

# Gamba Grass & Land Tenure in the Northern Territory

---



CENTRE FOR  
CONSERVATION  
GEOGRAPHY

*Strategic Tools and Conservation Innovation*



***This report was commissioned by The Pew Charitable Trusts for the Gamba Grass Roots Alliance, and prepared by Techa Beaumont and Leonie Seabrook from the Centre for Conservation Geography, March 2020***

*Front and back cover photos: Tiana Bremner*

---





## Introduction

Gamba grass (*Andropogon gayanus*) is a highly invasive declared weed regarded as one of the most significant threats to ecosystems and livelihoods in the Northern Territory [1]. Because it creates a much higher fuel load than native grasses, gamba grass greatly increases the intensity of fires. The risk to human life and property from these fires in the broader Darwin region is of particular concern.

Under the *Weed Management Plan for Gamba Grass*, land owners and managers have legal obligations to either control gamba grass (if their property is in the Control Zone) or eradicate gamba grass (if their property is in the Eradication Zone<sup>1</sup>) [2]. Despite these requirements, surveys and anecdotal evidence show that gamba grass continues to spread in many locations and across different land tenures [2–4].

The inability of public and private landowners to control gamba grass is reaching a crisis point, particularly in the Darwin and Darwin Rural areas, but also in iconic public spaces such as Litchfield National Park. Despite the best efforts of under-resourced government agencies, the weed is also leaping across landscapes, along roads, and deeper into the Eradication Zone, highlighting the urgent need for intensified efforts to stop its spread.

Leading researchers point to a 'lack of adequately resourced on-ground action across the region of potential invasion' [5]. The scale of this deficiency is evident in exponential rates of gamba grass expansion in some locations.

In this report we outline where known records of gamba grass occur and their documented spread, by location, tenure and land manager. Understanding which land managers are struggling to manage gamba grass will help the NT Government assess the additional resources needed and where to most strategically apply them to stop further spread.

*Photo: John Woinarski*

<sup>1</sup> Landowners and managers in Zone B, the Weed Management Control Zone, are required to control, contain and reduce the size of infestations on their property. Zone B extends from the north coast around Darwin to just above Katherine. Land managers in Zone

A, the Weed Management Eradication Zone, are required to eradicate gamba grass infestations on their property. Zone A consists of the rest of the Territory land mass (see maps 1 and 2, Appendix B).





## The status and recent spread of gamba grass

Following are the key results of our analysis of the occurrence and recent spread of gamba grass:

1. **Freehold and Crown lands show the greatest increase in known gamba grass records from 2010–2018**, with a particularly abrupt increase on freehold land in the Darwin Rural area (Figure 5). While this is partly due to increased survey effort, it also parallels a rapid increase in the density and size of gamba grass infestations. Gamba grass is a major threat to this region.
2. **Roads are one of the primary pathways for gamba grass spread.** Records along roads have doubled since 2015 in both the Control and Eradication zones. Although roads represent only a small proportion of land area and gamba infestation, they play a major role in its spread to new locations, particularly in the Eradication Zone.
3. **Litchfield National Park has the largest infestation of gamba grass on public land** and about three quarters of gamba grass records in the national park estate.
4. **Large infestations of gamba grass on pastoral properties in the eradication zone jeopardise efforts.** These infestations are a major management burden and threat to adjacent properties, including national parks, Indigenous managed lands and carbon farming projects.

*Photo: Tiana Bremner*



# Recommendations

More resources and more intensive efforts are urgently needed to enable public and private land managers to meet their statutory obligation to control or eradicate gamba grass. In light of the scale and rapidity of gamba grass spread across different tenures, we recommend the following priorities for increased focus and resources:

1. **Conduct more education and outreach and provide financial support for freehold landholders and pastoral leaseholders.** Strengthen compliance and enforcement for landholders who do not respond to education and outreach.
2. **Provide greater support for the control efforts of the Parks and Wildlife Authority**, particularly for the large infestation in Litchfield National Park.
3. **Increase management of gamba grass on public lands.**
4. **Target areas highly susceptible to new infestations** due to geographical position or proximity to known vectors, such as those close to ground disturbance and roads, as a cost-effective way to limit further spread.
5. **Prioritise and provide sufficient funding to eradicate infestations in the Eradication Zone.** Eradicating these small infestations while it is still economically and technically feasible to do so will save significant resources in the long term.
6. As recommended by public agencies, including Bushfires NT [6], **apply a coordinated whole-of-government approach to address the growing gamba grass threat.** While this may require additional resources in the short term, cooperation between public and private landholders will result in more efficient and effective control. A coordinated approach is important in the Darwin and Darwin Rural areas, where vacant Crown land is often close to freehold land.









# Analysis of gamba grass infestations

In this section we analyse the tenure types and managers of land with gamba grass infestations by overlaying gamba grass records held by the NT Weed Management Branch with tenure and land manager data. We highlight tenure types and land managers with (a) significant known infestations, (b) a disproportionately high number of known infestations (compared to land area) or (c) rapid rates of expansion of known infestations. Understanding which land managers have the biggest burden of gamba grass or are struggling to control gamba grass is essential for effective control. We present the analysis in the following sections:

1. Overview of data limitations (see Appendix A for methodology)
2. Analysis of gamba grass records for each tenure class
3. Analysis of gamba grass records at the following scales and locations (see maps in Appendix B):
  - A. the Northern Territory as a whole
  - B. the Control Zone
  - C. Darwin and the Rural Darwin area in the Control Zone (where the majority of gamba grass infestations are located)
  - D. the Eradication Zone

## 1. DATA LIMITATIONS

Gamba grass records held by the NT Weed Management Branch come from a wide variety of surveys using different methods and from notifications by weed contractors, national parks staff, Indigenous rangers and others.

There are significant limitations and confounding factors in the survey data. Most significant are the variability in survey methods and locations, and the lack of comprehensive surveys since 2009–11. This means that overall gamba grass infestations since 2010 are likely to be much greater than indicated by this analysis. For example, there has been no systematic resurveying of parts of the national park estate, resulting in gross underestimates of the rate of increase, particularly in parks with dense infestations such as Litchfield and Mary River.

A contrary trend is that survey effort in some regions has increased – for example, with aerial surveys of the inner rural areas of Darwin. Despite this, modelling suggests that actual expansion rates are fairly consistent with the trends reported here.

To a lesser degree, and most relevant to records in the Eradication Zone, the lack of absence data from recent surveys may result in the inclusion of records of gamba grass infestations that have been eradicated, leading to overestimates of current infestation levels (NT Weed Management Branch, pers comm). We considered these limitations in our analysis below (see methodology in Appendix A for further details)

*Photo previous page: Edwina Cameron*





## 2. ANALYSIS OF INFESTATIONS BY TENURE

### FREEHOLD LAND

Freehold land, which makes up 15% of the Territory, has more gamba grass than any other tenure type in the Control Zone – 56% of known infestations. It also shows the greatest increase in gamba grass records over time. The most rapid growth is occurring on freehold land in the Darwin Rural area (Figure 5), where gamba-fuelled fires now cause destruction each year. Landowners are swamped in increasingly dense infestations and reaching a crisis point, necessitating more sustained and coordinated action. Supporting them will require more investment in education, outreach and financial support and, where this fails, enforcement of control measures.

