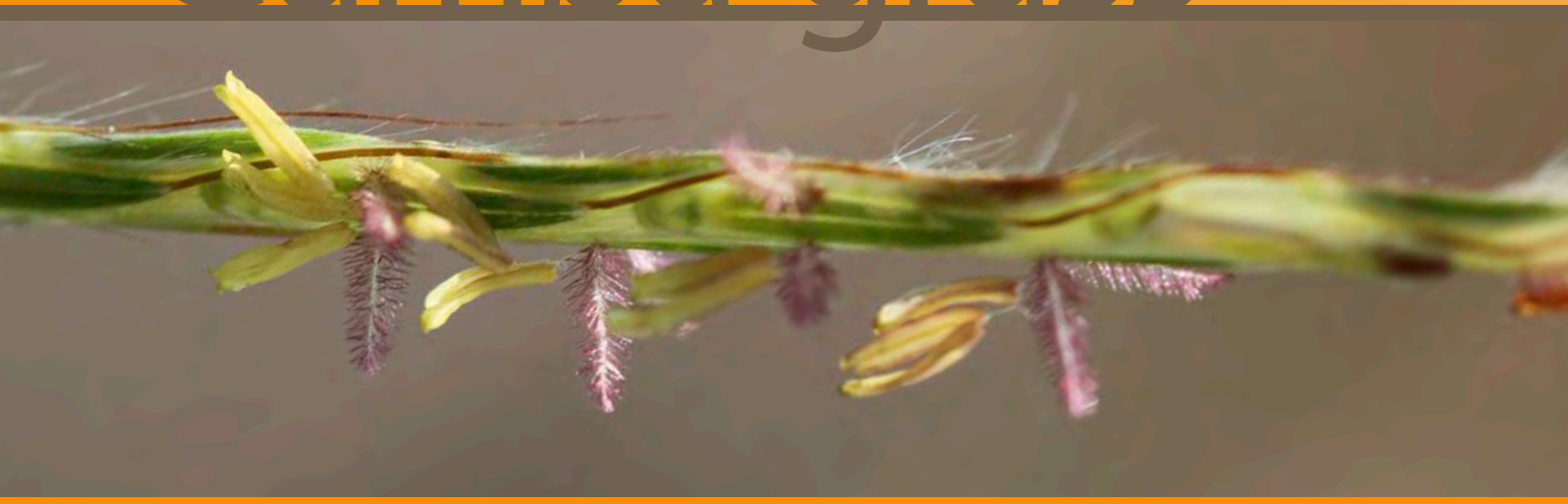
Australian Government
Department of Agriculture, Fisheries and Forestry

Weeds of National Significance

Gamba grass



National best practice management manual for gamba grass (*Andropogon gayanus*)

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2024

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We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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Principal authors and compilers

Matt Sheehan, Wild Matters Pty. Ltd.

Shauna Potter, Wild Matters Pty. Ltd.

Case study and chapter contributors

ACCESS (Australian Centre for Culture, Environment, Society and Space)

Diego Alvarez, formerly Territory Natural Resource Management

Susanne Casanova, Territory Natural Resource Management

David Connely, Tipperary Station, NT

Djurrubu Rangers, NT

Steve Dwyer, Department of Tourism and Hospitality, NT

Roderick Edmonds, Department of Tourism and Hospitality, NT

Darryn Higgins, Cook Shire Council, Qld

Cameron Heeb, Douglas Daly Research Farm, NT

Jamie Marschall, Douglas Daly Research Farm, NT

Natalie Rossiter-Rachor, National Environmental Science Program (NESP) Resilient Landscapes Hub

Samantha Setterfield, University of Western Australia

Tim Schatz, Department of Agriculture and Fisheries, NT

John-Paul Slaven, Department of Primary Industries and Regional Development, WA

Rachael Thurlow, Territory Natural Resource Management

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National Gamba Grass Reference Group

Jennifer Atchison, University of Wollongong, NSW (JA acknowledges funding from the Australian Research Council FT200100006)

Paul Brown, Napranum Aboriginal Shire Council, Qld

Susanne Casanova, Territory Natural Resource Management

John Clarkson, formerly Queensland Parks and Wildlife Service

Rowena Eastick, formerly Territory Natural Resource Management

Emily Fagg, Northern Territory Cattlemen's Association

Keith Ferdinands, Northern Land Council, NT

Michelle Franklin, Department of Lands, Planning and Environment, NT

Shelley Inglis, Department of Lands, Planning and Environment, NT

Cameron JAWAI, Napranum Aboriginal Shire Council, Qld

Natalie Rossiter-Rachor, National Environmental Science Program (NESP) Resilient Landscapes Hub

Travis Sydes, Far North Queensland Regional Organisation of Councils

Wayne Vogler, Department of Primary Industries, Qld

Others

Emma Burcher, Department of Lands, Planning and Environment, NT

Jan Carson, South Endeavour Trust, Qld

Pauline Cass, Gamba Grass Roots, NT

Dave Chemello, Department of Biodiversity, Conservation and Attractions, WA

Natasha Clayton, Northern Territory Cattlemen's Association

Chris Collins, Department of Agriculture and Fisheries, NT

Louis Elliott, Department of Lands, Planning and Environment, NT

Leasie Felderhof, Firescape Science, Qld

Laura Fernández, Wild Matters Pty. Ltd., NSW

Darryn Higgins, Cook Shire Council, Qld

Raine Hitch, Rio Tinto, Qld

Kate Hodge, Hodge Environmental, Qld

Tim Hughes, South Endeavour Trust, Qld

Louise Kean, Department of Tourism and Hospitality, NT

Des Land, Rio Tinto, Qld

Robert Millar, Queensland Parks and Wildlife Service

Xav Murray, South Endeavour Trust, Qld

Andy Peart, Weedwalkers Top End Landcare Group, NT

Tom Price, Northern Land Council, NT

Farzin Shabani, Macquarie University, NSW

Andrew Storrie, Agronomo, SA

Jane Thomas, Jane Thomas Science Communication, NT

John Virtue, JG Virtue Biosecurity Services Pty. Ltd., SA

John Witheridge, South Endeavour Trust, Qld

Additional information sources

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NESP Resilient Landscapes Hub

Gamba grass invasion near Batchelor, Northern Territory.

Using this manual

Who should use this manual?

This manual has been written to assist land managers with responsibility for, or general interest in, managing gamba grass (*Andropogon gayanus*). This manual is intended to help people make decisions about gamba grass management in the context of broader land management in northern Australia, by providing a guide based on current knowledge and understanding of best practice. It's designed to support other valuable resources that are available at the state/territory, regional and local government levels.

Where does the information come from?

The information in this manual has been sourced from published material, existing research and reviews by technical experts. It also incorporates information gathered at workshops and meetings held with individuals and organisations managing gamba grass throughout northern Australia in 2022 and 2023.

This manual aims to provide a synthesis of the most up-to-date information on best practice management of gamba grass. However, we acknowledge that our understanding of gamba grass spread, impacts and management will continue to improve with new research and adaptive management.

How to use this manual

This manual has been designed to allow easy access to information and provide the necessary knowledge and tools to successfully manage gamba grass.

Arranged in five stand-alone yet complementary chapters, the manual presents a guide to the ecology and impacts of gamba grass (Chapter 1), how to plan a gamba grass management program (Chapter 2), how to reduce the spread of gamba grass and manage its impacts (Chapter 3) and case study examples of how gamba grass is being managed across northern Australia (Chapter 4). Chapter 5 provides sources of further information and supporting material that may be useful.

WoNS
WEEDS OF NATIONAL SIGNIFICANCE

Strategy and policy context

Gamba grass is one of 32 Weeds of National Significance (WoNS). These species are identified as nationally significant based on assessments of their invasiveness, potential for spread, and environmental, social and economic impacts. WoNS require coordinated and strategic management to prevent, eradicate, contain and minimise their impact. The *Gamba grass national strategic plan 2012–17* was developed with the goals of (i) preventing new infestations from establishing, (ii) ensuring established infestations are under strategic management and (iii) increasing capacity to manage gamba grass (Australian Weeds Committee, 2013). Further information on WoNS can be found at the Weeds Australia website.

Gamba grass is listed as a Key Threatening Process under the Australian *Environment Protection and Biodiversity Conservation Act 1999*. A national threat abatement plan outlines the priority actions required to reduce the threat gamba grass poses to biodiversity of northern Australia. Gamba grass is also listed as one of the key threats to Australia's biodiversity in the national *Threatened species action plan 2022–2032*, which has a goal of reducing the area of gamba grass by 2026.

It's important that the information provided in this manual is adapted by individuals to reflect their own environmental, financial and social circumstances and any legislative management requirements that may apply. Always seek local advice in planning weed control on your property or the sites you manage.

Darryn Higgins

Gamba grass control, Cape York Peninsula, Queensland.

Summary of the five chapters

1. Understanding gamba grass and its impacts
- identification
- invaded habitats and distribution
- life cycle
- impacts

2. Setting yourself up for success (planning)
- the importance of planning
- how to prioritise areas for control
- how to develop a management plan

3. Managing gamba grass
- management principles and challenges
- choosing a control method
- preventing weed entry and spread
- physical, herbicide and other control methods

4. Case studies
- what other land managers are doing
- applying integrated weed management
- overcoming challenges
- practical tips and learnings

5. Further information
- identification of co-occurring grasses
- additional planning information
  - declaration status of gamba grass in Australia
  - planning templates, evaluation question and health and safety considerations
- additional management tools
  - useful contacts
  - herbicide use, training and certification
- references

Chapter 1

Understanding gamba grass and its impacts

Samantha Setterfield[a] and Natalie Rossiter-Rachor[a]

[a] National Environmental Science Program (NESP) Resilient Landscapes Hub, The University of Western Australia, Perth, Western Australia, Australia.

At a glance

- **This chapter describes the biology, ecology and impacts of gamba grass.**
- **Gamba grass is a large perennial tussock grass from Africa that grows to 5 m tall.**
- **It was formally released in Australia in the 1980s as a pasture grass for cattle.**
- **It has invaded tropical savannas across northern Australia with a large potential for further spread.**
- **It spreads by seed transported via contaminated vehicles, machinery and hay; also by wind, water and animals.**
- **Gamba grass germination and establishment is higher in disturbed areas.**
- **Gamba grass produces large amounts of biomass which fuels intense and dangerous fires, resulting in serious environmental, cultural, social and economic impacts.**
- **It's a serious threat to native plants and animals.**
- **Understanding the biology and ecology of gamba grass is key to developing management strategies that will reduce its impacts.**

What is gamba grass?

Gamba grass (*Andropogon gayanus* Kunth) is a large perennial tussock grass which grows up to 5 m tall and can form dense monocultures. Introduced to northern Australia as a pasture species, it's since invaded savanna ecosystems in the Northern Territory, Queensland, and Western Australia (Setterfield et al. 2018). Gamba grass fuels intense

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Gamba grass tussocks grow up to 5 m tall and form dense stands.

Chapter 1

fires, reducing biodiversity and threatening the safety of people and property. Gamba grass can also reduce the availability of traditional foods for First Nations people and limit access to culturally significant sites.

Gamba grass has spread by both human means (sowing, vehicles, machinery, hay) and natural means (wind, water, animals). Management is critically important in reducing seed production, preventing further gamba grass spread, and minimising the impacts of gamba grass where it's established.

This chapter explores aspects of the ecology and impacts of gamba grass that are important to consider when managing gamba grass, including:

- where it grows and how to identify it
- its current and potential distribution in Australia
- its life cycle and the characteristics that enable it to spread rapidly and out-compete native grasses
- its reproduction and the main pathways of spread
- the range of impacts once it establishes, including the serious impacts on fire behaviour.

Origin and history

Gamba grass in its native range

Gamba grass is native to the savannas of tropical and subtropical Africa, in areas with a similar climate to northern Australia. It's found from Senegal on the west coast to Sudan on the east coast, and south to Mozambique, Botswana and South Africa (Csurhes and Hannan-Jones 2016). These savannas experience extended dry seasons, similar to those in northern Australia, and gamba grass is typically found growing below an altitude of 980 m with rainfall between 400 and 1,500 mm per year (Bowden 1964). There are several varieties of gamba grass within its native range in Africa. These differ in form, physical characteristics, climatic tolerance and the types of habitats they occupy, and include varieties that can survive in waterlogged soils (Bowden 1964).

Introduction to Australia

Gamba grass was introduced into northern Australia to trial as a pasture grass for cattle fodder, with the aim of increasing agricultural productivity (Grace

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Gamba grass forms dense, tall monocultures.

et al. 2004; van Klinken and Friedel 2017). A robust gamba grass cultivar 'Kent' was developed in the Northern Territory over several decades, starting at the Katherine Research Station in 1946 (Oram 1987). Kent was initially developed by crossing two varieties – one from Nigeria and another from Africa via Brazil (Grace et al. 2004; Oram 1987). Gamba grass pasture trials continued through the 1960s and 1970s, and it was officially released through the Northern Territory Herbage Plant Liaison Committee in 1978 and listed in the Register of Australian Herbage Plant Cultivars in 1986 (Oram 1987).

In the Northern Territory, the Kent cultivar was strongly promoted by the government to producers, and the cultivar was planted widely as a pasture grass and for mine-site rehabilitation (Whitehead and Wilson 2000). This cultivar is now a widespread weed and occurs in a range of land tenures across northern Australia (Setterfield et al. 2018).

Samantha Setterfield

Cattle grazing on gamba grass near Batchelor, NT.

In Queensland, the first herbarium records of cultivated gamba grass are from 1942 at pasture trials at Fitzroy Vale near Rockhampton (Csurhes and Hannan-Jones 2016). Later, herbarium records from 1992 document naturalised infestations of gamba grass in woodland near Bamaga (Csurhes and Hannan-Jones 2016). There are records through the 1990s and early 2000s from a range of locations in Cape York and near Mareeba (Csurhes and Hannan-Jones 2016).

In Western Australia, gamba grass was promoted as a pasture grass during the early 1990s, with a government technical note mentioning its benefits (McCartney 1991). It's believed that gamba grass was aerially broadcast at El Questro station in the East Kimberley in the early 1990s.

Identification

Gamba grass is an erect perennial grass which forms dense tussocks up to 1 m in diameter and 5 m tall. It produces numerous thick tillers, consisting of a stem and a seedhead. In Australia, gamba grass tussocks dry out in the dry season and begin regrowth early in the following wet season. Tussocks can live for several years, although the exact lifespan in Australia is unknown.

Gamba grass leaves are long, linear and up to 85 cm long and 3 cm wide, with a prominent white midrib. Leaves are generally covered with fine soft hairs, especially when young, although this can vary.

Gamba grass inflorescences (groups of flowers) consist of a hairy spikelet, giving a fluffy appearance (Cameron 1996). The seeds are light brown to brownish-black and are 2–3 mm long and 1 mm wide (Csurhes and Hannan-Jones 2016).

Gamba grass tussocks have three types of roots: an extensive network of fibrous roots just beneath the soil surface, vertical roots that extend down to a depth of over 80 cm, and cord roots which are stout roots that appear to act as an anchor for the plant (Bowden 1964).

The physical characteristics of gamba grass may vary across its geographic range in Australia. This may be in response to either variable environmental factors (e.g. soil type, nutrient availability, climate etc.) or genetic differences, due to the number of cultivars that are believed to be present. the most typical characteristics of gamba grass are described here.

Habit

- Gamba grass is a dense, clumping tussock grass with drooping leaves (typical form).
- Tussocks can grow to 5 m high and 1 m in diameter.
- There's seasonal variation in height and appearance, associated with flowering, seeding and environmental factors.

Gamba grass tussock

Dense mature gamba grass prior to seeding

Dense gamba grass after it has senesced (dried out)

Seedlings

- Seedlings typically have hairy stems and leaves.
- They usually grow near mature plants.

Stems and branches

- Stems and branches are fine and slender in young plants (a) and are robust and erect in mature plants (b and c).
- They're typically covered in soft hairs (a and b).
- Hairless varieties can occur (c).

(a) Fine stems

(b) Robust stems

(c) Hairless variety

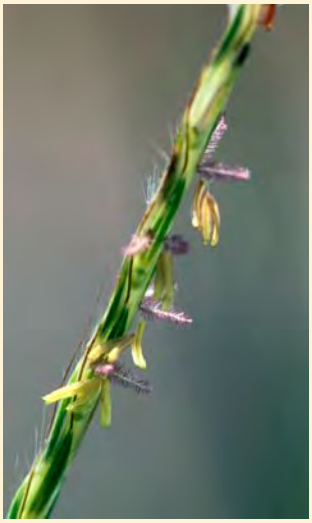
Leaves

- Leaves are 30–85 cm long and 3 cm wide.
- They have a distinctive white midrib.
- They're usually covered in soft, downy hairs (a).
- Hairless varieties can occur (b).
- Leaves can have a purple tinge (c).
- The leaf sheath is hairy (d).

Flowers and seeds

- Flower heads occur on tall stems above the leaves.
- Flower heads are large and branched and consist of V-shaped pairs of slender flower clusters (4–9 cm long).
- Flower clusters have 10–14 joints, each bearing a pair of very hairy flower spikelets.
- What are usually referred to as 'seeds' are flower spikelets. These are shed from the plant intact, along with their awns.
- The true seed inside the spikelet is light brown to brownish black and about 2.3 mm long and 1 mm wide.

Flower cluster



Flower spikelet

Spikelet with 'seed'

Chapter 1

Where does gamba grass grow?

Preferred habitat

Gamba grass has invaded the tropical savannas of northern Australia, which cover approximately 25% of the Australian continent, an area of around 2 million square kilometres (Hutley and Setterfield 2019). This region has a tropical climate, with a distinct wet season followed by an almost-rainless dry season. Gamba grass has a wide climatic tolerance and is well adapted to Australian savannas, including the annual drought period. In the Northern Territory, gamba grass grows in locations where the average annual rainfall ranges from approximately 1,700 mm (Darwin) to 700 mm (Daly Waters). In Queensland, it's been recorded in locations where the average annual rainfall ranges from approximately 2,000 mm (Weipa) to 900 mm (Mareeba) (Australian Bureau of Meteorology 2024).

Natalie Rossiter-Rachor

Gamba grass on rocky outcrop near Mareeba, Queensland.

NESP Resilient Landscapes Hub

Savanna invaded by gamba grass near Batchelor, ~120 km south of Darwin in the Northern Territory. This photo shows gamba grass in the early wet season, with gamba grass forming almost the entire understorey (in green).

Gamba grass has established in a broad range of habitats and soil types in northern Australia – from savanna woodlands on relatively dry lateritic soils and even rocky outcrops to the more closed forests on the black soil of floodplain margins (Flores et al. 2005). Gamba grass is often abundant in the wetter parts of the landscape, such as creek lines and other riparian habitats, but it doesn't tolerate prolonged inundation (Barrow 1995; Flores et al. 2005). Early growing advice was that cultivar Kent would grow on most soils of the Top End and that it was particularly suited to gravelly upland soils where other grasses couldn't survive.

Current distribution

Gamba grass is found in the Northern Territory, Queensland and Western Australia. The largest infestations are in the Top End of the Northern Territory and Cape York in Queensland. An intensive management program in Western Australia's East Kimberley region, has successfully reduced gamba grass occurrence, and it's considered close to being eradicated from the state (Snow 2022). Single plants occasionally establish outside the eradication zone, usually on major highways near the border with the Northern Territory. This region is actively monitored, and plants are controlled if found (D. Chemello, personal communication, June 26, 2024).

A map of recorded occurrences of gamba grass in Australia is shown in Figure 1.1. While some mapping exists at state, regional and local scales, large knowledge gaps remain in our understanding of the current distribution of gamba grass across northern Australia. Large areas of the Northern Territory and Queensland have no baseline survey data of gamba grass. In addition, some existing gamba distribution data is very old (20–50 years old), and the quality of that data can't be verified. Up-to-date current distribution data is critical for best practice weed management. It allows weed managers to plan and prioritise weed management to protect the assets valued by land managers.

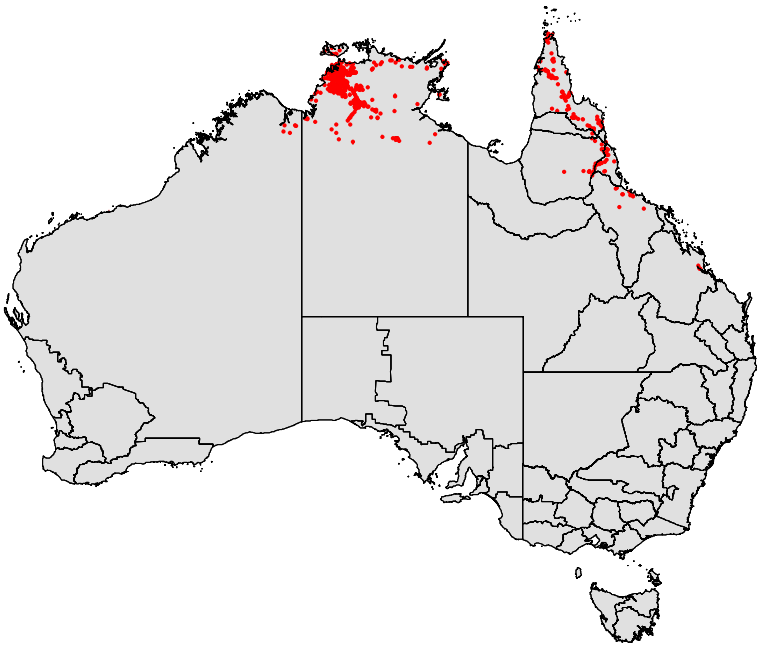


Figure 1.1 Reported occurrences of gamba grass in Australia (based on data ranging from 1960 to 2023). Sites older than 10 years where gamba grass has been confirmed eradicated were removed from the dataset. Source: Atlas of Living Australia 2023, reproduced by Dr Farzin Shababi, Macquarie University.

Potential distribution

Without active management, gamba grass could spread across much of northern Australia (Adams and Setterfield 2016; Csurhes and Hannan-Jones 2016). Habitat suitability modelling predicts a high risk of gamba grass invasion across the savanna regions of Western Australia, the Northern Territory and Queensland (see Figure 1.2; Pintor et al. 2019). Note that habitat suitability modelling should be used as a guide only. For example, existing naturalised populations of gamba grass are established further south than what is indicated as highly suitable in Figure 1.2.

Research suggests that gamba grass is still in the early stages of invasion and that it's likely to continue spreading across northern Australia. Climate suitability modelling of gamba grass potential distribution (Adams and Setterfield 2016; Csurhes and Hannan-Jones 2016), together with our knowledge of its ability to germinate under a wide range of temperatures, suggests that gamba grass currently occupies only a very small percentage of its potential range. This means we currently have a window of opportunity to strategically manage gamba grass where it occurs to prevent further spread and future impacts.

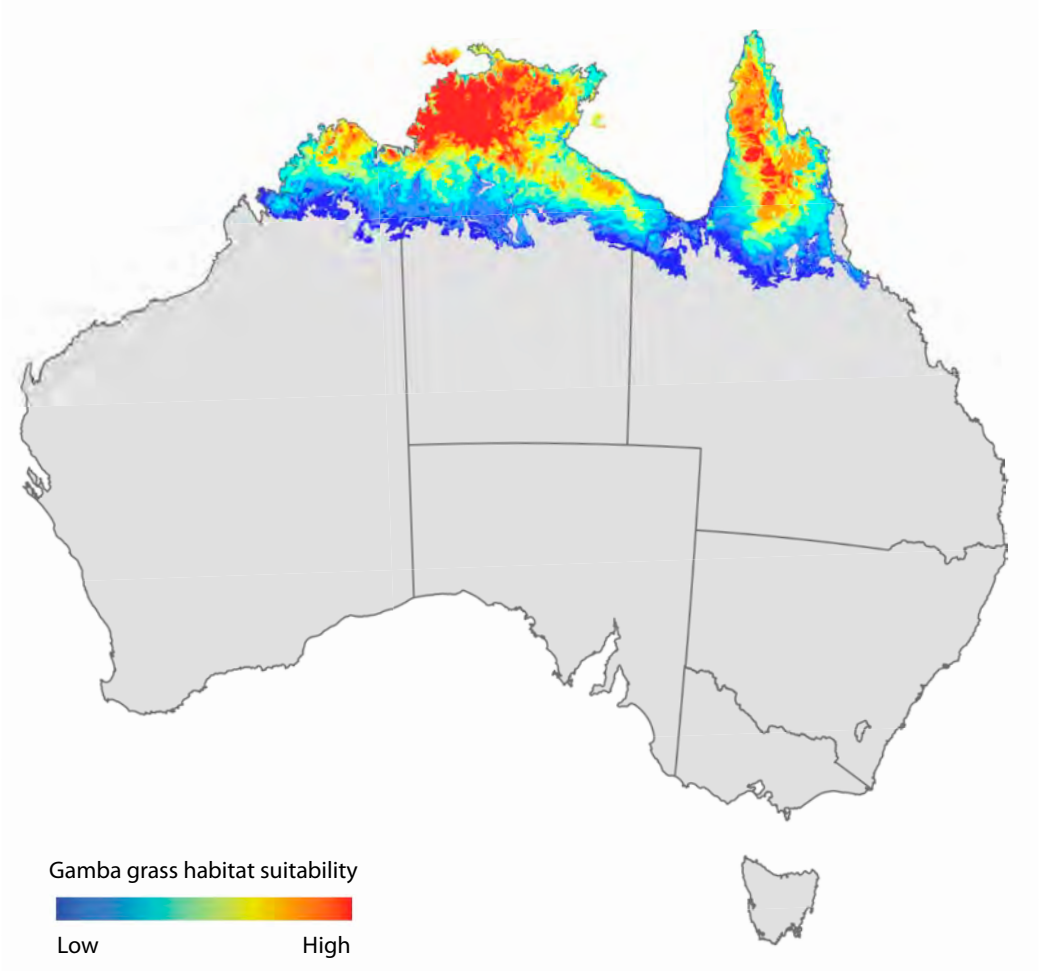


Figure 1.2 Gamba grass habitat suitability map. Reproduced with permission from Pintor et al. (2019).

Gamba grass life cycle

Germination

Germination mainly occurs between October and February, during the wet season (Table 1.1), but may occur at other times if there is enough soil moisture.

Active growth

Gamba grass actively grows mainly in the wet season and into the early dry season, up until June. The bright green growth of gamba grass into the dry season, when native grasses have already browned off, helps managers as it makes gamba grass easy to find by aerial and ground surveys (Rossiter-Rachor et al. 2023).

Flowering

Flowering starts in the early dry season. Gamba grass plants are triggered to start forming flowers when the day length is less than about 12–14 hours (Csurhes and Hannan-Jones 2016). This synchronised flowering generally occurs in April–May, but flowering may also occur at other times later in the dry season if there is enough soil moisture or it is slashed or grazed.

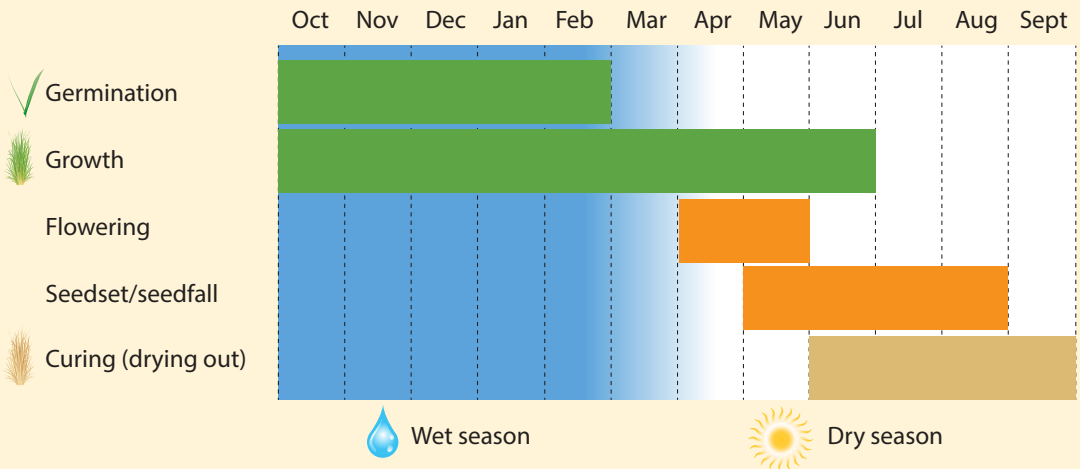
Seed set and seed fall

Seed matures approximately 4–6 weeks after first flowering (Harrison 1998), generally between May and August (Barrow 1995) but may occur in other months. It's worth noting that the timing of gamba grass seeding is later than native grasses across northern Australia, which generally seed March–May (late wet season to early dry season) (Murphy et al. 2021).

Senescence and curing

After seeding, gamba grass plants begin to senesce and dry out, a process known as curing. This happens during the mid-to-late dry season (June–August). Unlike native grasses, which cure at the end of the wet season, gamba grass doesn't fully dry until the late dry season (July–August) when the fire risk is at its highest (Setterfield et al. 2013). See 'impacts of gamba grass' section for further discussion.

Table 1.1 The general timing of the life cycle and growth pattern of gamba grass including germination, active growth, seed set, seed fall, and curing (drying out). The wet season is shown indicatively between October and March, but this varies across Northern Australia and year to year. Note that the timing of different stages will depend on the timing of the wet season and other factors like disturbance. Symbols courtesy of the NESP Resilient Landscapes Hub, nesplandscapes.edu.au.



Reproduction and spread

Seed production

Gamba grass seeds prolifically. A single plant can produce up to 244,000 seeds a year (Flores et al. 2005), and approximately 70% of these are viable (Barrow 1995; Bebawi et al. 2018; Flores et al. 2005). This is a far greater amount of viable seed per plant than is produced by either annual or perennial native grasses in northern savanna ecosystems (Flores et al. 2005).

The large amount of viable seed means that gamba grass seed is more likely to be dispersed and colonise new areas. Gamba grass seed heads are light and fluffy, and they're produced 2–4 m above the ground, increasing the likelihood of spread by wind.

Rowena Eastick

Gamba grass seeds blanketing the ground in a heavily invaded site.

NESP Resilient Landscapes Hub

Gamba grass seed heads.

Seed longevity

While gamba grass produces a large amount of seed, the seeds are only viable for a short period of time – making successful control achievable.

The longevity of gamba grass seed has been researched in a range of vegetation and soil types in the Northern Territory and Queensland. This includes studies of the viability of gamba grass seed:

- on the soil surface (Barrow 1995; Bebawi et al. 2018)
- buried at different depths (Bebawi et al. 2018; Flores et al. 2005)
- at different temperatures (Bebawi et al. 2018)
- in the wet–dry topics of the Northern Territory (Barrow 1995; Flores et al. 2005; Setterfield et al. 2004)
- in the dry topics of Queensland (Bebawi et al. 2018).

All studies found that the viability of gamba grass seed declined rapidly to less than 1% after 12 months (Bebawi et al. 2018; Flores et al. 2005; Setterfield et al. 2004). Viability was 0% after 24 months (Bebawi et al. 2018).

For example, a study by Flores et al. (2005) examined the viability of gamba grass seed at savanna and floodplain-margin sites at Mary River National Park (formerly Wildman Reserve), 100 km east of Darwin. The authors buried mesh bags containing seed in July, when gamba grass seed naturally falls. They retrieved the seed bags over the next 12 months. They found that seed viability declined steadily over time and was less than 1% nine months after burial – indicating that gamba grass has little or no residual seed bank (Figure 1.3). Specifically, they found that gamba grass seed viability:

- was approximately 70% in August (one month after burial)
- declined to approximately 50% by October (three months after burial)
- declined to less than 5% by January (six months after burial)
- declined to approximately 1% by April (nine months after burial)
- was negligible (approximately 0.1%) by July (12 months after burial).

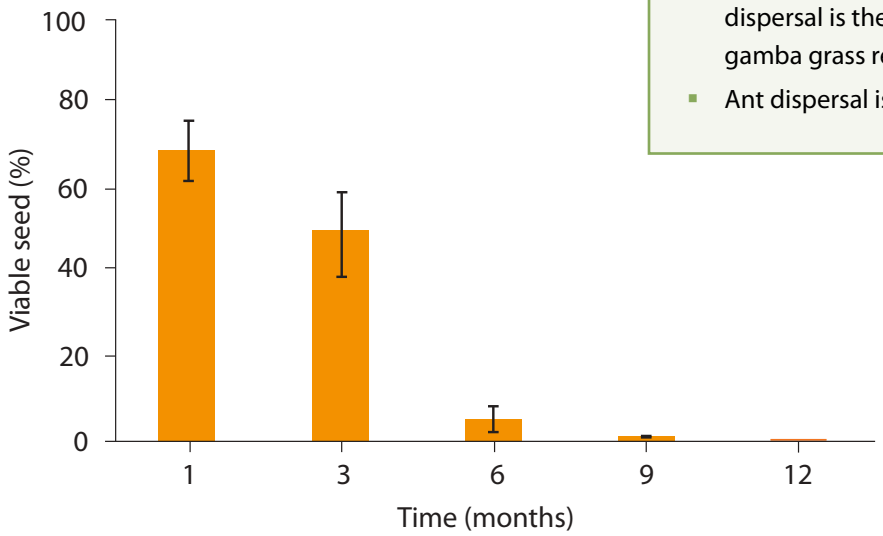


Figure 1.3 Proportion of viable gamba grass seed remaining after one, three, six, nine and 12 months after burial in unburnt savanna at Mary River National Park in the Northern Territory. Values are means ± standard error. Reproduced with permission from Flores et al. (2005).

It is good news that gamba grass seeds are short-lived. It means that if gamba grass control activities are followed up for 1–2 years, the soil seed bank will be exhausted, and localised eradication should be achievable – but only if all plants are prevented from seeding over the period and no further seed arrives at the site.

Gamba grass seed spread

Understanding and minimising the spread of gamba grass seed is critical to achieving successful management.

Seed spread: key points

- Dispersal over short distances (up to 100 m) is mostly by wind, water, birds and mammals.
- Dispersal over long distances (over 100 m) can also occur by wind and water during high wind and flood events. Human-assisted dispersal (e.g. vehicles, machinery, hay) can result in seeds spreading hundreds of kilometres. Long-distance dispersal is the most common way that gamba grass reaches new areas.
- Ant dispersal is likely to be minor.

Most gamba grass seeds fall close to the parent plant, but some can be transported far away. Gamba grass seed heads are small, light and fluffy – ideal for long-distance spread. This long-distance spread is how gamba grass becomes established in new locations, and it can greatly accelerate the invasion of gamba grass in a region. It can also result in re-infestation of sites after control.

Gamba grass seed is spread in two main ways:

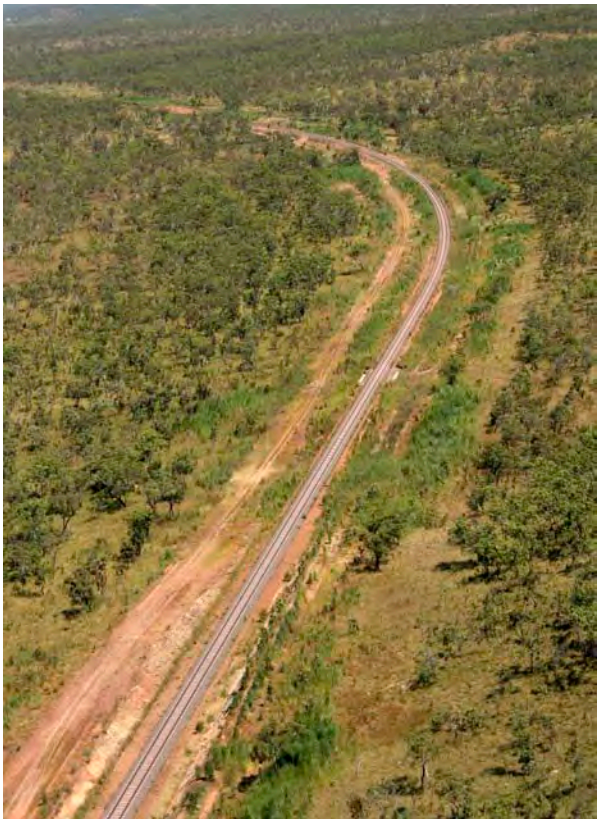
- human-mediated spread (e.g. deliberate spread by people, accidental spread by people and vehicles, contaminated produce, domestic/farm animals)
- natural spread (e.g. wind, water, birds and mammals).

