and advice for all ecologically concerned stakeholders within the NT (Territory NRM 2016a; Territory NRM 2016b).

Western Australia's Department of Primary Industries and Regional Development has an AgMemo page dedicated to acting on gamba grass (DPIRD 2018), however, these listed grasses aren't an issue for immediate concern in the state, yet, and thus state government disseminated information on these species is limited.

The NFF considers these grasses to be important pasture sources as per their submission to the call for comments on a draft version of this TAP (NFF 2011). AgForce has recently been asked to write a letter of support for CSIRO's biological control nomination to the EIC for gamba grass, and as such, they have reached out to their members to ask for their position on the issue (AgForce 2021). By engaging its members, it is simultaneously raising awareness of the complexities of the use versus threat of gamba grass, as well as seeking their official position on the matter.

The general public is made aware of these grasses often through the same means as graziers. Councils reach out to the public and use news sources and the internet to disseminate information. The problem is that if the grasses are impacting on the general public, this information can be quickly forgotten, and they disengage. Some people sign up to be volunteers ([Bush Heritage Australia] pers. comm., 28 January 2021), however they are in the minority. Community ownership of the grasses issue is lacking and awareness of the dangers of these grasses needs to be increased. The majority of where these grasses are posing a problem are in conservation areas, away from population centres, thus they don't have a direct impact on the public. This may change if intense fires fuelled by grasses becomes a major concern for towns, but until that happens, stakeholders may struggle to foster a sense of community ownership and engage people to help in control efforts.

El Questro station's main operations concentrate on its tourism interests. To help mitigate weed spread and increase awareness of the issue, the Environment Manager on the station erects signs with images in high traffic areas asking visitors to report the weeds of interest if they find it ([El Ouestro] pers. comm., 19 February 2021).

Case Study 4.3 Awareness in Conservation agencies

Conservation agencies, including privately owned organisations, Trusts and NRMs all have different priorities, depending on the land that they either own, manage or are involved with. Often, due to limited resources, these agencies rely on donations and grant funding to maintain their ecological projects. They also work collaboratively with local government, state government, research institutions, Indigenous ranger groups, volunteer organisations and private enterprise to foster the support that they need to tackle the conservation issue. By working collaboratively with different partners, they promote the TAP's objectives (often unknowingly) and foster a sense of community ownership of the issue and increase awareness among a variety of stakeholders. In this instance, extension materials could be as simple as talking to potential stakeholders and explaining the issue while asking for their support, or it could be advertising for volunteer help and/or employees. Physical extension materials such as publishing the details of a project targeted at one or more of the listed grasses, and the results upon completion are also produced. They can be disseminated in the form of a website, through social media or in printed media (Territory NRM, n.d.[a]; Terrain NRM 2020; Cape York NRM 2020; Bush Heritage 2021; Greening Australia 2018; South Endeavour Trust 2020).

Action 4.2 Outcome/output

- Indigenous land managers better engaged to address impacts of the five listed grasses on their land.

Across northern Australia, vast swaths of land are under Indigenous ownership and management, including pastoral leases, jointly managed national parks, and Indigenous Protected Areas, where Traditional Owners have entered agreements to conserve the cultural and biodiversity elements of the land. As previously discussed in this review, Indigenous land managers, and in particular Indigenous Rangers, are heavily involved in the abatement of the threat caused by the five listed grasses and NRMs, national parks and conservation groups rely on their expertise and personnel to enact weed control projects.

There are, as of February 2021, 127 Indigenous ranger groups throughout Australia, many of which are involved in weed control and fire management, and each group has different environmental priorities (NIAA n.d.). Rangers are responsible for their own managed land, and are also often invited onto pastoral land, national parks and defence areas to help with conservation projects ([Weed Management Branch, Northern Territory Government] 2021, pers. comm., 8 January). It is important to note that when Indigenous rangers are asked to help with weed control and spread efforts, they do not come onto the land as volunteers. Leaseholders must have the funds to employ the rangers and teach them the necessary weed control techniques ([Australian Wildlife Conservancy] 2021, pers. comm., 4 February; [Weed Management Branch, Northern Territory Government] 2021, pers. comm., 8 January).

Kakadu National Park is jointly managed by the Department of Agriculture, Water and the Environment and by the Traditional Owners of the region. There are many Indigenous groups

within and adjacent to the park that have been involved in weed control, whether by participating in research projects led by external stakeholders, in weed management projects hosted by the department, or if they Traditional Owners undertake their own projects. Previous case studies have outlined how Indigenous groups have been involved in weed management projects in the park, including in Case Studies 1.3 and 2.7.

Case study 2.5 stated that Indigenous land managers were integral in the management of gamba grass in the Mary River national park and in Case studies 3.1 and 4.1 highlighted the importance of Indigenous land managers controlling gamba grass to safeguard their carbon farming interests. Case study 2.17 also demonstrated how local Indigenous land managers could play an integral role in controlling mission grass that was impacting a valuable key asset and were able to mitigate adverse impacts and prevent the spread of the weed.

Indigenous land managers are engaged on a number of levels and across both their land and land held by private entities to conduct effective invasive grass management projects, which also have the added benefit of educating people on how to manage weeds, which is knowledge that can be built upon and taught to other members of the community.

Summary

- The TAP isn't promoted to affected communities, but many of its objectives are promoted through extension materials, many of which are publicly accessible and are provided by government entities and NRMs, to interested parties including Indigenous communities, pastoralists, conservation agencies and the public.
- Action 4.2 has not been wholly achieved, as the awareness of the issues that these grasses create has not been adequately disseminated to tourists and the general public
- Indigenous land managers, be they rangers or no, are engaged to address impacts of the five listed grasses on both their land and land held by private companies and government interests. They are relied upon by stakeholders across northern Australia to help conduct grassy weed management projects.

Conclusions and recommendations

Objective 4 has two actions that aim to build capacity and raise awareness among stakeholders of the impacts of these grasses and to encourage them to implement management. Both actions under this objective have made great progress in promoting community ownership; increasing awareness among stakeholders, and engaging Indigenous land managers, however, many people are still not aware of the dangers of these grasses, particularly tourists visiting the areas where they occur and the general public. When we spoke to stakeholders, many had never heard of the TAP, or if they had, were not engaged with it, unless it related specifically to their research or state/territory government work. More action needs to be taken to spread awareness and foster community ownership of the grasses issue.

Across Arnhem Land, Aboriginal Traditional Owners conduct landscape scale fire management work which is resourced through their engagement with the carbon market and savanna burning methodology.

Objective 5 – Implement coordinated, cost-effective on-ground management strategies in high-priority areas

To achieve efficiencies in management activities, it is accepted that sharing information and coordinating activities will result in the greatest gains. Applying immediate management to high priority areas that contain key assets is an important first step, to be followed by efforts to manage and reduce, where feasible, the density and area of occupancy of the grasses in other areas. Applying appropriate land rehabilitation activities will be important to support the land to regenerate following management actions. Identifying resources available at state, territory and Australian Governmental levels, and facilitating the acquisition of these resources to protect priority assets, is key to achieving the goal of this TAP.

Actions

5.1 Foster a coordinated partnership approach to the management of the five listed grasses. Facilitate information sharing and encourage coordination of the implementation of management and monitoring actions across all land tenures to maximise the efficiency and effectiveness of management programs.

5.2 Where feasible, implement immediate management actions in high-priority areas around key assets and spread pathways

5.3 Where feasible, implement management actions in other infested areas to reduce the area and/or density of occupancy of the five listed grasses

5.4 Where feasible, apply land rehabilitation methods to high-priority areas as they are cleared of the five listed grasses

5.5 Liaise with land managers of areas containing key assets to identify resources available for the implementation of priority actions

Action 5.1 Outcome/output

- Identification of key agency contacts and formation of advisory group (e.g., a grasses TAP advisory group)
- Cooperation across all land tenures towards implementation of management programs
- Development/identification of a website to share information

Action 5.1 is classified as high priority with a timeframe of 2-5 years. It calls for increased coordination in the existing and future management and monitoring programs with pastoral land managers, organisations, and other stakeholders. It encourages the facilitation of regional coordination that would improve communication and encourage sharing of information about the listed grasses. It also calls for this information to be readily available

for land managers and agencies to easily access to enable more effective and efficient management.

Whilst researching this review, it has been found that the desired outcome of the formation of an advisory group for the TAP has not eventuated. There is a vast network of stakeholders across northern Australia that are aware of each other, who are conducting research and management projects on gamba grass, mission grass, annual mission grass, perennial grass, and olive hymenachne, however, there is no formalised group that informs the TAP, and there is no formalised group that shares the knowledge that each stakeholder learns, outside of individual research alliances.

Cooperation across all land tenures has not occurred either. There are projects in regions where these grasses occur within northern Australia, which involve cooperation across different land tenures, however this is not a wide-scale approach. An example of where this does happen is in the Northern Territory where the Pew Charitable Trust work with Gamba Grass Roots and Top End landholders work to try and eradicate gamba grass from their properties (Clarke & Hart 2018). Another example of coordinated action is the 'Stop Gamba Grass in its Tracks' project is a Territory NRM initiative that sees the NRM work with groups, rangers, contractors, land managers and organisations across West Arnhem Land in a coordinated effort to prevent the further spread of gamba grass into Kakadu National Park throughout Arnhem Land. Within the West Arnhem Land region, there are isolated infestations of gamba grass, and the taskforce is working to locate and eradicate all infestations (Territory NRM n.d.[b]). Another example of facilitating regional coordination for gamba grass control is the 'Gamba Army,' project commissioned by the Northern Territory government and facilitated by Territory NRM. The project aims to protect high use community and recreational areas from gamba grass, and it also works to complement existing land manager weed control efforts by providing a workforce in priority areas over the 2020-2021 wet season. Gamba grass control efforts are being concentrated in the Darwin and Litchfield region. Commercial companies are being contracted by the project to provide a taskforce that can optimise periods of weed control based on rainfall, access and grass growth stage factors. This project aims to support local business and develop the capacity of the workers in the Gamba Grass Army (Territory NRM n.d.[a]).