### NATIONAL PARKS

National parks have a disproportionate share of gamba grass – 9.5% of known infestations on 5.1% of the Territory's land area. Gamba grass has been recorded in 21 national parks and other conservation areas (Appendix C). Litchfield National Park has about 74% of all infestations in national parks as well as the largest single infestation on public land. Government agencies acknowledge capacity limitations and that they can only do 'more with more' [3]. Insufficient resources for control of rapidly expanding infestations in Litchfield National Park along with its proximity to the dense infestations in the Coomalie district (NT Weed Management Branch, pers comm) contribute to making gamba grass the highest priority threat to the park [3]. Staff in Kakadu National Park and Nitmiluk National Park, both in the Eradication Zone, are also battling infestations. These spread from neighbouring pastoral properties [1–3], pointing to broader threats posed by insufficient resourcing for gamba grass eradication in national parks.

## **ROADS**

Roads remain one of the most pernicious pathways of spread across the Control and Eradication zones despite intensive management by the Department of Infrastructure, Planning and Logistics (NT Weed Management Branch, pers comm). Gamba grass records along roads have more than doubled in both zones since 2015 (Figure 2, Section 3A). The continued spread of gamba grass along roads deeper into the Eradication Zone will have potentially disastrous consequences for carbon farming and iconic tourist sites.

## **VACANT CROWN LAND/ THE CROWN LAND ESTATE**

Vacant Crown land also has a disproportionate share of gamba grass infestations and, along with freehold lands, show the greatest increase in gamba records over time. The diversity of land managers responsible for day-to-day management of Crown lands makes it difficult to identify who is responsible for managing infestations. The rapid spread of gamba grass on this tenure type indicates the importance of identifying and notifying land managers of their obligation to control infestations.

On lands controlled by the Department of Defence, aerial surveys have generally not been permitted, leading to an underestimate of infestations. Anecdotal evidence suggests there are serious infestations requiring attention.

## **PASTORAL LANDS**

Pastoral leases contain significant infestations in the Control and Eradication zones, primarily due to the introduction of gamba grass as a pasture grass for cattle.

The pastoral estate has the largest infested area within the Eradication Zone – 58.5% of all infestations across 43.5 % of the zone area. Of 233 pastoral properties, 36 have recorded infestations (see Appendix C for details). Nearly 95% of gamba records occur on just 11 properties. All but one of these (Amungee Mungee) are in the Control Zone. Amungee Mungee, Koolpinyah, Florina, Katherine Downs, Marrakai, Bonrook, Killarney, Manbulloo and Mainoru show rapid increases in gamba records since 2011, but due to the confounding factor of increased notification of pre-existing gamba infestations, as well as a lack of repeat surveys over time, the rate of increase cannot be reliably calculated.

Since 2015 several properties in the Eradication Zone have been granted permits to maintain gamba grass infestations [7]. For example, in 2019 Mainoru station was granted a permit to maintain 204 hectares of gamba grass for grazing [8].

While this permit has subsequently been surrendered, it is notable that a much smaller area of gamba grass infestation was recorded for Mainoru, indicating that infestations on pastoral properties in the Eradication Zone are vastly under-reported. Such disparities make it difficult to determine the rate of increase of gamba grass.

Pastoral stations represent a smaller proportion of known infestations in the Control Zone – 12.5% of infestations across 48.6% of the zone area. This is explained by the presence of large infestations on freehold properties and national parks.





### 3. ANALYSIS OF INFESTATIONS AT VARIOUS SCALES AND LOCATIONS

#### A. Gamba grass across tenure types in the Northern Territory as a whole

Gamba grass was introduced for pasture, and many of the densest infestations reflect those introductions. Since comprehensive surveys during 2009–2011 (NT Weed Management Branch, pers comm), only a few areas have been resurveyed. While some gamba clumps may have been re-recorded, many records reflect new infestations.

As of 2018, surveys of core infestations indicate that gamba grass infests *at least* 2000 km<sup>2</sup> within a 10,000–15,000 km<sup>2</sup> area where it commonly occurs (NT Weed Management Branch, pers comm). The majority of infestations (99%) are in the Control Zone (Map 1, Appendix B). There have been significant increases in gamba records just outside the Control Zone, suggesting a need for more monitoring and management in the Eradication Zone.

The lack of comprehensive surveys over the past decade means that the true extent of current infestations is likely to be much greater than indicated by these results. With the data demonstrating a strong trend of expansion, actual infestations probably exceed recorded infestations by a considerable degree.

*Photo: Tiana Bremner*

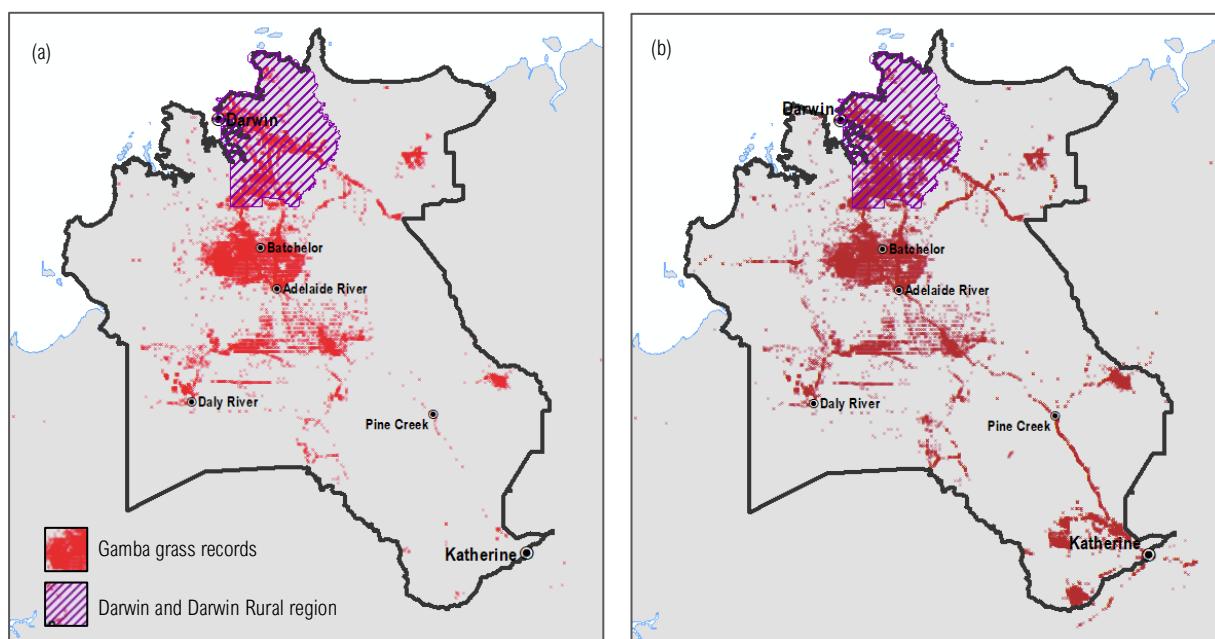


Figure 1. Gamba grass records in the Control Zone, (a) up to 2010 and (b) up to 2018

Figure 1 shows the change in records from 2010 to 2018. The greatest increase is evident along roads near Katherine and in the Darwin Rural region.

- The dominant land tenures in the Northern Territory are Aboriginal land trusts (44.8%) and pastoral leases (43.7%) followed by national parks (5.1%) and vacant Crown land (3.3%) (Table 1). Tenure types with a disproportionately high number of known infestations compared to land area Table 1.

Information on a Territory wide-basis should be interpreted with reference to the results for the Control and Eradication zones as some tenure types occur primarily within one or other of the zones. For this reason, analysis at the scale of (1) Control and Eradication zones and (2) Darwin and Darwin Rural region is more useful.