Deliberate spread by people was historically a significant pathway of spread, when gamba grass seed was intentionally sown for pastures and hay (Setterfield et al. 2018). Accidental dispersal by people remains a significant pathway of gamba grass spread, including seed spread via vehicles and machinery (particularly slashers and graders), contaminated hay and other products (including soil, sand and fill).

Samantha Setterfield

Gamba grass hay bales in the Northern Territory.

Gamba grass spreads rapidly along transport corridors such as roadsides and railway lines, as well as other linear reserves such as power and telecommunication easements and stocking routes. The higher levels of disturbance in these areas makes successful establishment more likely.



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Gamba grass spread along a railway corridor in the Darwin rural area. The gamba grass is lime green.

In the Northern Territory, the spread of gamba grass in the Batchelor region was accelerated by human-mediated dispersal of seed – mostly through the transportation of hay and traffic along major transport routes (Petty et al. 2012).

Wind is the main natural way that gamba grass seed is spread. The seed matures and falls during the windy dry-season months. While most seed falls within 5 metres of the parent plant, as shown

in modelling (Murphy et al. 2021) and field studies (Barrow 1995), seed can travel further by wind in given situations. Barrow (1995) observed seed fall 20 m away from that parent plant, and studies in Litchfield National Park in the Northern Territory have documented new gamba grass incursions several kilometres downwind from large source infestations. These were attributed to wind dispersal at higher wind velocities (Rossiter-Rachor et al. 2023). Anecdotal evidence suggests seeds can be picked up by wind during gamba grass fires and transported long distances (Neale 2019).

Water dispersal is another common natural way that gamba grass seed is spread. The light, fluffy seeds float and are easily transported by water. Gamba grass seed matures and falls in the dry season and can be spread during storms and flooding in the following wet season. Riparian habitats along the edges of rivers and creek lines are important spread corridors, particularly into remote locations, as the higher soil moisture and nutrient levels here are perfect for gamba grass germination.

Studies of gamba grass spread in Litchfield National Park also documented widespread colonisation of creek lines and drainage lines by gamba grass. The long-distance spread by water has contributed to the rapid spread of gamba grass in the park (Adams and Setterfield 2015; Petty et al. 2012).

Natalie Rossiter-Rachor

Gamba grass spread along a small creek line in Litchfield National Park, Northern Territory.

Wild animals, such as birds and mammals, can spread gamba grass seeds over short distances if the seeds work their way into feathers or fur (Murphy et al. 2021). This can also result in long-distance dispersal, although this is less common. Ant dispersal of gamba grass seed is likely to be minor, as the seed lacks an ant-attracting appendage (Murphy et al. 2021). Grain-eating birds have been observed feeding on gamba grass seed in the Northern Territory (Rendall 2022), although this doesn't happen often and the implications on spread, if any, are not known.

Martin Tobias Aakesson

Gouldian finch (Chloebia gouldiae) *with gamba grass seed in its beak, Lee Point, Darwin.*

Chapter 1

Understanding the ecology of gamba grass supports management success

- The biology, ecology and spread pathways of gamba grass have been well documented by research, helping guide effective management.
- Less than 1% of seeds remain viable in the soil seedbank after 12 months.
- Adult gamba plants are easy to find in the early dry season, when native grasses have senesced.
- Gamba grass is still early in its invasion, so control now will result in large benefits.

Gamba grass establishment

Gamba grass seeds generally germinate at the start of the wet season following the dry season in which the seeds were shed.

Water availability and temperature trigger germination, with seeds germinating across a broad range of temperatures (17–39°C) (Bebawi et al. 2018). At lower temperatures (13°C), seed remains viable but stays dormant until environmental conditions become favourable for germination. Consequently, in sub-tropical areas, seeds may only germinate in the warmer months of the year. In the tropics, gamba grass seeds can germinate at other times providing there is enough soil moisture (Bebawi et al. 2018; Murphy et al. 2021).

Gamba grass seeds can germinate and establish in undisturbed areas, but seedling establishment and survival is higher in disturbed areas (e.g. where the tree canopy has been removed, in burnt areas, or where the soil has been disturbed) (Barrow 1995; Flores et al. 2005; Setterfield et al. 2005). A study of seedling survival at Mary River National Park showed that simulating soil disturbance by cultivating the soil significantly increased the emergence of gamba grass seedlings (Flores et al. 2005).

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Young gamba grass seedlings growing in a shade house.

Impacts of gamba grass

Gamba grass produces large amounts of biomass every year and outcompetes native plants for space, light and other resources (Rossiter 2001). Its root system is more extensive than the shallower-rooted native grasses, enabling it to use more water and nutrients and contributing to its invasive success across northern Australia (Rossiter-Rachor et al. 2009). Once established, it can form dense monocultures, significantly impacting invaded communities.

Gamba grass invasion increases fuel loads

Gamba grass can grow to 5 m high and 1 m across, producing large amounts of biomass that can fuel bushfires. If dried and weighed, the fuel loads of native grasses is typically between 1 to 3 tonnes per hectare, whereas gamba grass fuel loads can be up to 30 tonnes per hectare (Figure 1.4) (Rossiter et al. 2003; Setterfield et al. 2010) – an order of magnitude greater. The impact on fire behaviour is compounded further by the life cycle of gamba grass compared to that of native grasses. Native savanna grasses start to dry out (or 'cure') after they've finished flowering in February/March, coinciding with the late wet season/early dry season. In contrast, gamba grass remains green well into the dry season and doesn't fully cure until July/August. This results in a large amount of fully cured fuel late in the dry season when air temperatures and wind speeds are highest and humidity is low (Rossiter et al. 2003; Setterfield et al. 2010) – perfect conditions for hot fires.

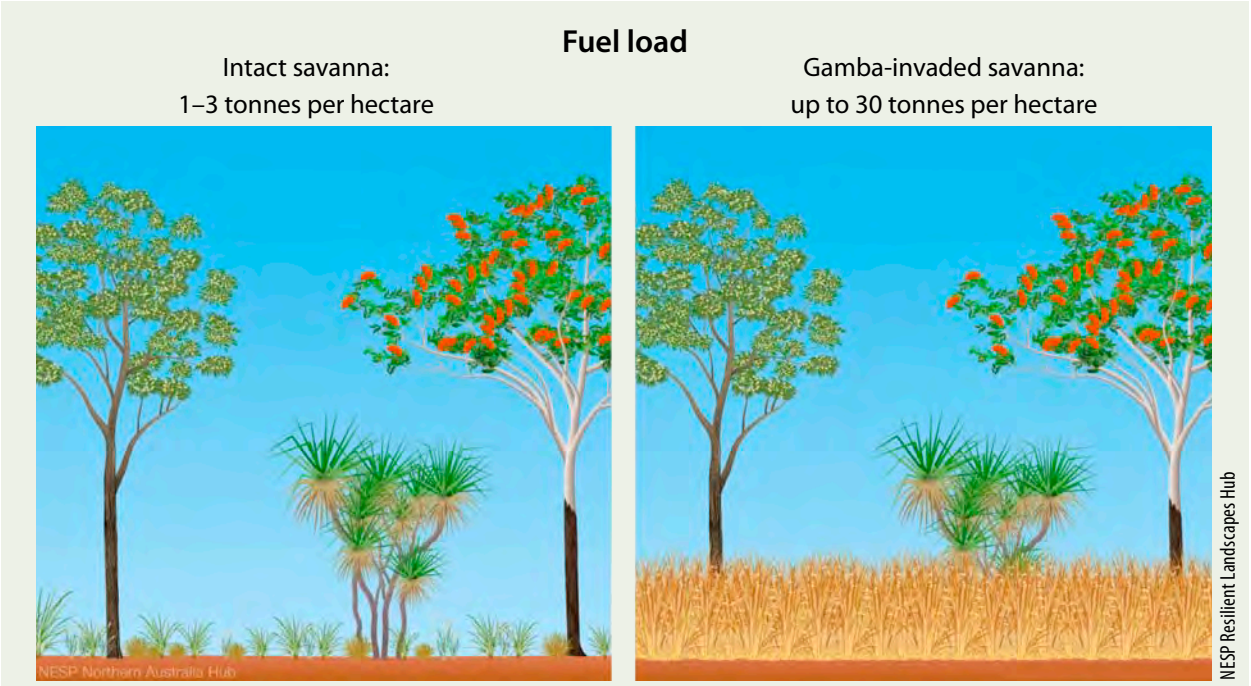


Figure 1.4 Diagrammatic comparison of fuel loads between native savannas and gamba grass-infested savannas. Graphic source: NESP Resilient Landscapes Hub.

A dense monoculture of gamba grass in the Darwin rural area in the late dry season. Note this gamba wasn't planted on this block but invaded from nearby pastoral properties. This infestation has been slashed to ensure the mandatory firebreak.

Gamba fires are more intense, faster moving and have taller flames than native grass fires

Gamba grass fires are up to 8 times more intense than native grass fires (Rossiter et al. 2003). In the first-ever comparison of fire intensity, Rossiter et al. (2003) calculated that, in the early dry season, the energy released per metre of fire front in a gamba grass fire was 15,700 kW/m, compared with a fire intensity in native grasses of 2,100 kW/m (Figure 1.5). A gamba grass fire in the Northern Territory recorded a fire intensity of 43,000 kW/m – the highest fire intensity ever recorded in the region (Setterfield et al. 2010). This grass fire intensity is similar to that of forest fires in southern Australia.

Gamba grass fires have taller flame heights than native grass fires. On average, the flames from gamba grass fires can char leaves 10 m high in the tree canopy – much greater than the 1.5-m char heights typically recorded after native grass fires. Even in low-intensity to moderate-intensity fires, the heat and flame height generated by gamba grass fires can reach up to 13 m and completely incinerate the canopy (Figure 1.5) (Rossiter et al. 2003; Setterfield et al. 2010).

Another consequence of the height and density of gamba grass is that it modifies the structure of the savanna grass fuel layer (Setterfield et al. 2010). Gamba grass leaves can extend from the ground layer to 5 m high, providing a ladder of fine fuels to carry fire into the upper tree canopy and ignite tree crowns (Setterfield et al. 2010). These types of fires didn't occur in northern Australian savannas before gamba grass invasion (Setterfield et al. 2010).

Gamba grass fires also spread at double the speed of native grass fires. This has significant consequences for native animals attempting to out-run or hide from the fire.

Samantha Setterfield

High-intensity gamba grass fire in the early dry season.

Samantha Setterfield

Gamba grass fires spread at double the speed of native grass fires, which can impact native animals trying to outrun the fire.

Frequently burning gamba grass creates a destructive grass-fire cycle

Gamba grass can sustain repeated fires, year after year. It can even sustain multiple fires within one fire season. This frequent burning benefits gamba grass and creates a 'grass–fire cycle' that is self-perpetuating and can only be halted by actively managing gamba grass.

Repeated fires kill mature savanna trees and prevent the next generation of tree seedlings from establishing. Without shading by the tree canopy and competition for resources from native grasses and woody plants, gamba grass can flourish. After burning, cover of gamba grass increases. A healthy

Fire intensity

Intact savanna:
2,100 kW/m

Gamba-invaded savanna:
15,700 kW/m

Fire char height

Intact savanna:
~1.5 m

Gamba-invaded savanna:
up to 13 m

Figure 1.5 Fire intensity (how hot the fire was) and fire char height (the maximum height of leaves that are blackened due to the flames) are both higher in gamba grass fires than native grass fires.

savanna woodland can be transformed into an invasive grassland within a relatively short period of time (Brooks et al. 2010; Rossiter et al. 2003; Setterfield unpublished data).

Frequent burning of gamba grass to reduce fuel loads only entrenches this grass–fire cycle. Other methods of control are necessary to break the grass–fire cycle. Reducing fire frequency or actively excluding fire in combination with herbicide application has been shown to effectively control the density of gamba grass infestations. Chapter 3 ('Managing gamba grass') has more information on best practice management methods for gamba grass.

Samantha Setterfield

Native trees, such as these Eucalyptus miniata *(Darwin woollybutt), can be killed due to the heat of gamba grass fires.*

Gamba grass invasion increases the fire danger and fire management costs

Most Australians are familiar with the fire danger risk index, which is calculated daily and informs the public of fire risk on a scale from moderate to catastrophic. When gamba grass invades at a regional scale, it increases the fire risk. For example, research by Setterfield et al. (2013) looked at the influence of gamba grass on the Grassland Fire Danger Index (GFDI). It was shown that, depending upon the year, areas with dense gamba grass (average landscape fuel loads of 10 t/ha) had a 6-fold to 8-fold increase in the number of days when the GFDI was high enough to invoke a total fire ban. The length of the severe fire-weather season increased by 6 weeks, with severe fire-risk days commencing in mid-June rather than late July in areas with dense gamba grass.

In September 2022, a new Australian Fire Danger Rating System was implemented across Australia. Regions with extensive areas of dense gamba grass have been accounted for with calculations based on higher fuel loads than nearby regions without this scale of invasion.

Natalie Rossiter-Rachor

A plane water-bombing a gamba grass fire.

Gamba grass increases the cost of controlling bushfires

Mitigating fire risk is difficult and expensive. While native grass bushfires are routinely controlled using equipment carried on the back on a 4-wheel drive ('grass-fire units'), gamba grass fires require more equipment, often including aerial fire-fighting capacity (water-bombing planes and helicopters). This aerial attack capacity is especially important in the Darwin rural area, where the risk to lives and infrastructure is high due to these fires. Fire fighters need personal protective equipment that is rated for attending 'structural fires' (i.e. buildings) and is rated to withstand the intense radiant heat generated by gamba fires (Setterfield et al. 2013).

The costs of fighting fires escalated quickly in the Darwin rural area following gamba grass invasion.

Natalie Rossiter-Rachor

Significant resources are required to control gamba grass fire each year.

Prior to invasion, when total-fire ban days were declared for the day, only 4-wheel drives had to be on standby in case of a fire, with a small number of staff. This involved minimal cost. By 2010, the equipment required to be on stand-by had increased to include a fixed-wing aircraft and 2 water-bombing helicopters (with pilots on standby for the day), water tankers, front-end loaders and multiple fire officers, as well as a Bushfires NT (Northern Territory Government) staff member that could coordinate an aerial fire-fighting campaign (Setterfield et al. 2010).

When a bushfire (or wildfire) occurs, the equipment that was on stand-by becomes operational and is used to control the bushfire. This has dramatically increased the cost of fighting individual fires. Setterfield et al. (2013) compared the costs of fighting fires at 6 sites before and after they were invaded by gamba grass. The cost of fighting a fire burning in native grasses averaged less than $1,000, while the costs of fighting gamba grass fires at the same 6 sites ranged from $6,000 to more than $43,000 (Figure 1.6; Setterfield et al. 2013). To date, the most expensive gamba grass fires to be documented by researchers occurred in a 5-day period in 2017. It cost over $300,000 to control 5 fires burning through dense gamba grass in the rural area around Darwin (Setterfield et al. 2018). The largest of these individual fires burned almost 100 km^2 in one day and cost more than $100,000 to manage for the day (Setterfield et al. 2018). A much smaller fire that burned less than 4 km^2 cost more than $55,000 to manage.

The 2023 Vernon Arafura Regional Bushfire Management Plan by Bushfires NT outlines the risk gamba poses to the region and the fire response to this risk.

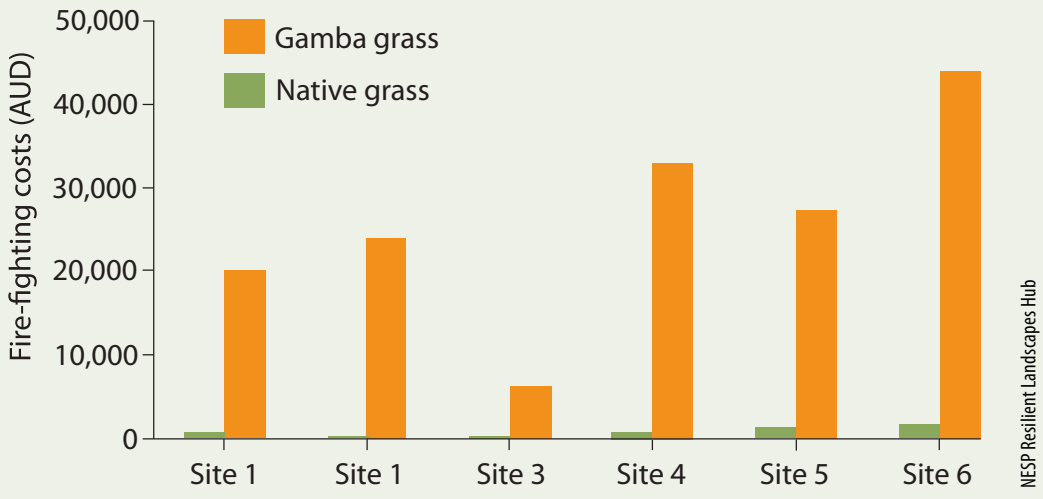


Figure 1.6 The cost of controlling individual fires increased by an order of magnitude following invasion by gamba grass (Setterfield et al. 2013).

Bushfires NT

The intense heat of gamba grass fire can damage horticultural orchards, as demonstrated by the incineration of this mango orchard during a gamba grass fire in the Northern Territory.

Gamba grass threatens biodiversity, including threatened species

Gamba grass poses a serious threat to biodiversity across northern Australia, displacing native plant species and reducing plant biodiversity in the understorey to only 1–2 native plant species (Brooks et al. 2010). In recognition of this serious threat, gamba grass was listed as a Key Threatening Process under the Australian Environment Protection and Biodiversity Conservation Act 1999, with a national Threat Abatement Plan outlining the priority actions to reduce the risk posed by gamba grass. In addition, gamba grass is listed as one of the key threats to Australia's biodiversity in the national Threatened Species Action Plan 2022–2032, with a goal of reducing the area of gamba grass by 2026 to protect biodiversity.

Gamba grass can impact fauna directly through mortality in fires and indirectly through changes to food resources and habitat availability. However, there are still large knowledge gaps about the specific impacts of gamba grass, and particularly gamba grass fires, on a range of native fauna.

Gamba grass fires impact on horticulture

Gamba grass fires impact on a range of land uses, such as primary production and horticulture. For example, primary producers may need to spend money on controlling gamba grass and protecting their assets from fire.

Bushfires NT

Mango orchard burnt during a gamba grass fire, Batchelor, Northern Territory.

Bushfires NT

Gamba grass fires can result in large smoke plumes from the burning of the large amounts of grass and tree biomass, such as the smoke plume of this large gamba grass fire in the late dry season.

Gamba grass fires are a risk to cultural values

Gamba grass invasion transforms native savanna and, consequently, has a dramatic impact on Indigenous cultural values (Setterfield et al. 2018). This is a consequence of the displacement and death of native plants and animals, reduction in the availability of traditional foods, direct impacts on significant and important sites, and restriction of movement through dense infestations (March 2011).

In addition to the impact on Indigenous sites and values, gamba grass invasion has significant economic impact on Indigenous Australians, through the time and effort to manage gamba grass, the loss of resources such as food, and impacts on incomes through carbon credits generated from strategic fire management in tropical savanna, which must exclude defined areas with gamba grass in them (Neale and Macdonald 2019).

The impact and risk to Indigenous cultural values from gamba grass is reflected in Healthy Country Plans. Gamba grass is identified as a key management interest in at least 10 Healthy Country Plans or Plans of Management which include Indigenous Protected Areas located in Western Australia, the Northern Territory and Queensland.

Samantha Setterfield

The intense heat of gamba grass fires can burn native trees, such as this mature Eucalyptus miniata *(Darwin woollybutt).*

Further information on recent research into gamba grass ecology and impacts can be found at gamba-uwa.hub.arcgis.com.

Setterfield SA, Rossiter-Rachor NA, Cramer VA and Thomas JE (2023) *Gamba grass research synthesis*, Australian Government's National Environmental Science Program.

Bushfires NT

Gamba grass fires increase the risk posed to built assets.

Chapter 2

Setting yourself up for success

Work to a plan

Planning is the critical first step in managing gamba grass. While it's tempting to jump straight in, it's important to plan so you can monitor and track progress over time and achieve the best possible outcomes. A well thought-out plan can:

- make weed-management tasks more realistic and achievable
- reduce the off-target impact of your control
- prevent reinvasion in the long term
- save time, effort and money
- inspire others who see your success
- allow you to more easily adapt your management if circumstances change.

The planning stage is where you come up with a realistic, long-term plan of attack that also identifies yearly activities that work towards long-term outcomes. This plan should:

- consider what we know about gamba grass biology and ecology (Chapter 1 – 'Understanding gamba grass and its impacts')
- communicate why you're managing gamba grass and the management perspectives of all involved
- take stock of your situation and tailor an approach accordingly
- identify appropriate control techniques that you'll use
- track what you've achieved over time
- consider and align to any legal obligations relating to the management of gamba grass in your given area or situation.

Figure 2.1 outlines the main steps involved in planning for gamba grass management. These are expanded upon on the following pages. Initial assessment of the weed situation (Step 1) and management options (Step 2) inform priority actions to go in the plan (Step 3). While implementing the plan (Step 4), make observations and keep records to inform an annual review of the plan (Step 5).

Matt Sheehan

Preparing for a remote area control program to implement a carefully thought-out strategic plan to eradicate gamba grass from Mudginberri, Kakadu National Park.

This chapter is based on the Introductory Weed Management Manual published by the Cooperative Research Centre for Australian Weed Management (CRCAWM 2004).

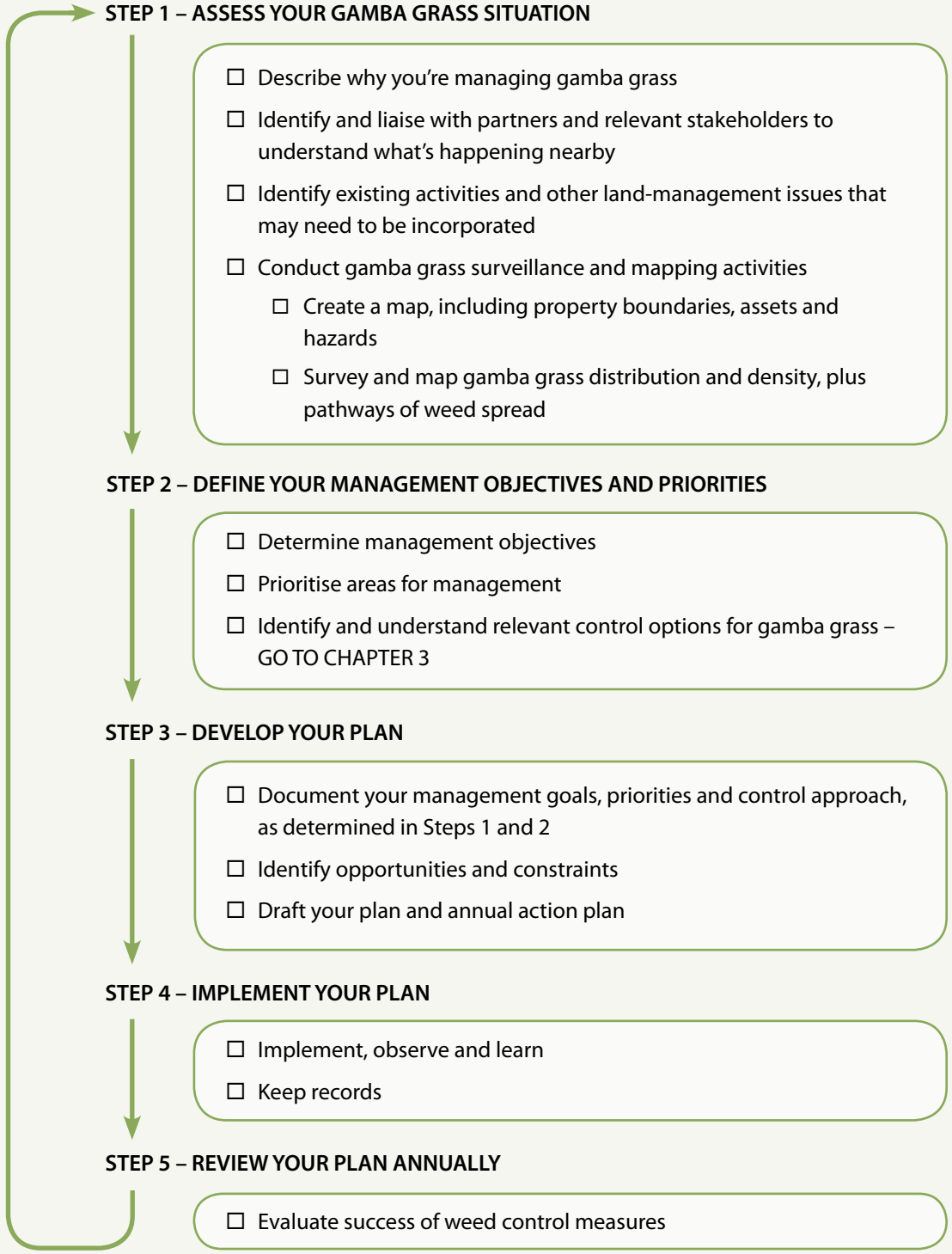


Figure 2.1 Suggested process and checklist to assist in the development of your management plan for gamba grass.

Step 1. Assess your gamba grass situation

Natalie Rossiter-Rachor

Gamba grass invading high value savanna. Developing and following a well thought out plan in situations like this will increase the likelihood of long-term successes that address multiple management goals.

The first step in developing a management plan is to understand the scale of your gamba grass problem and the opportunities and challenges that will influence its management. This information will provide background to the management plan (Step 3).

Understand why you're managing gamba grass

There are many different reasons to manage gamba grass. Understanding your management reasons will inform an appropriate management response. Because gamba grass can spread long distances, your management success also depends on how gamba grass is managed elsewhere. Acknowledging other reasons for managing gamba grass in surrounding areas and considering these where appropriate can help achieve consistent or complementary management outcomes at the landscape scale.

Table 2.1 summarises the range of common reasons for managing gamba grass. It identifies key impacts of gamba grass and provides a statement of what success looks like – what has to occur in broad terms to achieve outcomes. Listing all reasons and prioritising these will help in your planning. There may be more than one reason. For example, you may be managing primarily for protecting life and livelihoods, but the management area may also include cultural or biodiversity values which your management approach should also address.

Table 2.1 Common reasons for managing gamba grass, key impacts and desired outcomes of management.

Reasons for management	Impact of gamba grass	Desired outcome of management
Legal management requirements	Refer to Box 2.1	
Road safety 	Reduces visibility and amenity value	Maintain visibility and amenity
Life and livelihoods (including built assets) 	Increases fuel loads and fire intensity, posing a threat to life and built assets	Reduce risk of damaging fires
Cultural and natural asset protection 	Increases fuel loads and fire intensity, posing a threat to cultural and natural assets Displaces native species, changes ecosystem structure and function	Protect asset (from fire, competition and other impacts)
Livestock production 	Poses a risk to livestock and assets through increased fire risk and fire intensity Provides a source of seed that spreads to other high-value areas	Maintain competitive pastures and protect livestock and livelihoods from damaging fires Contain gamba grass to property by preventing seeding and seed spread

Regardless of the reasons for managing gamba grass, all desired outcomes can be achieved by considering three key principles in the development of a management plan.

1. **Removing or reducing gamba grass biomass** reduces the risk of catastrophic fires, decreases competition on desirable vegetation and minimises habitat modification.
2. **Reducing seed production** can bring gamba grass infestations under control within 3–5 years. Gamba grass seed is short-lived, so preventing or minimising seed production and killing mature plants can exhaust the seed bank.
3. **Reducing seed spread** can prevent new infestations from establishing. Gamba grass is still in the early stages of invasion across northern Australia. Stopping seed spread can prevent infestation of areas that are currently free of gamba grass.

Keep these principles in mind when developing your plan and when starting your control program. This will help keep you focused on achieving your desired management outcomes.

Box 2.1 Legal management requirements

You may be under legal obligations to manage gamba grass. Gamba grass is a declared weed in all states and territories. Management requirements vary from preventing the movement and sale of gamba grass through to an obligation to eradicate it.

In some areas, a zoned approach is taken, where a higher level of management is required if you live in an eradication zone, compared to if you live in a containment zone. As a minimum, your plan should reflect the legal management requirements for your region.

A guide to state and territory management requirements is provided in Chapter 5 ('Further information' on page 128). However, note that the legal status of weeds, and your associated obligations, may change over time. It's therefore important to check with weed authorities in your state or territory to ensure that you're fully aware of your legal obligations in relation to gamba grass and other weeds.

Work together on gamba grass

For successful gamba grass management, you may have to involve other people. This may apply for the following reasons:

- Land is sometimes under joint management, so it's important to communicate your management intentions to all land managers and gain their support or cooperation.
- Gamba grass causes impacts at the landscape scale. What happens outside your management area may affect your management. Providing opportunities for adjacent land managers to be involved may be critical for your success.
- You may need permission if your proposed activities will be done on someone else's land.
- You may need to get permits or other permissions for some control approaches or associated activities.
- Support from external sources may be available to you (e.g. government grants). These could be cash or in kind. Funding agreements may stipulate required activities or outcomes that need to be reflected in your management plan.
- You may need to seek external advice. For example, identifying gamba grass or developing surveillance or mapping methodologies may require the involvement of experts.

You may learn new information while managing gamba grass. Sharing information and outcomes with others contributes to improved management at the landscape scale.

When developing your plan (Step 3), list all stakeholders, how you'll communicate with them, and what role they'll play. Also identify the risk of not involving others.

If multiple stakeholders are involved, decide if the arrangements between stakeholders will be informal or formal.

Informal

This can be a grass roots approach in which, for example, a rural neighbourhood chooses to work together on a common gamba grass problem. Such cooperation could include:

- welcoming new landholder arrivals and providing them with information on local gamba grass (or other weed) problems
- organising property walks to discuss control methods
- sharing weed control equipment
- agreeing to let each other know if a gamba grass outbreak is observed
- having an in principle agreement that neighbours may control the occasional weed appearing just over the fence.

Rowena Eastick

Planning meetings should involve all critical stakeholders and partners in setting management priorities.

Formal

A more formal approach is to form a weed-focused group. Recommendations on how to achieve this are detailed on page 39 by the Australian Centre for Culture, Environment, Society and Space, University of Wollongong. Formal arrangements could include:

- establishing an agreed, common goal for gamba grass in the local area and following a common plan
- defining the boundaries within which gamba grass will be tackled
- sharing the organisational and weed management load
- documenting and promoting what has been achieved
- establishing a formal entity (e.g. incorporated association) with a committee of management.

Identify existing land-management activities

It's important to consider what activities are already occurring at the site, in relation to both gamba grass and other land-management issues. Consider if there has been past gamba grass management, what was done and how successful it was. This could help inform what you should (or shouldn't!) do in your new plan.

The site might be subject to other land-management activities, such as fire or pest animal control. These management activities could impact on gamba grass control. It's important to integrate any proposed gamba grass management activity into existing land-management activities to try to meet all land-management objectives.

Map gamba grass infestations, key assets and pathways

Maps can be used for planning and communication. Ideally, they should:

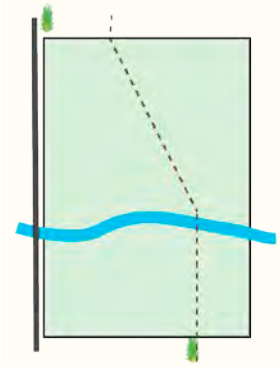
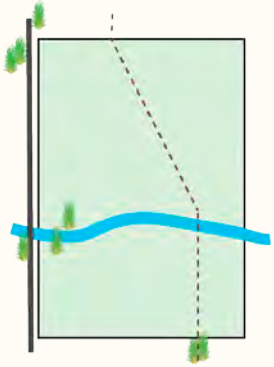
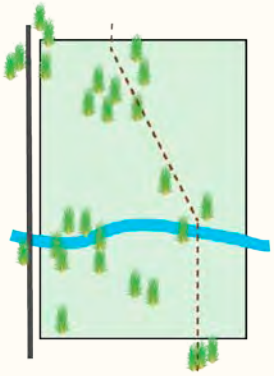
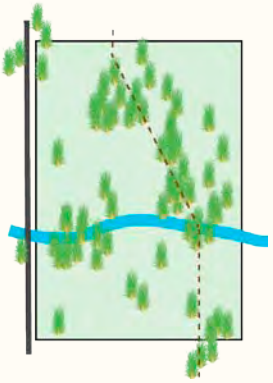
- communicate gamba grass locations and density levels, including changes over time
- identify management area boundaries and priority control areas (see Step 2)
- help you determine your management objectives (see Step 2)
- inform follow-up treatments (see Step 5)
- show assets, likely spread pathways and safety hazards (see 'What to map' section for more information).

Obtain a map of the management area or property, either as a hard copy or in a digital format to use on a tablet or smart phone. A map doesn't need to be complex. The goal is for people, now or in the future, to find their way around the management area and follow a logical and strategic approach to gamba grass management based on weed distribution, identified assets and access points. A hand sketch can work for small properties, while a computer-generated map may be better for larger properties.

Walk, drive or fly over the management area and determine the presence of gamba grass. Record infestations by hand and transfer this information to your management map later or use a data-capture device or purpose-built app (see Box 2.2).

It's also important to record weed density so you can assess in future years whether your efforts have been successful. Typical categories for recording weed density are described in Table 2.2, and further detail is given in McNaught et al. (2008).

Table 2.2 Strategic management objectives and actions required for different stages of gamba grass invasion.

				
Stage of invasion	**Absent** ▪ not known to be present in the management area (but may be present in the local area)	**Early stages of invasion** ▪ rare (< 1%): isolated individual plants ▪ low risk of reinfestation from neighbouring areas	**Scattered to frequent** ▪ light (1–10%): scattered patches and isolated plants ▪ medium (11–50%): frequent patches interspersed with isolated plants	**Widespread and dense** ▪ large, dense infestations (>50%) ▪ weeds found across most of the management area
Management objective	**PREVENT** Stop arrival and establishment	**ERADICATE** Eliminate all plants, including seeds	**CONTAIN** Prevent further spread beyond core infestations, reduce density of the core, and eliminate outlying infestations	**PROTECT ASSETS** Reduce impacts on high-value assets by reducing weed density and seed production
Management actions	**Spread prevention** ▪ implement hygiene protocols and other measures to prevent gamba grass from arriving and establishing **Search** ▪ ongoing surveillance for new gamba grass incursions ▪ education and awareness	**Spread prevention** ▪ implement hygiene protocols and other measures to prevent reinvasion **Control** ▪ remove all plants before they reproduce **Delimitation** ▪ monitor frequently to map extent of infestations	**Spread prevention** ▪ implement hygiene protocols and other measures **Control** ▪ implement an integrated control program to reduce density in core infestations ▪ for outlying infestation, search for and remove all plants before they reproduce	**Spread prevention** ▪ implement hygiene protocols and other measures **Control** ▪ implement an integrated control program ▪ protect high-value assets at risk from weed impact

What to map

Your base map should show gamba grass distribution and density, management area boundaries and priority control areas. You should also capture the following information:

- locations and types of **assets** (the things you're protecting) in your management area and, if possible, areas adjacent to it. This may include significant biodiversity areas, property infrastructure, and historical and cultural sites
- **pathways** for gamba grass spread. For example:
  - roads, tracks and other linear easements, such as stock routes and powerlines
  - water courses
  - storage and stockpile areas
  - likely movements of stock and native and feral animals
  - prevailing winds and topography where wind-dispersed weeds are likely to be deposited
- any **safety hazards** to reduce the likelihood of accidents or injury. For example, areas that are steep or have hidden ground hazards that make them unsuitable for walking or driving across.

Figure 2.2 provides an example of a simple map of gamba grass occurrence and density.