The final example of regional coordination in the Northern Territory example of co-ordinated action is in Harrison Dam where Northern Territory Field and Game have teamed up with Northern Territory Parks and Wildlife to work towards eradicating olive hymenachne from the dam (NT Field and Game n.d.).

In general, projects initiated by NRMs utilise stakeholders from across different land tenures to accomplish the task. The location, funding requirements and required work will determine who will be involved across the land tenures. Often regional governments will be involved in the project, along with Indigenous rangers, commercial enterprises and private businesses, volunteers from the community, and if the project is taking place on private land, then the landholder or manager will often dedicate resources to the weed monitoring and management actions. This is evident in projects across Queensland (e.g., Greening Australia's work in the Mungalla Wetland and Crooked Waterhole), the Northern Territory (see above mentioned projects) and Western Australia (El Questro gamba grass infestation).

A website to be used to share information about these grasses has not been established. The MERIT system through the Atlas of Living Australia contains the details of government grant funded projects that have dealt with these grasses, and there are federal and state/territory websites that discuss the grasses' impacts and control methodologies, however, a website that contains all of this information and that has a function to allow stakeholders to share and publish information on the site has not been developed. The next closest website that contains information about these grasses is '[Invasive pasture grasses in northern Australia - gamba grass, para grass, olive hymenachne, perennial mission grass and annual mission grass - Olive hymenachne | Department of Agriculture, Water and the Environment](#)' (DAWE 2014) where research papers relating the impact and abatement of these grasses has been uploaded, but it is out of date, and the material that has been developed is based on the best available information at the time of development (September 2014). There is an email address provided on the site where stakeholders can provide updates, however, due to only outdated information being present on the site, it is unclear if this update function is being utilised.

Action 5.2 Outcome/output

- Immediate management actions implemented in high-priority areas around key assets and spread pathways.

Action 5.2 stipulates that invasive grass stakeholders must, where feasible, implement immediate management actions around key assets and/or in close proximity to known spread pathways. This has been taken to mean that if a new incursion appears near a key asset or on a spread pathway, that immediate action is to be taken to remedy the situation. This action is also understood to mean that weed management plans are to be formulated by the manager of the key asset.

When speaking with stakeholders, they all had similar approaches to immediate management actions around their key assets. Infestations of the listed grasses are usually found when land managers are doing the rounds of their private properties. When they find an incursion, they map the location of the plant (either manually or using GPS) and then they either manually remove the offending plant/s or treat it with herbicide either straight away, or in the case of Litchfield National Park, include the incursion in an upcoming control program (Parks and Wildlife Commission of the Northern Territory 2017; [Bush Heritage Australia] pers comm., 28 January 2021; [South Endeavour Trust] 2021, pers. comm., 5 February). The Australian Wildlife Conservancy added that when they find gamba grass on their land, they cut off the heads and either lay the plant down or dig it up ([Australian Wildlife Conservancy] 2021, pers. comm., 4 February). The Defence Department implements weed management actions around its key assets and known spread pathways by running regular weed control programs using herbicide, and by keeping a buffer around the assets that need protecting from the listed grasses and their negative effects ([Department of Defence] 2021, pers. comm., 21 January). Anecdotally, many of these incursions would be on or close to roads and tracks within properties i.e., a spread pathway, as the land manager would be able to spot the incursion whilst traversing the land. Action protocols that land managers take have already been discussed in Action 2.3 of this review.

The primary spread corridors are main roads and railways, maintained by the state and territory jurisdictions, and telecommunication lines maintained by private enterprise. While some land managers of conservation agencies opt to manage the roadsides adjacent and close to their properties to prevent spread, it is the primary responsibility of the agency that manages the transport corridor to control the grass incursions along the road, railway or port.

The Australian government enforces strict quarantine and biosecurity requirements for all imported goods, as per the *Biosecurity Act 2015*, to minimise the threat of potential incoming incursions. This includes weed seeds. Each port and airport is a potential spread pathway for these incoming incursions. Infrastructure and industry must also comply with the legislated standards of the state or territory that they are in. Darwin Port for example has an environmental management plan that outlines the actions it takes to control all flora and fauna pest management, including weed spraying programs, feral animal trapping and general pest control, while adhering to the *Environmental Protection and Biodiversity Conservation Act 1999*, *Weeds Management Act 2001* and *Weeds Management Regulations* (Landbridge Group 2020).

The state and territory run road and railway corridors are key assets of which their structure must be maintained for human safety. This includes managing roadside weeds to ensure clear visibility and eye-line, and to discourage mammals and reptiles from using roadside grasses as habitats and potentially causing road and railway hazards. Maintaining invasive grasses along the edges of these assets is also imperative in helping to prevent weed spread. The Northern Territory, Western Australia and Queensland transport departments all have management plans for mitigating their role in spreading weed seed but do not have explicit instructions on immediately controlling new incursions. The management plans focus on a more generalised need to control the weeds through the use of slashing, herbicide and manual removal, although they do discuss the benefits of minimising ground disturbance for a variety of ecological reasons (Mainroads Western Australia 2015; DBCA 2015; DTMR 2017; NT Gov 2021; DTMR 2013; Queensland Rail n.d.). The Northern Territory government is particularly proactive in providing guidelines on how industry and recreation, including telecommunication lines, can prevent the spread of weeds through immediate action and hygiene practices (NT Gov 2021). An informal comment that was made by several stakeholders is that an easy mitigation measure is to ensure that the direction of grading and slashing of roads and roadsides is undertaken in the direction of the existing grassy weed infestation, to avoid spreading the reproductive plant material. This, however, is not always performed.

Telstra's environmental site maintenance and remediation efforts outlined in their 'Health, Safety and Environment Framework for Telstra Suppliers of Services and Products' that to prevent the spread of weeds construction materials should not be sourced from sites with declared plants or infested with species likely to become environmental weeds, and that machinery operating in or travelling through areas with weed species should be cleaned to appropriate standards before traversing into 'clean' areas. The document does not talk discuss immediate pest management protocols.

Horizon power, an electricity company in Western Australia does have a vegetation management manual that discusses their use of herbicides and surfactants to treat weeds at the base of their electricity poles. The plan also outlines that minimal disturbance is to be

made when clearing land to install new poles so as to preserve the natural environment and discourage weed invasion (Horizon Power 2018). Ergon Energy in Queensland discusses on their webpage their clean down and land access protocols to manage their biosecurity obligations in accordance with the Queensland *Biosecurity Act 2014* (Ergon Energy 2021).

It is important to note that the weed management plans held by transport departments, telecommunications and electricity companies do not stipulate which weeds they are targeting. They only discuss weeds to be managed, in general terms, and do not specify that any of their actions are targeted at the listed species in the TAP.

When immediately managing new incursions, private land managers and ports seem to prioritise action, whereas other spread corridors owned by government or large businesses tend to focus on weed control when it might pose a risk to operations.

Action 5.3 Outcome/output

- Management actions implemented to reduce plant density and/or areas infested.

Action 5.3 encourages that where feasible, management actions should be implemented to permanently remove large infestations of these grasses, but also, to work to reduce the area and/or density of the infestation where it is not possible to eradicate.

This review has outlined many case studies where land managers have undertaken projects to eradicate and/or control the listed grasses on their properties. Particular examples have been given where Charles Darwin University, Kakadu National Park, Litchfield National Park, Northern Territory Defence properties, El Questro station and tourist resort, Mary River National Park and Greening Australia have taken action to eradicate large infestations of one or more of these grasses, and where that hasn't been possible, they have sought to reduce the area and density of the infestations by implementing control actions. To read these examples again, please refer back to case studies: (Charles Darwin University Case study 2.8) (Kakadu National Park case studies 2.6, 2.7, 3.2) (Litchfield National Park case study 2.12) (Department of Defence case study 2.10) (El Questro case study 2.9) (Mary River case study 2.5) (Greening Australia case study 2.18).

Throughout this review, examples of how conservation agencies, that manage and/or own their land holdings, have implemented action against the listed grass species in the TAP have also been included. Bush Heritage Australia, South Endeavour Trust and Australian Wildlife Conservancy are three prime examples of conservation agencies that give the land managers of their properties individual licence to control the weeds on their land. The agencies rely on the managers' expertise and ability to strategically utilise the resources at their disposal, and to make connections with local ranger and volunteer groups to help with any major conservation projects that they are hosting on their land ([Bush Heritage Australia] pers comm., 28 January 2021; [South Endeavour Trust] 2021, pers. comm., 5 February; [Australian Wildlife Conservancy] 2021, pers. comm., 4 February).

Action 5.4 Outcome/output

- High-priority areas subject to land rehabilitation programs where feasible

This action is a medium priority and encourages land managers, where feasible, to apply land rehabilitation methods to high-priority areas as they are cleared of the give listed grasses. This will help to reduce the likelihood of the grass infestations from re-establishing.