Table 1. Area and proportion of gamba grass infestation per land tenure in the Northern Territory

Land tenure type	Infestation area (km <sup>2</sup> )	Proportion of infestation (%)	Land tenure area (km <sup>2</sup> )	Proportion of land tenure (%)
Aboriginal land trust	12.32	3.1	603,727	44.8
Commonwealth land	1.36	0.3	129	0.0
Defence	0.17	0.0	12,905	1.0
Freehold	222.16	56.3	10,278	0.8
Mining tenure	0.00	0.0	287	0.0
National parks & other reserves	36.90	9.4	68,780	5.1
NT Land Corporation	8.54	2.2	858	0.1
Other leasehold	33.20	8.4	14,591	1.1
Pastoral leasehold	49.91	12.7	588,832	43.7
Roads	4.16	1.1	2,912	0.2
Vacant Crown land	25.74	6.5	45,005	3.3
Totals	394.45	100.0	1,348,304	100.0

Although roads have only a small proportion of known infestations, they are a major pathway for spread of gamba grass. Rates of expansion in both the Control and Eradication zones are concerning (Figure 2), and warrant an assessment of the impediments to effective roadside management as the basis for a more concerted intervention to stop the spread.

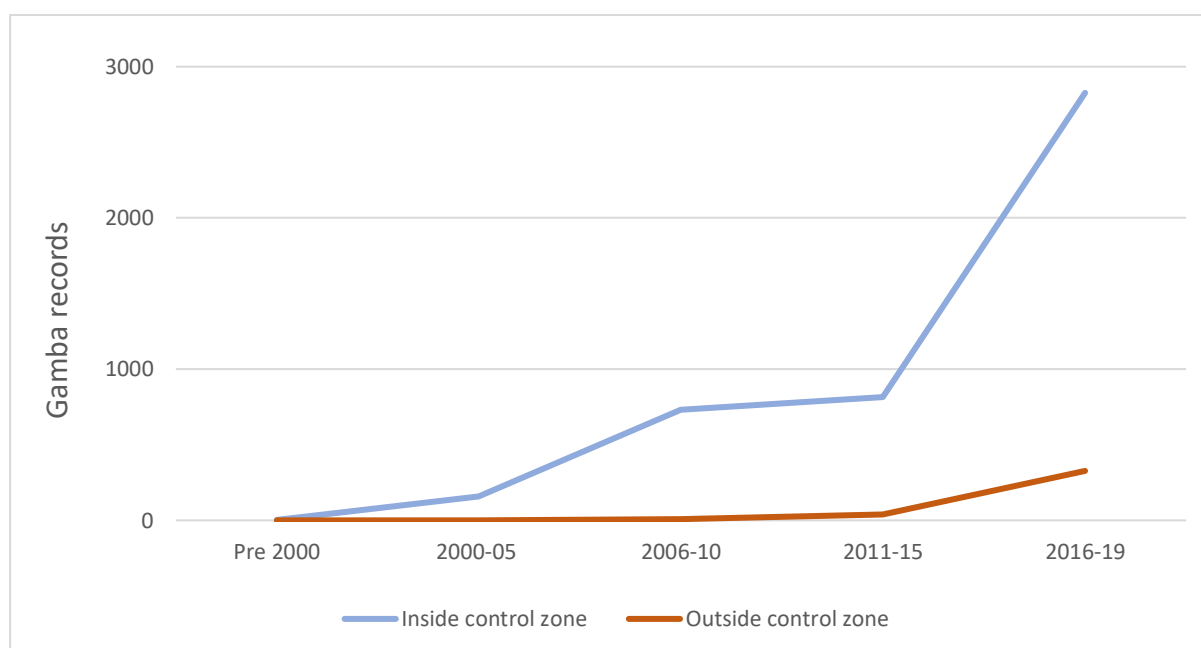


Figure 2. Changes in gamba grass records over time along roads



While Litchfield National Park has the most records of any conservation area by a substantial margin, other national parks and reserves such as Black Jungle / Lambell's Lagoon and Fogg Dam conservation reserves and Kakadu National Park have seen rapid increases in the number of gamba records (Table 2 and Appendix C). However, there have been no systematic surveys since 2011. In Litchfield National Park, opportunistic surveys along roads and tracks since 2011, (supported by anecdotal evidence and modelling) indicate that infestations are spreading more rapidly. While there are no recorded infestations in other national parks, in some cases there is a strong likelihood of spread from neighbouring infestations. For example, rangers in Nitmiluk National Park have reported infestations to the NT Weed Management Branch [2].

*Table 2 Changes in gamba grass records from 2011 to 2018 in national parks and other conservation areas*

Conservation area	Cumulative to 2011	Cumulative to 2018	Proportion of records (%)
Litchfield National Park	3782	3929	74.1
Mary River National Park	402	402	7.6
Black Jungle / Lambells Lagoon Conservation Reserve	25	313	5.9
Charles Darwin National Park	239	239	4.5
Manton Dam Recreation Area	137	137	2.6
Fogg Dam Conservation Reserve	4	96	1.8
Kakadu National Park	14	53	1.0

*Photo: Josh Wyndham-Kidd*





## B. Gamba grass, tenures and land managers in the Control Zone

The Control Zone, which makes up about 3% of the Northern Territory, has 99.4% of known gamba grass infestations (Table 2). Tenure types with a disproportionately high number of infestations compared to land area (indicated in red in Table 3) are:

- **Freehold land** (14.7% of the Control Zone): 56.3% (221 km<sup>2</sup>) of known gamba grass infestations
- **Roads** (0.3% of the Control Zone): 1.1% of known gamba grass infestations
- **Vacant Crown land** (2.3% of the Control Zone): 6.5% of known gamba grass infestations.

Other noteworthy findings are:

- 16% of known infestations are on land managed by the Crown Land Estate or the Northern Territory Government (vacant Crown land, other leasehold and roads)
- 12.7% of known infestations are on pastoral leases
- 9.4% (37 km<sup>2</sup>) of known infestations are in national parks and reserves, with 74% in Litchfield National Park. This is likely to be a significant underestimate.

*Table 3 Area and proportion of recorded gamba grass infestation per land tenure type in the Control Zone*

Land tenure type	Area of gamba (km <sup>2</sup> )	Proportion of gamba area (%)	Land tenure area (km <sup>2</sup> )	Proportion of land tenure (%)
Aboriginal Land Trust	12.3	3.1	4373	10.8
Commonwealth lands	1.4	0.3	88	0.2
Defence	0.2	0.0	340	0.8
Freehold	222.2	56.3	5917	14.7
National parks and other reserves	36.9	9.4	3725	9.2
Northern Territory Land Corporation	8.5	2.2	668	1.7
Other leasehold	33.2	8.4	4543	11.3
Pastoral leasehold	49.9	12.7	19595	48.6
Roads	4.2	1.1	124	0.3
Vacant Crown land	25.7	6.5	946	2.3
Totals	394.4	100	40318	100

*Photo: Edwina Cameron*



Owners of freehold land have a disproportionately high number of known infestations compared to land area. This is also the case for public land managers. While these trends reflect the importance of sustained resourcing of weed control by public agencies, it also potentially reflects more diligent reporting of infestations on these tenures than private tenure types. These agencies include the Department of Infrastructure, Planning and Logistics (DIPL), the Northern Territory Land Corporation (NTLC), Parks and Wildlife Commission of the Northern Territory (PWCNT), the Crown Land Estate and the Commonwealth (see Figure 3 below).