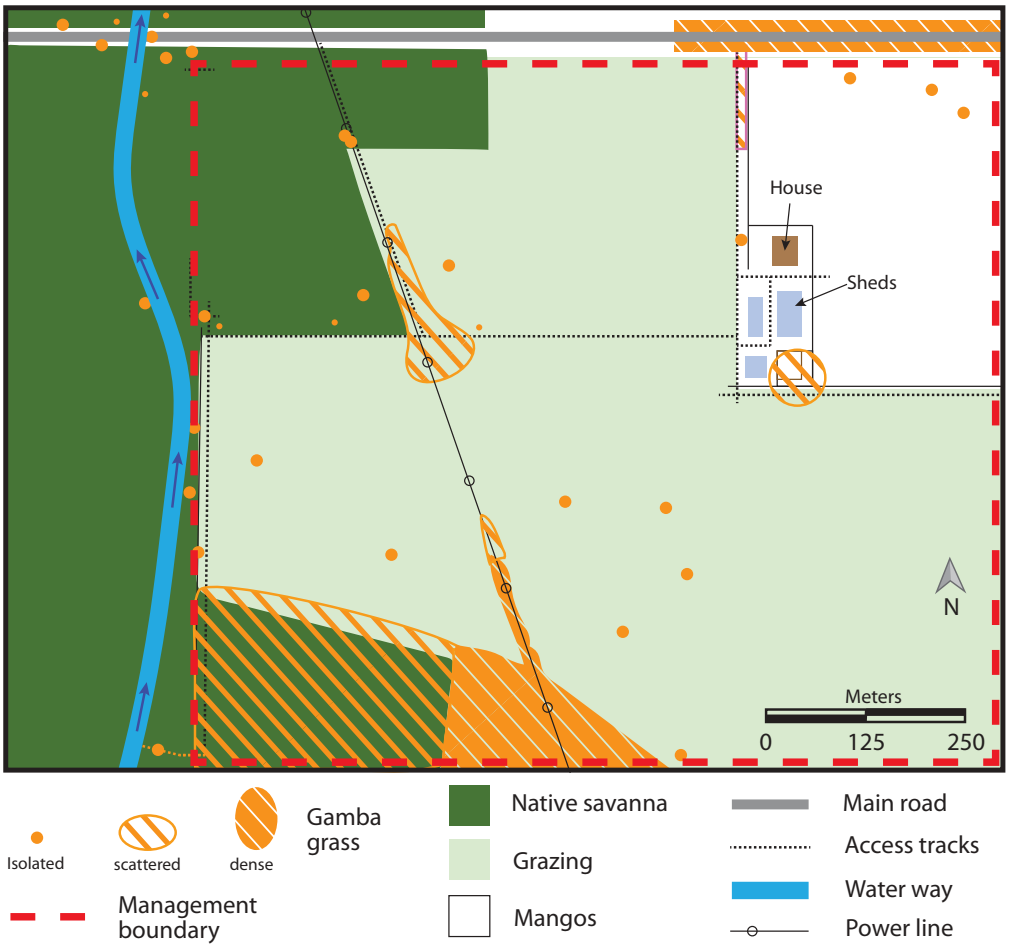


Figure 2.2 Example of a simple mud map showing weed occurrence, density, assets, spread pathways and access points.

Box 2.2 New gamba grass mapping and monitoring tools to support best-practice management

Natalie Rossiter-Rachor and Samantha Setterfield

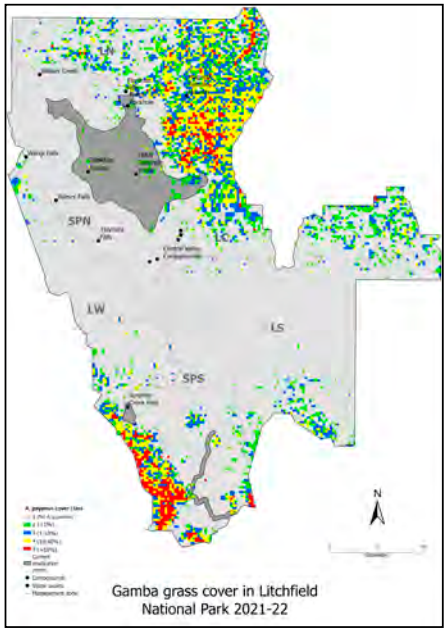
National Environmental Science Program (NESP) researchers are developing user-friendly gamba grass mapping and monitoring tools through a collaborative project with weed managers.

The new survey tools include an aerial survey map and drone-based mapping (still in development). These tools will help managers to:

- visualise gamba grass distribution
- examine landscape-scale patterns of gamba spread
- identify priority areas for control
- monitor and report progress.

The gamba grass aerial survey app will be available on tern.org.au

For further information: search 'NESP Resilient Landscapes Hub- Project 3' using your preferred search engine.



Output of the new mapping tool data from Litchfield National Park in 2021–22. Survey data shows gamba grass cover in grid cells (250 × 250 m) in five gamba grass cover classes (Rossiter-Rachor et al. 2023).

When to map

The best time to survey and map gamba grass will depend on three factors: the time of year, the mapping or surveying methodology you use, and what other land-management activities are occurring at the site.

Time of year

Gamba grass can be identified year-round, but it's easiest to identify in the dry season when it's in flower or seed. Ground-based surveying when gamba grass is seeding (between May and August) risks spreading seed, so make sure you take hygiene and spread prevention measures (see Chapter 3 – 'Managing gamba grass'). Mapping in the early dry season (March/April), after most native grasses have browned off and gamba grass remains green and hasn't yet set seed, is another good time to map gamba grass. If you're unsure whether you have a gamba grass infestation, contact a weed officer in your state or territory or send a specimen or good-quality images to your local herbarium (see Chapter 5 – 'Further information').

Mapping method and site attributes

Ideal timing may depend on your mapping method and the site. If it's a ground-based survey, it needs to be dry enough to access the area. If you're mapping using aerial or remote-sensing techniques (e.g. satellite imagery), you might have a bigger time window.

Other land-management activities

Other land-management activities may impact your ability to search for, detect and map gamba grass. For example, mapping immediately after burning or slashing may reduce your ability to accurately detect gamba grass plants.

Communicate your mapping intention to relevant land managers to coordinate land-management activities and minimise timing conflicts.


Rowena Eastick

Rowena Eastick

Photo monitoring provides a quick, inexpensive and reliable way of recording change at a site over time.

Remember: mapping isn't a one-off activity. It should be done initially to delimit the infestation and repeated periodically (every 2–3 years) to capture any changes in distribution and density. These changes will help determine if your control is being effective.

Establish a baseline of current gamba grass status

Information collected on weed distribution and density can be used to establish a baseline, record change and assess the effectiveness of management outcomes over time. Each time you produce an updated map and record weed density, you can compare it against your original baseline map.

You can also establish fixed photo points, where images are taken at the same spot and time each year. This ensures a long-term photographic record of change in weed distribution and density over time.

Step 2. Define your management objectives and priorities

This step requires you to consider the gamba grass strategies and control options available for your management area, based on the information collected in Step 1.

Identify strategic management objectives

Strategic weed-management objectives relate to the level of weed invasion. They are: **prevent**, **eradicate**, **contain**, and **protect assets**. Table 2.2 describes these objectives and the general actions needed to achieve them.

Decide on a feasible management strategy for your management area by considering:

- the distribution and density of gamba grass (including in the surrounding area)
- the extent to which you can identify and manage spread pathways
- whether gamba grass can be cost-effectively prevented or controlled
- the potential impacts of gamba grass.

The decision support tool in Figure 2.3 can assist with choosing the most appropriate management objective, and ensuring it's achievable through periodic review (based on monitoring). In summary:

- If you don't have gamba grass, your management objective is **prevention**. This should be confirmed over time with regular surveys to ensure that gamba grass remains absent.
- If gamba grass is detected, it's important to consider its density and distribution. If it's feasible to remove all plants and the seedbank, the management objective should be **eradication**. See Box 2.3 for more information.
- If infestations are beyond eradication, consider if you can **contain** it to a part of the management area and keep other areas clean.
- If gamba grass is widespread across your management area and the broader landscape, and can't be eradicated or contained, management efforts are best spent **protecting assets** from its impacts.

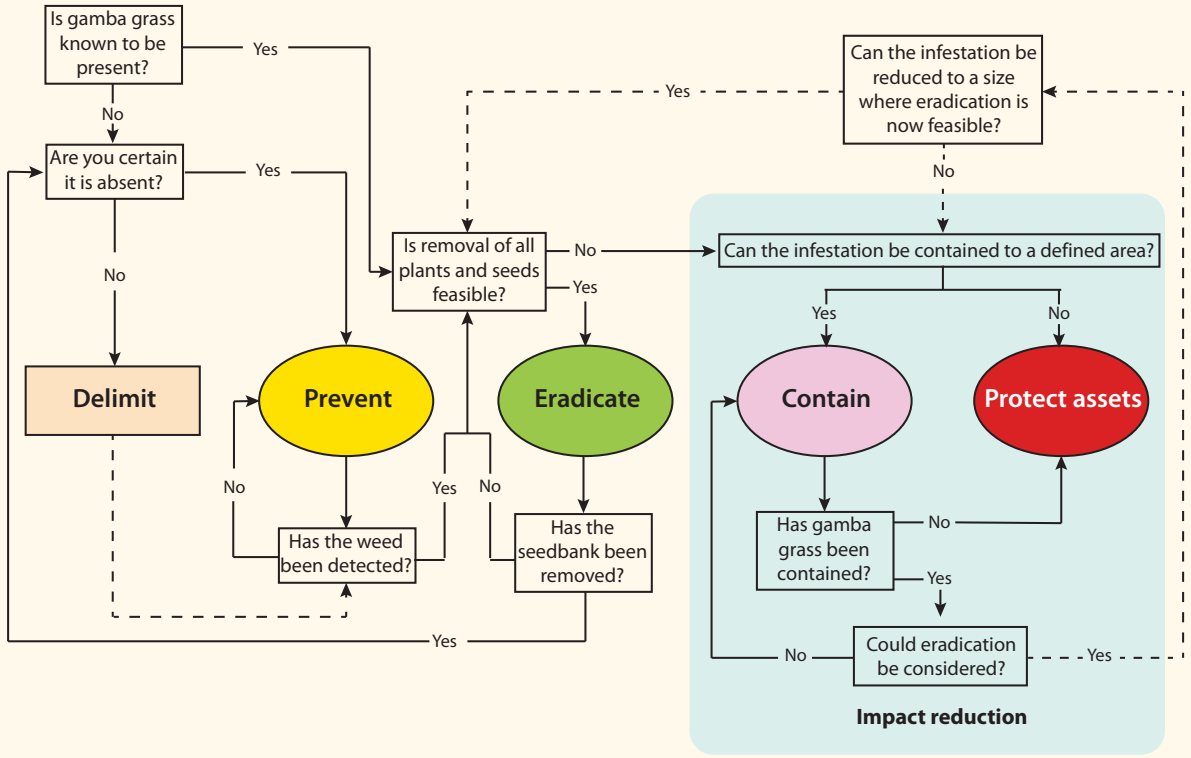


Figure 2.3 Decision-support tool for choosing and reviewing management objectives, adapted from the Gamba Grass Management Plan – Cape York Peninsula and Far North Queensland 2012.

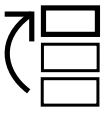
Box 2.3 Eradication – is it feasible?

Note that 'eradication' is a term often used but rarely achieved for weeds. Successful eradication requires the elimination of every single plant and propagule (both seeds and vegetative plant parts) in a defined area plus no further reintroductions from outside the area. This is extremely difficult to achieve. Generally, successful eradication is more likely where the weed is new to an area or property, when distribution and density of the weed is low. Fortunately, gamba grass has relatively short-lived seed, which makes eradication theoretically more achievable.

Factors required for successful gamba grass eradication:

- All infested areas are known.
- The chance of reinvasion from surrounding areas is low.
- All plants can be detected and treated before they set seed.
- This 'search and destroy' effort is maintained each year until the seedbank is exhausted.

See Chapter 4 ('Case studies') for examples of active gamba grass eradication programs.

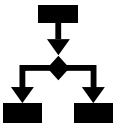


Prioritise sites

Regardless of the management objective you choose, your approach should prioritise all of the following that apply to your management area:

- new, small or outlying weed infestations
  - These should be intensively controlled (and eradicated where feasible) to stop them spreading further.
- areas with high risk of weed spread and areas of significant source of weed seed
  - Targeting known point sources of infestations is a strategic management priority that may benefit you as well as neighbouring lands that don't have gamba grass.
  - For example, roadsides, around gateways and other infrastructure, parking and visitor areas, stockyards, dams, troughs and watercourses should be targeted for weed control to limit further spread and reduce the risk of new infestations establishing.
- high-value assets
  - Where infestations are widely established, focus on reducing current and future impacts on important assets. For example, look after the best patches of bush, cultural heritage sites, infrastructure and livestock.

Seek advice and input from weed-management experts and neighbours to ensure that your priority-setting is sound and will be supported by those around you.



Choose control options

Understanding the full range of gamba grass control options will help you decide what will work best for your situation. A successful control option needs to effectively kill gamba grass, but it also needs to be practical and align with your resources and experience, now and into the future.

Gathering information on gamba grass and how to manage it will allow you to choose the best option. Refer to:

- Chapter 1 ('Understanding gamba grass and its impacts') to understand biology and impacts
- Chapter 3 ('Managing gamba grass') to explore management options
- Chapter 5 ('Further information'), for useful additional information and links to external resources (e.g. publications, legal management requirements, useful websites, etc.)

It helps to think 'outside the box' in terms of what control options you could adopt. You should also be aware of the limitations of control options. These may include off-target effects on desirable plants, time required to achieve effective control, and expense. Table 3.1 in Chapter 3 ('Managing gamba grass') compares the pros and cons of prevention and control methods for gamba grass.

Step 3. Develop your plan

This step brings together all the information you've gathered in steps 1 and 2. It also aligns your priority actions for the weed plan with your long-term goals for your management area and available resources.

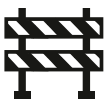
Set goals for your management area

Think about your reasons for managing gamba grass (Table 2.1) and what you hope to achieve. Describe your long-term goals. Setting long-term goals highlights what you value most about your management area, property or asset. In turn, this influences your weed-management priorities – whether those are economic, environmental, social or cultural impacts that you wish to prevent or manage.

Identify opportunities to work smarter

Identify any ways you can make gamba grass prevention and control more efficient or effective. You might be able to share equipment with a neighbour or split the cost of hiring a spray contractor. There may be multiple weeds that you can control by the same method. There might be opportunities to apply for grant funding to undertake weed control. Other forms of assistance may be available through your local weed authority or natural resource management organisation.

Use the information you gathered in Step 1 ('Work together on gamba grass') to determine opportunities. Working in a coordinated or collaborative way may enhance your knowledge, improve your outcomes, and expand the pool of available resources.



Consider any constraints

Consider and plan for any constraints that may limit or direct what you can do to prevent or manage gamba grass in the management area. Consider finances, people, infrastructure, equipment and competing priorities. Examples of possible constraints or considerations include:

- funds to spend on weed control and the cost of individual control options
- availability to conduct weed control when it needs to occur
- skills and knowledge
- availability of equipment or labour
- seasonal variability and other access restrictions
- workplace health and safety considerations
- natural dispersal of gamba grass
- timing of burning (planned or bushfire)
- suitability of available control techniques
- preferences regarding herbicide use
- legal requirements to control declared weeds
- avoiding unintended damage (e.g. risks of herbicide drift, contamination of waterways, off-target damage to desirable vegetation).

Draft your plan

Your plan doesn't have to be overly complicated, but it's good to have something in writing that, as a minimum, describes your decision-making, outlines your strategic long-term plan, and details your yearly control activities. You can refer to it as a reminder and use it to communicate to others. An example of the type of headings and content to include in your plan is captured in Chapter 5 ('Further information').

Develop an annual plan of action

As well as providing a 3–5-year overview of your goals and objectives, your plan should include annual activities, detailing what you need to do each year to work towards your long-term management objectives. At its simplest, a weed plan can be a calendar of actions required at certain times of the year.

Consider your long-term goals for the management area, analysis of the weed situation and management options, the constraints you're working under, and the opportunities to address these. Draft a calendar of actions you can feasibly undertake to address gamba grass in specified areas of the management area.

Think about the timing of these actions in relation to each other and other land-management activities. Are there conflicts? Can you implement further efficiencies to save costs or time? The plan doesn't need to be perfect. It can be refined until you achieve something workable for the year.

Seek advice and input from weed management experts (e.g. local biosecurity officer, farm advisor, Landcare officer) and neighbours to ensure that your management approach is sound and will align, if needed, with the weed-control activities of others.

Remember: gamba grass management can't be achieved in one year, so the yearly plan must support and work towards your long-term management objective.

Step 4. Implement your plan

Refer to your plan regularly as you implement your weed-management program and use it as a guide and a communication tool to all others involved. You could program actions into an electronic diary (such as your smartphone) so you get pop-up reminders. Use your plan to keep on track, stay motivated and remind you of why you're managing gamba grass. Remember that the plan is a high-level summary of what you're aiming to do, and that each action will likely need further division into tasks.

A plan is a guide, and you still need to be flexible with your timing to adapt to unforeseen circumstances such as floods, fires or extreme weather events. You may also need to alter the timing of weed management activities, based on other factors such as varying seasonal conditions or other urgent property-management needs that could arise.

Learn from doing

Use the implementation of your weed plan as an opportunity to observe the effectiveness of your actions, so that you can make improvements to your plan and methods of weed management. Treat it as a continuous learning exercise and challenge yourself on how it could be done better. For weed-control actions, consider the following questions:

- Did it cost more or take more time than expected?
- Did you achieve a satisfactory level of weed kill?
- Did you experience scheduling clashes between weed management and other important activities and needs?

Make diary notes throughout the year on what you've observed and learned. Failures are just as important to record as successes, because this is how a plan can be improved over time.

Keep good records

In line with the 'learn from doing' approach, log your activities as you undertake them. Keep records of:

- all costs
- time taken
- weed locations
- control methods
- areas treated and their size
- equipment and supplies used (e.g. amount of herbicide)
- weather conditions at time of control
- level of weed control achieved.

Step 5. Review your plan annually

Review your weed plan annually to inform what changes you need to implement the following year. Gamba grass requires multiple years of follow-up control so you may not be making major changes to your plan initially (unless a control method is clearly not working). When substantial gains have been made against gamba grass, you may shift your focus to other weeds of lower priority or other land-management needs.

Monitor and evaluate your plan

Monitoring approaches range from simple to complex and, at a minimum, should include:

- maps that document expansion or reduction of infestations against the maps you prepared at the start of the program (Step 1)
- photo monitoring to:
  - provide an easy 'visual' method of assessing progress over time
  - document the size and condition of gamba grass at the time of control
- a log of activities, dates, climatic and environmental factors to help determine why some methods may have worked one year but not in another (see 'Treatment Record Sheet' in Chapter 5 ('Further information'), page 131)
- an assessment of costs through records of expenditure and revenue
- records of herbicides used and their efficacy
- quadrats or transects to quantify changes in weed densities or the response of native plants
- a record of failures as well as successes to ensure ongoing improvement and development of your management practices.

Based on the findings of your monitoring, review your program and assess if your management activities are meeting goals and objectives. Where management outcomes weren't as successful as expected, determine why and, where possible, adjust management to overcome barriers to success. You may want or need to share your review with others to get their feedback and perspective. Perhaps they'll see opportunities to improve your plan where you can't. Sharing your review with others can motivate yourself and others and contribute to a shared sense of responsibility for complex management issues.

To review gamba grass control, ask yourself broad questions such as those outlined in Table 2.3. Draw on the monitoring undertaken in Step 1 to measure these questions against a baseline. If weed control has been poor, then you need to determine why. Seek professional advice on what changes you should make to your control techniques and your broad management approach. Weed management is a long-term undertaking, and you need to be confident that the time and money invested will give you effective results.

Table 2.3 Example annual review questions.

Review questions	Monitoring techniques that can address questions
Has the extent (area) of the weed infestation increased or decreased?	Update the property map to record any changes in weed distribution or any new weeds.
Has the density of the weed increased or decreased?	Check against categories in Table 2.2.
Are desirable plants recovering?	Desirable vegetation can also be assessed using the categories in Table 2.2.
Which control methods have been most successful?	Measure and compare weed kill.
How much is control costing?	Calculate costs per hectare from your record-keeping, including cost for your time.

Follow up

The key to successful gamba grass management is a commitment to an appropriate follow-up program. Follow-up is essential because:

- Seeds in the soil may keep germinating for 1–2 years.
- Seeds may continue to arrive at the site from other areas and form new infestations.
- Large, dense infestations may take many years to contain.
- Gamba grass tussocks are large, and it's common for some plants to survive initial control efforts.

You'll need to determine how often you'll follow up. The most important consideration is that your follow-up is implemented often enough to stop new seed production and reduce spread. If you have dense infestations at the start of your control program, you should (where practicable) follow up as soon as a few weeks or a month after treatment to mop up any plants that were missed or not completely killed. After that, a minimum of one treatment per year will be required.

Repeat the annual planning cycle

Updating your plan should become quicker each year. Reviewing progress (Step 5) from the previous year informs any updates needed to assess the situation (Step 1). Any new information on weed-control techniques, plus observations on how well the methods worked in the previous year, will inform analysis of weed-management options (Step 2). The previous year's plan will provide a template for drafting the revised plan (Step 3).

Every 3–5 years, spend more time assessing the current state of gamba grass prevention and management on your property. Ask yourself whether you're truly on track and making substantial progress. Involve others in the process to act as peers and provide new insights and observations.

If the planning process is working well for you, then inform and encourage others to do the same and make broader landscape gains on weed management. The next section provides tips on how to achieve a coordinated approach to weed management across neighbouring properties.

Darryn Higgins

Foliar spraying gamba grass on Cape York.

Better together: build networks and shared objectives to achieve landscape-scale control

Coordinated control of gamba grass provides many benefits to land managers, from building neighbourly relationships and support networks, through to reducing the spread and impact of the weed itself. Making connections with others may provide motivation, knowledge and friendships and help ease the burden of weed control. Working together can be especially beneficial in breaking the back of established gamba grass infestations.

This section provides tips for land managers and weed-management professionals to leverage and coordinate communities to achieve landscape control.

Tips for land managers

There are many examples across Australia of land managers successfully working together across properties to reduce their shared weed burden. These tips come from observing community groups working with a diverse range of weeds.

1. **Identify a group of people** concerned about gamba grass and passionate about working together. Locate them through a community meeting, social barbeque, social media group, etc.
2. **Develop a common goal** – e.g. to prevent gamba grass from going to seed, reduce local spread, local eradication.
3. **Define a clearly bounded area to work together** on weed control – e.g. a river corridor, small valley, several adjoining properties, or a rural residential estate. Define an area consistent with the amount of time and resources you have to invest in weed management. Too large an area can mean results take too long to see, and motivation can wane.
4. **Develop a plan to prioritise your efforts** within the clearly bounded area. This may involve focusing on the lightest infestations and outliers, then working in towards the densest infestation. Include:
   - the activities the group will use to address gamba grass, e.g. working bees, individuals looking after specific sections, employing a contractor to reach difficult-to-access areas or to manage particularly dense infestations
   - the frequency (e.g. weekly, monthly) and timing (e.g. Tuesdays) of any group work
   - whether there are any native animals or plants currently benefiting from gamba grass – where practical, this needs to be considered so that management activities can be undertaken to ensure gamba grass is controlled while minimising impacts to other species.

   Ensure you have the permission (and involvement) of all landholders before commencing planning and work.
5. **Ensure a social component to activities** – keep motivation going through social activities, e.g. sharing afternoon tea at the end of a working bee. This enables groups to reflect on what they've achieved together

beyond what they could have achieved alone, determine their plan's effectiveness, and whether the clearly bounded area is too big or small.

6. **Share the load** – organising working bees, contractors and other weed-control activities can become an administrative burden that undermines the group's longevity. Assign group roles based on experience, expertise and interest in key areas such as:
   - communication – for sharing information about group activities on social media or email
   - recruitment – for inviting and welcoming new people to the group
   - grant writing – to apply for funding to support group activities
   - plant identification – to teach members to identify gamba grass and other plants.

   Also share the weed-control load. Groups of neighbours might rotate work on each other's properties, finishing each rotation with a barbeque or other social activity.

7. **Document your journey** – e.g. photos or brief written accounts of weed-management impacts to showcase your successes, develop a collective sense of achievement, and attract new recruits. Recording lessons learned may also be useful for other groups.

8. **Connect with others** – make connections with groups addressing gamba grass in neighbouring areas or further afield. Share your knowledge and resources and identify the activities and decisions that have (and haven't) worked. Link with local and state government and non-government organisations for potential funding, resources and support.

Tips for weed professionals

The following points guide professional weed-control officers and project officers in understanding and working with their local communities to develop coordinated weed-management programs for priority regional weeds.

1. **Know who** – identify, understand and encourage social relationships.

   Identify existing land manager networks

   Networks, including those that aren't weed specific, may be leveraged for communicating weed-related messages and events. For example:
   - First Nations people and Traditional Owner organisations
   - farming networks – producer groups, sustainable farming, restorative agriculture
   - volunteer networks – Landcare groups, community associations, rural fire services
   - agronomist and other advisor networks
   - local government
   - regional natural resource management bodies, regional managers of reserves (e.g. conservation, water) and existing cross-agency bodies (e.g. roadside environment committees).

   Understand the local community

   Understanding the composition, capacities and perspectives of the community will help to determine weed-control priorities, preferred control methods, underlying issues related to weeds and weed control, and where tensions are likely to emerge. Consider:
   - the proportion of land managers that are First Nations people or organisations, land managers, production farmers, hobby

farmers, government or corporate (e.g. forestry)

- how these proportions have changed over time
- which land managers and weed-management experts people currently turn to for advice
- who may be most interested in building their capacity to manage gamba grass.

Build trust

Encourage the formation of positive relationships among land managers and other stakeholders. Consider:

- bringing together – early on – land managers who may not know one another
- prioritising weed management along private and public boundaries to demonstrate commitment to being a good neighbour
- developing relationships with other relevant stakeholders with land-management aspirations – e.g. First Nations people/organisations and community groups – to broaden the weed-management knowledge base and practice.

2. **Know what and know why** – prioritise gamba grass relative to other weeds and land-management issues.

Establish the community's priority weeds

Where does gamba grass fit in relation to the list of weeds that are declared for control? What are the other key weeds of community concern? These may be different from locally declared weeds or other formal priorities. Are some segments of the community more concerned about gamba grass than others?

Establish the community impacts of gamba grass

What are the motivating factors that drive people in the community to control gamba grass? Are they to do with protecting livestock? Being a good neighbour? Caring for nature? Having a tidy-looking property?

Identify the benefits of controlling gamba grass

This includes not only reduced weed density and spread but also environmental, economic and social benefits resulting from working together on weeds.

3. **Know where** – where is gamba grass located and most likely to spread to?

Map the weed extent

Establish where the core and outlying infestations are. Gamba grass may be widespread in some areas but emerging in others. Knowing its extent and density will be important to develop a plan for where to prioritise on-ground works, how to allocate resources, and how to identify stakeholders in adjoining areas who could benefit from joining the initiative.

Consider any boundaries crossed by gamba grass

Management implications will need to be considered if gamba grass crosses any land-tenure boundaries.

- Does gamba grass spread across private land or public land?
- Does it spread along corridors, such as rivers, roadsides, travelling stock routes or irrigation channels?
- Do opportunities exist to coordinate the timing of management along corridors

or across boundaries for more effective management?

- Are there stakeholders whose jurisdiction spans similar boundaries to gamba grass who could facilitate coordinated responses?

4. **Know how** – what approaches have been used to control gamba grass locally?

   Identifying and examining stories of previous target weed-control success, failure and experimentation provides for collective learning and insights into the time and approaches needed to achieve success. Were there any weaknesses inherent in unsuccessful past efforts where land managers had given up? And how long did any successful effort take to achieve?

5. **Know when** – identify the most effective time to control gamba grass.

   Timing is critical to successful weed control. Consider how the optimum weed-control time fits with other community commitments such as burning, roadside maintenance activities, etc. Will land managers have the capacity to control gamba grass at the optimum time of weed control or have the flexibility to adjust if the season is unpredictable?

6. **Bringing it all together** – develop a weed-management plan.

   Develop a landscape-scale weed-management plan that brings together your understanding of both gamba grass and the local community. This is fundamental to leading an effective weed-management program. Consider establishing a steering committee to help develop the plan, engage with diverse stakeholders, and oversee its implementation. Follow the five steps at the beginning of this chapter.

Acknowledgements: This section was prepared by the Australian Centre for Culture, Environment, Society & Space (University of Wollongong) with contributions by Associate Professor Nicholas Gill, Associate Professor Jenny Atchison, Associate Professor Sonia Graham, Dr Gina Hawkes, Dr Kaitlyn Height, Dr Rebecca Campbell, Crystal Arnold, Diana Dawson, Jennifer Smart, Janine Bailey, and Laura Butler.

Chapter 3

Managing gamba grass

Rowena Eastick

Foliar spraying dense gamba grass in the Northern Territory.

At a glance

- **Limit the spread, establishment and seed production of gamba grass.**
- **There are limited ways to prevent and control gamba grass, but they're effective.**
- **Consider gamba grass control when planning other land management activities, such as burning.**
- **Be flexible – manage gamba grass when it's optimal to do so, rather than only when it suits you.**
- **On grazed lands, establish and maintain competitive pastures and adopt sustainable grazing management practices.**
- **Where gamba grass is used for grazing, reduce seed production and seed spread through rotational grazing and adoption of hygiene protocols.**
- **Burning, slashing or grazing won't reduce gamba grass density permanently – it will grow back and is likely to spread it further.**
- **Permanently removing gamba grass is better and more cost effective than suppressing it.**

This chapter outlines current methods that are available or are being used to control gamba grass. Not all these options will be suitable for your situation, so refer to Chapter 2 ('Setting yourself up for success') and follow the steps to help you choose the right control methods. Chapter 4 ('Case studies') also provides examples of where land managers have put this theory into practice.

This chapter draws on information from the following information sources:

- NT Government https://nt.gov.au/weeds
- Territory NRM https://www.territorynrm.org.au/
- Qld Department of Agriculture and Fisheries https://www.qld.gov.au/search
- WA Department of Primary Industries and Regional Development https://www.agric.wa.gov.au/
- NSW WeedWise https://weeds.dpi.nsw.gov.au/Weeds/

Chapter 3

General tips for successful weed control

Prevention is cheaper than control

- Ensure vehicles, machinery, livestock and produce do not carry weed seeds or propagules (vegetative material that is capable of reproduction).
- Report sale or use of declared plants to your local weeds officer or weed authority.

Find weeds early

- Search for the target weed(s) and act quickly if found.

Prevent weed spread

- Take measures to contain weed infestations and prevent further weed dispersal.

Plan your control approach

- Obtain information about managing the target weed(s)
- Map infestations
- Treat weeds when they are young
- Use the recommended control method
- Minimise damage to non-target plants
- Establish and promote competing vegetation

Undertake follow-up control

- Continue follow-up treatments over several years. Some plants may have been missed, some may not have died and new seedlings may emerge.

Adapted from the Weed Control Handbook for Declared Plants in South Australia (NRM Biosecurity, 2017).

What is best practice management?

Best practice management is the use of control methods that have been found, through experience and research, to be the most effective and practical ways to achieve a management objective (such as reducing the impact of gamba grass). As best practice control methods for gamba grass are evolving, it's important to note that the methods described here are only as good as our current knowledge, and not all methods will have the same level of success in all situations. Also, some control methods currently in use haven't been sufficiently tested or aren't yet approved. Such methods aren't discussed in this chapter except where research is ongoing and preliminary results are promising.

There are still opportunities to improve the effectiveness of gamba grass control. Documenting and sharing the methods and outcomes of your control programs will contribute to the available knowledge base and highlight areas that need further research.

Choosing a management option

Current methods for effectively controlling gamba grass aim to prevent introductions, intercept spread, detect new infestations, and control existing infestations through hand removal or herbicide application. Other methods that don't kill gamba grass can be integrated with these control options to improve outcomes or meet other land management objectives. These include buffers, barriers, slashing, grazing and burning. Table 3.1 summarises these methods, describes the pros and cons of each, and includes other critical information, such as timing.

Table 3.1 Summary of methods currently available or in use for gamba grass control.

	Advantages	Disadvantages / limitations	Caution!	Timing	Integrate with
Prevention methods					
Spread prevention (page 48)	▪ reduces weed entry and spread ▪ avoids future costs and impacts ▪ low ongoing cost	▪ high set-up costs ▪ maintenance requirements ▪ managing spread pathways may not be possible when they are outside your management area ▪ ongoing effort needed to obtain everyone's compliance	▪ must be undertaken alongside surveillance	▪ year-round but especially when in flower and seed (April to August)	▪ surveillance ▪ all on-property activities ▪ all appropriate control strategies
Surveillance, detection and intervention (page 55)	▪ reduces impacts and need for control	▪ time consuming and ongoing ▪ may be made more difficult by other land management activities (e.g. fire)	▪ can be difficult to detect gamba grass unless flowering, by which time it may have set seed	▪ any time if personnel are experienced in identification ▪ easiest when in flower/seed (April to August) ▪ in the early dry season when it remains green and many other native grasses have dried off	▪ spread prevention ▪ all appropriate control strategies if detected ▪ all on-property activities
Control methods					
Manual removal (page 57)	▪ highly effective and low cost ▪ ideal for small infestations and outliers ▪ minimal equipment needed ▪ no off-target impacts ▪ suitable for organic certified properties	▪ time consuming and labour intensive ▪ not practical for large infestations ▪ more difficult for mature plants	▪ must dispose of all plant parts appropriately to prevent spread ▪ follow-up needed for seedlings and missed plants	▪ any time if personnel are experienced in identification (easiest when in flower/seed (April to August) ▪ easiest following rain when soil is damp or when native grasses have dried off	▪ herbicide control – manual removal ideal for removing outliers around core infestations that are being managed through herbicide control
Herbicide control (page 59)	▪ very effective ▪ quick to apply to multiple plants ▪ can be used for isolated plants through to large, dense infestations ▪ several application options, depending on the situation	▪ currently limited herbicide options available* (glyphosate) ▪ appropriateness of available application methods will depend on the situation and time of year ▪ risks of off-target impacts to desirable plants * flupropanate can be used in some situations in Qld only	▪ legal requirements to follow all label instructions ▪ must follow safety directions	▪ for glyphosate, when plant is actively growing ▪ for flupropanate, prior to rains	▪ all other control strategies and suppression methods
Slashing (page 76)	▪ promotes new growth, increasing herbicide uptake and palatability ▪ reduces herbicide usage and costs ▪ can reduce seed set ▪ reduces biomass and fire intensity	▪ doesn't kill gamba grass ▪ ineffective if used on its own ▪ can spread seeds ▪ not cost-effective in the long term	▪ hygiene measures needed to minimise risk of spread ▪ may need to slash multiple times each year	▪ before seed set (approximately September to May)	▪ herbicide control ▪ grazing

Table continued on next page/...

	Advantages	Disadvantages / limitations	Caution!	Timing	Integrate with
Physical barriers (page 73)	▪ may reduce seed spread ▪ may offer protection to adjacent gamba grass-free areas	▪ high maintenance ▪ doesn't prevent seed spread completely ▪ may be unsuitable for fire-prone area	▪ additional surveillance and control activities needed at the barrier	▪ all times of year, especially when in flower and seed (April to August)	▪ prevention and surveillance activities ▪ herbicide control ▪ manual removal ▪ any other management tools (slashing, fire or grazing)
Buffers (page 75)	▪ may offer some protection to clean areas by reducing seed spread ▪ may satisfy legal requirements in some instances (refer to Chapter 5 – 'Further information')	▪ doesn't kill gamba grass ▪ ineffective if used on its own ▪ doesn't prevent medium-long distance seed spread ▪ not cost-effective in the long term	▪ buffers require frequent and ongoing maintenance to be effective	▪ maintain year-round	▪ herbicide control ▪ any other suppression activities (slashing, fire or grazing)
Fire (page 81)	▪ effective in some situations when combined with herbicide control ▪ can improve site access ▪ promotes new growth, increasing visibility and herbicide uptake ▪ reduces herbicide usage and costs ▪ can reduce seeding or kill seeds in some situations ▪ improves palatability	▪ doesn't kill gamba grass ▪ can spread seeds in some situations ▪ can cause mass germination of seedbank ▪ frequent burning can have negative impacts on soils and native plants and animals	▪ must not burn when gamba grass is in seed	▪ late wet season ▪ early dry season	▪ herbicide control ▪ grazing
Grazing (page 78)	▪ reduces biomass ▪ maintains palatability ▪ reduces fire intensity ▪ may reduce seeding	▪ doesn't kill gamba grass ▪ ineffective when used on its own ▪ can spread seeds if present ▪ less effective in large-scale woodland settings	▪ may contribute to degradation in some environments (e.g. conservation areas)	▪ most beneficial during wet season; however, can be grazed all year in some regions if palatable	▪ slashing ▪ fire

Legal requirements to control gamba grass

As of December 2024, gamba grass is:

- an eradication target throughout WA
- a containment target in and around Darwin and an eradication target across the remainder of the Northern Territory (refer to NT's gamba grass declaration zones on the NT government website)
- a category 3 weed across Qld, however may be a local prevention, eradication or containment target in Qld, depending on the local government area; contact your local government to obtain a copy of their biosecurity plan.