As previously discussed in this review there are two approaches towards rehabilitation after the removal of the listed species and/or other disturbances (e.g., land clearings, feral animals, and fire) have occurred; one is to actively rehabilitate with native species to choke out or shade out any invasive seedlings, and two, is to do nothing and let the native seeds in the soil seed bank germinate and rehabilitate the cleared site themselves. The second approach is the favoured of the two, particularly in wetland areas where olive hymenachne and para grass have been cleared, as the aim is to preserve the wetland and reduce the biomass in the waterway. Clearing up the waterway allows for native flora and fauna that rely on aquatic environments to return to the area and populate their indigenous habitat. Some of the restored species may be important to Indigenous heritage and amenity, so by allowing the waterway to remain clear, these resources can be further utilised. By following these two land rehabilitation schools of thought, ecosystem function and biodiversity can improve, and Indigenous cultural values, facilities and carbon farming environments are preserved. For more information about these two rehabilitation methods, please refer to case studies 2.13 and 2.14.

Action 5.5 Outcome/output

- Resources identified to implement priority management actions

This action is a high priority to be completed within 2-5 years of the TAP's inception. The TAP recognises that land management programs can be expensive depending on the available control methods and the size and extent of the infestations, and thus recommends that land managers identify available, cost-effective resources to implement priority management actions, as well as identify sources of funding. Having a static time frame of 2-5 years on this action seems ill-considered, given that the available resources and funding options are ever changing, depending on available research, technology, funding opportunities and management resources at any given time, let alone the changing extent of the existing, expanding, and new incursions. It is recommend that this action remain a high priority, but that the timeframe is changed to being fluid.

The available sources of external funding largely come in the form of state and federal government grants (see Appendix A). Funding may also come from private industry, but funding opportunities would be allocated at their discretion.

Through the NT Government run Gamba Action Program, land managers throughout peri-urban Darwin have access to free herbicide (limited), spray equipment loans and weed management advice for free, and can hire a contractor through the program to provide weed

control services, if the land manager needs the assistance (DENR n.d.). This program can help mitigate some of the costs of gamba grass management within Zones A and B.

Conservation groups and NRMs rely on the assistance of Traditional Owners and Indigenous Rangers to enhance local biodiversity in a range of conservation initiatives, including the control of the listed grasses. They also rely on volunteers in general (e.g., general public, Landcare groups) to work on tasks that require highly intensive labour ([Bush Heritage Australia] pers comm., 28 January 2021; ([Terrain NRM] 2021, pers. comm., 3 February 2021). TO's and rangers are instrumental in environmental monitoring and are engaged in active control actions by the organisations where possible. Often organisations will rely on the prior knowledge that these groups have of where the incursions are, which can save on their own monitoring costs, and sharing resources between the TOs and rangers, and conservation groups can also assist in the cost-effective implementation of management practices. There are usually costs associated with hiring rangers and Traditional Owners, in the form of remuneration. In instances such as Greening Australia's work on the Mungalla wetlands, the wetlands were situated on Mungalla Station, owned by the Nyqaiqi Aboriginal people. Working alongside the property owners and building relationships with rangers and TO's are critical in maintaining long-term stewardship of the land that the control measures were taken on. By establishing a long-term plan for the upkeep of the treated area, costs can be saved for ongoing management, as long as the landowner is proactive in maintaining the site. Unfortunately, this has not seemed to have occurred with the Greening Australia project in Mungalla wetlands and Crooked waterhole, with re-infestation having occurred ([Greening Australia] 2021, pers comm. 02 February).

Working together with external stakeholders and utilising their resources can help keep costs down. El Questro station conducted sporadic gamba grass control actions including burning the grass until 2017, when the environment manager of the property got an independent contractor to arrange for other stakeholders to work with the station to control the infestation. Independent contractors from the Northern Territory who had gamba grass specific experience were hired specifically to target the incursion. These contractors were familiar with the plant and knew how to identify it and enact control measures, including pulling out the offending plants, and drafting them. By contracting specialised people and coordinating with external stakeholders, El Questro station have managed to nearly control/eradicate their gamba grass infestation and save on internal labour and time costs. El Questro also has olive hymenachne, sighted in 2017 via aerial survey. It is a small, localised incursion that was treated with bioactive glyphosate to prevent it spreading and becoming a more costly problem. Now management of the incursion consists of monitoring up and down stream for new incursions and keeping a log and treating any plants that grow ([El Questro station] 2021, pers. comm., 19 February).

Terrain NRM is going to begin a grassy weed management project targeting olive hymenachne and para grass in Queensland in 2021 called 'Fish, Homes and Highways' in the Murray and Lower Herbert wetlands and coastal ecosystems (Terrain NRM 2020). This project will be strategic about where the work is done across the targeted floodplain to minimise spread. If you minimise spread, you can minimise the ongoing control costs. They will use direct herbicide, shade watercourses with revegetation and utilise fire management, all of which when used together can treat the existing incursion and prevent further re-infestations ([Terrain NRM] 2021, pers. comm., 3 February).

Glyphosate herbicide is still one of the most successful and cost-effective methods to manage these invasive grasses. It is the most widespread tool used as it has direct results and is easy to apply. The issue with glyphosate however is that it has off-target effects as it kills all plants and there are reports of its use leading to cancer in humans. It is, however, the most useful and powerful herbicide that is available to treat these grasses. As stated in case study 2.15, research has been conducted in Queensland to determine if there is another herbicide that is as effective as glyphosate that has less off-target effects. The closest option that was found was fluproprate which does kill gamba grass, but at very high concentrations, thus excluding it from being a cost-effective resource.

The use of fire to reduce the biomass of these grasses, and thus reducing the risk of future hot bushfires, is a popular tool used in northern Australia, however, the research indicates that unless it is a very hot fire that completely destroys the plant and its seed stock, then it will simply serve to further disturb the land, providing a larger area for the listed grasses to infest. It is difficult to create a controlled fire that is hot enough to achieve the desired effect without it further disturbing the land, thus this resource may not be as an effective method of control in the long run, due to its potential to cause a more widespread infestation (RIRDC 2011).

The listed grasses in the TAP were first introduced into Australia as pasture crops, so it is no surprise that a cost-effective control measure is to use cattle to graze on the grasses and keep them at a low enough height that they don't grow a seed head and create more plants. As South Endeavour Trust found, when they took the cattle off of the wetland on one of the reserves, olive hymenachne germinated and infested the site. Case study 2.2 demonstrates research that shows that bovine rotational grazing of gamba grass has a beneficial effect on controlling the pasture, while maintaining healthy and quick-growing livestock. A similar strategy has been used in Mungalla wetland, where the number of paddocks was increased, and rotation grazing was implemented. Olive hymenachne was being relied upon by the owners of the property as the pasture for their cattle. The aim of the rotational approach was to reduce the amount of olive hymenachne in the waterway, improve overall productivity and reduce the dependence on the ponded pasture in the wetland by grazing other grasses in the paddocks, thus reducing the conflict in removing the offending grass species (Greening Australia 2019). A problem with having cattle grazing these invasive grasses, is that you must have enough cattle on the land to keep the whole pasture at a low height, which can be costly to implement. There is also the ecological cost, as cattle movements can be destructive to fragile ecosystems such as wetlands and areas with heavy rainfall.

Buffalo are also believed to be a cost-effective resource to control olive hymenachne in the Top End as they graze the grass much in the same way as cattle. In the Arafura swamp in East Arnhem land, buffalo eat the olive hymenachne and there is concern that a successful buffalo control program would mean that the grass would spread. Louis Elliot (Weeds Management Team - Northern Territory Department of Environment, Parks and Water Security) theorised that if the buffalo were to be controlled in this area (there are ecological concerns surrounding the buffalo's presence in the swamp) then a spraying program would have to be implemented at the same time as the removal of the animals to prevent the olive hymenachne from spreading. This concern is supported by the botanists in the DAWE's North Australian Quarantine Strategy branch ([North Australian Quarantine Strategy branch] 2020, pers. comm., 14 December) who remarked that when buffaloes were removed from floodplains in the Top End that had para grass present, the grass' abundance increased.

While there are numerous cost-effective management options available to land managers, they often have high initial outlay costs. When interviewed Terrain NRM on 03 February 2021 and Bush Heritage Australia on 05 February 2021 both made the point that sights of grass infestations must be prioritised based on the key asset that they are threatening and often times, sites are prioritised where an outcome can be obtained to justify the cost of the control measures. While there are many tools available to land managers, with new technology being utilised including drones and satellites for mapping, and research being conducted into how to better use the existing control measures, the fact remains that the infestations of these grasses are widespread, particularly throughout Queensland and the Northern Territory, and land managers often don't have the monetary resources to fund the control programs that they need to conduct to control the larger infestations on their properties. Many stakeholders that were interviewed for this review made the observation that people are more likely to implement control action against smaller, more management infestations, where they can get a definitive result.

A common feedback that was received during this review process was that there isn't enough money available to implement the widespread effective control that is needed to tackle these grasses. Matters are also complicated when there aren't complementary weed statuses across Queensland, Northern Territory and Western Australia for the mission grasses and para grass, thus people are less likely to act on the existing infestations. Gamba grass is viewed as the worst of all of the listed grasses in the TAP due to its capacity to spread and the high biomass of an infestation, which causes bushfires to be much more destructive than a native grass fire. Feedback from stakeholders across the board was that the most cost-effective and effective control measure will be a biocontrol – but this does not exist yet.