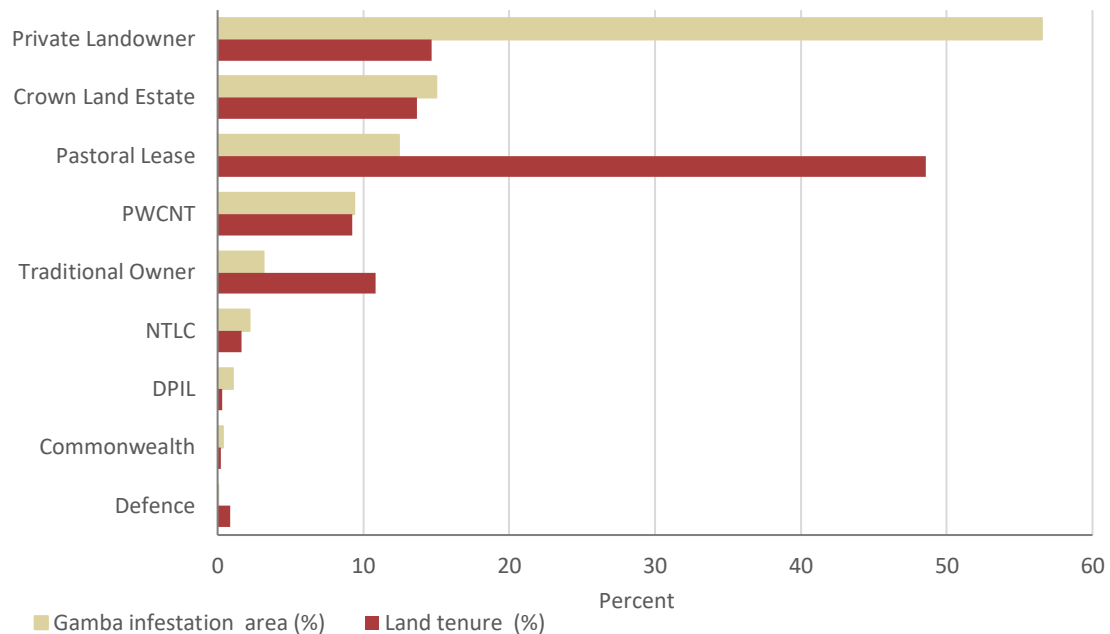


Figure 3. Land managers, proportion of gamba grass infestation and tenures in the Control Zone

The highest growth in known gamba infestations as well as the highest number of known infestations are on freehold land (Figure 4). Land managed by the Crown Land Estate, pastoral leaseholders and Department of Infrastructure, Planning and Logistics all show a similar increasing trend. While other land managers have not documented the same rate of increase of known gamba infestations since 2010, this may simply reflect a lack of follow up surveys.

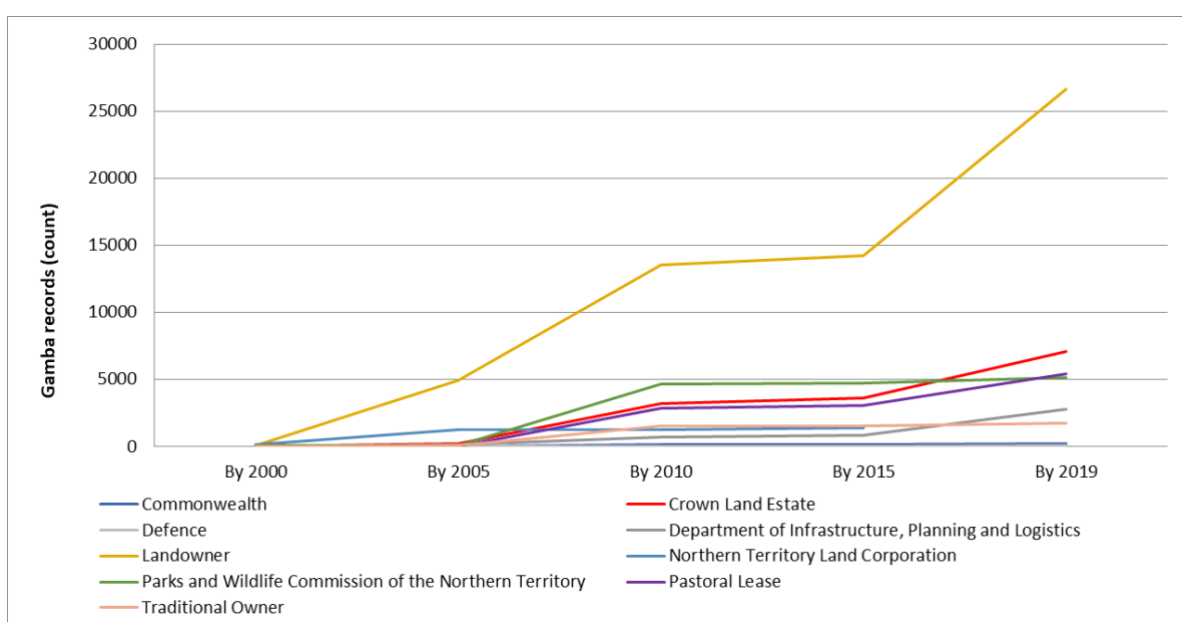


Figure 4. Change in number of gamba grass records by land manager in the Control Zone





### C. Gamba grass and tenure in the Darwin and Darwin Rural areas<sup>2</sup>

Almost 52% of known gamba grass infestations are in Darwin and the Darwin Rural area even though they make up only 8% of land area within the Control Zone and 0.2% of the Northern Territory as a whole (see Figure 5). The largest and most rapidly expanding infestations are on freehold land and Crown land.

According to the NT Weed Management Branch, many areas with increasing infestations are populated, with houses and infrastructure [9]. The ongoing spread increasingly intersects with fire management priorities as districts such as Ludmilla, Howard Springs and Berry Springs experienced severe bushfires in 2019, fuelled in part by dense gamba grass.

As noted above, gamba grass records do not accurately reflect actual infestations. However, modelling by the Centre for Conservation Geography in 2018 of data from 2 comparable surveys in Berry Springs<sup>3</sup> provides evidence that the rates of gamba grass spread obtained in this current analysis are comparable to actual rates of spread [9]. The 2018 analysis examined the rate of expansion of gamba grass infestations across 42,000 hectares. From 2010 to 2016, dense infestations (>10% ground cover) expanded 5-fold. The area with gamba grass infestations more than doubled, while heavily infested areas increased from <2% to >5% of the study area [10]. The densest infestations (>50% of ground cover) expanded more than six-fold, demonstrating how quickly gamba grass can take over landscapes once established [10].

<sup>2</sup> The boundary for Darwin Rural covers the local government areas of Darwin, Litchfield and Palmerston, Unincorporated (Elrundie) area and NT Rates Act area.

<sup>3</sup> In 2018, CCG did detailed modelling of an area around Berry Springs where there had been comparable aerial surveys of gamba grass in 2010 and 2016. This provided results that are not limited by the same data issues and confounding factors as the larger collection of gamba grass records from multiple surveys that do not overlap in terms of geography or methodological approach.