At a minimum, you're obliged to work towards the management objective of the state, region or local government in which you're operating. Refer to Chapter 5 ('Further information') for the current declaration status of gamba grass throughout Australia. Contact your local biosecurity officer for further information.

Safety and welfare

Safety and welfare should be your top priority when managing gamba grass. The main risks associated with gamba grass management are listed below, along with ways to manage them.

Risk	Mitigation
Risks associated with available control methods (e.g. chemical handling)	Wear personal protective equipment (e.g. leather gloves, eye protection, mask or respirator, long-sleeved shirts, long pants, leather boots). Undertake training in control techniques.
Heat-related risks	Wear personal protective equipment (e.g. sunscreen, wide-brimmed hats, long-sleeved shirts, long pants), drink ample fluids, work in coolest parts of the day, take regular breaks.
Difficult terrain (injury risk)	Wear personal protective equipment. Take communication tools (e.g. phones, EPIRB, UHF radio, etc.)
Injury from wildlife	Take first aid and snake-bite kits.
Vehicle/machinery accident	Work/travel in pairs or groups. Undertake and maintain relevant training.

Managing gamba grass can also affect you psychologically. For example, the impacts of gamba grass and the challenging nature of management can cause stress. Ensure you're well supported and seek help if you need it. The resources below may be helpful for you or someone you know that requires support.

Beyond Blue: www.beyondblue.org.au 1300 224 636

Lifeline Australia: www.lifeline.org.au 13 11 14

Chapter 3

Prevention

The most cost-effective way to manage weeds is to prevent them from spreading and establishing in the first place. Many areas across northern Australia are still free of gamba grass – but they're at risk of invasion. Investing time and money in spread prevention activities will reduce the chances of gamba grass seeds reaching areas that are currently free of the weed. Gamba grass spreads along both natural pathways and human-assisted pathways. Understanding these pathways can help you when developing strategies to reduce the likelihood of spread.

Figure 3.1 shows how gamba grass can spread through the consolidation and expansion of existing infestations. This initially occurs through localised spread mechanisms (such as wind, animals and water) and then by further spread along long-distance pathways (such as roads, machinery and equipment, and intentional introduction). Linear landscape features, such as rail lines, stock routes, power easements and rivers, can also be significant pathways of long-distance spread. Consider both the local scale and the landscape scale in your gamba grass management programs.

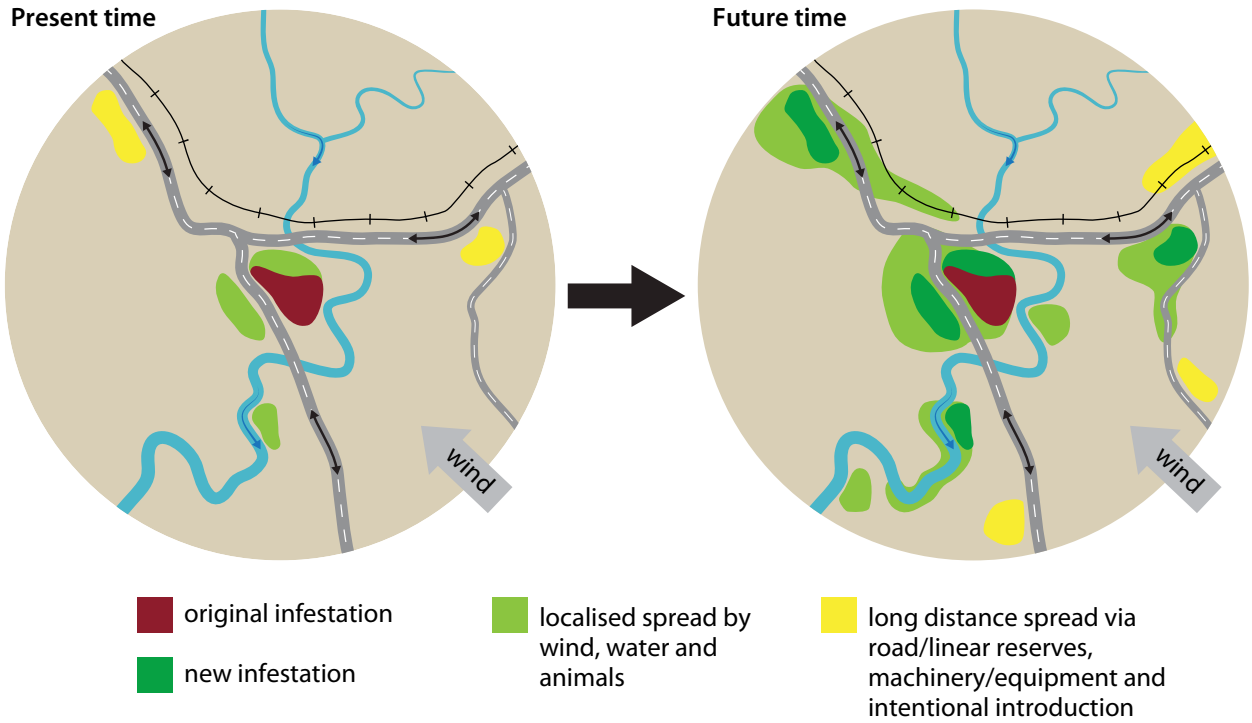


Figure 3.1 Example of gamba grass spread over time at the landscape scale.

The practices outlined in this section will help prevent or limit the spread of gamba grass in all land-use situations. They can also help prevent the spread of other weeds. For example, mission grasses (*Cenchrus* spp.) and Siam weed (*Chromolaena* spp.) can co-occur with gamba grass. If propagules of these weeds are on a vehicle, a hygiene procedure for gamba grass (see below) will assist in preventing the spread of these important weeds too.

Make it a priority to control gamba grass before seed set to reduce risk of spread. If seed is present, use the following to help reduce further spread.

- If small infestations or isolated plants, consider removing seed (see page 57).
- Minimise movement and stay on formed tracks and roads.
- Implement hygiene measures, both personal (clothing footwear and equipment) and on vehicles.
- Try to exclude fire while in seed.

General strategies to reduce weed spread

All people entering the property you're managing should act to prevent or minimise the spread of weeds. This could apply to fellow land managers, friends, tourists, utility managers or contractors who could be unknowingly carrying seeds of gamba grass or other weeds.

- Consider using vendor declarations for buying and selling stock feed, building and landscaping products, or other goods that may be contaminated.
- Request that contractors, vehicle and equipment entering the management area are clean and free from gamba grass seeds. Where possible, use contractors who have a reputation of being weed-aware.
- Share your property hygiene protocol with visitors and encourage them to follow it.
- Consider erecting signage at entrances to the property advising of the measures that are in place to prevent the spread of weeds.
- Carry out periodic surveillance following earth-works on roads, tracks, culverts or other areas to ensure that gamba grass hasn't been introduced or established in these disturbed areas.

It's good practice to take these precautions at all times of the year and in all situations, but it's critically important when gamba grass is flowering or in seed (April to August).

Rowena Eastick

Signage can inform others that gamba grass management is occurring, or of any hygiene requirements that apply to the site.

Follow these general strategies in your day-to-day activities to reduce the movement of gamba grass and other weeds:

Education and awareness

- Learn to correctly identify high-priority weeds, including gamba grass.
- Identify and regularly inspect high-risk areas of spread onto and within a management area, e.g. fence lines, along roadsides, water courses.

Early actions

- Control or report gamba grass as soon as you find it.
- Don't harvest pasture, grain or fodder crops while gamba grass is in seed.
- Determine if any planned activities are likely to intercept known infestations of gamba grass or other priority weeds, and develop a spread-prevention plan.
- Keep roads, laneways and buffer zones free of weeds.

Hygiene

- Avoid entering or working in areas where gamba grass is in seed.
- Inspect and clean vehicles, machinery and equipment when exiting areas of known weed infestations, and be clean before entering areas of high sensitivity (e.g. areas of conservation significance, farms).
- Establish designated clean-down areas and monitor for weed growth.
- Ensure clothing and footwear are free of soil and weed material before stepping into vehicles.
- Where possible, begin work in clean areas or in areas with the least amount of infestation and work towards infested or high-density areas.
- If transporting weeds for disposal following physical removal, secure the load and carry out hygiene procedures.
- Undertake an accredited vehicle and machinery hygiene training course.

Rowena Eastick

Gamba grass establishing following the construction of a culvert. Seed may have arrived on contaminated machinery or fill.

Rowena Eastick

Gamba grass infestation on a power easement that's been slashed during seeding. This practice can lead to further spread along the easement and long-distance spread. Reduce this risk through hygiene measures and by not slashing when the plants are seeding.

Trace forward and trace back

It is important to think about where gamba grass has come from and where it might go and how it might get there. For example, gamba grass often grows in areas where equipment and machinery are stored before being transported to remote communities. It also commonly grows in quarries, where gravel and crushed rock are sourced for various civil works, including road construction. This presents a significant spread risk to areas that are currently free of gamba grass or are part of an eradication management objective.

- Controlling gamba grass at point sources should be considered a management priority.
- Ensure all machinery, equipment, produce and material are seed free before moving.
- Consider establishing inspection and quarantine areas at the receiving environment.
- Carry out routine surveillance at the receiving environment.

Be proactive. If you don't have gamba grass or are in the process of eradicating it, think about all the pathways through which seeds could re-enter. Use Chapter 2 ('Setting yourself up for success') to develop strategies to intercept these pathways and reduce the likelihood of gamba grass seed arriving or establishing at your site.

Weed Management Branch, Northern Territory Government.

Weed Management Branch, Northern Territory Government.

Gamba grass on country often originates from seeding plants at storage facilities where seeds can contaminate freight and vehicles and be transported to remote areas.

Vehicles, machinery and equipment hygiene

Vehicles, machinery and equipment play large roles in spreading gamba grass seeds. Vehicles involved in weed management can easily spread weeds between sites. A simple rule of thumb is to ensure that vehicles, machinery and equipment are free of all weed material (seeds and other propagules) before they enter a property or management area and when they leave. Figure 3.2 highlights areas of a vehicle where reproductive material can become lodged and where inspections and cleanings should be carried out.

Inspect and, where necessary, clean vehicles, machinery and equipment before leaving an infested site. Dustpans and brooms, air compressors and high-pressure wash units are all effective and practical ways of cleaning vehicles and machinery. The Civil Contractors Federation have developed a detailed checklist of inspection points for both vehicles and machinery (Table 3.2).

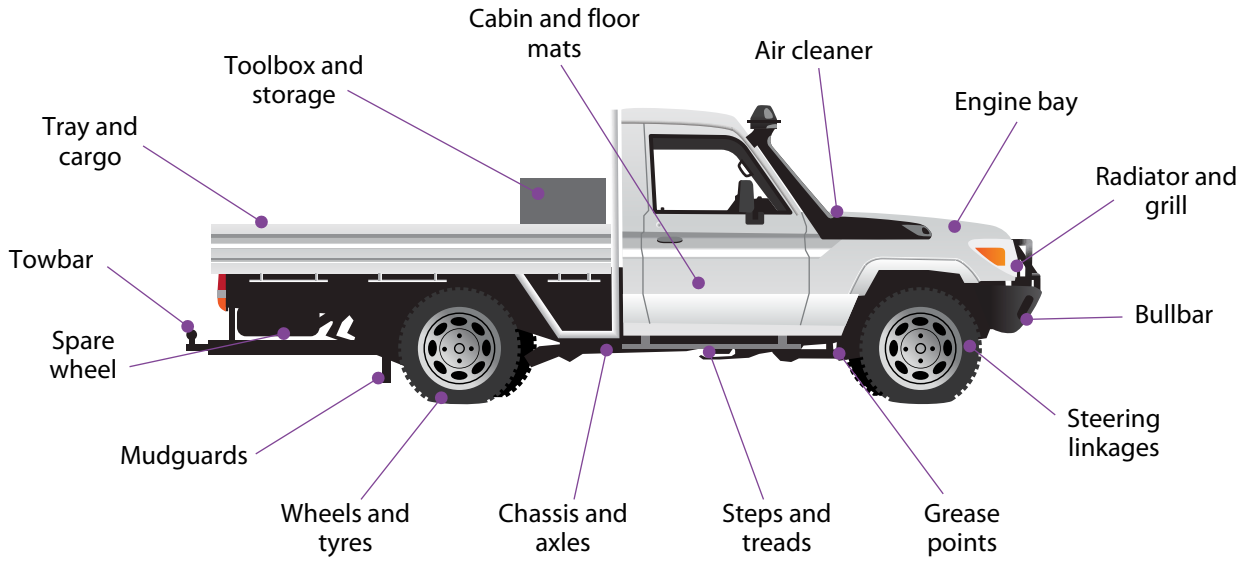


Figure 3.2 Vehicle parts that require attention during clean-down procedures. Symbol courtesy of the NESP Resilient Landscapes Hub, nesplandscapes.edu.au.

Table 3.2 Checklist for inspecting equipment and vehicles.

Best Practice Standards	
Lights and accessories ▪ lights ▪ toolboxes ▪ tynes and rippers ▪ support frames ▪ hoses.	**Slashers** ▪ top ▪ underside ▪ recesses ▪ crevices.
Underside of the vehicle/ machinery ▪ guards and plates ▪ chassis rails and brackets ▪ recesses ▪ around fuel tank ▪ axle housing, spare tyres ▪ ledges, gaps, crevices.	**Wheels and steering** ▪ treads ▪ outside and inside rims ▪ wheel arches ▪ mud flaps ▪ brackets and brakes ▪ steering components.
Track area (for excavators) ▪ shoe ▪ links ▪ sprockets ▪ idler wheels ▪ track adjuster guards ▪ lubrication points ▪ inside the track area.	**Cabin** ▪ carpets ▪ mats ▪ footwells ▪ pedals ▪ controls ▪ seats ▪ air-conditioner.
Engine ▪ chain cases ▪ plates ▪ radiator fins and grille ▪ between cooling cores ▪ engine mounts ▪ recesses ▪ floor of the engine bay ▪ air filter ▪ battery box.	**Blades, buckets and arms (for excavators)** ▪ front and back of cutter edge ▪ teeth ▪ pivot points ▪ turning circle ▪ hydraulic rods ▪ inside and back of bucket ▪ hoses ▪ wear plates.

Source: Civil Contractors Federation (2011) *A guide for machinery hygiene for civil construction*.

Matt Sheehan

Gamba grass seed heads can easily contaminate vehicles and be spread long distances.

Clean-down facilities

Cleanings and inspections minimise the risk of spread. Clean-down facilities should be constructed in a degraded area near the boundary between core infestations and clean areas. Facilities may use high-pressure hoses, compressed air, vacuuming or physical removal (e.g. hand brush). A range of facilities can be constructed based on needs and budgets, and they can be purpose built or developed for general use for a range of purposes.

When cleaning, always:

- appropriately dispose of any seed collected
- monitor the clean-down site for emerging gamba grass or other weed seedlings, and control as needed.

Matt Sheehan

Matt Sheehan

Clean-down facilities. (a) A gamba grass clean-down and inspection bay near Cooktown in Far North Queensland. Coarse aggregate is the base of the bay where physical inspections are carried out, before the vehicle is cleaned using high-pressure water pumped from tanks. (b) A local government high-pressure clean-down facility in operation in Queensland.

Surveillance

Surveillance includes searching for new populations of gamba grass and/or periodically assessing changes to known distributions and their density (e.g. have they increased or decreased?). Importantly, surveillance can confirm that an area is free of gamba grass.

There are many ways that surveillance can occur – actively (e.g. specifically looking for gamba grass using a strategic methodology) or opportunistically (e.g. finding and recording gamba grass while carrying out other tasks). There are also various tools and technologies that can be used to assist with surveillance activities. It is important to decide what type of surveillance to undertake and identify the most effective places to search.

Surveillance provides an opportunity for new infestations of gamba grass to be **detected**, **delimited** and subsequently **eliminated before** they become **widespread**.

Surveillance can also confirm that gamba grass is absent from an area.

Finding new infestations

Conduct regular surveillance to detect new incursions or range expansions of gamba grass. It's important to monitor high-risk sites and control detected plants before they set seed.

Areas to check during regular land management activities include:

- fence lines
- property boundaries
- roads and tracks
- rocky outcrops
- riparian areas, drains and flood-out areas
- infrastructure (e.g. around sheds, yards, tanks, culverts)

- previously treated sites and surrounding areas
- historic pasture trial sites or abandoned pastoral leases
- high-priority conservation areas
- receiving environments of gravel or crushed rock (e.g. roadsides, culverts).

Remember that gamba grass is more likely to establish on bare or disturbed ground than in areas of intact vegetation. Record and map the locations of treated or removed plants so that it's easy to return to the same location to search for new plants.

Chapter 2 ('Setting yourself up for success') has more information on mapping.

Matt Sheehan

Aerial surveillance in Kakadu National Park. This is an effective method for remote locations.

Chapter 3

Control methods

This section outlines the control methods that are currently available for gamba grass. The main methods are manual removal, herbicide control, and other management tools, including barriers, buffers, slashing, grazing and fire.

A critical part of developing your control program is deciding which control method or combination of control methods to use. Key considerations include the size of the infestation (some control options can only be used in certain situations) and whether the infestation is difficult to access or is in a sensitive site (such as an area of conservation significance). Table 3.1 compares the advantages, disadvantages/limitations, timing and other considerations of each method. A summary of situational suitability is also provided in a table under the discussion of each method.

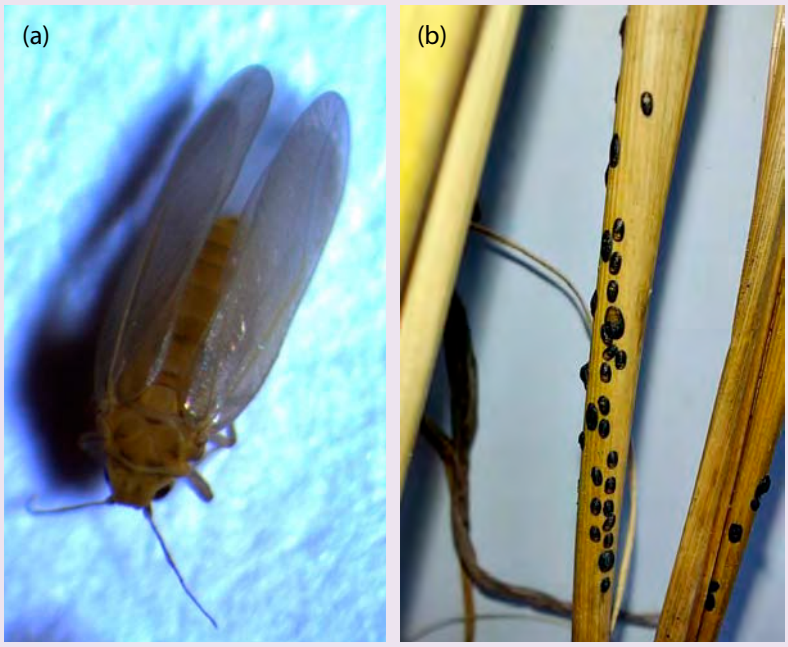
Biocontrol options for gamba grass – early days

Biological control (or biocontrol) uses an invasive species' natural enemies, such as herbivores and pathogens, to help control the pest species. These natural enemies are referred to as 'biocontrol agents'.

While no biocontrol agents are currently available for gamba grass in Australia, the Environment and Invasives Committee has endorsed gamba grass as a candidate for biocontrol. This means that research can begin to identify and test potential biocontrol agents.

Preliminary surveys conducted by CSIRO researchers in gamba grass's native range (South Africa and Zimbabwe) have identified a seemingly host-specific whitefly species (*Tetraleurodes* sp.). Further systematic surveys and studies will be required to understand how this species damages gamba grass and its suitability as a biocontrol agent.

Australian researchers are actively looking for opportunities to commence comprehensive native range surveys for other potential biocontrol agents for gamba grass.



Rhodes University, South Africa

Whitefly Tetraleurodes *sp. in South Africa. (a) adult fly and (b) black sessile pupae attached to culms (stems) of gamba grass.*

Manual removal

Suitable for:	Less suitable for:	Examples of situations
✓ small infestations or isolated plants	× large or dense infestations	→ new plants that have emerged in a drain/ culvert
✓ small plants (<2 m)	× large plants.	→ isolated plants on a roadside in an eradication zone
✓ remote and accessible areas.		→ isolated plants outside a containment line.

Hand pulling or grubbing out plants with a mattock or hoe is a feasible, cost-effective management method for isolated plants or small infestations. Manual removal is particularly good when:

- you come across an isolated plant
- seedlings emerge following earthworks, fire or other soil disturbance
- you want to contain core infestations by removing outlier plants that are starting to spread.

Raitech

Hand removal of gamba grass, El Questro, WA.

Steps to manual removal

1. Remove seeds

Matt Sheehan

Mature seeds detach from stems very easily. If seeds are present, carefully gather a handful of stems, bend them over, and place ends with seeds in a bag before cutting them off.

2. Hand pull or grub out

Casuarina Coastal Reserve Adopt-a-Spot program

Hand pull or grub out whole plants and roots.

Shake off any excess soil to prevent regrowth.

3. Dispose of appropriately

Territory NRM

Territory NRM

Ideally, bag and remove plants or seeds for disposal in an approved deep-burial facility. In some instances, plants without seed can be dried on site by hanging in a tree or leaving on a track. Ensure that the disposal method is environmentally and culturally appropriate for your situation.

Timing

Manual removal is easiest when the soil is moist – minimising effort and maximising likelihood of removing the entire plant. Remove plants before they set seed to reduce the risk of spread away from the site. While manual removal can theoretically be carried out at any of its life stages, from seedling through to large mature plants, young gamba grass plants that are less than 2 metres in height are the most suitable for this control method. Seedlings are very hard to identify, therefore it's advised that you mark the area and return when it has grown to a stage where it can be more easily identified (ensure this is before it produces seed). Large mature plants can be too difficult to manually remove and an alternative control method should be considered.

Manual removal is commonly integrated with other control methods in a management program. For example, a containment strategy might involve treating a core infestation with herbicide and manually removing any outliers and small plants that re-emerge after treatment.

Follow-up is critical to remove any plants that were missed or have established since the initial control. Follow-up will increase the likelihood of success and should be conducted at least once per year.

Grasses can be very difficult to identify. If you are not completely sure the plant is gamba grass, contact a weed expert or submit a specimen to the herbarium before removing. Refer to Chapter 5 ('Further information') for herbaria contact details.

Weed Management Branch, Northern Territory Government

A young gamba grass plant – a suitable size for manual removal.

Herbicide control

Herbicides are a fundamental tool in the control of gamba grass. This section provides critical information to help you tailor a herbicide control program for your situation based on available application methods and learnings from experienced gamba grass managers.

Key points

- You may need multiple treatments per year to control gamba grass – this has time and cost implications.
- Follow-up is critical and should continue for 3–5 years.
- Aim to prevent seeding between treatments. This will deplete the seedbank over time.
- Timing of treatments and integration with other control options will depend entirely on your situation.
- Remember: spray gamba grass when it's ready, not when you are.

This section outlines critical information on:

- herbicides available for use on gamba grass – pages 59–62
- herbicide application techniques for gamba grass – pages 63–72.

A factsheet on how to use herbicides legally, safely and effectively is provided in Chapter 5 ('Further information').

Before commencing any weed control ensure you:

- **read the factsheet Using herbicides legally, safely and effectively in Chapter 5 ('Further information')**
- **are aware of legislation regarding herbicide use**
- **refer to weed control contacts in Chapter 5 ('Further information') for advice and assistance.**

Herbicides used on gamba grass

Glyphosate use on gamba grass can be covered under 'general weed control' for certain situations for several glyphosate products (Table 3.3). While gamba grass is not listed on the label of any herbicide product, two products can be used in certain situations (Table 3.4). Several minor-use permits cover the use of glyphosate on gamba grass in specific situations and a Queensland permit allows the use of fluproponate.

Additionally, state or territory legislation may enable use of certain herbicides where a weed isn't specified on the label. For example, using glyphosate for ground-spraying gamba grass in the Northern Territory is enabled under section 22(3) of the *Agricultural and Veterinary Chemicals (Control of Use) Act 2004* at a rate of 10 mL/L.

Rowena Eastick

Hand gun application of glyphosate.

Chapter 3

Glyphosate is a non-selective herbicide used on many annual and perennial broad-leaf weeds and grasses. It isn't residual, meaning it only kills existing plants, and it's deactivated on contact with the soil. Glyphosate is absorbed by the leaves and stems and is translocated throughout the plant via the sugar transport system (phloem). It acts by inhibiting an enzyme needed for the production of amino acids used in protein synthesis for plant growth. Only healthy and actively growing plants should be treated. Other factors, such as plant stress, extreme weather, water quality and leaf characteristics (e.g. hairy or waxy) can affect glyphosate uptake. Glyphosate also comes in a range of formulations and concentrations, so this must be considered when diluting herbicides (see Box 3.1 and Box 3.3 for further information).

Flupropanate is a soil-active, residual herbicide that requires rain to wash it into the soil where it can be absorbed through the root system of plants. A single application has the potential to control mature plants and germinating seedlings. Effectiveness and residual timeframes will vary depending on soil type and rainfall. Flupropanate is considered a grass selective herbicide, however it is important to note that it will still cause off target damage to native grasses.

Tables 3.3 and 3.4 contain more details on herbicide concentrations, application methods and situations where it can be used. Use these tables as a guide only, as permits do expire and new products may become available. Check the permit or label before application to ensure it's still valid to use the product.

Box 3.1

Water quality and herbicide effectiveness

Poor water quality can reduce herbicide effectiveness by:

- increasing chemical breakdown in the spray water (hydrolysis)
- reducing herbicide activity (inactivation) through contaminants, such as clay and silt, or trace elements binding to the herbicide
- precipitating the pesticides out of solution
- blocking spray lines.

Key water quality factors impacting herbicide effectiveness are hardness (calcium content), salinity, presence of mud or silt and pH. The table below summarises the effects these factors have on the effectiveness of glyphosate and flupropanate. As a rule, use clean water and avoid dam water, hard water and alkaline water.

Herbicide	Hard water	Saline water	Muddy water	Alkaline water	Acidic water
Glyphosate (e.g. Roundup®)	✗ Reduces glyphosate effectiveness	✓ Doesn't affect glyphosate effectiveness	✗ Reduces glyphosate effectiveness	✗ Reduces glyphosate effectiveness	✓ May increase glyphosate effectiveness
Flupropanate (e.g. Taskforce®)	✓ Doesn't affect flupropanate effectiveness	✓ Doesn't affect flupropanate effectiveness	✗ Taskforce® label recommends avoiding silty water	✓ Doesn't affect flupropanate effectiveness	✓ Doesn't affect flupropanate effectiveness

Read the label prior to mixing and applying herbicide. The effect of water quality will be outlined on the product label, usually in the section on tank mixing.

Table 3.3 General use provisions for use of glyphosate on gamba (current as at April 2024).

State/ territory	Application method	Situation in which the herbicide is registered	Comments
All	**Spot spraying** Handgun/knapsack	Domestic, commercial, industrial, public service and agricultural areas	Covered under a general weed control table e.g. Roundup Biactive® label Rate dependent on formulation – refer to label

Table 3.4 Herbicides permitted for use under minor-use permits (current as at December 2023).

Active ingredient	State/ territory	Application method	Situation in which the herbicide is registered	Permit number
Flupropanate 745 g/L present as sodium salt as the only active constituent	Qld	**Foliar application (e.g. spot gun)** 300 mL flupropanate product + 700 mL of water to make a 1 L solution (refer to permit instructions)	Pastures, non-crop areas, urban open space, woodlands, roadsides, nature reserves and revegetation sites	PER94351 Expires May 2027
Glyphosate 360 g/L	Qld	**Spot spray/High-volume, low-concentration foliar application (e.g. handgun, knapsack)** 1:100 dilution (refer to permit instructions)	Non-agricultural areas, domestic and public service areas, commercial and industrial areas, bushland/ native forests, roadsides, rights-of-way, vacant lots, wastelands, wetlands, dunal and coastal areas	PER11463 Expires April 2027
	NSW, ACT		Native vegetation, forests, non-crop areas, open public spaces, domestic and urban areas	PER9907 Expires April 2027
	Qld	**Low-volume high-concentration foliar application (e.g. splatter gun)** 1:9 to 1:20 dilution (refer to permit instructions)	Non-agricultural areas, domestic and public service areas, commercial and industrial areas, bushland/ native forests, roadsides, rights-of-way, vacant lots, wastelands, wetlands, dunal and coastal areas	PER11463 Expires April 2027
	NSW, ACT		Native vegetation, forests, non-crop areas, open public spaces, domestic and urban areas	PER9907 Expires April 2027
	Qld	**Boom spray** 10 L/ha	Non-agricultural areas, domestic and public service areas, commercial and industrial areas, bushland/ native forests, roadsides, rights-of-way, vacant lots, wastelands, wetlands, dunal and coastal areas	PER11463 Expires April 2027
	WA		Agricultural non-crop areas, non-crop areas, commercial and industrial areas, wetlands, bushland and forests	PER13333 Expires Mar 2025
	NSW, ACT	**Wick-wiping** Undiluted to 1:20 dilution	Native vegetation, forests, non-crop areas, open public spaces, domestic and urban areas	PER9907 Expires April 2027

Table continued on next page/. . .

Active ingredient	State/ territory	Application method	Situation in which the herbicide is registered	Permit number
Glyphosate 450 g/L	WA	**Wick-wiping** Undiluted to 1:5 dilution	Agricultural non-crop areas, non-crop areas, commercial and industrial areas, wetlands, bushland and forests	PER13333 Expires Mar 2025
Glyphosate 540 g/L	NT	**Aerial application** Aircraft (fixed wing aircraft or helicopter)	Fire-break establishment along fence lines, fire-access trails, railways and roadways. Aerial spraying permitted within pastoral and non-arable lands only	PER93598 Expires Oct 2028
Glyphosate 540 g/L	NT	**Aerial application** Helicopter	Fire-break establishment along fence lines, fire-access trails, railways and roadways. Gamba grass control in specific national parks* with heavy infestations	PER93599 Expires Oct 2028

* Refer to permit for the national parks that this permit applies to.

Optimum herbicide treatment time

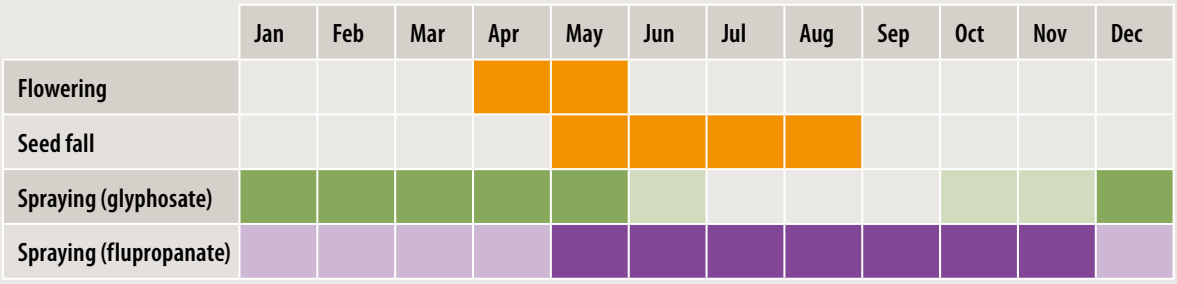
Table 3.5 provides general guidelines for when it's suitable to treat gamba grass with herbicide. Note that times shown are indicative only, as climate is changing and becoming less predictable. There are also climatic differences across the geographic range of gamba grass in northern Australia. This influences the life cycle of gamba grass, when gamba grass will be responsive to herbicide treatment, and when sites can be accessed. Observe the plants' growth stage at your site and respond appropriately.

For glyphosate application, spray when gamba grass is green – it's actively growing and will respond to herbicide application. Ensure you can access the site and the weather conditions are suitable for spraying. Treatment won't be effective if the gamba grass is brown – usually between June and August, but could be as early as May and as late as October.

Avoid spraying during seeding. Herbicide treatment is still effective if a plant is in flower or seed. However, you risk spreading gamba grass further if seed is present. If you must spray then, be sure to put in place hygiene procedures to reduce seed spread (refer to pages 49–54).

For flupropanate application, spray in the late dry season or early wet season (refer to Box 3.1).

Table 3.5 Indicative timing of flowering and seeding and the theoretical best times for spraying gamba grass. Darker colours indicate typical timing, while lighter shades indicate additional months that may be suitable depending on start and end of wet season, which varies across Northern Australia and year to year (e.g. variability of when the plant is actively growing, and when seed is present).



Herbicide application methods

Application methods include:

- spot spray (glyphosate) – handgun or knapsack application (high-volume, low-concentration foliar applications)
- spot spray (fluproponate) – spot gun or metal tree injector (refer to Box 3.1)
- splatter gun (low-volume, high-concentration foliar applications)
- broad-acre treatments, including boom application and aerial application with crewed aircraft or drones
- wick-wiping.

These application methods are discussed in the following sections.

Regardless of application method:

- ensure all spray equipment is correctly calibrated before use
- always use clean water and strictly follow all herbicide label and permit directions and rates (see Box 3.1)
- apply glyphosate when gamba grass is actively growing and not under drought stress
- for glyphosate, complete spraying at least an hour before rain so that the herbicide is absorbed and not washed off
- consider using a GPS tracker, flags, stakes or fence-droppers to help you divide up and mark areas being treated; consider using dye in your herbicide mix
- incorporate hygiene protocols into your spraying programs to minimise spread of gamba grass or other weeds you may encounter at the site (refer to pages 49–54)
- set achievable goals on how much area you can treat in one session
- take your time and have regular breaks.

Integrated weed management

Slashing, grazing or burning gamba grass can sometimes make it easier to traverse a site, see all gamba grass plants, and spray entire plants. Whether or not you should integrate these methods into your management will depend on your situation and objectives. Refer to pages 76–83 for a discussion of both the advantages and potential risks of integrating these methods with herbicide treatments.

For general guidelines for using herbicides, refer to the Herbicide fact sheet In Chapter 5 ('Further information').

Time follow-up treatment to prevent seed production

Regardless of your control approach, you likely won't achieve 100% kill on the first treatment if the gamba grass is dense. Any gamba grass that survives will produce seed, adding to the soil seedbank or spreading to new areas. Your follow-up treatment should be timed to prevent further seed set.

- Carry out your initial knock-down, aiming to spray as much gamba grass as you can.
- When plants start to show signs of dying (e.g. yellowing or wilting), revisit the site and spray any plants or parts of plants that are still green and healthy.
- Ideally, continue follow-up control at intervals to prevent seeding for the next 2–3 years, targeting both missed plants and new seedlings.

While this may sound excessive, investing in intensive follow-up will pay off in the long term. The seedbank of gamba grass only lasts for 1–2 years in the soil. Intensively managing to prevent further seeding means less effort is needed in following years, as long as no further seed is coming onto the site from elsewhere.

Handgun or knapsack

High-volume foliar spraying with handgun or knapsack (spot spraying)

Suitable for:	Examples of situations
✓ most situations (small infestations or isolated plants through to large, dense infestations)	→ roadside management and other linear reserves
✓ remote sites and accessible sites	→ infestations among desirable vegetation and areas with conservation significance
✓ plants of all sizes	→ small-acre peri-urban blocks and built-up areas.
✓ control and follow-up treatments.	

This application method delivers high-volume, low-concentration herbicide to all foliar parts (leaves) of the plant. Also called 'spot spraying', it refers to the direct treatment of individual plants irrespective of density. 'Handgun' typically refers to spray units with high-volume (300–500 L) vehicle-mounted tanks and an automated herbicide delivery system. These units are designed for large or dense infestations. Knapsack or backpack spray units are carried by the operator and are useful for remote work where vehicle access is limited. However, these units can only carry a limited amount of herbicide (typically 15 L) and so this method is most suitable for small, scattered infestations. Spot spraying is the most commonly used and versatile application method, suitable for a range of situations and weed densities.