Summary

- Action 5.1: An advisory group to inform the TAP has not been formed.
- Examples of cooperation across land tenures within northern Australia towards implementation of management programs were listed.
- A website that can be used to share information about the listed grasses in the TAP has not been developed.
- Action 5.2: Examples of immediate management actions that are undertaken by landholders have been listed, and the actions within the environmentally related management plans of organisations that are responsible for spread pathways have been outlined.
- Action 5.3: Management action examples by stakeholders were listed. Land managers are undertaking action to reduce plant density and/or areas infested on their properties. This action looks different for each landholding.
- Action 5.4: This point reiterated that land rehabilitation programs for high-priority areas consist of active planting of native grasses to choke out invasive seedlings and planting native species to shade out seedlings. Many stakeholders also choose to not revegetate the cleared area, opting to let native grasses germinate from the soil seed bank to revegetate the area.
- Action 5.5: outlined examples of cost-effective resources that are used by stakeholders to implement priority management actions.

- Action 5.5 also shouldn't have a static timeframe from after the formation of the TAP as the resources that are available for the implementation of priority actions may change depending on the user's circumstances.

Conclusions and recommendations

Objective 5 has five actions that aim to foster the implementation of coordinated cost-effective on-ground management strategies in high-priority areas. We can see by examining the progress made on each action that this is occurring, however, efforts are hindered by lack of funding and resources, as well as by the lack of a complementary weed status for all five listed species across northern Australia. Examples were provided where coordinated action is taking place across Western Australia, Northern Territory and Queensland, but there is still a lot of work to be done on this objective, which involved changing and evolving actions.

Objective 6 – Monitor, evaluate and report on the effectiveness of management programs

The rationale behind this objective is to help determine the success of management actions, management plans that should identify assets and include monitoring of managed sites. Reporting on progress and on the effectiveness of control activities will help to refine methodologies and priorities and assist in evaluating the success of this TAP.

Actions

6.1 Ensure that management plans for high-priority areas include recognition of the asset being protected as well as appropriate monitoring of managed sites. Encourage monitoring to enable the effectiveness of actions to be determined

6.2 Report on progress and effectiveness of management programs against their goals

Action 6.1 Outcome/output

- Management plans for high-priority areas that include monitoring and evaluation components
- Management plans linked to threatened species recovery plans where appropriate

Formal management plans are often formulated by corporations or organisations that are responsible for landholdings utilised by the general public. The review of this action includes two case studies, but would also like to mention the strategy used by Kakadu National Park - *A strategy for the conservation of threatened species and threatened ecological communities in Kakadu National Park 2014-2020* (Woinarski & Winderlich 2014). This paper details actions that can be taken to mitigate the threats in the park that impact on threatened species, many of which have recovery plans. This strategy though does not solely focus on threats from invasive grasses, instead concentrating on all threats to these species, and offers pathways to solutions.

Through stakeholder engagement, it was found that private enterprises and landholders have a more *ad hoc* approach to having management plans that include monitoring and evaluation components. There is an expectation set by conservation organisations that manage landholdings that the managers of each property are to monitor existing and new infestations and evaluate their management techniques based on their findings. Individual management plans for private landholdings are not published, and the activities conducted on the properties are at the discretion of the individual manager and the overarching conservation group ([South Endeavour Trust] 2021, pers. comm., 5 February). Typically, private landholders, including farmers, don't have formalised weed management plans. Each farm's weed control techniques and protection of any threatened species present on their property are of the individual's concern.

Case study 6.1 Litchfield National Park's monitoring, evaluation and links to threatened species recovery plans

Litchfield National Park has selected the most valued parts of the park to focus on for planning, action and monitoring. Rangers are to evaluate the conservation targets for each valued area of the park by giving an indicator measure rating of good, fair, poor or very poor. The ratings help influence the management techniques utilised against the invasive grasses and to uphold other biodiversity targets. Three types of monitoring are used to check the health of the biodiversity within the valued areas of the park. These are: Ranger field estimates at monitoring plots; detailed biodiversity surveys at fire monitoring plots including the use of camera traps and photo monitoring points; and remote sensing using NAFI and Landsat. Informal surveillance is also a part of other park duties and supports the three main monitoring activities. For monitoring of gamba grass and mission grass within the park, transect monitoring of plots for each habitat within the high-priority areas is conducted. The presence/absence of the target grasses around the outside of the plots is also noted (Royal Commission into National Natural Disaster Arrangements 2020; Department of Environment 2021).

The Litchfield National Park Integrated Conservation Strategy (2020) links to threatened species recovery plans by listing the listed species' habitats of concern as nested values under the Key Values. The species in the nested values list don't all have national recovery plans – some of them are considered threatened species by the Northern Territory or are deemed valued species by the park (Royal Commission into National Natural Disaster Arrangements 2020).

Case study 6.2 Charles Darwin National Park's monitoring, evaluation and links to threatened species recovery plans

Periodic monitoring of existing weed infestations occurs to evaluate the success of control programs within the park. Management strategies are formulated based on the findings of research and monitoring activities within the park. The weed management program for the park seeks to keep the highest-priority areas free from weed colonisation, and any Class B weeds found in the area through monitoring programs are to be eradicated. These areas are the western section of the Park and access tracks, roads, fence lines and key locations weed free. Regular surveillance is carried out for new weeds entering the park and to prevent the spread of existing weeds and periodic monitoring of existing infestations occurs which helps Rangers to evaluate future control programs. The park has found that storm water drains, and creek lines are an entry point for weeds to be transported into the park, including *Mimosa (mimosa pigra)*, mission grass, *stachytarpheta urticifolia* (Dark Blue Snakeweed), *Senna alata* (Candle Bush) and *Phyllanthus emlica*. These weeds add to the already present weeds of concern within the park, including gamba grass. Monitoring activities also help to inform the Fire Action Plan (DEPW n.d.) for the park, which is to be updated annually after consulting the NT Fire Service. Mosaic burning will take place to maintain habitat diversification in woodland areas and prescriptive burns will be utilised to protect the areas that have early curing rates or large fuel loads. Mission grass and gamba grass are both considered major threats to the park as they provide high fuel loads for fires and can spread through open undisturbed woodland whereas the other weeds present in the park largely remain confined to disturbed sites and drainage lines.

High priority is given to studying the area required to maintain healthy populations of Chestnut Rails and Beach Stone-Curlews and develop methods to monitor their populations. This management plan does not explicitly link with any specific threatened species recovery plans within its intended weed management actions. The appendix of the plan lists all of the flora and fauna species within the park, some of which are endemic to the area, and these are a high priority to protect from any ecological and man-made threats. Migratory species that have habitats within the park are also a high priority to protect, as per the international treaty – Bonn Convention and the bilateral agreements between Japan and China (DEPWS

Action 6.2 Outcome/output

- Reports provided on management programs

This action is a high priority with a timeframe of 1-5 years. Through researching the actions of this TAP, it has been found that most organisations have some form of reporting, to evaluate the implementation of management actions and to keep track of their grassy weed infestations and the success of the control methods. Any organisation or land manager, including NRMs and Greening Australia, that receive government funding for their weed control work are required to report to the funding body; for federally funded projects, they must report using the MERIT tool (within the Atlas of Australia web portal) every 6 months on the progress of the project and the actions that were taken. Often these projects don't concentrate on one of the weeds within the TAP – instead, the project may be trying to achieve another conservation objective, and to obtain that an element of weed control of one

or more of the listed grasses happens and is reported into MERIT. This reporting may be as simple as providing the number of hectares over which weed control has been conducted.

NRMs, e.g., Terrain NRM and FNQ NRM, have internal reporting systems and have their own mapping portals to plug their datasets into, but a broad roll-up of their work is still included into the MERIT system, if they have received government funding.

Internal reporting systems can use role-specific software, or they can be as simple as an excel spreadsheet with charts or observations and actions noted in a farm diary, for each landholding within an organisation ([Department of Defence] 2021, pers. comm., 21 January). Bush Heritage Australia uses ARC GIS software to map grasses and uses MIRADI software to produce internal reports and charts that uses information from management plans, threats and threat abatement work and budgetary data that has been inputted into the system ([Bush Heritage Australia] pers comm., 28 January 2021). Managers within the Australian Wildlife Conservancy are required to formulate annual work plans and report four times a year to the conservancy on their actions, including the control of weeds that they deem to be a concern ([Australian Wildlife Conservancy] 2021, pers. comm., 4 February). The South Endeavour Trust though, does not have a formal reporting structure for their management actions in place, preferring an *ad hoc* approach and relying on managers to know the outcomes of their weed control projects, with the Trust director, speaking with the managers and visiting the properties regularly. The Trust does report on projects funded by grants to the relevant funding body but does not have a system in place internally. The Trust focusses on the outcomes each manager produces, and if an action doesn't work, the approach is changed the following year ([South Endeavour Trust] 2021, pers. comm., 5 February).

Internal reporting also occurs for organisations including local governments who produce internal reports once they have enough data collated about their weed control actions (TCC 2020). This action has been achieved by many organisations and companies, but it's adoption may need to be increased by private land managers.