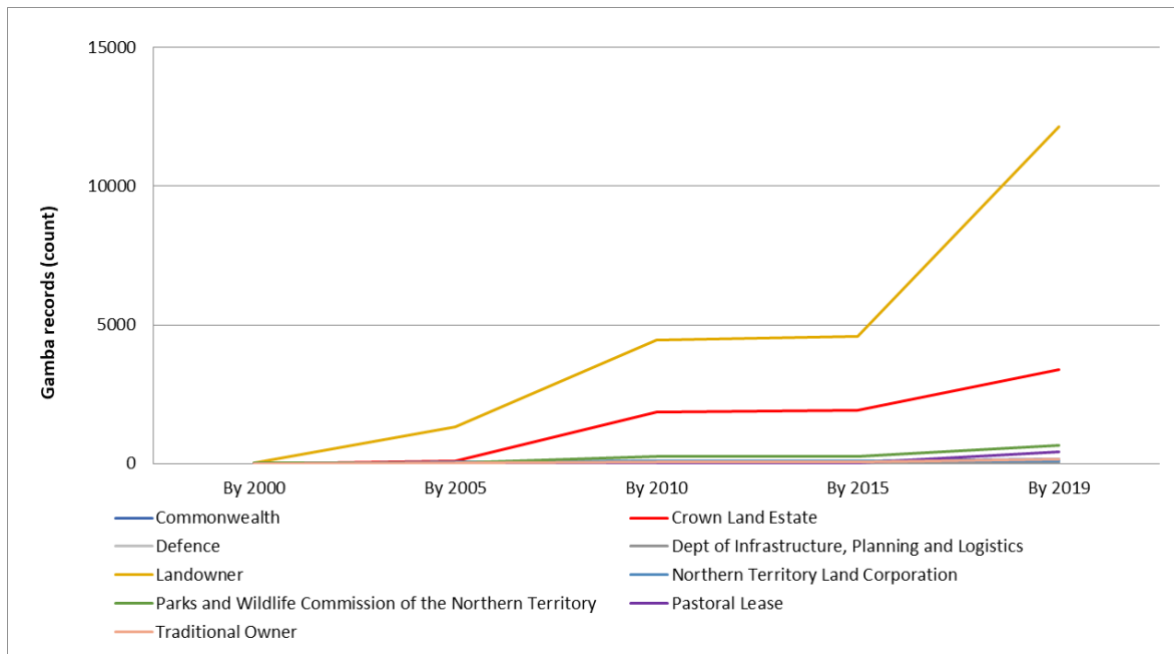


Figure 5. Trends in gamba grass records to 2018 in the Darwin Rural area

Photo: Tiana Bremner





#### D. Gamba grass and tenure in the Eradication Zone

The Eradication Zone is the front line of efforts to stop the spread of gamba grass. Preventing the establishment of new infestations is vital to protect the ecological integrity of these areas, as well as minimise impacts on the growing carbon farming industry, Indigenous land management, tourism and recreation.

Close to 60% of known infestations in this zone occur on pastoral properties (Appendix C). A substantial proportion also occur on freehold properties (14.5%), national parks and other reserves (8.1%), other leasehold (7.6%) and roads (6.2%).

A number of pastoral properties have been granted permits to graze gamba grass on their leases, representing a significant risk of spread to surrounding properties that, in many cases, are free of known gamba grass infestations. A 2019 permit granted to Mainoru station for 204ha of gamba grass was a major concern to the Mimal Indigenous Ranger group, who manage 20,000 km<sup>2</sup> of surrounding land. They operate successful carbon farming operations and gamba grass is their biggest weed threat [8]. This concern and the potential impact on the carbon farming operations contributed to the station owner deciding to return the permit.

As discussed above, permit areas for pastoral stations have been significantly larger than indicated by known gamba grass records, reflecting the lack of surveys in the Eradication Zone, and the historical under-reporting of gamba grass on the pastoral estate.

Core infestations in the Eradication Zone are mostly near Mataranka and Katherine, and along the Victoria Highway from Katherine towards Western Australia. Gamba grass records more than tripled from 2015–18 at all these locations (Figure 6).

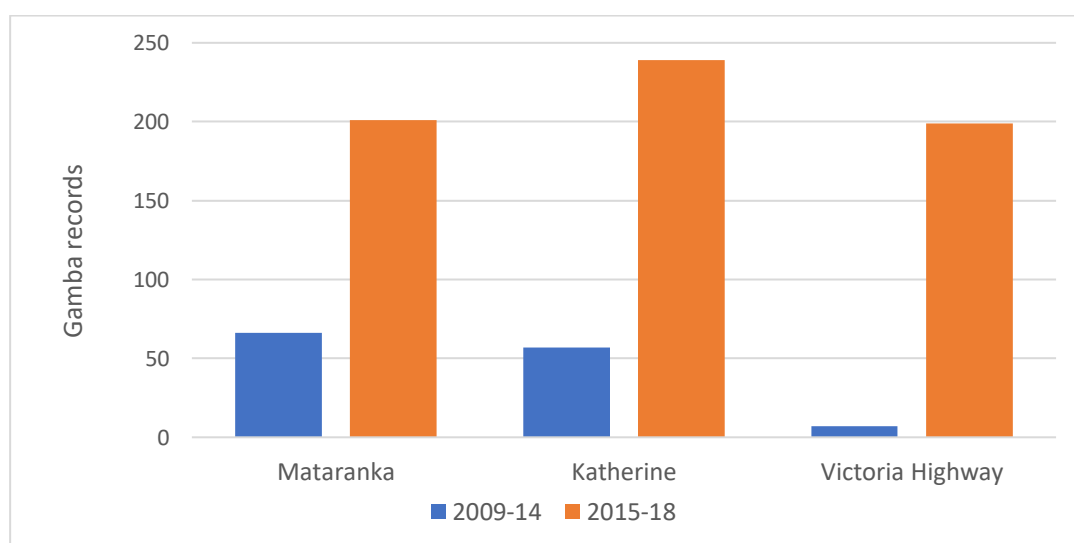


Figure 6 Change in the number of gamba records over time in regions of the Eradication Zone around Katherine



Even taking into account data limitations (e.g. the lack of eradication records;<sup>4</sup> see methodology in Appendix A), the records indicate a concerning trend of gamba grass expansion deeper into the Eradication Zone. This suggests that despite current eradication efforts (NT Weed Management Branch, pers comm), gamba grass is spreading along roads and rapidly expanding from new and existing infestations. This is consistent with a government review of gamba grass management responses finding that that only 50% of known infestations in the Katherine area were being managed [11].

Eradication of infestations in the Eradication Zone is generally considered to still be economically and technically feasible. Prioritising and providing sufficient funding to eradicate smaller infestations in this zone is an essential and cost effective measure that will save significant resources in the long term [1].