Application (with glyphosate)

Spray actively growing gamba grass. This includes all growth stages, from seedlings to mature plants. Ensure at least 40 cm of regrowth after the dry season or following fire or slashing.

Ensure every gamba grass plant is completely coated with herbicide spray, including every individual tiller, otherwise the plant will survive. Follow up treatments with further spot-spraying or manual removal, as some plants may have been missed and new seedlings will often emerge.

Rowena Eastick

A partially sprayed tussock that has survived herbicide treatment.

Optimising spot spraying in dense infestations

To kill gamba grass, herbicide (glyphosate) must be applied to all above-ground parts of the plant. This is relatively easy for small or isolated plants but is more difficult for large (>2 m) plants or dense infestations. There are several reasons for this.

- It may be difficult to access and spray entire plants – plants will survive partial spraying and continue to seed.
- Dense gamba grass commonly establishes in wooded areas, making control more complex.
- Handgun-based spraying is limited by vehicle access, hose length and the amount of herbicide that can be carried.

The 'chocolate-block' technique – a structured method for applying herbicide

This method, coined by Northern Territory Gamba Army Team Leader Hamish Clark, is an effective way to spray large, dense gamba grass infestations within wooded areas. It maximises efficacy and operator safety by minimising effort, reducing missed plants and the likelihood of operators walking through treated areas.

The technique (Figure 3.3) uses a linear access feature, such as a fence line, fire trail or slash line. The treatment area is then divided into blocks at right angles to this linear feature.

- Divide the area into blocks based on the length of the hose, terrain, vegetation density and nozzle spray range. This example has a hose length of 100 m and a spray range of 10 m.
- Drag the hose out to its full extent along the centre line (labelled 'A' in Figure 3.3).
- Spray a block to the left of the centre line (labelled '1'), then spray block 2 to the right of the centre line 'A'.
- Sequentially treat blocks 3, 4 and so on, back to the spray rig.

When all blocks are treated, move the vehicle with spray rig along to centre line 'B' (in this case, 20 m to the right) and repeat.

Working in pairs on neighbouring centre lines improves efficiency and reduces the likelihood that areas will be missed.

Remember to:

- consider wind direction and work within blocks to avoid spray drift, either to yourself or adjacent operators
- set up some reference points using flagging tape to mark out the blocks.

Refer to Chapter 4 ('Case studies') for examples of how land managers have tackled large, dense infestations.

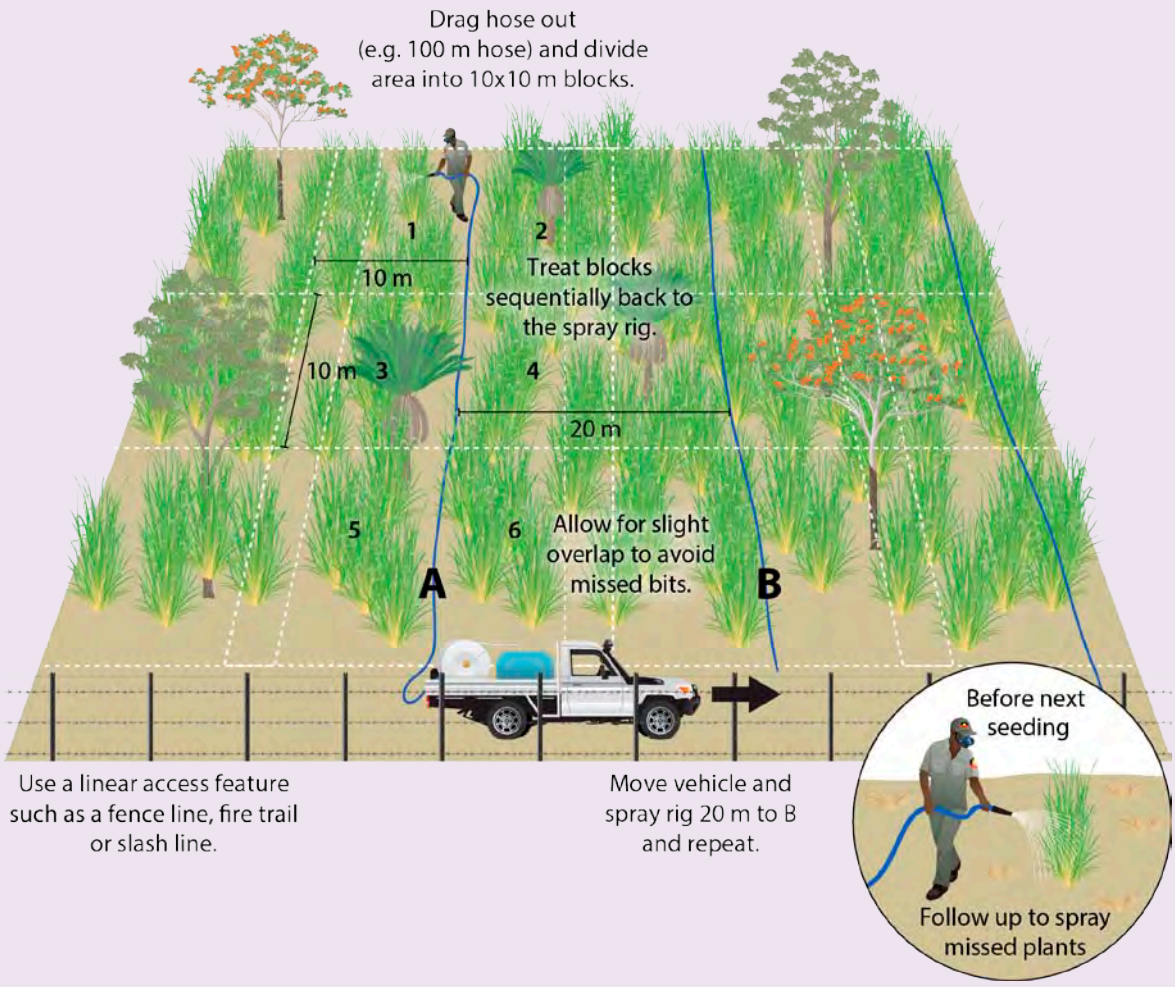


Figure 3.3 Applying herbicide using the 'chocolate-block' technique. Symbols courtesy of the NESP Resilient Landscapes Hub, nesplandscapes.edu.au.

Trials continue in the search for new herbicide options for gamba grass

There's a strong desire amongst gamba grass managers to identify effective herbicide alternatives to glyphosate, including herbicides that are more selective to reduce off-target impacts and herbicides that have residual or lasting effects following initial treatment.

Thanks to researchers at Biosecurity Queensland and The University of Queensland, we now have a permit in Queensland for the use of flupropanate on gamba grass. Trials will continue to understand the effectiveness of these new techniques long term.

Research into other herbicides will also continue, including trials of spot application of the herbicide sulfometuron-methyl for gamba grass control.

Contact your local weed officer for information on changes to herbicide control options or to hear about any opportunities to take part in control trials for gamba grass.

Box 3.2

Spot application using fluropropanate (Queensland only at June 2024)

Suitable for:	Less suitable for:	Examples of situations
✓ small/scattered infestations or isolated plants	× large-scale weed control	→ sites only accessible in the dry season
✓ both remote and accessible sites	× areas with dense gamba grass monocultures	→ infestations among desirable vegetation and areas with conservation significance
✓ plants of all sizes		→ sites in the early stages of invasion
✓ follow-up treatments		
✓ sites with mixed vegetation		
✓ year-round application		

Trials conducted by Biosecurity Queensland and The University of Queensland on the herbicide flupropanate (e.g. Tussock™) concluded that effective control can be achieved when flupropanate is applied to individual gamba grass plants through spot application. While treatment can be applied at all times of the year, it was found to be most effective in the late dry season and early wet season.

Advantages of flupropanate application:

- Flupropanate is a grass-selective herbicide, and therefore has minimal off-target impacts on broadleaf plants. However, care should be taken to minimise impact on desirable grasses.
- Unlike glyphosate, flupropanate is absorbed through the roots and can therefore be applied to the tussock in the dry season, where it will enter the soil following first rainfall. This is good for sites that are hard to access at the optimum time for glyphosate spraying.

In April 2024, a permit was issued by the APVMA to allow spot application of flupropanate on gamba grass in Queensland (see Table 3.4).

Application

Apply one 5 mL shot solution (see Table 3.4 for rate) to the centre of each tussock using a metal tree injector, spot gun or similar applicator.

- DO NOT exceed 3 litres of product per hectare or apply when there are more than 2000 gamba grass plants per hectare.
- DO NOT exceed a maximum of one treatment over the same area per year.

There is also a 14-day withholding period associated with this product, where areas that have received spot treatment cannot be grazed or cut for stock feed.

For more information refer to the permit at the APVMA website https://permits.apvma.gov.au/PER94351.PDF

Box 3.3

Gamba grass typically has hairy leaves which can reduce the absorption of glyphosate. The product beads on the leaf surface and in the northern Australian climate, may evaporate before it's absorbed or be washed off by wet season rainfall. Adding a surfactant or wetting agent improves glyphosate penetration. For information on adding a wetter, talk to your local weed officer or check the APVMA website.

No wetting agent

Wetting agent added

Rowena Eastick

Splatter gun

Suitable for:	Less suitable for:	Examples of situations
✓ initial knock-down of tall, dense infestations	× scattered infestations	→ natural environment with dense large plants
✓ infestations among mixed vegetation.	× small plants.	→ steep escarpments and riparian areas that are difficult to access
		→ abandoned cropping areas
		→ areas with limited vehicle access.

Splatter guns deliver low-volume, high-concentration herbicide to foliar parts of the plant. They are widely used in the control of woody weeds, such as lantana (*Lantana camara*) and bitou bush (*Chrysanthemoides monilifera*). Recent trials conducted by The University of Queensland concluded that splatter guns showed great promise when used as an integrated management tool for gamba grass control. The high herbicide concentrations knock down stands of mature gamba grass without having to achieve 100% foliar cover. This opens up dense infestations for follow-up control with handguns or knapsacks, reducing chemical use and spraying time.

Melissa Setter, Biosecurity Queensland

Splatter-gun application of glyphosate to control gamba grass at a trial site in Queensland.

Application

Apply approximately 4 mL/m in strips across the target vegetation. Further trial work will refine the technique for use on gamba grass.

CAUTION

Broad-acre applications of glyphosate can kill desirable vegetation. Be sure to consider and manage this risk.

- Assess your situation and the appropriateness of boom or aerial application of herbicide.
- Determine the potential off-target impacts and how to mitigate or reduce them.
- Develop a long-term strategy for ongoing management and restoration.
- Use skilled operators with experience in gamba grass control in your situation.

Broad-acre treatments

Broad-acre spraying methods, such as boom spraying or aerial application, may be appropriate on large land parcels with dense infestations of gamba grass. These treatments deliver a uniform blanket of herbicide to the foliage across the treatment area compared to the more selective application achieved with handgun and knapsack application (spot spray).

Boom spraying

Suitable for:	Less suitable for:	Examples of situations
✓ large, dense infestations (90–100% gamba grass cover) with vehicle access	× scattered infestations or isolated plants	→ abandoned cropping areas
✓ degraded or modified areas or where there's been a change in land use	× small infestations	→ some roadsides and tracks
✓ maintained service areas.	× mixed vegetation (among desirable vegetation)	→ historical grazing areas converted to cropping.
	× steep areas or where there's limited vehicle access.	

Boom spraying is usually done with a vehicle-mounted boom or boomless jet. Boom-spraying gamba grass can be cost-effective for large and dense infestations which are readily accessible on the ground.

Talk to your local weed officer to discuss the appropriateness of boom spraying for your situation and specifics on application methods.

Rowena Eastick

Boomless jet sprayer being used to control gamba grass on tracks and track edges in Charles Darwin National Park, Northern Territory.

Aerial spraying

Suitable for:	Less suitable for:	Examples of situations
✓ large, dense infestations (90–100% gamba grass cover)	× scattered infestations or isolated plants	→ degraded savanna on terrain that's steep or hard to access
✓ all terrains, including areas that are steep or otherwise hard to access	× small infestations	→ areas of broad-acre grazing that have been converted to horticulture
✓ degraded or modified areas or where there's been a change in land use.	× mixed vegetation (among desirable vegetation) or where there are canopy trees	→ abandoned cropping areas.
	× built-up areas.	

This section describes aerial spraying by helicopter or fixed-wing aircraft. Refer to the box below for information on uncrewed aerial vehicles (e.g. drones).

Advantages of aerial application:

- You can treat a lot of ground very quickly – multiple strategic sites can be treated in the same period.
- You're less constrained by seasonality, access and topography than with ground-based control. This may increase the treatment window. It's especially useful if you have a short treatment window before seeding.

Parks and Wildlife Commission, NT

Helicopter equipped with a boom spray unit in Lichfield National Park for spraying large, dense gamba grass infestations.

Drones

Uncrewed aerial vehicles such as drones have been used to successfully control grassy weeds such as *Sporobolus* spp. While the application of this technology to gamba grass is not well documented, it is likely to be suitable for small or scattered infestations in remote locations.

Drone-based applications may:

- reduce the off-target impact associated with other aerial herbicide applications by effectively spot-spraying individual plants
- enable treatment of gamba grass in mixed vegetation, including open woodland settings
- be less constrained by seasonality and terrain than ground-based control – increasing accessibility and the window for treatment
- be more cost effective and time effective than ground-based control in areas that are remote or hard to access.

However, limitations must be addressed before drones are a viable treatment option for remote locations. These include sight-line flying restrictions, chemical carrying capacity and battery life.

For further information on chemical control using drones, contact your local weed officer who may be able to put you in touch with an accredited and experienced drone operator.

Note: Drones are considered aerial vehicles and are regulated under Aerial Chemical Application rules. This means that a drone operator must have relevant qualifications and registrations, and they must abide by any aerial application requirements as per the label and as per the APVMA Spray Drift Policy. There may also be different requirements for qualifications and registrations in each state and territory.

Rowena Eastick

Wick wiping

Suitable for:	Less suitable for:	Examples of situations
✓ removing large plants in open production systems	× steep terrain, rocky or uneven areas*	→ abandoned cropping areas
✓ infestations on level ground that's free of rock, logs or stumps.	× areas where there are trees, shrubs or other things taller than gamba grass.*	→ mixed-grass production systems (e.g. humidicola and signal grass pastures)
		→ hay crops.

* Wiper height can't be adjusted automatically, limiting its use in several situations.

Wick Wipers Australia

Wick wiping selectively 'wipes' herbicide onto foliage. It's most effective when the target weed is taller than desirable species. This reduces off-target damage to desirable vegetation and minimises the amount of herbicide needed. Gamba grass is a good candidate for wick wiping because it grows faster than desirable species after slashing. The resulting height difference means that gamba grass is the optimal height for wick wiping. Apply when gamba grass is leafy and 1–2 m tall.

Equipment is mounted onto a vehicle or hand-held. Most devices consist of a rope wick or rotating carpet wiper saturated with concentrated herbicide that's 'wiped' over the plants.

Wick wiping has been successful in managing perennial grassy weeds, such as giant rat's tail grass (*Sporobolus pyramidalis, Sporobolus natalensis*), serrated tussock (*Nassella trichotoma*) and Chilean needle grass (*Nassella neesiana*), in specific pastoral and turf-management settings. While documented use of wick wiping on gamba grass is limited, it's currently in use on Cape York Peninsula for the management of gamba grass in hay crops. Herbicide rates of 1 part glyphosate 360 to 2 parts water (plus wetter) have been very effective. Further trials are currently underway in the Cook Shire, Queensland, for use on gamba grass in humidicola and signal grass. Talk to your local weed-management professional for more information this technique.

Application (based on use on other perennial grassy weeds and current trial on gamba grass)

- Crash-graze pastures to reduce the height of all desirable species. In non-grazing settings, consider slashing and allowing time for gamba grass to re-establish to approximately 50 cm above desirable vegetation. Wick wiping is most effective on green, actively growing foliage.
- Set wiper at a level of 10 cm above the pasture/ desirable species.
- Travel at low speeds (<8 km/hr). Depending on the type of wick wiper, you might need to do two passes in opposite directions to get adequate herbicide coverage.
- Keep wiper wet with herbicide at all times.
- Avoid dripping herbicide onto non-target species.
- Remember that seedlings or young plants will be missed, so monitor treated areas for small, missed plants and remove by chipping or spot spraying, or re-wipe when taller.

Other management tools

A suite of other management tools may make manual removal or herbicide control more effective, or meet other short-term land-management objectives.

These tools are:

- physical barriers and buffers
- slashing
- grazing
- fire.

These tools temporarily reduce gamba grass impacts by:

- reducing seed set, which reduces spread
- reducing biomass, which reduces fire severity.

These tools are often the go-to approach when maintaining service areas, reducing the public safety hazard associated with gamba grass, and protecting infrastructure. This is because they're a quick fix. For example, slashing gamba grass on a roadside immediately addresses sightline and visual amenity issues and reduces fire risk.

These tools should be integrated with herbicide treatments or manual control to achieve multiple management objectives, such as short-term public-safety outcomes and long-term conservation and cultural outcomes.

WARNING

Remember – while these 'other management tools' may provide short-term benefit, they:

- don't kill gamba grass plants
- don't reduce gamba grass in the long term
- may lead to increased density of gamba grass
- may increase spread
- are more costly long term than herbicide control and manual removal
- won't lead to eradication of gamba grass on their own.

Do not use these methods as your only long-term management tools. Use these methods in combination with manual removal or herbicide control, or as a one-off back-up management option.

Barrier fencing and buffers

Barrier fencing

Suitable for:	Less suitable for:	Examples of situations
✓ protecting assets from upwind infestations	× large-scale infestations	→ threatened native savanna with adjacent gamba grass infestation
✓ very small-scale areas that can be maintained.	× fire-prone areas.	→ reducing seed spread from a property where gamba grass is being actively grazed.

Physical barriers, such as barrier fences, can reduce the spread of weeds that have wind-borne seeds. Examples include serrated tussock (*Nassella trichotoma*) and thistle species in southern Victoria. While physical barriers don't completely prevent spread, they can help contain weeds at the property scale. Place barriers at the down-wind boundary of the property that has gamba grass to contain core infestations and protect adjacent high-value weed-free areas (Figure 3.4).

Barrier fences are typically made from mesh or shade cloth that's fine enough to obstruct the wind dispersal of seed.

The effectiveness and practicality of barrier fencing for use on gamba grass haven't been documented. Barrier fencing can be maintenance-intensive, and the prevalence of fire in northern Australia may make it impractical in many situations.

ONLY consider barrier fencing:

- **at a very small scale (e.g. to directly protect an asset or to reduce gamba grass seed spreading from your property)**
- **where fire is unlikely or can be excluded.**

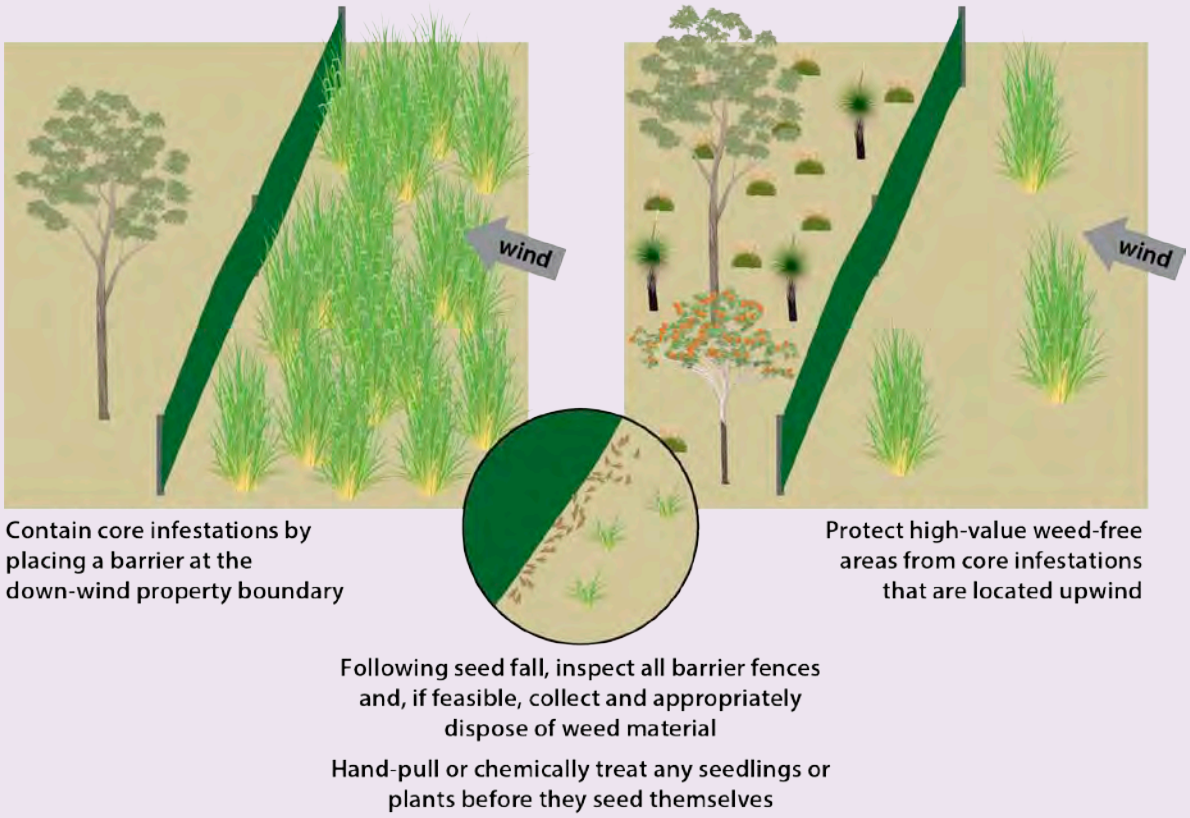


Figure 3.4 Examples of where barrier fencing may be useful in slowing spread. Symbols courtesy of the NESP Resilient Landscapes Hub, nesplandscapes.edu.au.

Buffers

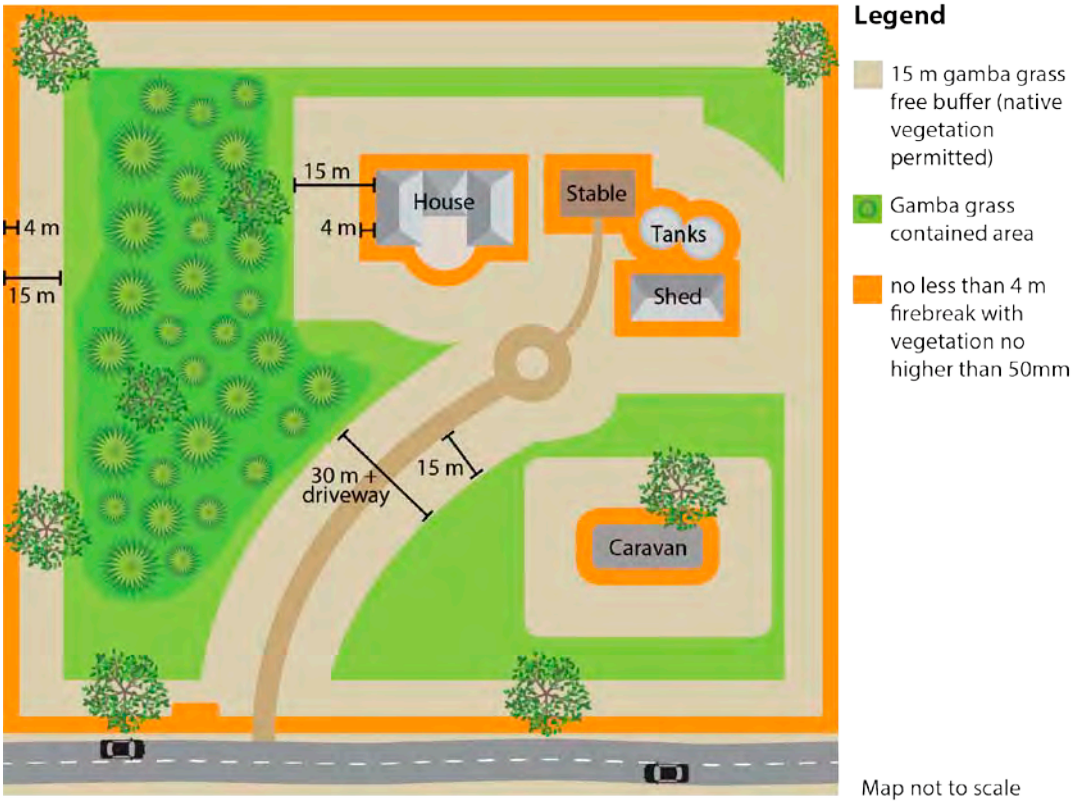
Suitable for:	Less suitable for:	Examples of situations
✓ boundary management ✓ separating clean areas from infestations ✓ small-scale areas that can be maintained.	× large-scale infestations × areas where the management objective is eradication.	→ in the NT containment zone, properties >3 ha must maintain a 15 m wide gamba grass-free area around boundaries, driveways and infrastructure. Properties that adjoin the eradication zone require a 500 m buffer.

A buffer zone is a designated area with no seeding gamba grass that separates an infestation from an adjoining area that's free of gamba grass. This may be the property boundary or other linear feature. In some parts of northern Australia, buffers are a minimum legal requirement when managing gamba grass. Given that most gamba grass seeds fall with 5 m of a parent plant, a well-maintained buffer of sufficient width may reduce seed spreading into adjoining properties.

Key points

- Buffer zones should be wide enough to reduce the spread of gamba grass seed to surrounding properties. Widths of 40–50 m are typically encouraged or required.
- Buffer zones may surround the entire property. However, it's better if a buffer zone only surrounds the area/s containing gamba grass.
- Buffer zones can contain gamba grass, but they must be managed so that no seeding occurs. Ideally, you'd remove gamba grass from the buffer and maintain its weed-free status.
- Buffer zones don't require the clearing of native vegetation. If you want to remove vegetation, you may need permits or other approvals.

Prevent seed set in the buffer zone by controlling plants through herbicide application or manual removal. Slashing, grazing or burning can also be used in buffer zones to reduce seeding.



Slashing

Suitable for:	Less suitable for:	Example situation
✓ reducing biomass ✓ linear reserves, fence lines, vacant land, modified areas and around infrastructure.*	× conservation areas × areas with mixed vegetation.	→ slashing roadsides to reduce fire risk, reduce seed production, and promote growth prior to herbicide spraying.

* Also consider spraying these areas with herbicide or hand pulling.

Slashing isn't commonly used for gamba grass management *per se*, but rather to address other management priorities that are impacted by gamba grass. For example, slashing roadside vegetation (including gamba grass) maintains visual amenity and road safety. Slashing gamba grass in urban areas reduces fire risk.

Slashing doesn't kill gamba grass – in fact, it's a major contributor to its spread. However, if you carefully time slashing and integrate it with herbicide control, you can achieve multiple management objectives, including reducing the density of gamba grass.

Slashing can:

- promote gamba grass growth and remove dry, rank material, which:
  - improve access to tussocks during control
  - improve herbicide coverage and control effectiveness
  - reduce the amount of herbicide needed, which reduces costs
- reduce seed set
- reduce fire risk (short term)
- increase site visibility (short term)
- improve gamba grass palatability
- create opportunities for desirable species to establish and compete with gamba grass.

For best results, slash gamba grass before or as it comes into flower and allow it to regrow to a height of approximately 40 cm (refer to Figure 3.5). Then apply herbicide using the most appropriate method for your situation. Always clean equipment and machinery before moving to new sites.

Slashing as a back-up plan

Sometimes, things don't go to plan. For example, a late wet season may prevent access for herbicide control prior to gamba grass flowering. Or there may be conflicting priorities preventing gamba grass control at the optimal time. In these instances, the most important thing to do is to reduce seed set. Slashing may temporarily reduce seed set so that your previous years' efforts aren't wasted, and you can resume your regular management program the following season.

Timing

Timing will depend on the reason for slashing. Slashing is usually done when gamba grass is tall.

- Slash before seeding to reduce spread risk.
- Slash at a time that allows some regrowth and follow-up herbicide application.
- You may need to slash more than once per season to meet multiple management objectives (e.g. reduce seed production and maintain visibility and visual amenity).

Remember that slashing won't prevent seeding – it will just reduce the number of seeds produced.

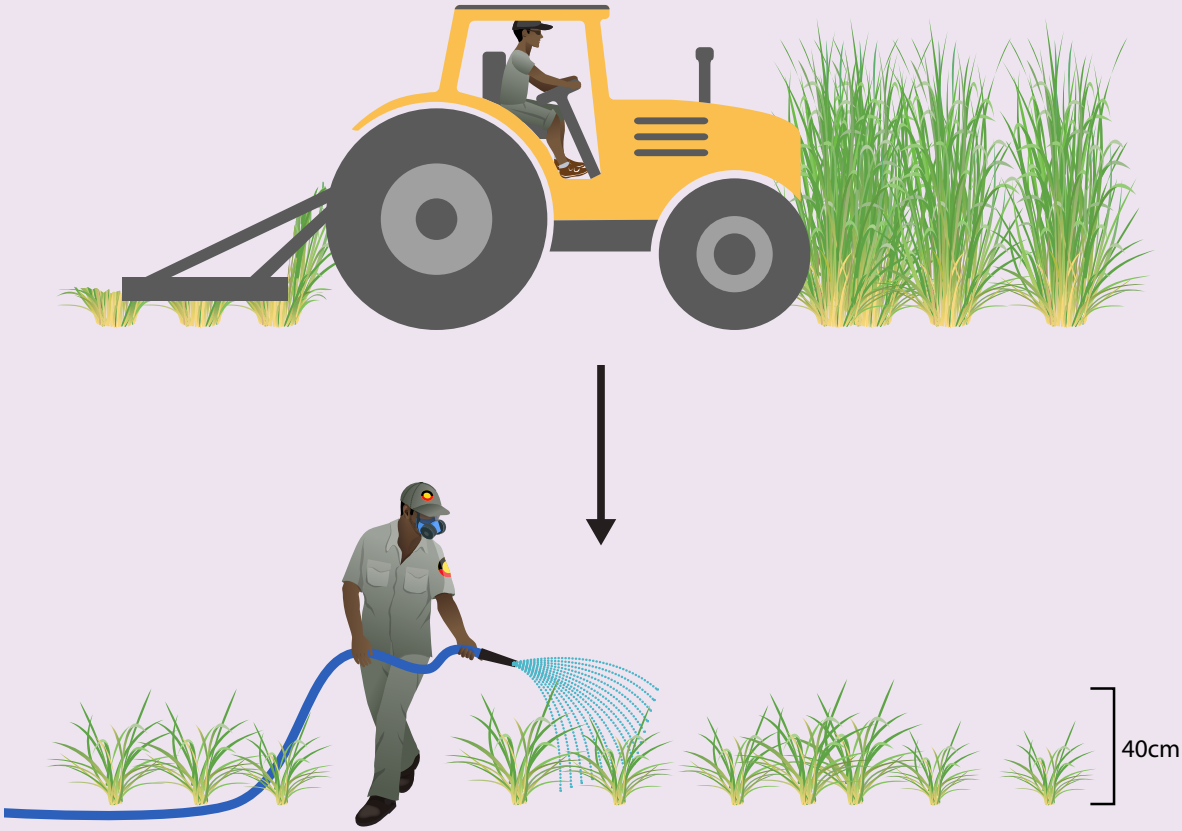


Figure 3.5 Slashing gamba grass and integrating herbicide control. Symbols courtesy of the NESP Resilient Landscapes Hub, nesplandscapes.edu.au.

Matt Sheehan

Slashed gamba grass in a vacant block in an urban area, Darwin.

Matt Sheehan

Grazing

Suitable for:	Less suitable for:	Examples of situations
✓ reducing biomass and seed set ✓ grazing properties ✓ vacant land and linear reserves.	× conservation areas.	→ modified natural areas where grazing has been historically present → crash-grazing of linear reserves and stocking routes.

Grazing doesn't kill gamba grass but may be useful for control in some situations. Where gamba grass is grazed, you can help reduce seed production and the off-farm spread of seed by improving pasture management, grazing practices and farm hygiene.

Controlling gamba grass through grazing

Integrating grazing of gamba grass into other management activities can be a beneficial and effective approach to manage modified systems, such as maintained easements, vacant land, blocks or semi-natural areas with a long history of grazing.

Continuous grazing of gamba grass with low to moderate stocking rates isn't a suitable strategy to manage gamba grass. Grazed gamba grass grows quickly, becomes tall and unpalatable, and will produce seeds and spread. Rather, rotational grazing with high stocking rates keeps gamba grass short and reduces seed set. Trials at the Douglas Daly Research Farm (Northern Territory) have shown that this is very effective at controlling gamba grass (see case study 4 on page 100).

Grazing natural areas

Carefully timed grazing could reduce gamba grass seed set and reduce fuel loads in some natural systems, such as fire-sensitive communities. However, this poses risks to environmental and cultural values and may only be appropriate in some areas. The stock would need a water supply as well as fencing to contain them to the desired area (temporary electric fencing can be used). Before adopting grazing as a management tool, it's important to understand how grazing impacts other values within the management area. Consider a different management option if these impacts are likely with the stock densities needed to reduce gamba grass biomass and reduce seeding.

Pasture management in pastures free of gamba grass

Gamba grass can threaten grazing systems that are free of gamba grass. Maintaining pastures in good condition with high crown and foliage cover, together with on-farm hygiene measures, will help stop invasion by gamba grass. Pastures that are in poor condition or overgrazed are at a greater risk of invasion by gamba grass and other weeds due to bare soil and the reduced vigor of existing grass species. Where gamba grass is present and unwanted, integrate grazing with herbicide control, manual removal and burning.

Intentional grazing of gamba grass

Where you're intentionally using gamba grass as stock feed, all states and territories legally require you to take reasonable steps to minimise spread from the property (refer to Chapter 5 ('Further Infomation'). Four reasonable and practical steps you can take are listed below.

- Keep gamba grass below a height of 60–90 cm to limit seed production and potential spread. This will also help to maintain some palatability and reduce potential fire hazards over the dry season.

Achieve this by doing the following:

- Graze gamba grass with high stocking rates (>10 animals per hectare) to keep it short. This requires rotational grazing or spelling of the paddock so the grass can re-grow before being grazed again. The high stocking rate needed to keep the grass short isn't suitable for long-term set stocking, as the paddock will become over-grazed and there won't be enough feed for the animals. For best results, graze at high stocking rates down to a grass height of about 20 cm. Then remove grazing pressure to allow it to re-grow to about 90 cm before being grazed again. This is a very effective strategy to control gamba grass and optimise cattle growth. Note that gamba grass grows too fast in the wet season to be controlled by low stocking rates (<4 animals per hectare)*.
- Have stock in reserve to increase grazing if grass height nears 90 cm.
- Consider slashing where stocking rates are insufficient to control growth and reduce seed production.

- Eliminate gamba grass from areas on the property where it can't be grazed and may go to seed and spread. For example, around sheds, storage areas, fences, gates, driveways, rock outcrops and within vegetation.
- Follow hygiene measures for all on-farm and off-farm movements.
- Don't make hay from gamba grass while it's in seed or after seeding.

* On smaller properties or where stocking rates are unlikely to minimise seeding, address this by temporarily increasing stocking rates (e.g. buying in cattle) or integrating grazing with other methods, such as slashing.

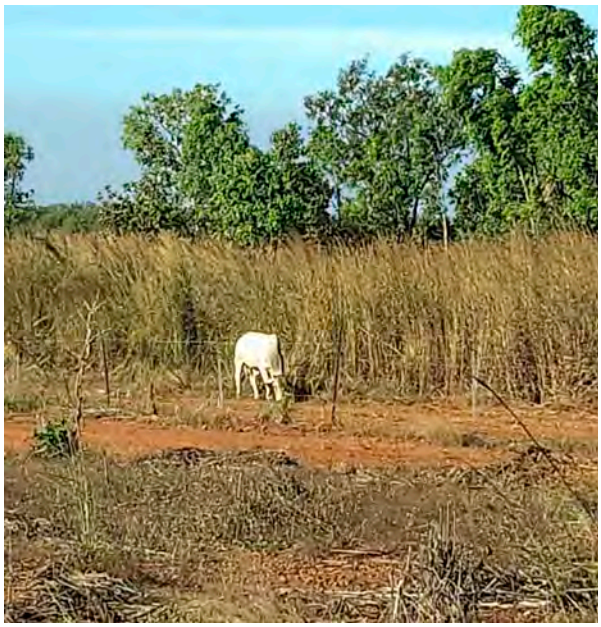
Refer to Chapter 4 'Case studies' (case study 4 page 100), for an example of grazing management of gamba grass.