Case study 6.3 Prioritising Threatened Species in Northern Australia

The National Environmental Science Program's (NESP) Northern Australia Hub has conducted research in northern Australia to map the distribution of 1425 plant and animal species of conservation concern from terrestrial and freshwater ecosystems. Hotspot maps that show the numbers of species of conservation concern in a particular area were created, as well as maps of vulnerability that combine information on a species' distribution with the extent of a key threatening process and the sensitivity of that species to the relevant threat. Maps of key threatening processes, including the increased fire risk and altered landscapes caused by gamba grass are also being produced (NESP n.d.[d]; NESP n.d.[e]).

The maps generated by the monitoring and mapping project can help managers prioritise which species need most urgent conservation management by identifying those that are exposed to multiple processes that threaten their survival. Managers can make informed decisions on which species to prioritise in their conservation efforts and include the appropriate measures in their grassy weed management strategies (NESP n.d.[d]).

This project has also produced a user guide for the maps and data generated from this project, which includes a table of the threatened species modelled in this project, which includes species that have threatened species recovery plans (Pintor et al. 2019).

Summary

- Action 6.1 is a high priority that encourages landholdings to have management plans that include monitoring and evaluation components, the use of which is demonstrated by Litchfield National Park and Charles Darwin National Park's publicly available management plans. Private landholding's management plans often include these elements, but they are not formulated to as high a degree as those of publicly assessable holdings.
- Management plans could improve their linkages to any appropriate threatened species recovery plans.
- Action 6.2 asks for examples of reporting on management plans, with government funded projects reporting to the MERIT tool. NRMs have internal reporting processes on their management actions too, and conservancy groups also report internally. Report systems for individually owned landholdings are unknown.

Conclusions and recommendations

Objective 6 concentrates of the monitoring and reporting components of grassy weed management. This review has found that management plans to incorporate monitoring and evaluation components, but that their links to threatened species recovery plans aren't always a priority, with plans concentrating on eliminating the threat to the overall biodiversity of the land. Reporting on management programs does occur and can take the form of reporting to the funding body and there are often internal reports conducted for the interests of the land managers.

Contemporary issues

Inclusion of other grasses

Throughout the consultation process, stakeholders outlined that their concerns about invasive grasses extended beyond the five listed in the TAP. Grader grass (*Themeda quadrivalvis*), thatch grass (*Hyparrhenia rufa*) and buffel grass (*Cenchrus ciliaris* and *C. pennisetiformis*) were all listed as grasses of high ecological concern by NRMs, DAWE representatives, national park management plans, council biosecurity plans and conservation groups across the Northern Territory and Queensland. Grader grass has also been found in El Questro, in Western Australia. Various stakeholders also expressed concern about aleman grass (*Echinochloa polystachya*), Tully grass (*Urochloa humidicola*) and giant rat's tail grass (*Sporobolus pyramidalis*, *S. natalensis*), but not the extent of buffel, grader and thatch grasses.

Numerous stakeholders would like to see these three grasses also included in the TAP, due to them increasingly impacting on the biodiversity of northern Australia. This review recognises that buffel grass is a conflict species and has its own threat abatement advice and may not be able to be included in a reviewed version of the TAP, but this review does recommend investigating the potential to include thatch and grader grasses into a revised TAP.

Carbon farming

The Carbon Farming Initiative (CFI) is a voluntary carbon offsets scheme where land managers throughout northern Australia can earn carbon credits by changing land use or management practices to store carbon or reduce greenhouse gas emissions. Many Indigenous communities in northern Australia take part in this initiative which helps support local economies. Land managers that participate in the initiative conduct cool burns to help prevent hotter bushfires which release more carbon into the atmosphere. There are 899 identified properties that can be included in this scheme, however as of 2013, 199 have been excluded due to the gamba grass presence on the land. If gamba grass is found on a property designated for carbon farming, it will be removed from Savanna Burning Programs, and a permanent exclusion of 6.25-hectare region around the offending plants is implemented. This reduced amount of program viable land results in the loss of local income. This results in a strong motivation to keep Gamba Grass out, but unfortunately, it also results in a potential lack of willingness to report Gamba Grass. Gamba grass is a fire climax grass which means its high biomass contributes to a hotter and larger bushfire which can burn more savanna and trees than a typical native grass fire (Beaumont et al 2018).

Gamba grass threatens the future viability of many existing and potential individual carbon projects; thus, this review suggests that the government examine the issue of gamba grass and carbon farming and develop policy to mitigate under reporting of gamba grass on carbon farming properties.

Further WONS declarations

Through the research component of this review, it is evident that gamba grass and olive hymenachne receive the lion's share of funding and weed management across northern Australia. It has been suggested by numerous stakeholders that these grasses receive more attention than para grass, annual and perennial mission grasses due to them being declared

Weeds of National Significance (WoNS). This review recommends that the government investigate the plausibility of declaring para grass, mission grass and annual mission grass as WoNS. There has been no action taken towards complementary status of all five listed grasses in the TAP, and annual mission grass (*Cenchrus pedicellatum*) is still not declared as a restricted or prohibited weed in either Western Australia, Northern Territory or Queensland. Declaring all five species as WoNS would encourage land managers to take further action on para grass, mission and annual mission grasses, whilst also achieving complementary weed status across all jurisdictions to which the TAP applies.

Awareness of the TAP

Feedback from stakeholders was that many were not aware of this TAP's existence, and thus actions have not been taken in direct relation to the policy objective. Those that were aware of the TAP used the document in their government supported work. To increase awareness of the TAP, this review suggests that a requirement is made for funding program applications where the applicant must provide linkages to how their operational project will implement the actions within the TAP.

Looking Forward

This review has concluded that the key threatening process of the impact on northern Australia's biodiversity by the five listed grasses has not been abated and that the goals and objectives of the threat abatement plan have not all been met. While the Minister will make a decision about a future threat abatement plan according to the Environment Protection and Biodiversity Conservation Act, this review provides some recommendations should a new threat abatement plan be drafted.

Recommended updates include:

- Change the actions in objective 2 and 3, and objective 5 (action 5.5) to have fluid timeframes, rather than the static ones that the TAP currently stipulates. Technology, management plans, available resources, land manager circumstances and key assets constantly change, thus having the current static timeframes within the TAP should be changed to accommodate these in flux circumstances and to include land managers that have already established these actions within their own weed control methodology.
- Retain the actions that are considered 'completed' by this review, but change their timeframes to fluid, and change the wording to encourage land managers to 'maintain' and build upon their actions as they stand in accordance with the TAP.
- Add grader grass, aleman and thatch grass to the TAP and reword the document to allow the inclusion of further invasive grasses upon the advice of future reviews.
- More focus on wider community-based invasive grass control programs that involve on ground control on private and public land.
- New action: Develop and deliver communication strategies targeted at the general public and tourists to northern Australia to raise awareness of the listed grasses, the

threats posed by them and instruct them on how to avoid contributing to the spread of the grasses through their movements.

- New action: Undertake research into barriers to uptake of best practice control methods.
- New action: Develop economic models into the costings of controlling or eradicating the grasses where possible.
- New action: Develop economic models into the costings of the impact of the listed grasses if control efforts are not improved.
- New action: Encourage research into biological control agents for the listed grasses.

Conclusion

The 2012 ‘Threat abatement plan to reduce the impacts on northern Australia’s biodiversity by the five listed grasses’ aimed to address objectives that could help to abate the threat of grassy weed invasion and reduced biodiversity. There have been advancements in the past nine years and several actions outlined in the TAP have been achieved. There have also been advancements in the understanding of how to control these grasses and technology including drones and satellites are now being used in monitoring projects.

While information on how these grasses spread and advice on how to control the grasses is publicly available, and there are projects targeting these weeds, there are still barriers to uptake of best practice control methods, and ongoing work and resources need to be provided to ensure that land managers can identify the grasses and their impact, use cost-effective methods and gain experience in the use of the methods available. More effort is needed to engage farmers and conservation land managers to control these grasses, and eradicate where possible, both for the immediate future and to prevent further spread and degradation of northern Australia’s biodiversity.

A wider, landscape-scale approach to invasive grass management is needed, rather than the existing model of *ad hoc* projects undertaken by land managers, NRM and researchers. More financial and physical resources need to be made available, and a biocontrol agent for these grasses need to be explored and developed to add to the control toolbox. The CSIRO’s 2021 bid to the EIC to develop a biological control agent for gamba grass may provide a solution for the one species and may help to spur action to seek similar controls for the other listed grasses. The five grasses listed in the TAP are not the only invasive grasses impacting on the biodiversity in northern Australia, with others including grader grass, thatch grass and buffel grass of great concern to the region.

It is concluded that the issues raised in the 2012 TAP and its objectives are still valid in 2021 and likely to remain so into the future, but there are now more contemporary issues that the TAP needs to consider. Some revision of actions and their level of priority are required.

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APPENDIX A: Australian Government Funded Research

Below is a table that lists government funded projects that have involved an element of controlling one or more of the listed grasses in the TAP.

There are two different types of government funded projects listed below. The first table outlines the projects which have been conducted by external stakeholders, but which received Commonwealth funds. The second table lists the projects conducted by the National Environmental Science Programme (NESP) and projects conducted by the National Environmental Research Program (NERP). All of the NERP projects have been completed and took place between 2012-2015. The NESP projects have taken place between 2015-2021, with a mix of completed and ongoing projects. These projects are supported through funding from the Australian Government's National Environmental Science Programme, led by the Department of Agriculture, Water and the Environment, and works with a variety of researchers and academics.