*Photo: Tiana Bremner*

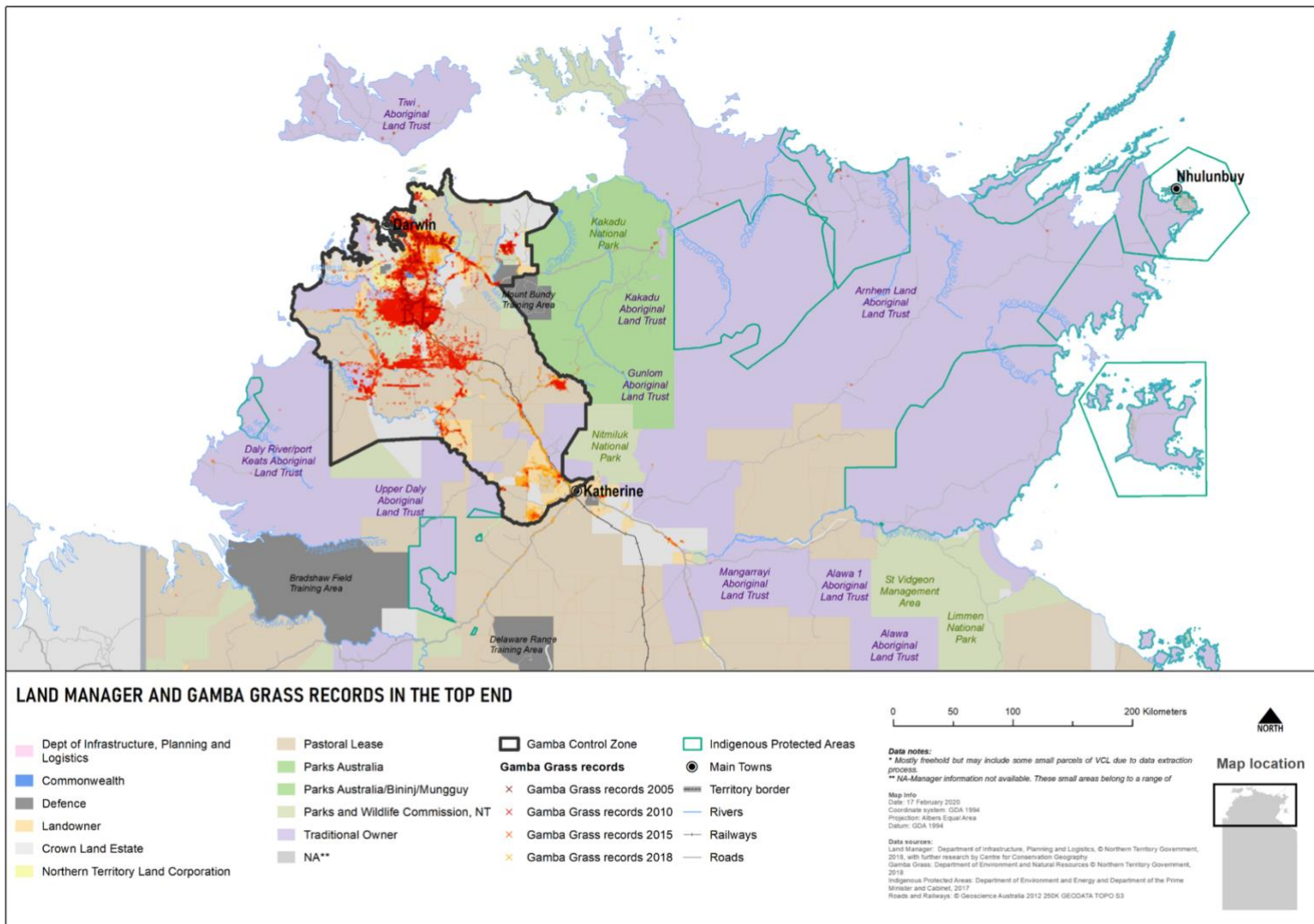


<sup>4</sup> Many records relating to gamba grass alongside roads in the Eradication Zone are understood as being the product of eradication efforts, i.e. they are recorded when management action is taken to eradicate the infestation. There is no complementary record to confirm the success

or failure of the management action, or the absence of gamba grass in the same location at a later date. For this reason it is unclear how many of the known gamba grass records in the Eradication Zone may be as a result of successful eradication action.