Note

If you're in an eradication zone, intentional grazing of gamba grass may not be permitted. You may need to actively control your gamba grass and transition to alternative pastures (see below). Check the legal status of gamba grass in your region and the management requirements.

Transition to alternative pasture

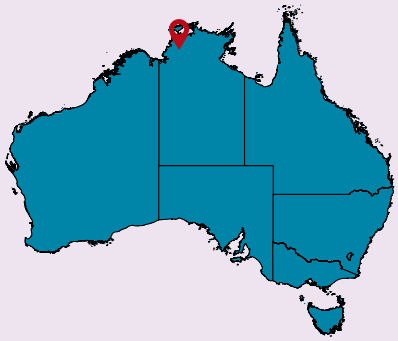
Another option is to move away from gamba grass altogether in favour of alternative pasture species that don't have the risks that gamba grass has. This is expensive and will require a determined effort to exhaust the gamba grass seedbank in the soil. This transition takes 3–5 years. Consult your local pasture adviser for recommendations on suitable low-risk alternative species in your region.



Matt Sheehan

Rank gamba grass is actively avoided by livestock.

A grazier's perspective – Tipperary Station, NT



Tipperary Station is a large cattle station in the Northern Territory. It supports mixed enterprises, including grazing, broad-acre farming, horticulture, a carbon-abatement program, tourism and farm-stay work. The property also has outstanding natural assets.

Station managers, have a multi-faceted perspective on gamba grass and managing it for their mixed enterprises and land uses.

> *"Gamba grass, if managed well, can be very beneficial. It increases the stock carrying capacity of the land, grows a huge volume of feed, and has high protein content early in the wet season. But it comes at a major cost. Gamba grass can become a thick monoculture if it's not managed properly or grazed with enough cattle. Vast areas become unproductive, unusable and it can compromise non pastoral enterprises. Cattle avoid tall gamba grass, and you can't walk or drive through it."* David Connolly, General Manager, Tipperary Station.

David Connolly

Gamba grass monocultures negatively impact Tipperary's resting paddocks and carbon-abatement program. It also invades the natural areas on the station and spreads to adjoining Litchfield National Park, where it's significantly impacting natural values.

Fire is also a threat to station infrastructure, horticulture crops and the natural areas on and adjoining the property.

> *"A gamba grass fire is something that no land manager wants to experience. It'll shoot flames 30 metres high, and we've experienced it jumping four kilometres ahead of itself. We've noticed that where we've had hot gamba fires, the eucalypts are suffering - even dying - and ecosystems are changing."*

David Connolly

Recognising the good and bad aspects of gamba grass was an important first step in developing a strategic whole-of-property approach to managing gamba grass on Tipperary Station. Management on the station has two objectives: contain gamba grass to grazing areas (and keep it palatable through rotational grazing), and continually eliminate it from other areas through chemical control and physical removal.

Station managers believe their integrated approach to gamba grass management is reducing seeding and seed spread across the property and to Litchfield National Park. A key learning from Tipperary Station is that gamba grass requires active management even in a production setting.

> *"You only get benefit from gamba grass if you intensively manage it. Otherwise, it becomes a threat and a nuisance to you and your neighbours. With careful integrated management, you can benefit from it and reduce the negative impacts. This is ongoing hard work and expensive. But doing nothing is not an option. If we stop, we'll lose, both in a production sense and a biodiversity sense, on and off the station."*

Fire

Matt Sheehan

Fire scars and active fires in Kakadu National Park, NT.

Fire is part of the landscapes in which gamba grass grows. It has been used extensively to manage land well before the arrival of gamba grass in the 1980s, and often occurs as bushfires in the dry season. Because fire is a permanent feature in the landscapes invaded by gamba grass, it's important to understand the interaction between the two and how fire can help or hinder management of gamba grass.

Gamba grass is extremely tolerant of fire. Fire can kill young seedlings, but mature gamba grass plants survive and thrive following fire. Fire also creates bare ground, and the resulting mass germination of gamba grass seeds perpetuates the cycle of gamba grass growth. Updrafts caused by fires can pick up the light, fluffy seeds and spread them across large distances. For these reasons:

- always integrate fire with herbicide control
- don't use fire as a management tool for gamba grass during seeding
- carefully consider the timing of both herbicide treatment and fire.

Eastick (2016) provides further discussion of the advantages and disadvantages of timing of burning and herbicide application.

This section explores gamba grass management that:

- excludes fire
- uses fire with other management activities (planned burning)
- follows bushfire (unplanned burning).

Matt Sheehan

Gamba grass management at Mary River National Park, NT is achieved through spot spraying with glyphosate and fire exclusion. Dense natives and dead gamba grass tussocks maintain ground cover, reducing gamba grass seed germination.

Excluding fire

Gamba grass seeds are short lived – only 0.1% remain viable after 12 months (see Chapter 1). Research shows that, in some vegetation communities, you can reduce germination of the soil seedbank by excluding fire after herbicide treatment – the mulch of dead gamba grass smothers the seeds, preventing germination. Maintaining this mulch cover for at least 12 months depletes the soil seedbank and needs less follow-up. You can achieve local eradication within 2–3 years by killing any remaining plants and preventing new seed from entering the site. See case study 5 on page 104 for more information about fire exclusion for gamba grass management. Additionally, native perennial grasses can establish when fire is excluded. These compete with gamba grass and increase ground cover, leaving fewer bare patches for gamba grass seeds to establish.

Things to note with this approach:

- Leaving dead gamba grass as mulch may increase fire risk in the short term and could increase fire intensity if a bushfire occurs. However, a single wet season will flatten standing gamba grass to ground level, reducing fire risk in the next dry season and providing good mulch to suppress seed germination.
- Dead gamba grass may also suppress the germination of native grasses. However, native grass seed is typically viable for longer than gamba grass seeds, and they are likely to start germinating after the dead gamba grass mulch has decomposed.
- Excluding fire can result in larger gamba grass plants and denser vegetation.
    - You might need several herbicide treatments in the same season to kill 100% of gamba grass plants.
    - You'll need to use more herbicide to kill large plants.
    - You might have some off-target damage (spraying desirable plants), but it's probably less damage than an intense gamba grass fire would inflict.

Reality check

Excluding fire may be difficult in practice, either because you're using fire for other land management purposes or you're unable to prevent bushfires.

Consider the following:

- Develop a management plan that outlines your fire-exclusion strategy. This may help to justify your approach to neighbours and interested parties. Engage with them to gather support for your approach.
- Put in place risk-mitigation measures, e.g. fire breaks around the management area.
- Have a back-up gamba grass management plan if fire does occur. Include surveillance to identify where gamba grass has spread and apply follow-up herbicide treatments to control any seeds that germinate.

Using fire with other management activities (planned burning)

The effectiveness of fire in managing gamba grass will depend on the timing of the burn, how it is integrated with other control methods and the objective you want achieve.

Burning must be timed carefully to benefit gamba grass management programs. Whether you're burning as part of a gamba grass management program or for other land management outcomes (e.g. road safety), be sure to consider the following:

- Don't burn when gamba grass is seeding (generally May to August).
- Complete any mapping or surveillance activities before burning starts.
- Keep fire intensities and flame heights low. This will minimise impact on desirable vegetation, such as trees, and reduce the risk of a burn getting out of control. Achieve this by:
  - burning when the moisture content in gamba grass is still high (e.g. late in the wet season)
  - avoiding burning when gamba grass has browned off but is still erect.
- Take advantage of the burn by using it as an opportunity to access the site and control plants at the appropriate time following the fire (e.g. before the next wet season and before seeding). For optimal efficacy, allow plants to recover after fire to a height of 40–50 cm, before treating with herbicide.

Rowena Eastick

Wet season burning of gamba grass, integrated with herbicide control.

Matt Sheehan

Surveillance and control are ineffective directly following a burn. Where possible, coordinate burning outside optimum times for surveillance and control activities.

Table 3.6 provides a summary of the main things to consider when deciding when to use fire and how to integrate it with herbicide control. The advantages and disadvantages of timing of burning and herbicide application is also provided in Eastick (2016).

Managing gamba grass following bushfire (unplanned burning)

Bushfires may impact your chosen gamba grass control plan. For example, if you've chosen to exclude fire and a bushfire occurs in your management area, this doesn't mean your management efforts are wasted. Rather, you'll need to adjust your plan and find the positives in the situation to put you back on track. A wildfire presents an opportunity to be adaptive in your gamba grass management program.

Practical actions to implement after bushfire:

- Add surveillance activities into your plan, particularly if seed was present during the fire. Conduct surveillance along the fire scar and any access tracks that were used during response or recovery operations.
- Re-map infestations after the fire, allowing sufficient time for the plants to regrow to a stage where they can be identified.
- Treat infestations with herbicide when gamba grass plants reach 40–50 cm or before they next seed.
- Identify any assets (e.g. threatened species, heritage sites, critical infrastructure) within the burned area where other management activities may need to be integrated with gamba grass control.

Table 3.6 Summary of the main things to consider when deciding when to use fire and how to integrate it with herbicide control.

	No burning (herbicide control only)	Burning before herbicide treatment		Burning after herbicide treatment+
		Wet-season* burns	Pre-control (early dry-season^) burns	
Summary	Preferred for conservation outcomes. Retaining dead biomass by excluding fire in some vegetation communities can: ▪ suppress/prevent seed germination and re-establishment ▪ reduce the amount of follow-up needed. Native perennial grasses can establish when burning is excluded. These compete with gamba grass and increase ground cover, leaving fewer bare patches for gamba grass seeds to establish.	Good compromise when balancing other land-management priorities. Wet-season burns reduce the biomass of gamba grass (old rank material) and surrounding vegetation, improving access and control efficacy. Be prepared to put more work into follow-up to target new seedlings and regrowth.	Not best practice in some situations. Use with caution. Early dry-season burns reduce the biomass of dead gamba grass and surrounding vegetation. While this may improve access and reduce risk of intense bushfires in the short term, plants may take a while to recover from the fire. It's possible that post-fire control in the same season may miss some plants if they have not regrown sufficiently to take up herbicide or if seedlings germinate after control. Be sure to follow-up the following season (early wet season before seeding). Seed may already be present on plants, posing a further risk of spread if burned.	Not best practice in some situations. Avoid burning after control where possible. Efficacy of this approach is timing and situation specific. E.g. Eastick (2016) found that a wet season spray followed by a burn 12 months later resulted in no regeneration in Charles Darwin National Park. Observations elsewhere have shown that post-control burning can result in: ▪ gamba grass seed germination^^ ▪ reestablishment of mature plants not killed by herbicide control. If using this approach: ▪ ensure sufficient time between herbicide treatment and the burn ▪ carry out intensive follow-up with herbicide the following season.
Things to note/words of caution	Large plants are harder to kill and require more herbicide. This approach may conflict with other land-management practices, either on your property or on adjacent land. It may be very difficult to exclude fire.	Timing is critical – both the burn and the herbicide control need to occur before seed set and in a window between rain events. Fire history also needs to be considered (e.g. there needs to be enough dry material to carry the fire).	Plant material dries out and becomes more flammable during the dry season. Burns late in the dry season will be more intense and pose greater risk to desirable vegetation and infrastructure.	If there is tall dead gamba grass it may result in hot fire that could cause damage to desirable vegetation or adjacent built assets. Burning after herbicide control may allow establishment of other high-biomass grassy weeds, such as mission grass or grader grass. Burning too soon after herbicide control can stop the herbicide working and allow the adult plants to reshoot.
		▲ High-frequency burns aren't suitable for all vegetation communities and can negatively impact biodiversity. Understand the vegetation communities that are present and how fire interacts with them. Determine if there are any plants or animals at the site that could be negatively impacted by fire.		
Making the most of chosen approach	Time follow-up to prevent seeding of any remaining plants. Develop a plan that explains your fire-exclusion strategy to interested parties. Consider establishing fire breaks to reduce risk of bushfire. Have a back-up plan if fire does occur.	Follow up regularly with herbicide treatment to control seed germination and regrowth. Incorporate the control of other grassy weeds and opportunistic invaders into your gamba grass control program.	Expect gamba grass germination and spread. Incorporate surveillance and mapping into your management plan. Undertake significant and repeated follow-up herbicide control of both seedlings and regrowth prior to seeding. Monitor wind direction during fire to predict where seed may travel. Carry out surveillance activities in these areas over the following seasons.	

* assumes high moisture content in gamba grass foliage (still green), plants haven't seeded, and plants are likely to regrow sufficiently that season to allow for herbicide treatment.

^ assumes high biomass and that gamba grass has browned off and won't be actively growing again until the following season.

+ assumes treatments kill gamba grass and dead biomass is retained.

^^ based on studies in specific vegetation types, and may not apply to all habitats. Timing of spray treatment and timing of subsequent fire may influence germination.

Chapter 4

Case study 1

Gamba grass in Western Australia: eradication is in reach

John-Paul Slaven, Department of Primary Industries and Regional Development, WA

Management objective: eradication

Key points

- **Eradication programs require surveys to determine the full extent of the infestation.**
- **Eradication programs require agreement and cooperation across all land managers.**
- **Successful eradication programs require exhausting the existing seed bank while preventing any further addition to the seed bank.**

Background

While gamba grass is well established in the Northern Territory (NT) and Queensland, it hasn't gained more than a toehold in Western Australia (WA). Released as a pasture species in the early 1990s on El Questro station, gamba grass spread unchecked until eradication efforts started in 2008.

The eradication program has evolved over time as project partners reflected on their learnings and adjusted the approach accordingly. This case study highlights how control methodologies evolved as project partners made the changes required to achieve eradication.

Raitech

Isolated gamba grass plant in El Questro, WA.

Case study 1

The problem

In the 1980s, the WA then-Department of Agriculture promoted gamba grass as a useful pasture species for pastoral leases in the region. Its production of quality green fodder at the start of the wet season, ability to spread and resilience to fire made it an ideal companion to popular fodder legumes.

While not widely adopted in the region, gamba grass was established on El Questro station in the East Kimberley through aerial broadcast over 1,770 ha in 1991. The area infested consists of low undulating shale hills supporting spinifex or grasslands with creek lines populated with paperbark and low eucalypts on Pago sands. This land is of low grazing potential and not ideal for the establishment of pasture.

Despite annual fires and heavy grazing, gamba grass successfully established on the small pockets of fertile land along creek systems in the area. Surrounding areas of high ridgelines and plateaus effectively confined gamba grass to one catchment. Its proximity to vast expanses of untouched wilderness and highly productive black-soil plains motivated stakeholders to embark on an eradication program.

The approach

Given the magnitude of the gamba grass problem in the NT, land managers and agencies in WA were concerned about its potential to spread. Following a 2007 assessment by staff of the then-Department of Agriculture and Food Western Australia (DAFWA), El Questro management decided to commence eradication. The following year, DAFWA listed gamba grass as a declared pest, requiring its eradication.

Methodology

El Questro rangers and biosecurity staff from DAFWA conducted initial control efforts between 2008 and 2012. Treatment consisted of grading access tracks and a 'burn, spray, burn' technique, where a late-dry-season hot burn was conducted, regrowth from opening rains was sprayed with glyphosate, and another burn conducted when gamba grass started to senesce.

In 2012, DAFWA and the then-Department of Parks and Wildlife (DPAW) began annual aerial surveys of the area to delimit the population and identify areas within the infestation for targeted management. DPAW sourced funds from the *Kimberley Science and Conservation Strategy* to employ Wunggurr Rangers to assist their own staff in eradication efforts.

Raitech

Hand removal of gamba grass.

Raitech

Placement of tussocks in trees to dry after hand removal.

Dense areas of gamba grass were treated by removing, bagging and destroying seed heads. This was followed by a burn to reduce foliage. Regrowth was then treated with a foliar application of glyphosate. Extended line surveys searched surrounding areas, with remaining plants treated again with glyphosate.

Rethinking the project

By 2016, much had been done to knock back the large populations of gamba grass, but eradication was proving more difficult to achieve than initially anticipated. New plants were still appearing, and there was inadequate data being collected to provide evidence of eradication. Greater coordination between project partners was also needed to achieve eradication.

The project partners agreed to adopt a new approach to eradication. The newly formed Gamba Grass Steering Committee (GGSC) resolved to make the following changes to the eradication program:

- Employ a contract coordinator to oversee the control program.
- Make greater use of professional licensed pest management technicians.
- Use volunteers for the first 2–3 seasons.
- Adopt a more effective methodology.
- Source funding for the new approach.

Funding was sourced from the Kimberley Rangelands Biosecurity Association and Rangelands NRM (natural resource management). The WA Department of Biodiversity, Conservation and Attractions (DBCA, formerly DPAW) and Department of Primary Industries and Regional Development (DPIRD, formerly DAFWA) continued to support the work.

In 2017, professional licensed pest management technicians were used for the first time in conjunction with staff from DBCA and DPIRD and volunteers. The following year, a contract coordinator was engaged to oversee on-ground eradication efforts. This has been maintained through to 2024.

For operational and logistical reasons, chemical control was not an option at the start of the program, so the initial control focused on manual removal by chipping gamba plants out of the ground with a geologist pick and wedging them in nearby tree forks as a visual reference for successive eradication surveys. This was a viable approach due to the relatively small size of the area and low density of the infestations. This also removed the need to carry chemicals and eliminated off-target damage. It's a very effective control for this situation and has continued as the primary control method.

Line surveys were conducted over each infested area multiple times from different directions to ensure no plants were missed. All plants found were recorded. Fire was not used as a management tool, although it was still present on a regular basis, either as prescribed burns or as bushfires. This had some impacts on gamba grass control operations.

The result

From 2017 to 2024, the infestation was reduced from more than 3,000 plants to less than 50 plants (see Figure 4.1.1). Key to this success has been the continued focus on delimitation surveys and on reducing seedbank contributions by ensuring control occurs before seed set and seedheads are removed from any remaining plants.

The volunteer component ceased in 2020, initially due to COVID-19 restrictions. However, it was not reinstated as it was no longer required. It's difficult for new personnel to become proficient at spotting and identifying gamba grass now the plants are at such low numbers.

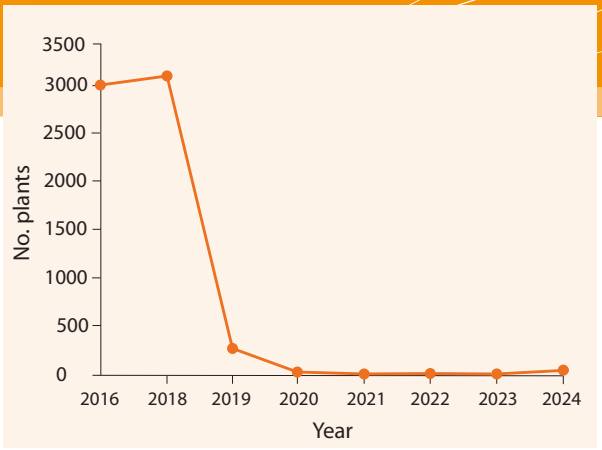


Figure 4.1.1 Reduction in gamba grass plants between 2017 and 2024.

The future

The eradication program continues, with all project partners committed to conducting surveillance in the infestation area for up to five years past the date the last plant was found.

Challenges faced by the GGSC in the future include:

- maintaining eradication efforts with high staff turnovers and a shortage of experienced personnel
- lack of contractors in the region
- the impact of fire on eradication outcomes – it can reduce effectiveness of searching and potentially spreads seed.

Additionally, it's critical to maintain funding to support the project through to eradication. Propagules will continue to arrive in WA from core infestations in the NT. Adopting hygiene protocols, conducting surveillance on major pathways from the NT, encouraging reporting of any plants, and acting quickly on those reports will be critical to keeping WA free of gamba grass.

Key learnings

- Collecting good quality data is critical. This includes individual plant locations, plant numbers, total area surveyed (including where nothing was found) and plant life stage (especially whether it has gone to seed).
- Having a coordinator is crucial. This improved communication between multiple partners, helped to bring together all the data, and facilitated reporting of the control program to the committee.
- As plant numbers become low, it's critical to have people in the field who can identify the plant and respond quickly. Relying on volunteer assistance becomes less viable as the program progresses.
- Ideally, exclude grazing and burning from the eradication area so the plants flourish and can be easily found and treated. Be adaptive – every season will be different (e.g. amount and timing of rainfall, timing of germination and seeding, access).

Raitech

Gamba grass found during followup surveys.

Case study 2

Surveying and planning: keys to successful eradication of a historical gamba grass infestation at Mudginberri, Mirarr Estate, Kakadu National Park

Territory Natural Resource Management in collaboration with Djurrubu Rangers

Management objective: eradication

Key points

- **The closer you get to eradication, the harder gamba grass is to find.**
- **A well planned and coordinated aerial survey program, integrated with a targeted control program, is an effective way to eradicate isolated infestations in remote areas.**
- **Other land management activities, such as burning, can hinder gamba grass detection during surveying.**
- **Supporting rangers through training is critical when adopting new approaches to managing gamba grass.**

Background

The Mudginberri area occupies more than 30,000 ha of lowland savanna country close to the regional town of Jabiru within Kakadu National Park (Kakadu) in the Northern Territory (NT; Figure 4.2.1). Mudginberri is in the NT gamba grass Eradication Zone (page 122).

Facilitated by Territory Natural Resource Management (TNRM) and led by Gundjeihmi Aboriginal Corporation's (GAC) Djurrubu Rangers, the gamba grass eradication program at Mudginberri is informed by First Nations' knowledge of the region, previous weed management works in Kakadu, and best practice land-management principles.

The area historically supported an active station and abattoir during the 1970s and 1980s, focusing mainly on buffalo. The abattoir closed in the mid-1980s, and the station was included in the Stage 2 declaration of Parks Australia in 1987. GAC undertakes some land-management activities in Mudginberri under contract from Kakadu and holds partnerships with many other agencies, including TNRM. TNRM has supported GAC over the period 2018–23 through regional projects funded by the Australian Government's National Landcare Program.

The problem

Gamba grass was planted in the Mudginberri area around 1983 as pasture for the station's buffalo stock. Grassy weed management commenced in 1987, when the Mudginberri area was incorporated into

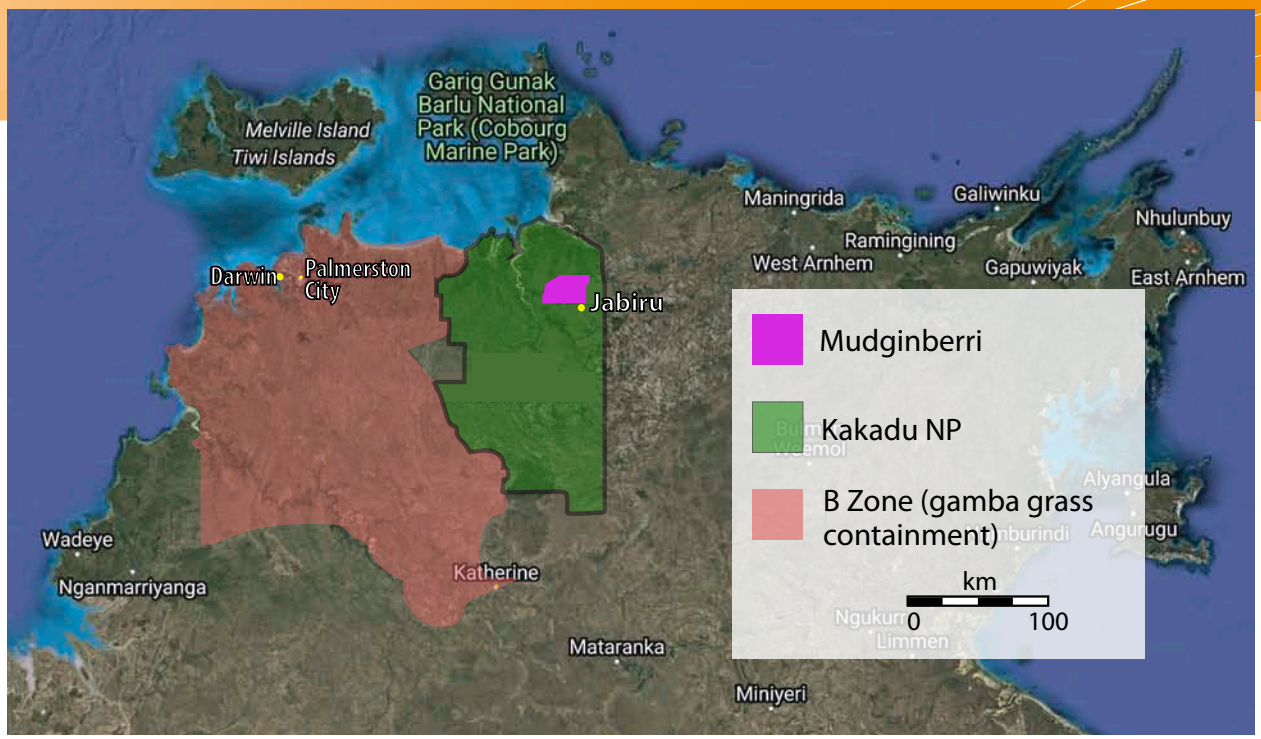


Figure 4.2.1 Aerial image showing the location of the 30,866-ha Mudginberri area within the Northern Territory.

Kakadu National Park. However, due to seasonal inaccessibility and other constraints, gamba grass has persisted in the area in discrete, scattered patches distributed over approximately 10 km^2.

These infestations occur in remote locations where there's no routine monitoring – meaning there's a risk they could remain undetected and continue to spread. Additionally, seasonal watercourses in the Mudginberri area prevent on-ground access until after gamba grass has started seeding in May. Fire is a constant threat for Mudginberri, and fuel-reduction burning is carried out early in the dry season. This can increase localised spread and the density of existing patches. Burning early in the dry season can also hinder detection of gamba grass for surveillance mapping, so timing of these activities is critical.

The approach

Between 2020 and 2022, staff from Djurrubu Rangers, NT Weed Management Branch, TNRM and Kakadu collaborated to plan an eradication program using best practice control methods. The plan identified seasonal access constraints and workable solutions so that rangers could identify and physically reach areas before seeding and fire.

Diego Alvarez, TNRM

Large gamba grass tussocks tower over Djurrubu Ranger Craig Djandjoriekk in 2022.

The preparation and preliminary work set the stage for Djurrubu Rangers to deliver their highly successful 2023 eradication program. This included:

- building capacity and capability in planning, surveying, weed hygiene and treatment
- developing techniques for detection in hard-to-reach places
- treatment and trialling of methods for hard-to-reach places (including the use of helicopters)
- data recording, management and interpretation
- monitoring techniques to lead to eradication.

Detection in hard-to-reach areas

In previous years, accessibility issues and a lack of reliable survey data have hindered gamba grass eradication efforts.

A key action to support the eradication outcome of this project was to develop a survey **methodology** that would detect and accurately record **all** individual gamba grass plants in the landscape with sufficient time to return and treat them before burning or seed set.

Matt Sheehan

Preparing for remote gamba grass control.

Sean Spicer, Djurrubu Rangers

Gamba grass infestation along a seasonal waterway recorded during the 2023 aerial survey. Dense canopy cover and presence of native grasses can hamper the detection of gamba grass.

The following factors had to be considered when developing the methodology:

- The area is frequently burnt by bushfire, usually early in the dry season before or during gamba grass flowering and seeding. It isn't best practice to survey immediately after fire, as it is likely plants will be missed.
- The dense tree canopy cover of the area's significant riparian environments can reduce gamba grass detection when surveying aerially. There are also several native grass species which may be mistaken for gamba grass.
- The area is difficult to access, requiring off-road vehicles. There are also seasonal constraints, such as water courses during the wet season, that may prevent access until after gamba grass seeds.
- Infestations tend to be in discrete patches, usually less than 100 m diameter. This means infestations may be missed.

Survey methodology

In early 2023, project partners agreed on a 30,866-ha area to be aerially surveyed for gamba grass. The search area was based on historical data, data-deficient locations, pathway analysis, and the potential for gamba grass spread within the landscape.

Surveying took place between February and early March 2023, with treatment occurring in March and

Case study 2

New technique for detecting gamba grass earlier in the year

At Mudginberri, the best time to detect gamba grass is around mid-April, when most native grasses have turned brown but gamba grass is still green. Without this contrast in colour, surveys are much more likely to miss gamba grass plants, particularly when relying on aerial surveys.

Prior to this project, aerial gamba grass surveys were typically conducted from April onwards to exploit this colour difference. However, for an eradication program, all control works should be performed prior to seeding, which starts around May, to disrupt seed bank recruitment.

A new method was needed to accurately detect gamba grass from the air with high confidence earlier in the year. This would allow Djurrubu Rangers to:

- undertake treatment and follow-up work prior to seed set and
- avoid the risk of wildfires undermining survey and control activities.

TNRM and Djurrubu Rangers trialled surveying at different times of the day. They discovered that gamba grass could be distinguished from other grasses before 9:30 am, when the sun was low in the sky. In the early morning, the hairs on the leaves of gamba grass hold drops of moisture (dew). This gives the tussocks a droopy appearance, and the leaves look silver-blue. These characteristics allow gamba grass to be easily distinguished from surrounding native grasses.

Diego Alvarez, TNRM

Gamba grass patch (centre bottom) standing out among native spear grass in the early morning at Mudginberri.

Now, surveying is conducted early morning from February to March, meaning control can be completed prior to seed set.

April. The site was divided into 12 blocks, ranging from 1,702 to 2,448 ha. It took between 100 and 150 km (roughly 1.5 hours) of flying to survey each block – totalling 18 hours' survey time for the entire area. Follow-up visits to sites that had gamba grass took an additional four hours (on average) per block. These visits were to confirm gamba grass identification and treat it with herbicide. The combined helicopter hours for survey and treatment for the 12 blocks totalled 66 hours.

Each block was surveyed by flying transects of 200 m, a distance chosen to:

- ensure no small patches or individual plants were missed
- reduce or eliminate data gaps or doubling-up on waypoints
- make flying over the target area easier for the pilot and surveyors to positively detect and record accurate waypoints.

Transects were flown at low speed (40 kt) and altitude (~100 ft). Testing found that this optimised the detection of small infestations or individual plants within Mudginberri, even with denser tree-canopy cover. The survey team consisted of two observers and one coordinator. All three team members searched, and the coordinator recorded the waypoint, patch size and density. If required, the pilot deviated from the transect line for verification or waypoint recording, and the helicopter track logs also recorded flight paths to assist with presence/absence data. These surveys found a total of 150 gamba grass patches within the Mudginberri area (Figure 4.2.2).

Data management

Following each daily survey and treatment works, a designated data manager retrieved data from the recording devices (Djurrubu Rangers used their operations application, Fulcrum, to ensure ease of point-data recording and follow-up treatment), created maps of surveyed areas and any treated patches, and provided the navigation tracks for the next day's transect survey to the helicopter pilot. Data management required a computer with internet access and geographic information system (GIS) software, such as QGIS or ArcGIS, to assist with data curation.

On-ground treatment work

Any gamba grass patches that were identified and recorded during the early-morning surveys were treated later that day. In remote areas, rangers were dropped in by helicopter to treat gamba grass using backpack spray units. Other sites were accessed using quad bikes with spray tanks installed. Additional materials for chemical mixing and refilling were taken to site, including herbicide, measuring jug, a pump or bucket for water access and appropriate personal protective equipment. Rangers' tracks and gamba occurrences were recorded while spraying to inform future surveys and to track progress.

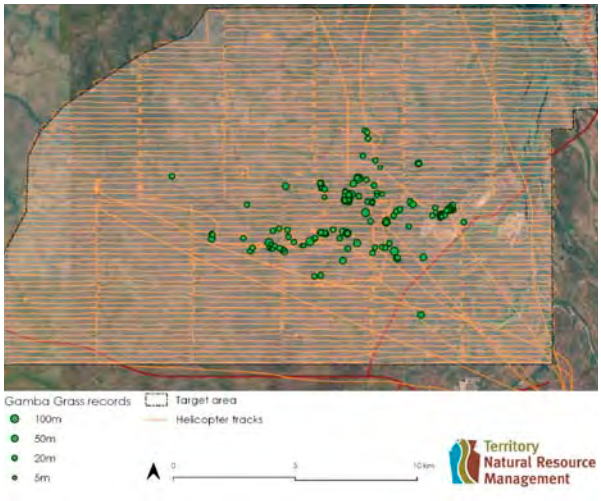


Figure 4.2.2 Results of the helicopter surveys, with gamba grass distribution shown in green and helicopter transects and flight paths in orange.

Roles and responsibilities for each person (coordinator, surveyors, data curator, treatment persons, supporting staff) were clearly noted during the project planning (Figure 4.2.3).

Supporting land managers

This approach to managing gamba grass was significantly different from previous management approaches. A critical factor in the success of this approach was the support offered to rangers and other land managers. This included training in the methodology, involving rangers in the planning phase, and communicating the benefits of taking a strategic, adaptable approach.

The result

Methodologies for aerial detection surveys and data collection have been developed, tested and refined over the project lifetime. Eradication efforts in 2023 used 60 days of Djurrubu Ranger time to collect fine-scale baseline data over 26,237 ha of landscape. This data then underpinned treatment of the identified

Mudginberri Gamba Grass Eradication Program 2023 – daily workplan to detect and treat – Activity Schedule (tackling 1 block per day)			
Time	**Activity**	**Who**	**Equipment**
7 am – 8.30 am (as early as possible)	Aerial survey of the block at 200 m transect spacing: ▪ Collecting flight tracks of survey ▪ Marking waypoints of gamba grass seen ▪ Recording patch size	1 × program coordinator 2 × team leaders 1 × pilot	▪ Tablet/device to record waypoints and tracks ▪ Helicopter ▪ Helicopter navigation system pre-loaded with survey transect lines for pilot to follow
8.30 am – 12.30 pm (until all detected patches are treated, or get rained out)	On-ground treatment of patches detected during block survey: ▪ Mixing herbicide (if doing this on site) ▪ Spraying gamba grass (including use of quads/backpacks) ▪ Collecting treatment data (points and tracks) on tablets/devices if this is not being done by coordinator ▪ Tidy up and preparing for the next day's work	2 teams each with: 1 × team leader 1 × assistant	▪ Tablet/device to record waypoints and tracks ▪ Communications devices ▪ Quad bikes (if using) ▪ If mixing on site: quad spray tank, empty backpacks, pump or bucket for creek, herbicide, measuring jug, PPE for mixing and spraying, ▪ If using premixed: backpacks of premixed herbicide, PPE for spraying
As above	Coordination of on-ground treatment and mixing/refilling: ▪ Liaising with teams on ground and moving them to new spots when required ▪ Refilling backpacks and tanks as required ▪ Collecting data on treatment, incl. herbicide record sheet, ▪ Transferring data from tablets/devices at conclusion of the day's work – sending data to data manager ▪ Tidy up and preparing for the next day's work	1 × program coordinator	▪ Tablet/device to record waypoints and tracks ▪ PPE for mixing ▪ Communications devices ▪ Internet access at conclusion of day – to transfer data from devices
As above	Ferrying treatment teams and equipment to/between patches	1 × pilot	▪ Helicopter
12.30 pm – 3.30 pm	Data management: ▪ Retrieving data from devices ▪ Making maps of surveyed area and treated patches ▪ Providing tracks for next survey to the chopper pilot	1 × data manager (could be program coordinator if they have the skills)	▪ Computer ▪ GIS software ▪ Internet access

Figure 4.2.3 Daily plans for gamba eradication works, with aerial surveys conducted each morning, followed by treatment and more data collection, and data management duties at the end of the day.

150 gamba grass sites and will be used to track progress and inform follow-up treatment works.

All data collected has been provided to NT Weed Management Branch for inclusion in their gamba grass eradication tracking system. This baseline data will inform treatment and enable the measurement of progress towards the goal of eradicating gamba grass from the Mudginberri area.

The future

Aerial surveys are an effective and efficient way to detect gamba grass and prioritise treatment in remote locations. They will continue to inform the ongoing eradication program in the Mudginberri area. Surveys will be repeated in the future to monitor progress towards the eradication goal and inform necessary management adaptations.