For more information on the NESP and NERP projects, visit <http://www.nespnorthern.edu.au>.

Disclaimer: many of these projects may concentrate on a different ecological improvement plan, but as a part of the undertaken works, a listed grass may be also be addressed. The listed grass in the project may therefore not be the main focus of the funded works, nor are the grass control efforts the sole beneficiary of the funds allocated to the project.

Applicant name	Project Title	Project Description	Program:	Funding Length (years)
GAMBA GRASS				
Parks & Wildlife Commission of the Northern Territory	Gamba Grass Eradication and Containment in Litchfield National Park	The project aims to contain and eradicate Gamba grass in designated areas within Litchfield National Park. This will be achieved by implementing coordinated land management activities to protect key environmental assets from ecosystem degradation, habitat loss and species decline. The project will lead to better protection of other key assets such as visitor infrastructure and Aboriginal sites of significance. The project will also include adaptive monitoring and reporting activities to evaluate program effectiveness and promote awareness of the threat among relevant community stakeholders and ways in which they can assist.	Green Army Green Army Round 2	6 months
Parks & Wildlife Commission of the Northern Territory	Gamba Grass Eradication and Containment in Litchfield National Park	The aim of the proposal is to build on the work previously done through Round Two of the programme. The project will eradicate Gamba grass in designated areas within Litchfield National Park. This will be achieved through the implementation of coordinated land management activities to protect key environmental assets from ecosystem degradation, habitat loss and species decline. The project will also lead to better protection of other key assets such as visitor infrastructure and Aboriginal sites of significance. The project will also include adaptive monitoring and reporting activities to evaluate program effectiveness and will promote awareness of the threat among relevant community stakeholders and ways in which they can assist.	Green Army Green Army Round 3	6 months
Tablelands Regional Council	Strategic eradication, containment, & reducing the risk	Gamba grass (<i>Andropogon gayanus</i>) is listed as a key threatening process under the EPBC Act 1999 and is acknowledged as one of the most significant weeds of Australia's northern savannah with well documented cultural, social, environmental and economic impacts. The links between gamba grass and increased fire intensity pose a	Biodiversity Fund Round 1	4.5 years

	of spread of Gamba grass	significant threat to the future of biodiverse carbon management in the savannah communities of Far North Queensland. This project will implement a collaborative management plan for strategic eradication, containment, and reduction of the risk of spread of gamba grass across Cape York Peninsula and Far North Queensland through a coordinated multi-agency and cross-regional response.		
Territory NRM	CFoC Regional Delivery of NRM priorities for the Top End of the Northern Territory	One of the four NRM regions, the Top End is the most heavily populated region with the highest concentration of development activities, but also the largest area of undeveloped coastline and wetland habitat in the Northern Territory. The highest priority threats to ecosystem health include feral species (primarily water buffalo, cane toads and feral pigs), invasive weed species (particularly Gamba grass and other WoNS), inappropriate fire regimes and climate change. In addressing these regional priorities for the preservation of threatened species and ecological communities, it is essential to not only build community (including indigenous) capacity for on-ground actions but to develop and share a comprehensive knowledge base for all NRM participants.	Caring for Our Country 2 Regional Delivery 1318	2 years

Batchelor Institute of Indigenous Tertiary Education	Kungarakan Warai Landcare Project Planning	This Project will engage a Facilitator to develop a document with the Warai and Kungarakan Traditional Owners of the Finnis River Land Trust Area. The document will determine the resources and goals necessary to, and develop a grant application for a Rangers Project Proposal. This proposal is in response to the critical land matters compromising Kungarakan and Warai homelands, the critical threat to the environment and its woodlands; weeds of national significance in treating and eradicating Gamba grass and Mimosa. The project Works on the relinquished Woodcutters Mine and builds a responsive long term capability to work across the harmful environmental exposure of the abandoned Rum Jungle mine and threatened downstream areas.	Caring for Our Country 2 Community Environment Grants 1314	1 year 4 months
Australian Trust for Conservation Volunteers	Connecting corridors of green: A united urban & peri urban landcare approach	The Darwin area has peri-urban and coastal landscapes which contain significant biodiversity values supporting nationally threatened species. Native vegetation communities around Darwin are under pressure from urbanisation, industrialisation, wildfire and fire-promoting weeds. For over 15 years Landcare groups have been active within the region, however major threats have not been managed strategically to date. This project will create a coordinated partnership by bringing stakeholders together to protect, extend and reinforce vegetation communities and manage threats to the regions biodiversity by reducing the extent of invasive species, managing wildfires, re-vegetating key sites and building capacity through training and education.	Biodiversity Fund Round 1	6 years
Australian Wildlife Conservancy	Strategic control of invasive grasses & riparian weeds at 4 regional sites	The project will deliver strategic weed control at 4 sites in each of the 4 major regions of Nth Australia (Kimberley, Top End, Gulf, Cape York). The project will focus on weeds with greatest potential impact on ecological health & landscape connectivity – invasive grasses that disrupt fire regimes & riparian weeds that degrade veg structure. At each site, these weeds are present at relatively low infestations; reducing densities below target levels will prevent them from being unmanageable in the future. Sites include multiple properties of	Biodiversity Fund Round 2 – Northern Landscape Strategy	3.75 years

		mixed tenure that link to protected areas. Sufficient preliminary work (mapping, trial control, stakeholder engagement) has been carried out over the past 1-3 years to ensure the project's success.		
Territory NRM	Engaging our Communities	This project will engage and support community participation in planning, capacity development and knowledge sharing activities to enhance regional collaborations and deliver improved on ground environmental and sustainable production outcomes. Activities will include regional forums, workshops, training opportunities and the NT NRM Conference. The project will also enhance community participation in on ground activities that maintain environmental values of Sites of Conservation Significance and other sensitive habitats, and support voluntary proactive initiatives such as the Darwin Harbour Clean-up event. TNRM's Indigenous Traineeship Program will provide trainees with on the job and formal training and placement with Indigenous host organisations.	National Landcare Programme Regional Funding	3.5 years
Territory NRM	Managing our Landscapes	Land managers will be engaged and supported to plan and implement coordinated cross tenure management actions to maintain the health and environmental values of landscapes and ecosystems in the NT. A range of on-ground works will be delivered to implement appropriate fire regimes and reduce the threat of Weeds of National Significance and vertebrate pests identified as regional priorities under the NT INRM Plan and Threat Abatement Plans. Actions will also target the maintenance of environmental values of Sites of Conservation Significance and implement Threat Abatement Plan actions associated with marine debris.	National Landcare Programme Regional Funding	3.5 years
Cape York NRM	Thenacull station natural and cultural management program -Stage 2	The project will work with the traditional owner families, whose country covers and extends outside of Maryvalley station, north of Laura, to build skills and capacity to work towards a future land and sea ranger program. The project will build management knowledge, skills and capacity through: accredited training, practical on-country cultural heritage, wetland and timber assessments, plant and animals surveys, a review and update of existing collated traditional	Green Army Green Army Round 4	5 months

		knowledge materials including fire and wetland traditional and contemporary management plans and video graphic materials, training in endangered species management specifically the Golden Shouldered Parrot, pest and weed management, and fencing of significant species.		
Cape York NRM	Thenacull station natural and cultural management program -Stage 1	The project will work with the traditional owner families, whose country covers and extends outside of Maryvalley station, north of Laura, to build skills and capacity to work towards a future land and sea ranger program. The project will build management knowledge, skills and capacity through: accredited training, practical on-country cultural heritage, wetland and timber assessments, plant and animals surveys, a review and update of existing collated traditional knowledge materials including fire and wetland traditional and contemporary management plans and video graphic materials, training in endangered species management specifically the Golden Shouldered Parrot, pest and weed management, and fencing of significant species.	Green Army Green Army Round 4	5 months
Cape York NRM	Maryvalley Station natural and cultural management program -Stage 1	The project will work with the traditional owner families, whose country covers and extends outside of Maryvalley station, north of Laura, to build skills and capacity to work towards a future land and sea ranger program. The project will build management knowledge, skills and capacity through: accredited training, practical on-country cultural heritage, wetland and timber assessments, plant and animals surveys, a review and update of existing collated traditional knowledge materials including fire and wetland traditional and contemporary management plans and videographic materials, training in endangered species management specifically the Golden Shouldered Parrot, pest and weed management, and fencing of significant sites.	Green Army Green Army Round 4	5 months
Cape York NRM	Thenacull station natural and cultural	The project will work with the traditional owner families, whose country covers and extends outside of Maryvalley station, north of Laura to build skills and capacity to work towards a future land and	Green Army Green Army Round 4	