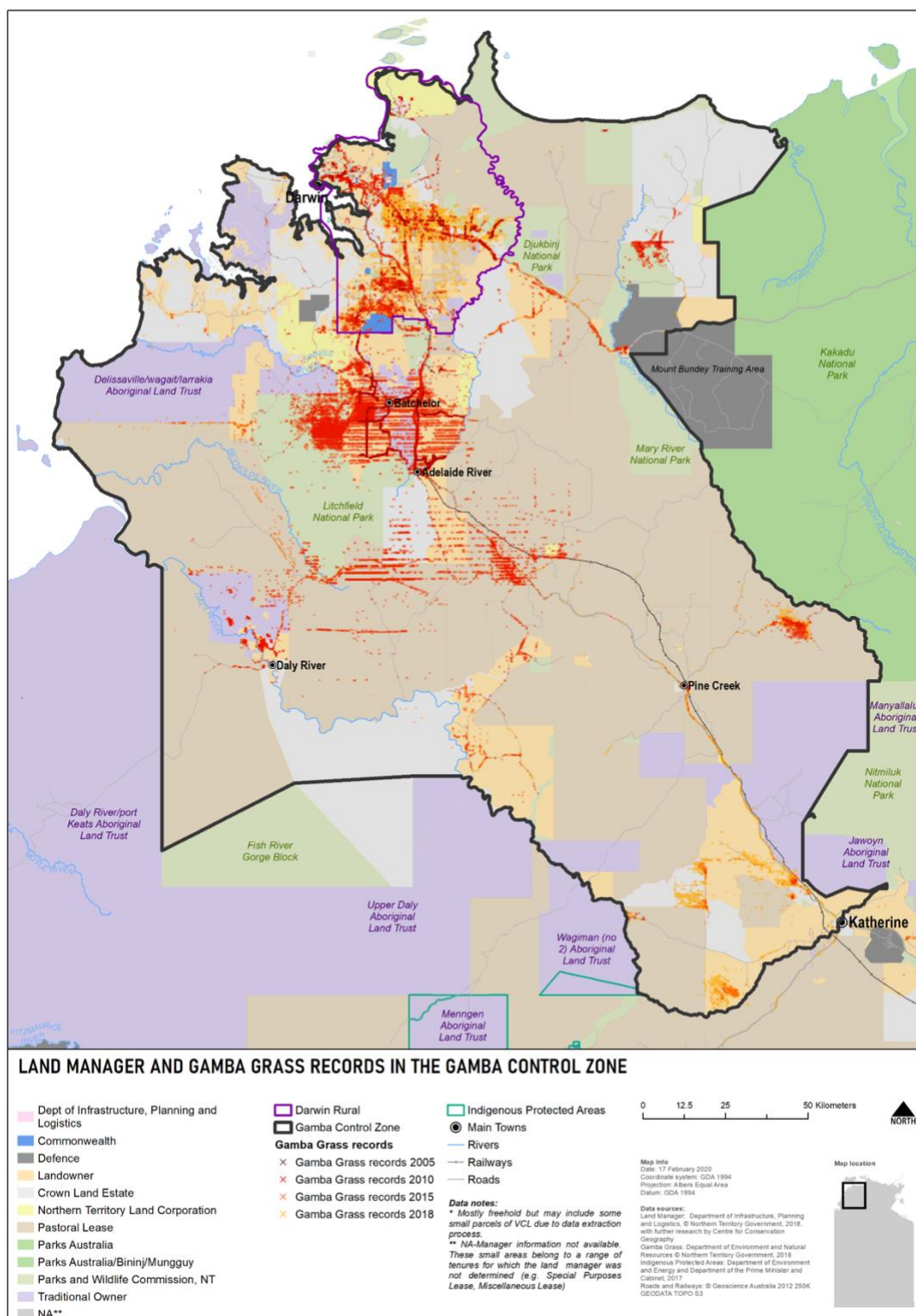


# Maps

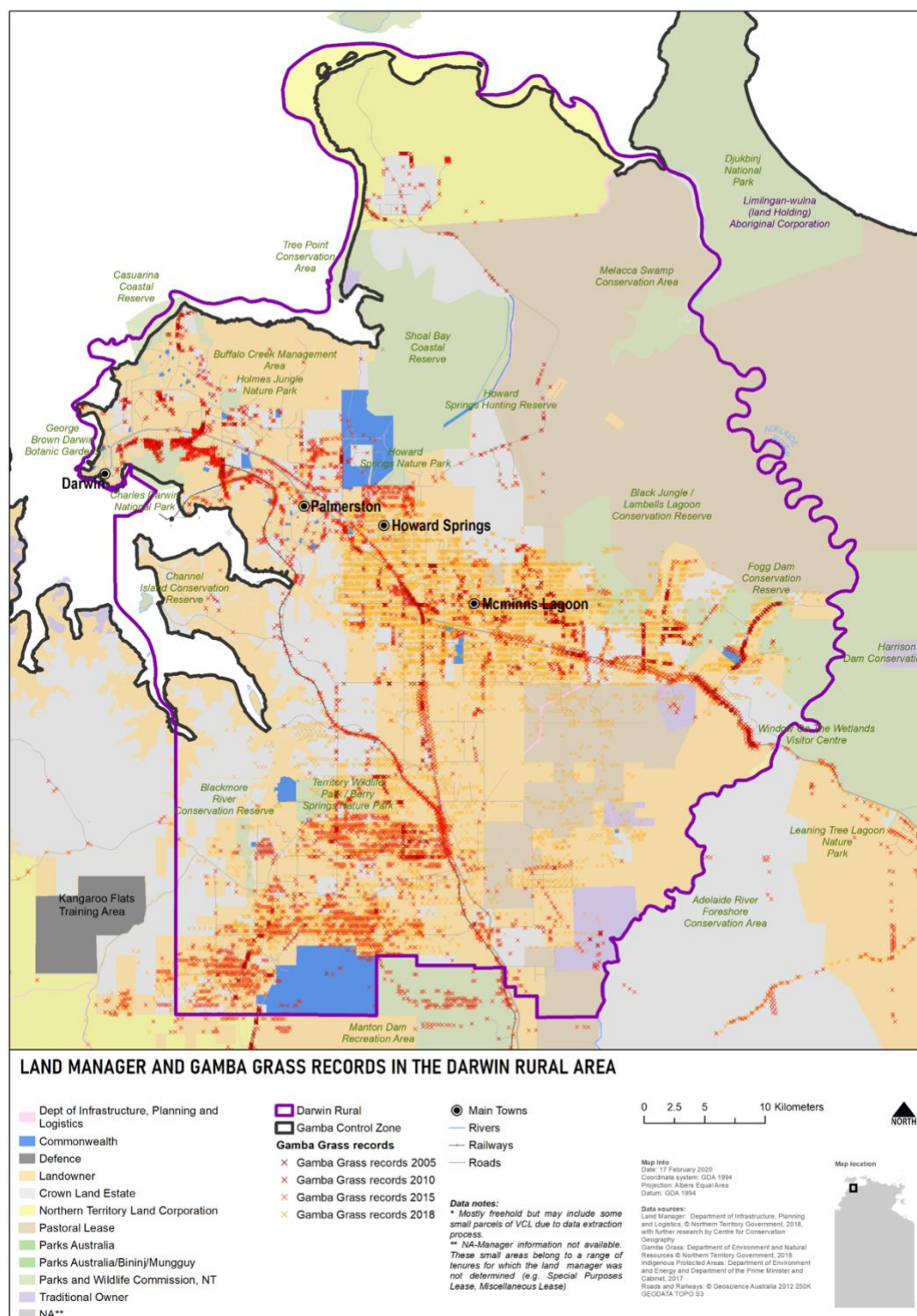


Map 1. Gamba grass records and predominate land managers in the Top End of the Northern Territory





Map 2. Gamba grass records and predominate land managers in the gamba grass Control Zone



Map 3. Gamba grass records and predominate land managers in the Darwin and Darwin Rural areas



## References

1. Beaumont T, Keily T, Kennedy S (2018) Counting the cost: Economic impacts of gamba grass in the Northern Territory, Centre for Conservation Geography.
2. Department of Environment and Natural Resources (2018) Weed Management Plan for Gamba Grass (2018), Darwin, NT, Weed Management Branch, Department of Environment and Natural Resources.
3. Gamba grass still not eradicated (2019) Turfmate, 2019. Available from: <https://turfmate.com.au/gamba-grass-still-not-eradicated/>.
4. Zillman S (2019) ABC News, Eleven years, millions of dollars and no closer to eradicating weed of 'national significance', 2019. Available from: <https://www.abc.net.au/news/2019-08-12/gamba-grass-spreading-in-iconic-national-parks/11403808>.
5. Setterfield SA, Rossiter-Rachor NA, Adams VM (2018) Navigating the fiery debate: the role of scientific evidence in eliciting policy and management responses for contentious plants in northern Australia. *Pac Conserv Biol* 24: 318.
6. Department of Environment and Natural Resources (2018) Savanna Regional Bushfire Management Plan 2018.
7. Neale T (2019) A Sea of Gamba: Making Environmental Harm Illegible in Northern Australia. *Science as Culture* 28: 403–426.
8. Fitzgerald D (2018) ABC Rural, Decision to allow NT cattle to graze invasive weed under fire, 2018. Available from: <https://www.abc.net.au/news/rural/2018-09-27/nt-cattle-station-granted-permit-to-graze-weed-gamba-grass/10306602>.
9. Herbert L (2016) ABC Rural, Aerial survey reveals gamba grass increase, 2016. Available from: <https://www.abc.net.au/news/rural/2016-09-19/gamba-grass-increase-in-top-end/7859044>.
10. Kennedy S, Beaumont T (2018) Case Note: Gamba grass infestations at Berry Springs.
11. Weeds Management Branch, Northern Territory (2017) Review Report: Weed Management Plans for Gamba grass, Mimosa and Bellyache bush, Department of Environment and Natural Resources, Northern Territory of Australia.

# Appendix A: Methodology

## Tenures

A simplified land tenure dataset was developed by CCG from the Digital Cadastral Database of the Northern Territory (DIPL 2018<sup>5</sup>), the NT Pastoral Lease database (DIPL 2015<sup>6</sup>), the NT Aboriginal Land Trusts database (DLPE 2016<sup>7</sup>) and the NT Parks dataset (PWCNT 2018<sup>8</sup>). Defence tenures were identified from the 250k topographic annotation.<sup>9</sup> Detailed cadastral data for mostly freehold land was not able to be accessed. Some analysis was done to separate the major roads and some other unknown categories using visual analysis and comparison with overlays such as road data. A metadata document showing how different tenures were grouped is available if required.

## Land managers

Land managers were identified from the datasets and from checking sources such as management plans in the case of national parks and other reserves. The principal day-to-day manager who would be responsible for weed control measures was selected if joint management was applicable, eg in some national parks. The analysis here aimed to identify the principal categories of land manager: therefore, some categories of land manager may not have been identified. The main land managers for each land tenure is shown in Table 4.