Key learnings

- To eradicate gamba grass from an area, detect and treat each plant prior to seeding or burning. Otherwise, patches will persist over the long term.
- Where annual fire regimes are in place, survey sites before fires occur and with sufficient time for treatment prior to seeding. It's not possible to accurately detect gamba grass plants directly after a burn.
- Accurate records are critical. Record locations of infestation to enable follow-up treatment and monitoring until it's confirmed that no gamba grass remains.
- For this eradication program, systematic aerial transect surveys are most useful when undertaken at a scale that matches how far an observer can see (line of sight) in that terrain type.
- Wet-season detection surveys for gamba grass are most effective when done early in the day when plants are covered in dew and take on colouration that differentiates them from other grasses.
- Supporting rangers through training is critical when adopting new approaches to managing gamba grass.

Case study 3

Helping our neighbours: managing gamba grass across catchments, agencies and tenures

Darryn Higgins, Cook Shire Council, Queensland

Management objective: containment/asset protection

Key points

- **Gamba grass is spreading throughout Cape York.**
- **Pooling equipment, labour and expertise from surrounding regions for short, intense periods is an effective way to both map and treat gamba grass in remote areas with limited management capacity.**
- **The project has resulted in improved gamba grass mapping data across multiple land tenures.**

Background

The Annan–Endeavour rivers catchment is a minor catchment in Cook Shire, covering 218,243 ha on Cape York Peninsula (the Cape) and including the town of Cooktown. Gamba grass has been recorded at various locations throughout the catchment over several years. However, the extent of its distribution isn't fully known. It's a big task for one management authority – the Cook Shire Council – to map and control gamba grass over such a large geographic scale. Since 2021, various agencies across Far North Queensland have been helping survey and treat gamba grass in the catchment and raise public awareness about the threats posed by this species.

The problem

Gamba grass has been present in the Annan–Endeavour catchment, and more broadly on the Cape, for several decades. Its establishment has been slow and its spread has not been well documented due to the scale and remoteness of the area. Unfortunately, historical data is largely comprised of surveys and works undertaken on roadsides, with little data available on gamba grass distribution on private landholdings.

There are mixed feelings about gamba grass in the region. Some land managers still see it as a valuable pasture species and not their responsibility to manage, while others have watched its expansion in the neighbouring Northern Territory (NT) and fear what might happen if it's left unchecked on the Cape. Modelling suggests that the Cape is highly suitable for gamba grass and it's likely to result in densities and impacts similar to that seen in parts of the NT. Gamba grass is still considered in the early stages of invasion on the Cape – therefore, the time to act is now.

Case study 3

Adopting a strategic management approach is difficult with only one control authority for a very large region, incomplete distribution data, and low participation from land managers. In 2021, Cape York Natural Resource Management (NRM) gathered together local stakeholders from within the Annan–Endeavour catchment to assess the potential of managing gamba grass across the region. A basic map was produced by collating data provided by several agencies. To address the bias towards roadside mapping, Cook Shire Council also undertook a survey of private landholdings adjacent to historical gamba grass locations. This survey identified 39 individual allotments with gamba grass.

Results of combined mapping confirmed that gamba grass distribution was more widespread than initially thought, and effective treatment was considered beyond the capacity of many landholders. The stakeholder group discussed various strategies to manage the species within the catchment and decided upon a taskforce approach using funding provided by Cape York NRM.

The approach

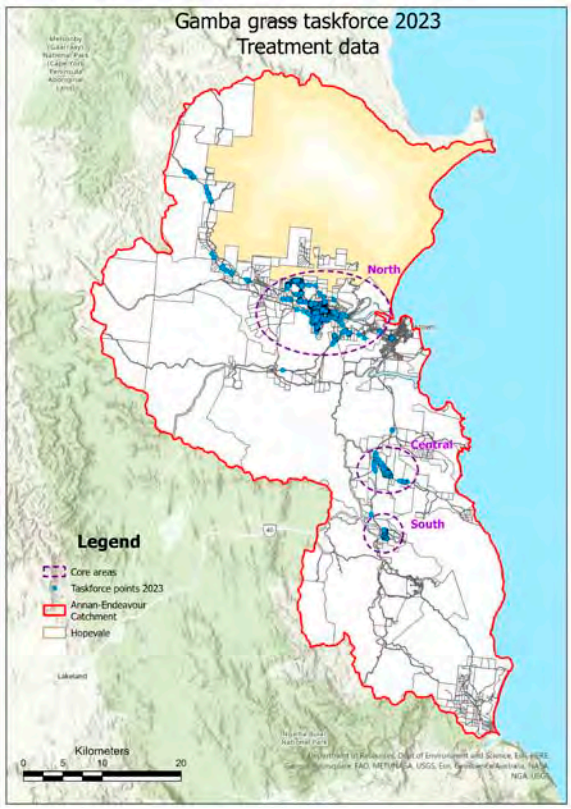
The regional taskforce concept was developed and fostered by the Far North Queensland Regional Organisation of Councils (FNQROC). Under a memorandum of understanding, member councils agreed to support their partners in nominated projects to manage invasive plants and animals.

A request for assistance was extended to FNQROC members and other stakeholders in 2021 to map and control gamba grass. Various agencies accepted the request and have been participating in the catchment-scale project since 2022. Participating member councils and organisations include Douglas Shire Council, Hinchinbrook Shire Council, Tablelands Regional Council, Mareeba Shire Council, Cairns Regional Council, South Cape York Catchments, Balngarrawarra Rangers, Jabalbina Rangers, Department of Natural Resources and Mines, Manufacturing and Regional and Rural Development, Queensland Parks and Wildlife Service, and Biosecurity Queensland.

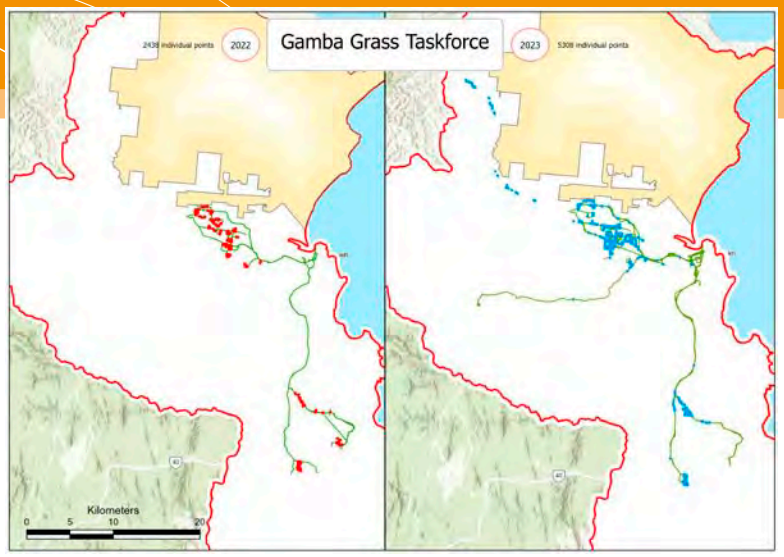
In the 2023 season, the taskforce consisted of 10 field teams from eight agencies. In addition, Biosecurity Queensland provided technical support, and Cape York NRM provided logistical support and funding. Gamba grass was treated across 59 private landholdings and adjacent roads across a three-day period during April 2023.

The result

In 2023, the three-day blitz was equivalent to 60 days of labour. This temporary boost in highly experienced professional personnel meant that gamba grass could be mapped and treated within the catchment to a level that couldn't be achieved by a sole agency.



Gamba grass taskforce treatment areas within the Annan–Endeavour catchment.



Gamba grass distribution records from 2022 and 2023.

The 10 teams collected 2,438 waypoints in 2022 and 5,308 waypoints in 2023. Collation of this data showed there are three distinct infestations within the Annan–Endeavour catchment – one each in the north, central and south of the catchment. Management strategies for each of these infestations are based on distribution, density and the overall willingness of landholders to participate in the program.

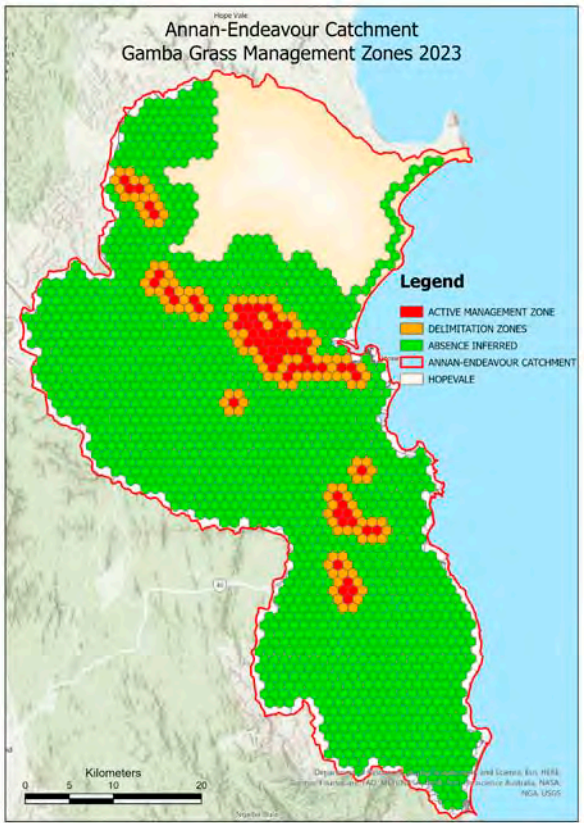
> *"Our management objective for the northern and central infestations is currently containment. The intention of continued taskforce involvement in these areas is to reduce gamba grass density to a level that's manageable by landholders using affordable or loaned equipment. It's anticipated that these infestations will reduce in area over time." Darryn Higgins.*

During the taskforce program, waypoints were recorded every time an isolated plant was treated or every 10 m where gamba grass was continuous. There was a wider distribution and a far greater density of points in 2023 compared to 2022. This has been attributed to improved detection skills and increased participation since the 2022 survey, rather than significant spread of gamba grass over that period.

Taskforce members attended, surveyed and treated all identified allotments during the 2023 season, so they were confident that the infestation was accurately defined.

A broad snapshot of the catchment in 2023

One method of visualising the distribution of gamba grass within the catchment is by using 1-km^2 grids. Using data collected during the taskforce program, each of these grids was assigned one of three categories. The red hex grids contain gamba grass, the orange are likely to contain gamba grass based on proximity to the core infestations, and green infer the absence of gamba grass.



Gamba grass presence/absence mapping of the Annan–Endeavor catchment.

> *"Using grids provides us with one method of examining the catchment without becoming overwhelmed by an area in excess of 200,000 hectares. It also provides a coarse 'snapshot' to compare against in future years and assess whether distribution of the species has expanded, decreased or remained static."* Darryn Higgins.

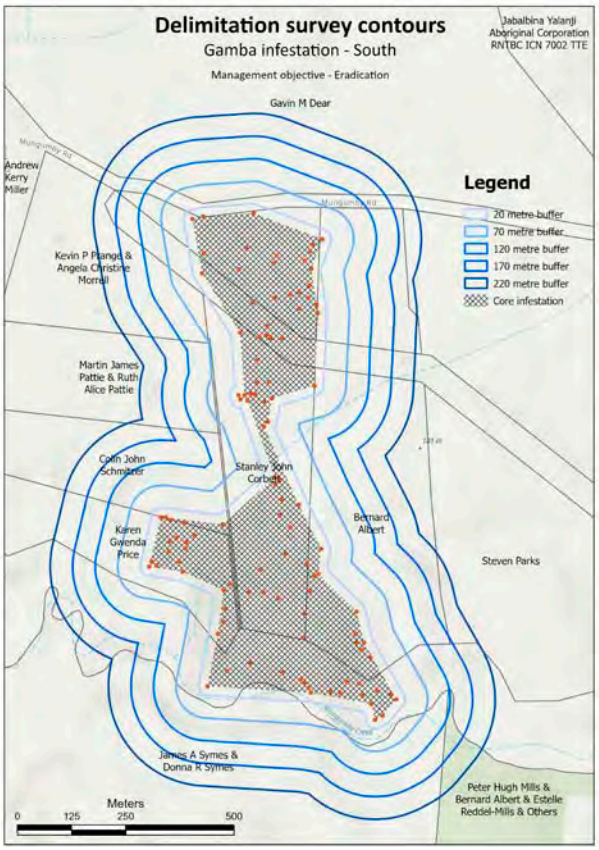
Case study 3

Control was focused on identifying and managing gamba grass within the red grids and attempting to confirm presence/absence in the orange and green grids.

Eradication in the south?

Based on waypoint data, it was calculated that the infestation in the south was limited to an area of 22 ha – relatively small in comparison with the central and northern infestations. In addition, all landholders within this area are willing to participate in the program. Given these factors, the management objective for the southern infestation is eradication.

The immediate post-taskforce objective following the 2023 season was to survey the area surrounding the recorded waypoints. Consequently, a finer-scale map was produced. The area surrounding the known infestation was divided using 50-m contours. Each of these contours are being walked by Cook Shire Council biosecurity staff to either confirm the absence of gamba grass or expand the core infestation should additional plants be identified.



Map showing the delimitation surveys approach that is conducted around core infestations.

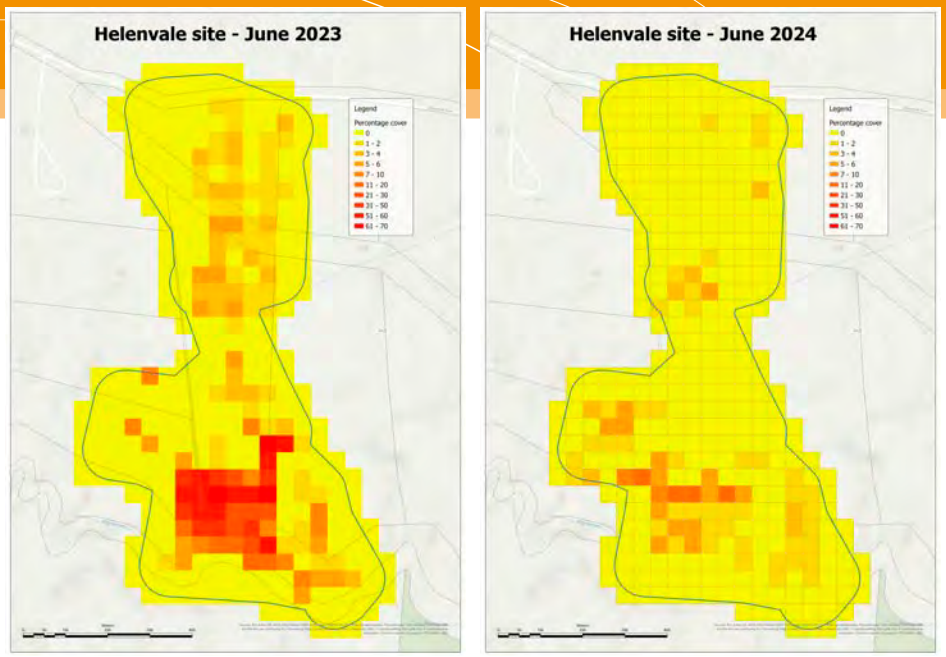
Additionally, four trial sites were established within the southern infestation to monitor i) the efficacy of wick wipers in controlling gamba grass, ii) the landscape response to indiscriminate use of glyphosate, and iii) pasture rennovation using pasture species.

These trials are a component of the Strategic Invasive Grass Project, administered by Biosecurity Queensland and funded by the Australian Government, that joined the taskforce as a partner in 2023.

2024

The taskforce returned in 2024, treating gamba grass across 40+ landholdings over three days with nine teams (seven from local governments and two from the Queensland Government). There was no evidence of spread due to floods associated with Cyclone Jasper in mid-December 2023, and there was a measurable reduction in the density of gamba grass in the target areas. Some properties have transitioned to private management of gamba grass using equipment either loaned under the auspices of the taskforce or privately acquired. Cook Shire Council continues to supply limited quantities of glyphosate for free to participating properties that have moved to private management. The challenge will be fostering this transition across the remaining properties.

Progress toward the goal of eradication at the southern site is evident in the images below. To assess the site on an annual basis, it was divided into 322 1,600 m^2 grids. Biosecurity staff estimated the percentage cover of gamba grass in each grid in 2023 and 2024. There was a marked reduction in the density of gamba grass between the two years.



Comparison of gamba mapping data from June 2023 and June 2024, showing no expansion of the infestation and considerable reduction in density.

The future

While dependent on funding, participating agencies intend to expand on and repeat the taskforce's activities yearly into the future. In the meantime, Cook Shire Council's Biosecurity Services team will monitor and treat gamba grass within the catchment while communicating a transition plan to residents, so that residents are prepared to continue management when the program concludes.

Trial plots where treated areas were planted with a combination of humidicola and signal grass are now gamba grass free. Given its success, this strategy is now being applied across the entire southern infestation. A post-taskforce survey was undertaken in July 2024 to measure the success of the taskforce approach. The results of the survey are expected to be available in early 2025.

Utilising this cross-tenure, multi-agency, regional approach has been very successful. The gamba grass problem in the Annan–Endeavour catchment has been quantified, and it's anticipated that the spread of gamba grass has been slowed, with localised eradication considered attainable in at least one area. The longer-term success of this initiative will largely depend upon the local community taking increased responsibility for management.

Key learnings

- Follow-up treatments in the same season are critical – plants will be missed in the first sweep. Landholders should be encouraged to undertake these.
- Establishing memoranda of understanding is an effective way to administer such arrangements.
- It's critical to work to a long-term strategic plan and have a transition plan post-taskforce.
- A collaborative effort is effective in raising local awareness and providing professionals with first-hand experience of a species uncommon in their region. Everyone in the area now knows what gamba grass is and what its impacts are. This was not the case in 2021.
- GIS maps inform control and management and are a valuable communication tool for a broad audience.
- Broad-scale application of glyphosate to control gamba grass requires a strategy to rehabilitate the treated site.

Case study 4

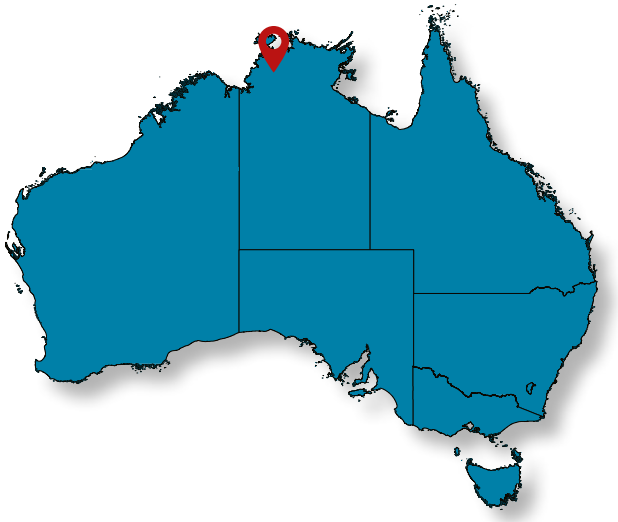
Managing gamba grass using rotational grazing in the Douglas Daly, NT

Tim Schatz, Northern Territory Department of Industry, Tourism and Trade, with assistance from Cameron Heeb and Jamie Marschall, Douglas Daly Research Farm

Management objective: asset protection

Key points

- **Gamba grass is a declared weed and must be controlled.**
- **When tall and rank, gamba grass has little grazing value and is a fire hazard.**
- **Rotational grazing can keep gamba grass short and palatable, reduce seed production and spread, and result in good weight gains in cattle.**

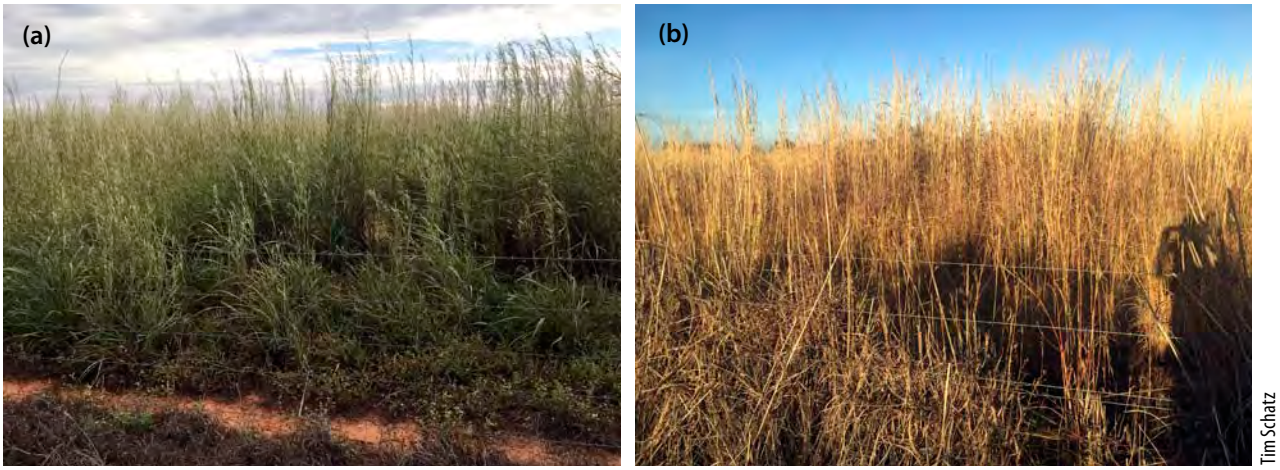


Background

The Douglas Daly Research Farm (DDRF) is a 3,100-ha research facility managed by the Northern Territory Government. It's located at the junction of the Daly and Douglas rivers, 230 km south of Darwin. The rainfall (1,200 mm annually) and soil of the Douglas Daly region are suitable for a range of production enterprises including cattle grazing, cropping and hay production. DDRF was established in the 1960s, and its purpose is to host research, development and extension of agriculture in the Top End of the Northern Territory (NT). The focus of agriculture within the Douglas Daly region has changed over the years, from cropping in the 1980s and intensive livestock production in the 1990s, to a diverse mix of agricultural industries in later years. Research at the farm has reflected and, in some cases, driven these changes.

The problem

Gamba grass is valued as a pasture species by many graziers in northern Australia, and it continues to be intentionally grazed. However, land managers in the NT are legally required to manage gamba grass on their properties, even on properties outside the eradication zone. This can be achieved by minimising seed production and preventing spread. However, gamba grass grows rapidly when grazed with traditional methods (e.g. set stocking, where the grazing paddocks are rarely rested), leading to the production and spread of seed, increased fire hazards and impacts on other values such as the environment. Tall gamba grass is also less palatable for stock and results in poor growth rates in cattle.



Tim Schatz

Tim Schatz

Tall gamba grass (a) in seed and (b) browned off, both stages that offer little little nutritional value to stock and present significant seed spread and fire risk.

Anecdotal reports from some commercial cattle producers suggest that intensive rotational grazing – where groups of stock are frequently moved through a series of paddocks and the pasture is given time to re-grow before being grazed again – keeps gamba grass short and palatable. This results in better livestock productivity, regulated plant growth, less production and spread of seed and reduced fire hazards. Rotational grazing is potentially a win–win control option for graziers and the environment. However, limited robust, objective data exists on the results of rotational grazing and it has only been adopted at small scales. To address this, a rotational grazing trial was established at DDRF in 2018 at a paddock infested with gamba grass. The objective was to investigate if rotational grazing improves cattle production while reducing the negative impacts of gamba grass and, if so, to advise graziers outside the eradication zone on how they can adjust their farm management practices to improve both productivity and environmental outcomes. This case study documents this trial.

The approach

Establishing the rotational grazing trial

The trial site on DDRF is 180 ha. It was historically one of the worst performing parts of the property in terms of cattle production due to the tall, dense, rank tussocks of gamba grass that dominated the paddock for many years. These tall tussocks aren't palatable to cattle and other grazing animals (e.g. wallabies). These animals avoided the tall gamba grass and overgrazed other grasses, leaving just the gamba grass tussocks with bare ground between them.

Tim Schatz

Cattle grazing the trial area at Douglas Daly Research Farm in December 2020.

Case study 4

In 2018, the paddock was subdivided into five smaller paddocks (20–38 ha) for rotational grazing. A mob of 360 cattle rotationally grazed the five paddocks, with the aim of keeping the grass short and palatable, preventing it from seeding, and giving it time to recover before being grazed again. Some of the paddocks were burnt in November 2018 to remove the old rank tussocks of gamba grass before grazing commenced about six weeks later, after the first rains of the season.

Paddock	Area (ha)	Stock density (head/ha)
Hazels	38.0	9.5
Shottons	25.0	14.4
Hauslers	36.0	10.0
Front of Hay	19.5	18.5
Parkers	34.0	10.6
Gamba	27.0	13.3
Total	**179.5**	**2.0**

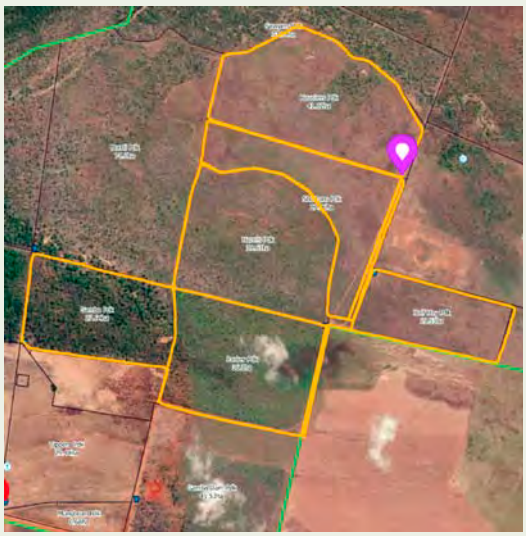


Figure 4.4.1 The paddocks, sizes and stocking densities of the 360 head of cattle in the gamba grass grazing trial.

The overall stocking rate over the 180-ha trial area was 2 head/ha. However, when the mob of cattle was in one of the small paddocks, the grazing density ranged from 9.5 to 18.5 head/ha, depending on the size of the paddock (see Figure 4.4.1). The cattle stayed in a paddock for 2–6 days, depending on how the pasture was holding up to the grazing pressure.

Cattle were removed from the trial area from May until after it had rained (usually in November), as gamba grass has limited grazing value during the dry season.

Trial extension

Communicating the trial results to pastoralists was just as important as the trials themselves.

Field days were held at DDRF in 2019 and 2021, so that local cattle producers could see the trial area and hear about the results. This was an opportunity to communicate land management responsibilities in relation to gamba grass and how a change to pasture management could help to meet land management responsibilities while improving productivity. The field days were well attended and people were very interested in the grazing strategy. It's likely that more cattle producers will adopt this grazing strategy to manage gamba grass in the future.

NT DITT

Field day in April 2019. This paddock was burnt in November 2018 to remove rank material and then rotationally grazed over the wet season.

The result

The trial – which is ongoing – is demonstrating that rotational grazing is very effective at controlling gamba grass by limiting its growth and spread. It also increases the growth rates of cattle grazing on country already infested with gamba grass.

Each year since the start of the trial, gamba grass has been kept short by grazing, hasn't produced any seeds, and hasn't spread off site.

The average daily gains of cattle grazing in the trial area are shown in Table 4.4.1. In most years, the growth was recorded from mid-December to early April. Note that data was not collected in 2019–20.

Table 4.4.1 The average daily gain (ADG) of cattle in the gamba grass grazing trial.

Wet season	Yearling bulls ADG (kg/day)	Two-year-old steers ADG (kg/day)
2018–19	0.58	0.71
2019–20	NA	NA
2020–21	0.53	0.52
2021–22*	0.86	0.74
2022–23	0.56	0.43
Average	0.63	0.60

* Final weight recorded in late February instead of April.

The cattle weight gains recorded in the DDRF gamba grass grazing trial are considerably better than what was previously achieved in these paddocks under lower stocking rates (e.g. 0.2 kg/day) but slightly lower than what has been recorded on other improved pastures at DDRF (e.g. 0.9 kg/day on buffel grass).

The future

This grazing trial will continue, monitoring seeding, spread and live weight gain (LWG) long-term. Of particular interest is whether the nutrition from gamba grass declines over time as soil nutrients decline, and if this leads to reduced cattle LWG.

The trial's outcomes will hopefully result in more land managers adopting rotational grazing. However, this will be difficult to measure, as changes to management practices are seldom reported.

Key learnings

- Conservative set stocking of gamba grass is not a good grazing management strategy, as the gamba grass grows into tall tussocks which aren't palatable for livestock and produce many seeds. As a result, cattle weight gain is low, and the gamba grass spreads and becomes a fire hazard.
- Rotational grazing is a much better management strategy for gamba grass. It keeps the grass short and palatable and prevents seeding while increasing cattle weight gains.
- It's best to burn old stands of gamba grass to remove large tussocks, then give the grass about six weeks to grow after rain before commencing rotational grazing.
- Split the area to be rotationally grazed into a number of paddocks so that each paddock is spelled for about 24–30 days between grazes. The stocking rate over the entire area should be about 2 head/ha, but it will be much higher (e.g. 10–20 head/ha) when the mob of cattle are in any of the individual paddocks.

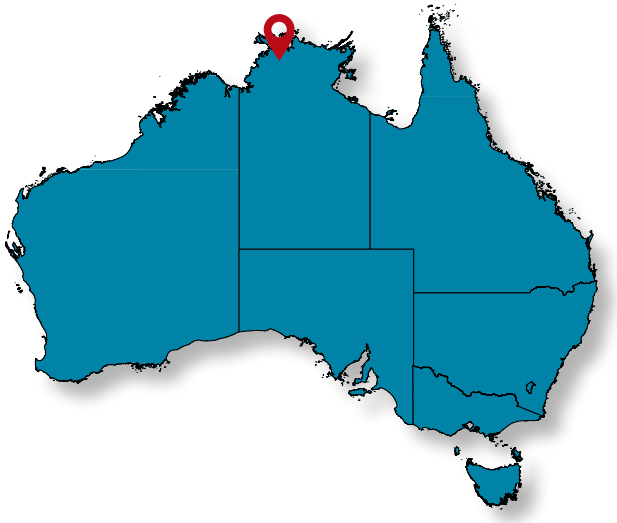
Case study 5

New ways to manage gamba grass and fire in the NT's Mary River National Park

Natalie Rossiter-Rachor and Samantha Setterfield, National Environmental Science Program (NESP) Resilient Landscapes Hub, The University of Western Australia

Steve Dwyer and Roderick Edmonds, Department of Tourism and Hospitality, NT

Management objective: asset protection



Key points

- **Mary River National Park rangers manage gamba grass strategically, by fine-scale herbicide application and, where possible, excluding fire.**
- **Maintaining tree structure and diversity and improving tree health have been a key focus of the park's weed and fire management.**
- **Excluding fire has substantially decreased fire frequency, with large areas of the park now burnt very infrequently.**
- **These changes are helping the native savanna woodlands regenerate in areas formerly infested with gamba grass.**
- **Research has played a key role helping rangers at the park turn this invasion around by guiding and providing evidence of the effectiveness of management changes.**

Background

Mary River National Park is approximately 100 km east of Darwin in the Northern Territory. The park comprises approximately 121,525 ha of wetlands and savanna, with an average annual rainfall of 1,524 mm. It is made up of several land parcels separated by other land tenures. This case study focuses on the Wildman block, an extensive wetland and savanna complex on the Mary River. The park is recognised by the Northern Territory Government as a Class 1 (most important) biodiversity National Park. The main purpose of the park is to protect and conserve the outstanding natural, cultural, historical and visitor values.

Gamba grass was planted on the station adjoining the park to the north in 1985, and trial plantings occurred to the south-east in the 1970s (Flores et al. 2005). Extensive interviews with researchers and land managers about planting activity in the 1970s to 1990s showed no evidence of gamba grass being planted in the Wildman block, suggesting that gamba grass arrived there from these adjacent sites. Gamba grass established on the Wildman block and, by 1998, became a monoculture over large areas of the park. This created a significant management

issue, particularly for fire management. Gamba grass is a serious threat to the savannas and wetlands of the park, particularly on the northern Wildman block.

The problem

Gamba grass has invaded a significant area of the park over the last 30 years and has resulted in substantial increases to both fuel loads and fire intensity. Managing gamba grass in the park is a significant challenge for park managers.

Matt Sheehan

Damage to canopy trees by gamba fires.

Historically, gamba grass was managed in the park by burning early in the fire season to reduce fire risk. Often, 4-m tall gamba grass was set alight to safeguard the properties to the north from a more damaging late-season fire.

> "*The regime was to burn it early, then once it was all laid down, burn it again and again and again. That was the mentality we all had 15 years ago, and no one realised that we were giving it exactly what it needed to thrive.*" – Roderick Edmonds, Mary River Senior District Ranger.

This pattern of management started to concern the Senior District Ranger at the time, Steve Dwyer.

> "*Over time, I could really notice the difference that the fires were having, killing the trees. I began to think we could possibly do something differently.*"

Michael Douglas

Gamba grass in Mary River National Park in the early 2000s.

The approach

To develop a more strategic approach to gamba management based on the ecology and biology of the plant, a partnership was formed between the Mary River National Park rangers, and NESP researchers, Dr Natalie Rossiter-Rachor and Professor Samantha Setterfield. The aim was to foster the recovery of healthy native savannas.

> "*We knew from our research that frequent, high-intensity gamba grass fires were threatening the values of the park and that, anecdotally, these intense gamba fires were thinning the tree canopy. Our research had also shown that gamba seeds are short lived in the soil seedbank, with the majority of seeds lasting less than one year. This increases the likelihood of management success by the rangers.*" – Samantha Setterfield.

Steve agrees with this and adds:

> *"Knowing that seeds are short lived and require light and low competition to germinate, it made perfect sense to develop a management approach that excludes the two things gamba grass loves – fire and light – and so reduces the threat to the parks natural values.*

The park managers implemented a strategic approach to gamba grass management which consisted of the following components.

Case study 5

Reducing the frequency of gamba grass fires and using ground-based chemical spraying

The first management change was to stop burning gamba grass annually on the Wildman block. To manage the potential risks, additional fire breaks were established and maintained to allow for rapid response to any wildfires that either originated in the park or in surrounding areas.

Initially, the focus was on establishing gamba-free buffers around trees to protect their canopies. Management then shifted to large-scale strategic control of gamba grass by cutting in parallel management tracks through the dense areas of gamba grass. This allowed access to these areas and they were treated in 20-m strips each side of the management tracks, using vehicle-based quick-spray units. Over time, crews could penetrate further in to the gamba areas and break them up. Sites were revisited several times in the same season to spray any plants that were missed or only partially sprayed. The grass was left to die, and the dead gamba grass shaded the soil and helped to inhibit germination of gamba grass seed. The canopy of recovering vegetation also provided shade and reduced germination of gamba grass seed.

NESP Northern Australia Hub

A gamba grass infestation in Mary River National Park in the early stages of management. Note the live gamba grass (green) and the sprayed, dead gamba grass (brown). Care was taken to spray around milkwood trees.

> *"We spray it chemically, we exclude fire, and we try to get shade back over because gamba hates competition."* – Steve Dwyer.

Fine-scale aerial spraying of gamba grass

Rangers also used strategic aerial spraying to control gamba grass and protect important trees such as milkwoods (*Alstonia actinophylla*) from intense gamba grass fires. Careful aerial spraying was carried out in open areas with 100% cover of gamba grass and no canopy, integrated with on-ground spraying of the remaining gamba grass underneath important trees.

NESP Northern Australia Hub

Professor Samantha Setterfield taking measurements in the park to determine the health of the savanna.

Establishing long-term monitoring of the management approach

Any weed-control program should include a monitoring program to measure the effectiveness of the management approach. This was especially important in this case, where there was such a drastic shift in the management strategy. Aerial mapping and vegetation surveys were undertaken, with the intention of them being repeated every five years to capture changes in gamba grass distribution and density and savanna health.

The results

Gamba grass management in the park has changed considerably over the last 15 years, and NESP research on the ecology and impacts of gamba grass has supported and guided these management changes. Freed from the dense cover of gamba grass and repeated fires, milkwood seedlings are thriving around the mature trees.

> *"Because of the weed and fire management that Steve, Rod and their team have implemented, the gamba grass has decreased, fires are less frequent and we've got a healthy native savanna."* – Dr Natalie Rossiter-Rachor, Charles Darwin University.

Roderick says that having scientific data that quantifies the ecological changes helps to refine and further develop the park rangers' annual weed and fire management activities and has informed the integrated conservation strategy for the national park.

The data has also been an important part of the conversation with land managers about possible alternative approaches to gamba management, in locations where similar weed and fire management activities are appropriate.