	management program -Stage 3	sea ranger program. The project will build management knowledge, skills and capacity through: accredited training, practical on-country cultural heritage, wetland and timber assessments, plant and animals surveys, a review and update of existing collated traditional knowledge materials including fire and wetland traditional and contemporary management plans and video graphic materials, training in endangered species management specifically the Golden Shouldered Parrot, pest and weed management, and fencing of significant sites.		
Territory NRM	CFoC Regional Delivery of NRM priorities for the Gulf Savanna of the Northern Territory	One of four NRM regions, the Gulf Savanna is an area of low population density and has a high concentration of pastoral land. It also includes a stretch of coastline extending along a large portion of the Gulf of Carpentaria. The highest priority threats to ecosystem health include feral species (such as cats and pigs), invasive species (Prickly acacia, Bellyache bush), inappropriate fire regimes and climate change. In addressing these regional priorities, it is essential to not only build community (including indigenous) capacity for on-ground actions but to develop and share a comprehensive knowledge base for all NRM participants.	Caring for Our Country 2 Regional Delivery 1318	2 years
RLP Territory Natural Resource Management Incorporated	Protecting the extraordinary natural values of the Northern Territory's Top End	This project addresses critical threats to protect some of Australia's most extraordinary natural values encompassed by the Kakadu WHS, the Kakadu Ramsar wetlands the Arnhem Land Plateau Sandstone Heath threatened ecological community, as well as the habitats of priority EPBC listed species (the Yellow Chat and the White Throated Grass Wren). The principle foci for activities will be in buffer zones surrounding the WHA to further enhance activities being undertaken within the World Heritage area. The project will facilitate a coordinated multi-stakeholder approach to controlling the spread of priority weeds and managing the impacts of feral animals within buffer zones. It will further mitigate key threats to Arnhem Land Plateau Sandstone Heath by coordinating fire management to	National Landcare Programme – Regional Land Partnerships	Ongoing (5 years)

		reduce the risk of destructive fires sweeping into fire sensitive landscapes and the habitats of EPBC listed species.		
Cape York – RLP NQ NRM Alliance Ltd	Biodiversity Bright Spots: Golden-shouldered parrot	This project will work with the Golden-shouldered Parrot Recovery Team to build and establish partnerships between land managers, Traditional Owners, scientists and government to implement actions contributing to the recovery of the endangered Golden-shouldered parrot. An EOI investment program will guide the implementation of on-ground activities to address known and emerging threats. These EOI projects will be adaptively implemented and monitored to determine effectiveness. Scientific, local and cultural knowledge of Golden-shouldered parrots, their habitat and threats across their range will also be increased. Overall, through collaboration with key partners, this project will deliver outcomes that will contribute towards stabilising or improving the trajectory of GSPs across the entire known range of the species.	National Landcare Programme – Regional Land Partnerships	Ongoing (4 years 4 months)
Northern Gulf – RLP NQ NRM Alliance Ltd	Biodiversity Bright Spots: Golden-shouldered parrot	This project will work with the Golden-shouldered Parrot Recovery Team to build and establish partnerships between land managers, Traditional Owners, scientists and government to implement actions contributing to the recovery of the endangered Golden-shouldered parrot. An EOI investment program will guide the implementation of on-ground activities to address known and emerging threats. These EOI projects will be adaptively implemented and monitored to determine effectiveness. Scientific, local and cultural knowledge of Golden-shouldered parrots, their habitat and threats across their range will also be increased. Overall, through collaboration with key partners, this project will deliver outcomes that will contribute towards stabilising or improving the trajectory of GSPs across the entire known range of the species.	National Landcare Programme – Regional Land Partnerships	Ongoing (4 years 5 months)
RLP NQ NRM Alliance Ltd	Catchments to Coral – GBR Coastal ecosystems and	Over 80% of eastern Cape York's coastal ecosystems are now either Aboriginal freehold or Cape York Peninsula Aboriginal Land (jointly managed with QPWS). The project will partner with local land management groups to: identify threatened ecological values or	Reef Trust – Reef Trust 7 – Coastal	Ongoing (3 years)

	species protection on Cape York	services they aspire to protect/restore; support the implementation of priority, strategic and targeted threat abatement actions; and, build community capacity for sustainable management of significant coastal habitat beyond the life of the project. The initial investment focus will be in the northern and central catchments, where there has been little investment in the past, supporting regional growth through direct employment on Country. Some 'no regrets' projects within the southern catchments, where there are more land managers and a greater capacity to deliver projects, is also planned.	Habitat and Species	
Greening Australia NT INC	Seedlings for Success	The project aims to assist landholders in rehabilitating their properties for nature conservation and to provide suitable habitat for the Black-footed tree-rat, by providing tubestock of key species to kickstart establishment of the native vegetation. The project will also increase the capacity of Land for Wildlife members and the general public in the areas of native plant identification, seed collection, site preparation techniques and native plant propagation through three 2 day workshops. Up-skilling landholders in revegetation techniques supports landholders who are interested in integrating nature conservation on their properties and contributes towards improved habitat quality, protection and restoration of remnant vegetation.	National Landcare Programme 20 million Trees Grants Round 2	3 years
Territory NRM	Improving our Natural Resource Base	This project will support sustainable practice change by farmers and fishers to maintain the long term production values and ecosystem services of the natural resource base for primary production in the NT. A range of on-ground works will be delivered to reduce the threat of weeds, vertebrate pests and soil loss on agricultural production, while the Territory Conservation Agreement Program will support adoption of innovative multiple-use strategies. The project will be delivered in partnerships with producers and industry groups to enhance involvement, up-take and leveraging of resources. Communication, engagement, and adoption pathways will reflect the needs and priorities of producers and will be supported by the NT Regional Landcare Facilitator.	National Landcare Programme Regional Funding	3.5 years

Barron River Catchment Management Association Incorporated	Slowing Storm-water run-off in catchments in the Atherton region	This project will deliver a plan of strategic on-ground works, as well as a range of strategic systems repairs activities to improve the quality of water run-off from agricultural and urban lands in the Atherton area. It will bring together actions from the many existing and new plans providing a whole of catchment framework for strategic action. This project will provide the Atherton Community with the first real opportunity to carry out extensive on-ground works to improve the water quality of the run-off in areas that end in high erosion sites. Through undertaking strategic whole of sub- catchment prioritization, in partnership with Tablelands Regional Council, the pressure will be reduced at the very high intensity erosion sites.	Biodiversity Fund Reef Rescue 2013/14	6 years
Rangelands Region	Reducing risk to Bilby habitat across the northern rangelands	The project will facilitate the engagement of Traditional Owners, Indigenous Rangers and pastoralists into complementary initiatives coordinated by Rangelands NRM to address known threats (unmanaged fire, predation and weeds) to active Greater Bilby habitat and protect EPBC listed Monsoon Vine Thickets (ecological communities). Rangelands NRM will engage and encourage continued collaboration between individual groups and/or collectives of Traditional Owners and their ranger programs (including Kimberley Land Council, Kanyirninpa Jukurrpa and Desert Support Services) as well as innovative pastoral producers, Department Biodiversity Conservation and Attractions (DBCA), Environs Kimberley, and Pilbara Mesquite Management Committee (PMMC). On-ground works will be focused around National Recovery Plan listed threats in priority areas with recently identified active populations to protect and improve bilby population trajectory in the WA rangelands over the next five years.	National Landcare Programme – Regional Land Partnerships	Ongoing (4 years 9 months)
Trees in Newcastle	Restoration of threatened species habitat	<ul style="list-style-type: none"> • Landscape connectivity in the Williams River and the Hunter Estuary Ramsar wetlands are under threat, affecting the ability of native fauna to move through the landscape. • Invasive plant species are threatening native vegetation and must be controlled to conserve biodiversity, particularly habitat for threatened species. • Trees in 	Biodiversity Fund Round 1	6 years 2 months

		Newcastle aims to:• Control environmental weeds and invasive species on a 9.8 Ha property managed entirely for conservation.		
PARA GRASS				
The Trustee for Wet Tropics Biodiversity Foundation	Revegetation of Lower Babinda Creek	The project revegetates 10ha of Babinda Creek. Revegetation with native species in riparian areas prepares endangered Regional Ecosystems for adaptation to climate change, with stabilisation of the banks reducing sediment load to the GBR Lagoon. Planting with framework species in adjacent areas provides for long-term reinstatement and connectivity between fragmented stands of endangered remnant Alexandra Palm (<i>Archontophoenix alexandrae</i>) Forest and Simple-Complex Mesophyll to Notophyll Vine Forest. The plantings include both threatened plant species and food source for endangered Southern Cassowary and other native fauna.	National Landcare Programme 20 million trees grants Round 2	2.5 years
Reef Catchments (Mackay Whitsunday Isaac) Limited	Protecting Species, Ecosystems, Coasts and Communities: Inland Sub-project	The Inland sub-project is a multi-species and ecosystem recovery project in the plains and ranges landscape of the Mackay Whitsunday Isaac region. This will be accomplished by landscape level amelioration of key threats on biodiversity values, in addition to specific threats acting on species and ecosystems identified by existing recovery plans, conservation advices and threat abatements plans	National Landcare Programme Regional Funding	3.5 years
BIOME 5 Pty Ltd	Thiaki Creek Rainforest Restoration Project for Biodiversity Recovery and Carbon	Sustained weed control, and tree growth and carbon monitoring for 16 ha established rainforest reforestation plots, and 12 ha of new plantings. The first stage of reforestation, in Jan 2011, was a planting of 27,000 seedlings of 25 native species. We need funds to complete weed control around the seedlings. We plan to plant 13,000 more seedlings on 12 ha. Our goals are to reconnect two parts of a large isolated remnant of highly fragmented endangered RE 7.8.4 forest, and to quantify the long-term trade-offs among cost effectiveness, biodiversity recovery and carbon pool development. We surveyed biodiversity and carbon pools before tree planting and propose to track changes in these and forest structure for 20 years.	Biodiversity Fund Round 1	5 years