*Table 4. Predominate land managers of each tenure class*

Land tenure class	Main land manager
Aboriginal Land Trust	Traditional Owner
Commonwealth lands	Commonwealth
Defence	Defence
Freehold	Private landowner
Mining tenure	NA
National parks and other reserves	Parks and Wildlife Commission of the Northern Territory
National parks and other reserves	Parks Australia
National parks and other reserves	Parks Australia/Bininj/Munggy
Northern Territory Land Corporation	NTLC
Other leasehold	Crown Land Estate
Pastoral leasehold	Pastoral leaseholder
Roads	Department of Infrastructure, Planning and Logistics
Vacant Crown Land	Crown Land Estate

<sup>5</sup> Department of Infrastructure, Planning and Logistics (2018). Digital cadastral database of the Northern Territory. Available at: [www.ntlis.nt.gov.au/metadata/export\\_data?type=html&metadata\\_id=2DBC7711FB906B6E040CD9B0F274EFE](http://www.ntlis.nt.gov.au/metadata/export_data?type=html&metadata_id=2DBC7711FB906B6E040CD9B0F274EFE) (accessed 15 June 2018). Cadastral data on Vacant Crown Land and Northern Territory Land Corporation parcels were supplied by the NT Weed Management Branch on 17 December 2019).

<sup>6</sup> Department of Infrastructure, Planning and Logistics (2015). Northern Territory Pastoral Lease Dataset (accessed 12 October 2015)

<sup>7</sup> Department of Lands, Planning and the Environment (2016). Northern Territory Aboriginal Land Trusts dataset (accessed 21 July 2016).

<sup>8</sup> Parks and Wildlife Commission of the Northern Territory (2018). Northern Territory Parks and Reserves. Available at: <https://ftp-dlrm.nt.gov.au/main.html> (accessed 10 May 2018).

<sup>9</sup> GEODATA TOPO-250K (Series 1) Topographic Data, Geosciences Australia



## Gamba grass distribution

Most of the analysis is based on infestation areas calculated from buffered survey points, using the diameter of the survey record, based on advice from the NT Weed Management Branch. This eliminated the possibility of recounting records for the same gamba clump. However, we used the count of survey records to analyse changes in gamba grass along roads, as the trends shown in the analysis were accurate. A comprehensive survey program was carried out around 2010–2011 to establish where gamba grass occurred and where it was absent. We are confident that records around these dates accurately reflect the distribution of gamba grass at that time. Most records since then reflect new infestations, although there may be some overlap of surveys. Some infestations have been eradicated, but this information is not systematically recorded.

## Processing

The weed dataset used for analysis was restricted to presence-only data (density category 2-6). This removed records where gamba was not found or had been eradicated. The tenure data and gamba grass area were combined using spatial overlays with the Identity tool in ArcGIS v10.7 to show changes in the distribution, area and number of records over time on different tenures. Further analysis was done in Microsoft Excel.

## Data sources

Dataset	Source
NT_tenure_albers_200210_landmanager.shp	NTCCG from various NT land tenure datasets .
DeptofDefence_fromGeotopo.shp	Geotop 250k, (2006) Commonwealth of Australia, Geoscience Australia
Roads	Geotop 250k, (2006) Commonwealth of Australia, Geoscience Australia
Government managed roads in NT	<a href="https://nt.gov.au/driving/management/who-manages-a-road-in-the-nt">https://nt.gov.au/driving/management/who-manages-a-road-in-the-nt</a>
NT_weeds (gamba grass)	Department of Environment and Natural Resources, North Territory Government
Gamba_classA_decl_zone_2013 (Eradication zone)	Northern Territory Government Weed Management Branch
Gamba_classB_decl_zone_2013 (Control zone)	Northern Territory Government Weed Management Branch

## APPENDIX B: Tables

*Table 5. Gamba grass survey records by year in national parks and other reserves*

(Note: The records in this table are drawn from a variety of different survey methods. They indicate the presence of gamba in various parks, rather than a comparative size of infestations. A lack of gamba grass records since 2010 is in general understood to be due to a lack of any comprehensive surveying of the existence of gamba grass in these areas rather than a lack of new gamba grass infestations. Many of these parks have documented significant expansion in gamba grass in the period from 2010 to 2018).

Name	Pre 2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Litchfield National Park	3782	0	17	0	55	0	75	0	0	3929
Mary River National Park	402	0	0	0	0	0	0	0	0	402
Black Jungle / Lambells Lagoon Conservation Reserve	25	0	0	0	0	0	288	0	0	313
Charles Darwin National Park	239	0	0	0	0	0	0	0	0	239
Manton Dam Recreation Area	137	0	0	0	0	0	0	0	0	137
Fogg Dam Conservation Reserve	4	0	0	0	0	0	92	0	0	96
Kakadu National Park	10	4	0	0	0	0	27	12	0	53
Harrison Dam Conservation Area	3	0	0	0	0	0	46	0	0	49
Djukbinj National Park	12	0	0	0	0	0	8	0	0	20
Leaning Tree Lagoon Nature Park	0	0	0	0	0	0	16	0	0	16
Territory Wildlife Park / Berry Springs Nature Park	0	0	0	0	0	0	15	0	0	15
Blackmore River Conservation Reserve	3	0	0	0	0	0	11	0	0	14
Holmes Jungle Nature Park	5	0	0	0	0	0	0	0	0	5
Knuckey Lagoons Conservation Reserve	3	0	0	0	0	0	0	0	0	3
Bullwaddy Conservation Reserve	0	0	0	0	0	0	0	2	0	2
Window On The Wetlands Visitor Centre	2	0	0	0	0	0	0	0	0	2
Adelaide River Foreshore Conservation Area	1	0	0	0	0	0	0	0	0	1
Buffalo Creek Management Area	1	0	0	0	0	0	0	0	0	1
Daly River (Mt Nancar) Conservation Area	1	0	0	0	0	0	0	0	0	1
Shoal Bay Coastal Reserve	0	1	0	0	0	0	0	0	0	1
Tjuwaliyn (Douglas) Hot Springs Park	1	0	0	0	0	0	0	0	0	1
Total records	4631	5	17	0	55	0	578	14	0	5300

*Table 6. Pastoral properties with gamba grass, shown cumulatively in 2011 and 2018*

(Note: There are major limitations in the known gamba grass record for pastoral properties, in particular in the Eradication Zone. Changes in the number of gamba grass records may indicate a recent notification of existing gamba grass on pastoral properties rather than a rapid expansion. Similarly, an absence of records, or minimal records does not imply the absence of gamba grass infestations or a small infestation on the property.)



Property	Cumulative to 2011	Cumulative to 2018	Gamba grass records (%)
Mary River East	437	1853	31.1
Tipperary	958	959	16.1
Douglas	824	824	13.8
Amungee Mungee	46	504	8.5
Koolpinyah	43	412	6.9
Florina	15	333	5.6
Litchfield	214	215	3.6
Katherine Downs	13	205	3.4
Ban Ban Springs	203	203	3.4
Mount Keppler	64	64	1.1
Marrakai	4	53	0.9
Mary River West	3	47	0.8
Bridge Creek	43	43	0.7
Douglas West	35	35	0.6
Elizabeth Downs	31	32	0.5
Old Mount Bunday	32	32	0.5
Bonrook	9	28	0.5
Killarney	0	26	0.4
Manbulloo	0	21	0.4
Mainoru	0	16	0.3
McKinlay River	13	15	0.3
Welltree	11	11	0.2
Claravale	0	9	0.2
Bullo River	0	3	0.1
Douglas South	3	3	0.1
Mount Ringwood	2	2	0.0
Scott Creek	0	2	0.0
Bloodwood Downs	1	1	0.0
Delamere	0	1	0.0
Flying Fox	0	1	0.0
Henbury	1	1	0.0
Labelle Downs	1	1	0.0
Legune	1	1	0.0
McArthur River	1	1	0.0
Victoria River Downs	0	1	0.0
Woolner	1	1	0.0
Total	3009	5959	100.0