> *"It's a real mind shift in management. To us now, it's a no-brainer that you would consider the biology and ecology of gamba grass and manage it by exploiting its weaknesses. I can sit in as many meetings as I want and talk to people about it, but the data and the photos that show the changes over time speak for themselves, and hopefully will persuade managers in other comparable environments with similar values to consider an approach like this."* – Steve Dwyer.

Michael Douglas

Natalie Rossiter-Rachor

A gamba grass-infested area at Mary River National Park has been restored to native savanna woodland through diligent management of gamba grass and fire.

Case study 5

The future

"Gamba is always going to be in the landscape, but we're not dealing with a wall of gamba anymore. It's at a low-enough density now to allow recruitment of milkwoods, jacksonia, acacia and other natives, so from a biodiversity perspective, we've been very successful. If fire was to come through now, the intensity would be lower and have less impact on native ecosystems." – Roderick Edmonds.

Matt Sheehan

Recovering ground layer and canopy in the absence of gamba grass.

While the current management approach needs to continue, Rod explains that there'll need to be some tweaks to management as the park continues to recover.

"As gamba grass densities decrease and native vegetation recovers, we'll need to get lots of people on the ground – volunteers and crews from other areas – to search for individual isolated plants and spray them. This can be integrated with ongoing aerial spraying in areas that remain dense."

Natalie Rossiter-Rachor

Steve Dwyer amongst a new generation of milkwoods with their parents in the background. These have established since the removal of gamba grass and the exclusion of fire.

Continued monitoring will be critical

Park rangers and NESP researchers have used aerial surveys to monitor changes to the distribution of gamba grass on the Wildman block since the implementation of the intensive management program. These landscape-scale surveys have provided evidence of the effectiveness of the management program. It'll be important to continue the monitoring program to quantify the recovery, inform future management, and justify future investment.

Key learnings

- Reducing frequency of gamba grass fires has been key to the management success at Mary River National Park.
- Fine-scale aerial spraying of gamba grass has been successful for large, dense infestations.
- Monitoring and research have provided evidence of positive management outcomes, which have been widely communicated.
- Intensive chemical-control programs require significant investment in equipment, maintenance and repair.

Chapter 5

Further information

Co-occurring grasses

Grasses can be difficult to identify. This guide provides information on grasses – both native and introduced – that commonly occur with gamba grass. They can look similar to gamba grass at certain times of the year. This section focuses on how each of these grasses are similar to and different from gamba grass.

Remember: If you're not certain whether the grass you have is gamba grass, either talk to a local weed professional or send a specimen to your nearest herbarium (contact details provided on page 121). Talk to the herbarium before sending a specimen to get advice on what they'll need. Data for distribution maps have been sourced from www.ala.org.au.

Cenchrus pedicellatus
annual mission grass

Introduced (Qld, NT and WA)

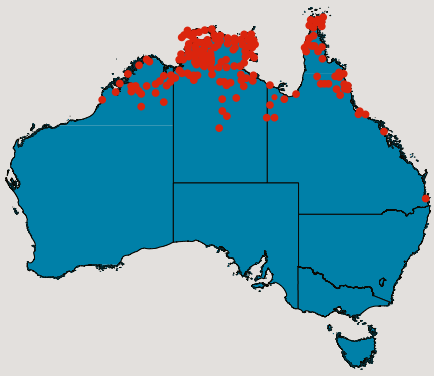
Erect, annual tussock grass to 1.5 m tall

Differences from gamba grass

- compact flower spike, white to off-white, sometimes with a pink tinge
- leaves lack white midrib and usually hairless or softly hairy.

Similarities to gamba grass

- slender stems with hairs at margins on the leaf sheath
- leaves can be a reddish-purple colour.



WMB NT Government

WMB NT Government

Cenchrus polystachios
perennial mission grass

Introduced (Qld, NT, NSW and WA)

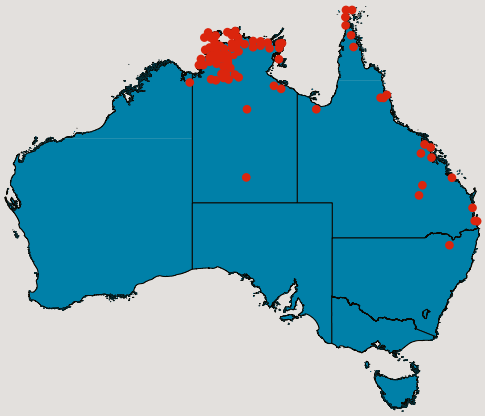
Erect, perennial tussock grass to 3 m tall, usually 2 m

Differences from gamba grass

- compact yellow flower spike, densely packed seedhead dries to yellow-brown/cream
- leaves lack white midrib.

Similarities to gamba grass

- leaves can be a reddish-purple colour.



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Cenchrus purpureus
elephant grass

Introduced (Qld, NT, NSW and WA)

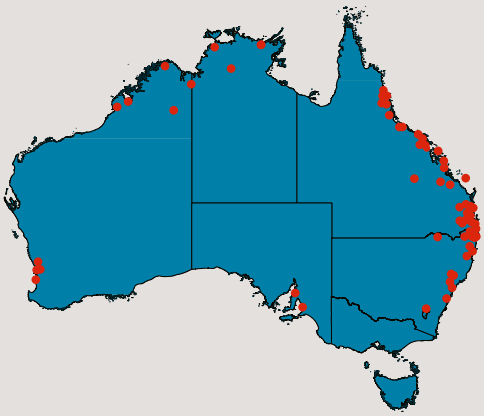
A very robust grass forming large, bamboo-like clumps (often 3–4 m tall)

Differences from gamba grass

- the leaf sheaths are hairless to stiffly hairy, and there is a dense fringe of hairs where the sheath meets the leaf blade
- the leaf blades are large (20–120 cm long and 1–5 cm wide)
- the seed head is spike-like (8–30 cm long and 1.5–3 cm wide) and very bristly.

Similarities to gamba grass

- leaf has a prominent white midrib.



J. Clarkson

J. Clarkson

Cymbopogon procerus*, *Cymbopogon bombycinus
lemon-scented grass

Native (Qld, NT and WA)

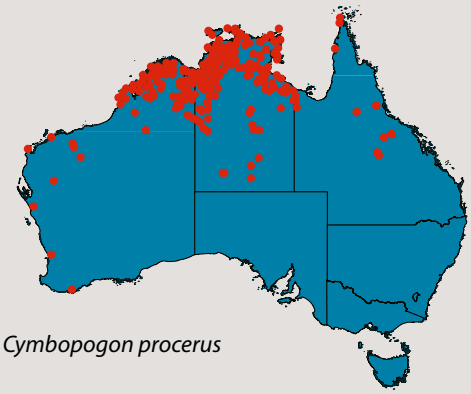
Erect, perennial tussock grass to 2 m tall

Differences from gamba grass

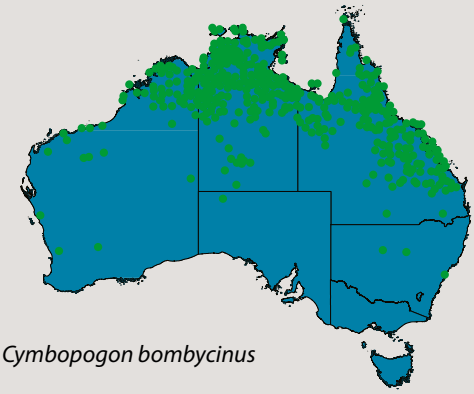
- crushed leaf and stalk smell like lemon/ citronella
- smooth stems, with only a white midrib at base of leaf.

Similarities to gamba grass

- long, fluffy seed heads, although not just at top of flowering stems like in gamba grass.



Cymbopogon procerus



Cymbopogon bombycinus

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WMB NT Government

WMB NT Government

Cymbopogon procerus

Heteropogon triticeus
spear grass

Native (Qld, NT and WA)

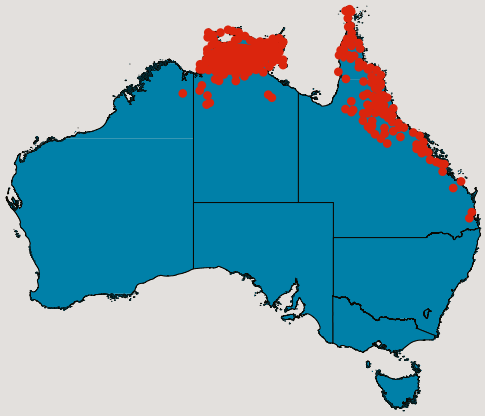
Erect, densely clumping tussock grass to 2 m tall

Differences from gamba grass

- has fan-like flatted base of stems
- slender, smooth stem with long leaf sheath
- long black awn on seed
- all leaves come from the base of the plant.

Similarities to gamba grass

- white midrib but narrower than gamba grass
- leaf margin slightly rough tip to base.



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Hyparrhenia rufa
thatch grass

Introduced (Qld, NT, NSW and WA)

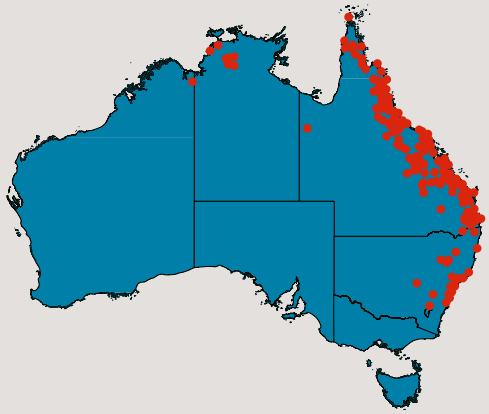
Densely bunched, erect, perennial tussock grass to 3 m tall, usually 2 m

Difference from gamba grass

- slender stems with alternate green and yellow segments
- narrow hairless leaves
- does not form big tussocks like gamba grass and has less leaves.

Similarities to gamba grass

- v-shaped inflorescence (reddish to rusty brown)
- leaf has a white midrib.



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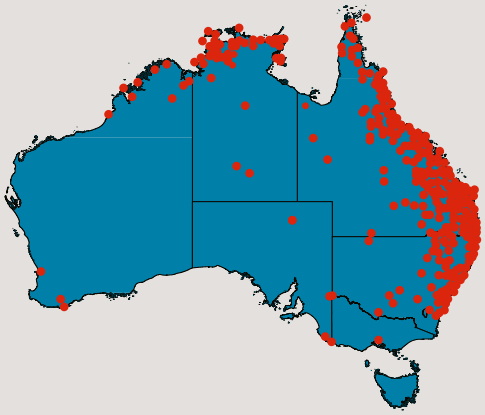
Megathyrsus maximus
Guinea grass

Introduced (Qld, NT, WA, NSW, Vic and SA)

Erect perennial tussock grass, usually 2 m but can grow to 4 m

Differences from gamba grass

- large, open inflorescence on slender stems above the leaves
- broad leaf without white midrib or hairs, margin rough to touch in both directions
- robust stems – some cultivars have short, prickly hairs.



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Mnesithea rottboellioides
northern cane grass

Native (Qld, NT and WA)

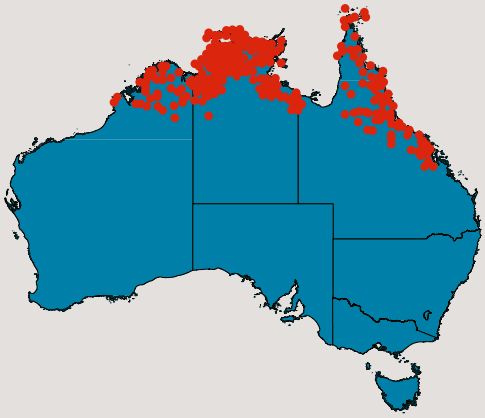
Erect, perennial tussock grass to 3 m tall

Differences from gamba grass

- inflorescence on several spike-like branchlets, up to 10 cm long
- hairless or sparsely hairy stems and base.

Similarities to gamba grass

- broad leaf with thick white midrib
- leaf margin slightly rough tip to base.



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Rowena Eastick

Rowena Eastick

Rottboellia cochinchinensis
itch grass

Native (Qld and NT)

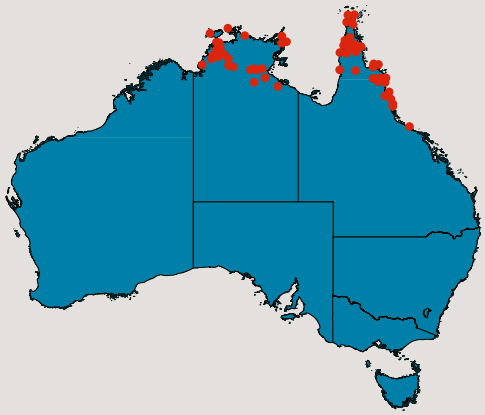
Erect, annual tussock to 3 m tall

Differences from gamba grass

- cylindrical inflorescence
- round, robust stems with stiff prickly hairs.

Similarities to gamba grass

- broad leaf with white midrib, but hairless, and leaf margin very rough from tip to base.



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Rowena Eastick

WMB NT Government

WMB NT Government

Sorghum spp. (referred to as _Sarga_ spp. in Queenland)
perennial sorghums (e.g. _S. plumosum_)

Native (Qld, NT, NSW and WA)

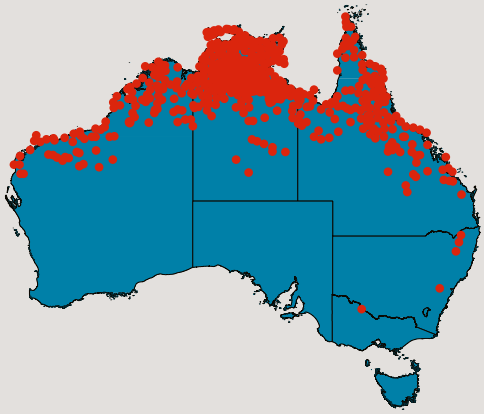
Erect, perennial tussock grass to 3 m tall

Differences from gamba grass

- leaf blade is narrow and hairless and can have a 'frosted' or dusty-looking coating
- large seeds and long robust awns on a large, open brown panicle inflorescence.

Similarities to gamba grass

- leaves have a white midrib
- dense tussock of hairless to hairy robust stems.



WMB NT Government

WMB NT Government

Sarga plumosum

Sorghum spp. (referred to as _Sarga_ spp. in Queenland)
tall annual sorghums (e.g. _S. intrans, S. timorense_)

Native (Qld, NT and WA)

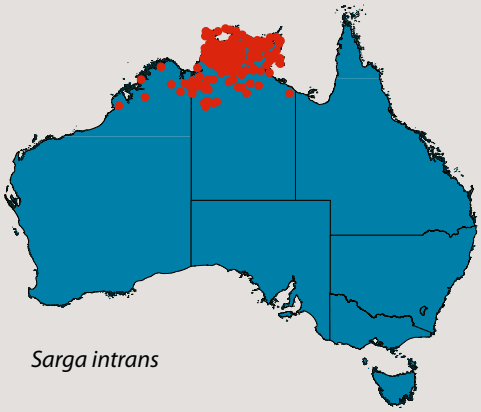
Erect, perennial tussock-forming grasses with stems to 3.5 m tall

Differences from gamba grass

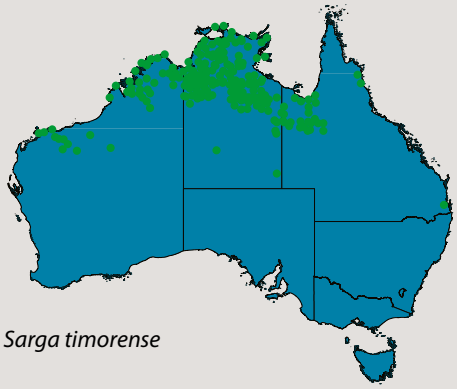
- large rusty-brown inflorescence
- leaves are narrower than gamba grass
- slender individual stems rather than a clump
- 'stilt' roots are common.

Similarities to gamba grass

- leaves have a white midrib.



Sarga intrans



Sarga timorense

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Sarga intrans

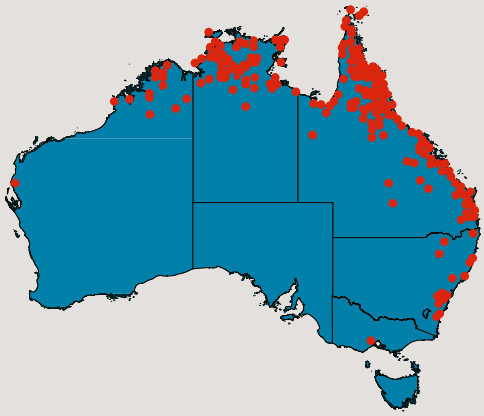
Themeda quadrivalvis
grader grass

Introduced (Qld, NT, WA, NSW and Vic)

Annual, generally distinct tufted grass with an upright habit growing 50–200 cm tall

Differences from gamba grass

- stems, leaves and seed heads turn reddish-brown or golden-brown as they mature
- seed heads consist of many drooping, fan-shaped flower clusters interspersed with short 'leaves'
- mature seeds (4.5–5.5 mm long) have a cluster of hairs at the base and are topped with a large, twisted awn (10–45 mm long).



J. Clarkson

J. Clarkson

Herbaria contact information

Australian National Herbarium
GPO Box 1700, Canberra ACT 2601
phone: (02) 6246 5084
email: canbr-info@anbg.gov.au
website: www.cpbr.gov.au/cpbr/herbarium

Queensland Herbarium and Biodiversity Science
Brisbane Botanic Gardens, Mt Coot-tha Road
Toowong Qld 4066
phone: (07) 3199 7699
email: queensland.herbarium@qld.gov.au
website: https://www.qld.gov.au/environment/plants-animals/plants/herbarium

State Herbarium of South Australia
Old Tram Barn, Hackney Road
GPO Box 1047
Adelaide SA 5001
phone: (08) 8222 9311
email: stateherbsa@sa.gov.au
website: https://www.botanicgardens.sa.gov.au/science/research/state-herbarium

Tasmanian Herbarium
University of Tasmania
College Road
PO Box 5058, UTAS LPO
Sandy Bay Tas 7005
phone: (03) 6165 5143
email: herbarium@tmag.tas.gov.au
website: https://www.tmag.tas.gov.au/collections_and_research/tasmanian_herbarium

The National Herbarium of New South Wales
Botanic Gardens Trust, Mrs Macquaries Road
Sydney NSW 2000
phone: (02) 9231 8111
email: herbarium.nsw@botanicgardens.nsw.gov.au
website: https://www.botanicgardens.org.au/our-science/science-facilities/national-herbarium-new-south-wales

The National Herbarium of Victoria
Royal Botanic Gardens
Dallas Brooks Dr and Birdwood Avenue
Private Bag 2000
South Yarra Vic 3141
phone: (03) 9252 2300
email: rbg@rbg.vic.gov.au
website: https://www.rbg.vic.gov.au/science/herbarium/

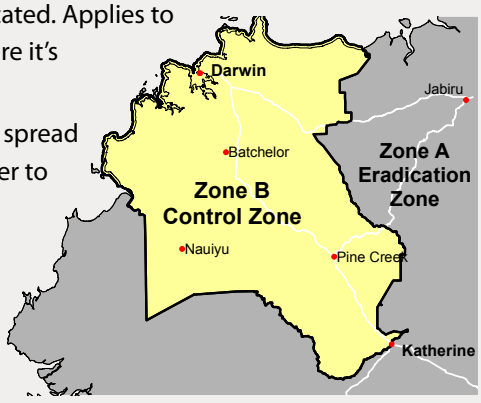
The Northern Territory Herbarium
Palmerston: Herbarium Building
The Boulevard
PO Box 496
Palmerston NT 0831
phone: (08) 8999 451

Alice Springs: Alice Springs Desert Park
Larapinta Drive
PO Box 1120
Alice Springs NT 0871
phone: (08) 8951 8791
email: herbarium@nt.gov.au
website: https://nt.gov.au/environment/native-plants/native-plants-and-nt-herbarium

Western Australian Herbarium
Conservation Science Centre
17 Dick Perry Avenue, Kensington
Locked Bag 104
Bentley DC WA 6983
phone: (08) 9219 9000
email: herbarium@dbca.wa.gov.au
website: https://www.dbca.wa.gov.au/science/research-tools-and-repositories/western-australian-herbarium

Additional planning information

Declaration status of gamba grass in Australia

Jurisdiction	Legislation	Declaration and requirements Description
Australia	*Biosecurity Act 2015*	Not permitted Not permitted for entry into Australia.
Australian Capital Territory	*Pest Plants and Animals Act 2005*	Declared **Must be suppressed:** all infestations of gamba grass on a premises must be controlled. **Notifiable:** presence must be notified to the Director General. **Prohibited:** supply and propagation is not allowed. This includes the importation of gamba grass plants or seeds, or materials contaminated with plants or seeds, into the ACT.
New South Wales	*Biosecurity Act 2015*	Declared **Prohibited matter:** a person who deals with prohibited matter or a carrier of prohibited matter is guilty of an offence. A person who becomes aware of or suspects the presence of prohibited matter must immediately notify the Department of Primary Industries. **Mandatory measure:** gamba grass must not be imported into the state or sold. **General biosecurity duty:** all plants are regulated to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Northern Territory	*Weeds Management Act 2001*	Declared – split declaration **Class A:** to be eradicated. Applies to all of NT except where it's classified as class B. **Class B:** growth and spread to be controlled (refer to Zone B in map). 

Queensland	*Biosecurity Act 2014*	Declared – whole of Queensland Gamba grass is a category 3 restricted invasive plant under the *Biosecurity Act 2014* (the Act). It must not be given away, sold or released into the environment. The Act requires everyone to take all reasonable and practical measures to minimise the biosecurity risks associated with invasive plants under their control. This is called a general biosecurity obligation (GBO). This fact sheet gives examples of how you can meet your GBO: Gamba grass (publications.qld.gov.au) At a local level, each local government must have a biosecurity plan that covers invasive plants. This plan may include actions to be taken on gamba grass. Some of these actions may be required under local laws. Contact your local government for more information.
South Australia	*Landscape South Australia Act 2019*	Declared – whole of South Australia Prohibited **Sale:** must not be sold or traded in any way, including as a contaminant of anything. **Movement:** must not be transported on a public road, including as a contaminant of anything. **Entry:** must not be imported into any region of South Australia.
Tasmania	*Biosecurity Act 2019*	Declared Prohibited: The importation, sale and distribution of gamba grass is prohibited.
Victoria	*Catchment and Land Protection Act 1994*	Declared – whole of Victoria **Restricted:** it's an offence to sell or trade gamba grass. You can't buy, sell, possess for sale, display, propagate, bring into Victoria or transport within Victoria gamba grass plants, plant parts, seeds or as contaminant in other materials.
Western Australia	*Biosecurity and Agriculture Management Act 2007*	Declared – whole of Western Australia **Prohibited:** gamba grass is an eradication target (C2 – eradication/prohibited).

Pre-planning questions

Ask yourself…	Draw out the reasons and possible solutions
Why is gamba grass a problem?	Refer to the 'Impacts' section of Chapter 1 and Table 2.1 in Chapter 2 to briefly describe the problem
What do we want to achieve?	What does success look like? For example: ☑ removing or reducing biomass ☑ reducing or preventing seed production ☑ reducing or preventing seed spread
What's my legal obligation to manage gamba grass?	Are you in an eradication zone and what's expected of you?
What are we currently doing to manage it?	How effective is it? What can we do better?
What else is being done?	Other weeds, fire management, etc, and does it support or conflict with gamba grass management?
Who's involved?	1. Who else should be involved in the planning process? 2. Who else should be involved in the review process?

Plan template

This template provides a suggested contents page of critical information to be included in your gamba grass management plan. It also includes a summary of each section and links to part of this manual or other documents that can help you populate this information.

Suggested headings and subheadings	Links to source data	Description
1. Overview/background 1.1 Description of gamba grass	Use info in Chapter 1	Draw from relevant information on biology and ecology. For example, list the habit, life cycle and characteristics relevant to management in 2–3 lines.
1.2 Description of management area		Describe your site or management area. Include information on the location, size, climate, rainfall, soil type and land use history. Describe any assets (natural assets, cultural assets, built assets and production values). You may want to include some information on adjacent areas (regional context).
1.3 The need for gamba grass management	Refer to Chapter 2 (Table 2.1)	Describe the drivers or reasons you need to manage gamba grass. List the impacts and threats presented by gamba grass.
1.4 Distribution of gamba grass and assets	Refer to Chapter 2, Step 1	Use the map created in Step 1 to set the scene and support the discussion on assets, management objectives and priority areas.
1.5 Legal management requirements	Use pages 122–123 as a guide. Also check with your weed management authority in your state or territory	Briefly describe the status of gamba grass in your region and what's legally expected of you. For example, are you in an eradication zone?
1.6 Stakeholders and partners	Refer to Chapter 2 'Better together' fact sheet on page 39	Identify who else should be involved in your planning process or on-ground management. You may decide that a joint management plan is preferable. If so, explain that partnership, who the partners are, and how it will work.

2. Management goals and objectives 2.1 Reasons or drivers for management	Refer to Chapter 2 Use Table 2.2	Restate your drivers from 1.3 above, and state what you want to achieve or what success would look like for your situation. Using distribution information, use Table 2.2 and Figure 2.3 to state your management objectives, any priority areas and long-term goals of what you hope to achieve through managing gamba grass.
2.2 Desired outcomes	Use Table 2.2	
2.3 Management objectives	Figure 2.3	
2.4 Priority management areas	Refer to Chapter 2, page 34	
3. Management options	Use Chapter 3	Identify the most appropriate control methods for your situation and stated goals and objectives. Describe any site nuances that you'll need to take into consideration.
4. Management action plan	Use Chapter 3 to select an appropriate management method Use Chapter 4 for ideas of what other people are doing	Create a table outlining your control program, control methods, timing and responsibility. Identify alternatives should something not go to plan (e.g. there's a wildfire, or the wet season is prolonged and the site isn't accessible). Include your follow-up control plan.
5. Evaluation	Refer to Chapter 2, page 37	Describe how you'll monitor control activities and how you'll determine the success or failure of your program.
6. Resourcing		Estimate the amount of time and money that will be required to carry out your planned control, monitoring and evaluation. Include costs for labour, chemicals, equipment and other logistics. Alternatively, consider if your efforts can be improved by working with others in a more strategic or coordinated way.
7. Appendices		Attach any other relevant information that you may require to implement your plan. This could include additional maps and overlays, stakeholder and partner contact details, and protocols that are being used (e.g. mapping, hygiene).

Safety and welfare information

For programs involving volunteers, a risk management tool called *Running the Risk?* is available from Volunteering Australia (www.volunteeringaustralia.org).

Further information on safety and welfare policy, standards, guidelines and legislation can be accessed by contacting the following government departments and volunteer organisations.

Jurisdiction	Website	Contact
National	https://safeworkaustralia.gov.au	info@swa.gov.au
	https://volunteeringaustralia.org	03 9820 4100 volaus@volunteeringaustralia.org
ACT	https://worksafe.act.gov.au	13 22 81 worksafe@worksafe.act.gov.au
NSW	https://safework.nsw.gov.au	13 10 50
NT	https://worksafe.nt.gov.au	1800 019 111 ntworksafe@nt.gov.au
Qld	https://worksafe.qld.gov.au	1300 362 128 https://worksafe.qld.gov.au/contact/general-enquiries
SA	https://safework.sa.gov.au	1300 365 255 help.safework@sa.gov.au
Tas	https://worksafe.tas.gov.au	1300 366 322 wstinfo@justice.tas.gov.au
Vic	https://worksafe.vic.gov.au	1800 136 089 https://myworksafe.vic.gov.au/s/customer-enquiry
WA	https://commerce.wa.gov.au/WorkSafe	1300 307 877 wscallcentre@dmirs.wa.gov.au

Additional management tools

State and territory contacts for weed control information

State and territory government departments provide information on controlling weeds. Contact details and helpful website addresses are provided below. Local/regional weed management authorities may also be contacted for information and advice.

State or territory	Department	Phone	Email	Website
ACT	ACT Parks and Conservation Service	13 22 81	ACTBiosecurity@act.gov.au	https://www.environment.act.gov.au/parks-conservation/plants-and-animals/biosecurity/invasive-plants
NSW	Department of Primary Industries	1800 680 244	weeds@dpi.nsw.gov.au	https://www.dpi.nsw.gov.au/biosecurity/weeds
NT	Department of Lands, Planning and Environment	08 8999 4567	weedinfo@nt.gov.au	https://www.nt.gov.au/environment/weeds
Qld	Department of Primary Industries	13 25 23	Not available at time of publication	https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/biosecurity/plants/invasive
SA	Department of Primary Industries and Regions	08 8303 9620	PIRSA.InvasiveSpecies@sa.gov.au	https://www.pir.sa.gov.au/biosecurity/weeds
Tas	Department of Natural Resources and Environment Tasmania	1300 368 550	biosecurity.tasmania@nre.tas.gov.au	https://www.nre.tas.gov.au/invasive-species/weeds
Vic	Agriculture Victoria	13 61 86	Refer to https://www.agriculture.vic.gov.au for contact options	https://agriculture.vic.gov.au/biosecurity/weeds
WA	Department of Primary Industries and Regional Development	1300 374 731	enquiries@dpird.wa.gov.au	https://www.agric.wa.gov.au/pests-weeds-diseases/weeds

FACTSHEET: Using herbicides legally, safely and effectively

Herbicide labels and legislation

The Australian Pesticides and Veterinary Medicines Authority (APVMA) regulates the availability of all pesticides, including herbicides. Herbicides are registered with the APVMA for specific applications as stated on the label, and state or territory governments regulate the use of herbicides after sale (see pages 61–62). A herbicide label is a legal document that defines where, when and how a herbicide may be used, on which weed species and at what rate. This is referred to as 'on label' use.

By law, you must read the label (or have it read to you) before using any herbicide product.

Off-label use

Off-label use is the use of a registered chemical to address a specific issue that isn't covered by an APVMA approved label or permit, such as:

- to control a different weed
- to protect a different host (such as a crop)
- to apply at a different rate (lesser) or frequency
- to apply in a different manner (not allowed in ACT, NSW and Tasmania).

Off-label use is permitted in all states and territories; however, conditions vary in each jurisdiction.

Minor use and emergency use permits

The APVMA may issue minor use and emergency use permits for herbicide applications that aren't otherwise registered for that particular use. Minor use permits can also be referred to as 'off-label' permits. Minor use and emergency permits are valid ('in force') for a limited time. See the APVMA website to find current permits.

If you're unsure which herbicides may legally be used on a particular weed, contact the APVMA or your local weed authority for advice and further information.

Chemical use training and certification

Chemical use training is required for people using herbicides as part of their job or business. Training is also recommended for community groups and may be required if working on public land. Training courses may be available through local councils or non-government organisations.

Commercial weed control operators must be licensed. It should also be noted that there may be shared responsibility between land managers and their contractors for any breaches of laws and regulations such as herbicide drift.

Safe use of herbicides

Operator safety

Herbicide labels will indicate the personal protective equipment (PPE) required for operator safety. This may include:

- impervious gloves
- eye protection
- respirator (with a filter appropriate to the level of herbicide toxicity)
- clothes, hat and boots that cover the whole body.

NESP

For herbicides with a higher risk to operator safety, additional PPE and precautions may apply, including wearing a full-face respirator and chemical-resistant overalls.

Always follow the herbicide label requirements and consult the Safety Data Sheet (SDS) on the health risks of exposure and PPE recommendations.

Environmental protection

Herbicide labels provide the mandatory measures an operator should adopt to protect the environment and non-target plants during the product's use. This may include instructions for preventing spray drift.

Herbicide users have a legal obligation to avoid spray drift damage and to ensure that the applied chemical stays within the target area. This is to avoid 'off-target' impacts to crops, native vegetation and other plants, and 'chemical trespass' onto neighbouring properties.

Measures to reduce the risk of spray drift include:

- spraying when the wind is 3–15 km per hour, or when no surface temperature inversion conditions exist
- using a coarse to very coarse spray quality nozzle type
- avoiding the use of high pump/sprayer pressures that create small droplets that float in the air
- having buffer zones.

Using herbicides near water

Riparian zones are sensitive habitats and a licence may be required to conduct weed control works. Only use herbicides that are registered or permitted for use in and around aquatic areas; some are formulated to be lower risk when used near water. Never:

- spray herbicides over waterbodies or plants standing in water
- add adjuvants to herbicides to be used near water unless they're registered for aquatic use.

Effective use of herbicides

Successful herbicide control is dependent on:

- selecting the right herbicide for the target species
- the growth stage of the target species
- the weather conditions during and after spraying
- how thoroughly the herbicide is applied
- the herbicide mix and application rate.

For spraying, wind speeds should be low (between 3 and 15 km/h). For glyphosate, it's generally recommended that there is no rain for at least 2 hours after spraying.

Don't apply herbicide to target plants that are under any sort of stress because it won't be absorbed and translocated effectively, resulting in a reduced level of control. Plants may be stressed owing to:

- dry soil
- low humidity
- air temperatures above 30°C
- frost.

Herbicide effectiveness can be maximised by:

- mixing it with dye to help minimise missed areas and prevent over-spraying (double spraying). Similarly, a foam marker or GPS can be used to indicate the edges of boom spraying
- using an adjuvant – an additive that improves herbicide uptake
- ensuring spray equipment is correctly calibrated and maintained, including by thoroughly cleaning it between uses.

If an adjuvant is used, always read the product label to ensure it's compatible with the herbicide and there are no restrictions on its use, e.g. adjuvants shouldn't be used near waterways.

Where to get help

Use the further contacts infomation listed in this chapter to direct any further queries about the safe use of herbicides and chemical use training and certification.

Herbicide Treatment Record Sheet				
Contractor		Date/Time		
Operator Names		Property/GPS Location		
Area Description (landmarks, etc.)				
Growth Stage (✓)				
Target Species	Seedling	Juvenile	Flowering	Fruiting
1				
2				
3				
Plant Growth/Comments (✓)				
Target Species	Active Growth	No Active Growth	Under Stress (comments)	
1				
2				
3				
Environmental Conditions				
Soil Conditions **(circle)**		Dry	Damp	Wet
Rainfall – Previous 12hrs **(Y/N)** None expected in next 12hrs **(Y/N)**				
Wind Direction				
Wind Speed				
Temperature				
Application Method (**circle**)				
Handgun or knapsack	Splatter gun	Wick wiper	Boom spray	Aerial spray
Operator signature		Project Officer signature		

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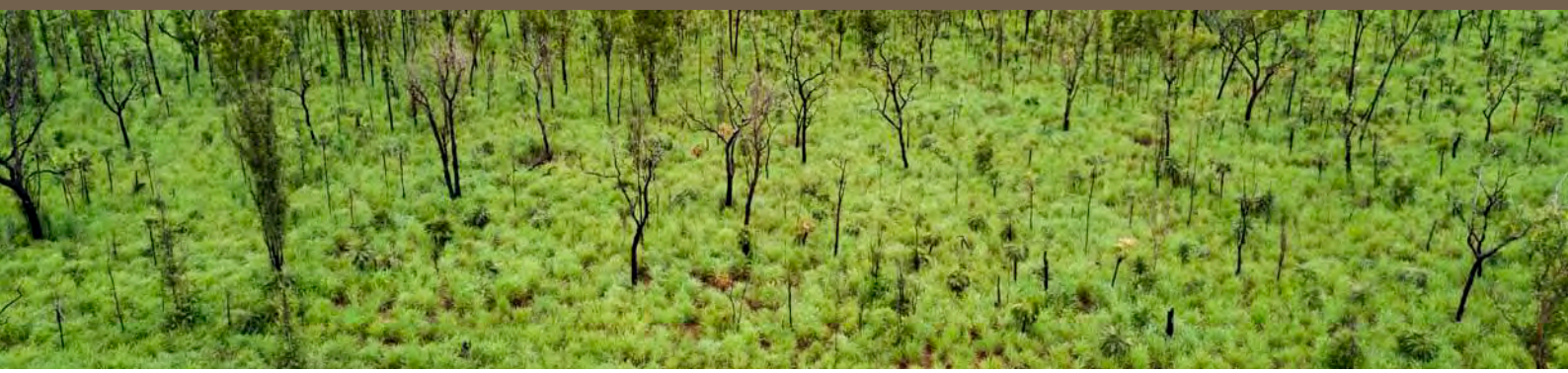

Gamba grass