MISSION GRASS AND ANNUAL MISSION GRASS				
Barwon Coast Committee of Management Incorporated	The Barwon's coast barrier sand dune system critical habitat protection	To enhance the habitat and population for: recognised nationally significant plants, Austral lotus threatened plant community Moonah Woodland. Support the breeding success of the Hooded Plover. To control threats such as pest plants, Bridal Creeper, invasive grass weeds, and woody weeds. To support community access to desired features in a managed manner. To provide opportunities for participants to participate in a work team environment and gain practical skills. Develop awareness and understanding of the coastal environment.	Green Army Green Army Round 1	6 months
Mulgrave Landcare and Catchment Group Inc	Corridor enhancement in Mulgrave Catchment, Wet Tropics	Fragmentation of riparian and wetland vegetation and near-threshold levels of invasive weeds are limiting the critical-mass benefits and connectivity to existing World Heritage Areas, of existing, relatively intact vegetation along the Mulgrave River, its tributaries and wetlands. Over 6 years, biodiverse plantings in larger degraded areas, riparian gaps & wetland fringes will be complimented by control of threatening hymenachne and pond-apple populations. Work will joint between 21 private landholders and the Mulgrave Landcare Group which has a high capacity and proven track-record for such work. This group will use a combination of volunteer effort and a work / training unit composed of trained staff and indigenous and other local youth.	Biodiversity Fund Round 1	6 years
South West Catchments Council	South West Environment	The South West Environment Project will work at a landscape scale across the South West NRM region to protect biodiversity and restore ecosystem function and resilience. It will help reduce the loss of natural habitat, degradation and fragmentation by targeting priority assets and sites such as landscape corridors and ecological refugia. Key objectives of this project are to: 1. Protect and conserve Matters	National Landcare Programme Regional Funding	3.5 years

		of National Environmental Significance including management of Ramsar Wetlands, Listed EPBC species and ecological communities by protecting and rehabilitating habitats through weed and pest control, revegetation activities and fencing. 2. Manage threatened ecosystems, habitat and native species through implementation of threat abatement plans, regional biodiversity management plans and appropriate management actions 3. Working with the community and project partners, protect and manage the South West coastline by carrying out coastal rehabilitation, beach cleanup events and raising awareness of coastal management issues. 4. Carrying out further research on the Ramsar listed Vasse Wonnerup wetland which will result in better understanding of its threats, management issues and will provide key management recommendations and strategies to protect this Commonwealth priority site in the future. 5. Build community awareness of biodiversity values, skills, participation and knowledge including Indigenous participation to promote conservation and sustainable use of biological diversity through events, workshops, on-ground implementation and field days. 6. Engagement of the Aboriginal community through consultation and participation in NRM project delivery.		
OLIVE HYMENACHNE				
Pioneer Catchment & Landcare Group Inc	The Rehabilitation of Reliance Creek Palm Vine Forest	This project aims to extensively reduce Cat's Claw Creeper (<i>Macfadyena unguis-cati</i>) & eradicate Hymenachne (<i>Hymenachne amplexicaulis</i>) in Reliance Creek National Park & adjoining properties, with revegetation, monitoring & control to ensure long-term outcomes. Reliance Creek National Park and adjoining properties contain approx 34ha of endangered palm-dominated lowland rainforest (RE's 8.3.1, 8.3.5). Cat's Claw Creeper is prevalent, taking over the canopy. Hymenachne infestations are sporadic but persistent, preventing natural recruitment. Pioneer Catchment & Landcare Group Inc will work collaboratively with	Biodiversity Fund Round 1	4 years

		local government representatives, adjacent landholders & National Park managers and assist them with advice & on-ground support.		
Fisheries Research & Development Corp	Revitalising Estuaries & Wetlands for Carbon storage, Biodiversity, Fisheries	Many of Australia's estuaries and wetlands have lost their ecological function to the detriment of carbon sequestration, biodiversity and fisheries productivity. Biodiversity Fund resources will undertake works in two case study areas - northern NSW floodplains [Clarence River] and the Great Barrier Reef catchments [Burdekin Barrattas]. Partners will be Fishing Industry Associations in NSW [Professional Fisherman's Association], Qld [Seafood Industry Association], Great Barrier Reef Marine Park Authority, Fisheries R&D Corporation, NRM groups and the community. Cash co-investment will build on these case studies to collate information nationally that demonstrates the investment opportunities and benefits for estuarine and wetland repair.	Biodiversity Fund Round 1	3 years
Cape York NRM	Conservation actions for enhancing wetlands of national significance, springs and waterways	This project contributes to targets of the National Convention of Biological diversity, the Kyoto Protocol, the United Nations Framework Convention on Climate change, the Australia's Biodiversity Conservation Strategy, and the Environment Protection and Biodiversity Conservation Act (EPBC) - Matters of National Environmental Significance by maintaining and/or enhancing the ecological characteristics of Wetlands of National Significance, including mitigating impacts on the Great Barrier Reef. As well as providing resources for community engagement and participation in the planning and delivery of on-ground works, the project will contribute to improving adaptive management and resilience of the assets and an increase in the Region's NRM knowledge base. It will work with land managers and community partners to deliver on-ground works and integrate project activities to achieve an increase in protection, rehabilitation and restoration of these areas. This program will contribute to the delivery of the Cape York NRM Plan adaption pathway target of 'protected and repaired freshwater and marine systems, 'impacts to threatened species reduced,' 'appropriate fire	National Landcare Programme Regional Funding	3.5 years

		management,' 'Preparedness for weather extremes' and the long term National Landcare Programme objectives of 'communities protecting species and natural assets'.		
RLP NQ NRM Alliance Ltd - Cape York	Catchments to Coral – GBR Coastal ecosystems and species protection on Cape York	Over 80% of eastern Cape York's coastal ecosystems are now either Aboriginal freehold or Cape York Peninsula Aboriginal Land (jointly managed with QPWS). The project will partner with local land management groups to: identify threatened ecological values or services they aspire to protect/restore; support the implementation of priority, strategic and targeted threat abatement actions; and, build community capacity for sustainable management of significant coastal habitat beyond the life of the project. The initial investment focus will be in the northern and central catchments, where there has been little investment in the past, supporting regional growth through direct employment on Country. Some 'no regrets' projects within the southern catchments, where there are more land managers and a greater capacity to deliver projects, is also planned.	Reef Trust – Reef Trust 7 – Coastal Habitat and Species	Ongoing (3 years)
The Trustee for Wet Tropics Biodiversity Foundation	Revegetation of Lower Babinda Creek	The project revegetates 10ha of Babinda Creek. Revegetation with native species in riparian areas prepares endangered Regional Ecosystems for adaptation to climate change, with stabilisation of the banks reducing sediment load to the GBR Lagoon. Planting with framework species in adjacent areas provides for long-term reinstatement and connectivity between fragmented stands of endangered remnant Alexandra Palm (<i>Archontophoenix alexandrae</i>) Forest and Simple-Complex Mesophyll to Notophyll Vine Forest. The plantings include both threatened plant species and food source for endangered Southern Cassowary and other native fauna.	National Landcare Programme 20 million trees grants round 2	2.5 years
RLP NQ NRM Alliance Ltd	Fish Homes and Highways: Restoring and protecting fish nursery and pathway values	This project will restore and protect the nationally-significant coastal ecosystem values of the Murray and Lower Herbert Basins, addressing key threats to connectivity and wetland health. The project will maximise benefits flowing to communities, including Traditional Owners, strengthening stewardship and partnerships that will sustain outcomes beyond the timeframe of the project.	Reef Trust – Reef Trust 7 – Coastal Habitat and Species	Ongoing (3 years)

	of the Murray & Lower Herbert Coastal Ecosystem			
Reef Catchments (Mackay Whitsunday Isaac) Limited	Protecting Species, Ecosystems, Coasts and Communities: Inland Sub-project	The Inland sub-project is a multi-species and ecosystem recovery project in the plains and ranges landscape of the Mackay Whitsunday Isaac region. This will be accomplished by landscape level amelioration of key threats on biodiversity values, in addition to specific threats acting on species and ecosystems identified by existing recovery plans, conservation advices and threat abatements plans	National Landcare Programme Regional Funding	3.5 years
Cape York NRM	Water Quality Improvement Plan – Cape York NRM	Project will identify environmental regional water assets and threats to the quality of these assets. The NRM body will undertake planning, supporting scientific studies and community consultation required to effectively prioritise investments in regional water quality improvement and ecosystem restoration. The outcomes of the prioritised investments will be improved health and resilience of the Great Barrier Reef ecosystem, and the protection of the ecosystem services it provides.	Caring for Our Country 2	1.5 years
Mungalla Aboriginal Corporation for Business	Restoration of a biodiverse north Queensland coastal wetland	The Mungalla wetlands, which are adjacent to the World Heritage Great Barrier Reef lagoon and the IUCN listed Halifax Bay Wetlands National Park, have been degraded by invasive plant species and human-induced changes to hydrological and nutrient regimes. While biodiversity values have been compromised there is excellent capacity for restoration. Through this project the Nywaigi Traditional Owners will recover these values by re-establishing natural hydrological connections, revegetating riparian corridors and wetland margins and managing the invasive plant species. These activities align with the recently devised Mungalla Wetlands Management Strategy.	Biodiversity Fund Round 1	6 years
Greening Australia	Restoration of Great Barrier	Project to rehabilitate wetlands and coastal ecosystems in partnerships with landholders along the Reef.	Reef Trust Reef Trust	3.5 years

	Reef Wetlands and Coastal Ecosystems		Phase 3 Investment	
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