Final Weed Management Plan

Charles Darwin University – Casuarina Campus

Prepared for Facilities Management, CDU

by

EcoScience NT

and

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Executive Summary

This weed management plan presents the results of field surveys to identify the diversity, distribution and density of weeds within the Casuarina campus of Charles Darwin University (CDU) during late 2017 and early 2018. It presents the results of weed control during the 2017-18 season (Section 3 - Results) and provides a legally compliant strategic weed management plan (WMP) detailing long term aims and objectives with recommended actions for the 2018/19 season (Section 4 – Weed control and management) . The structure and content of this document was compiled in accordance with the Consultants Brief (Appendix A) and has evolved in response to comments on the draft WMP from university staff, academics, postgraduates and other stakeholders.

The primary objective of this WMP is to prevent the spread, further establishment and reduce the impact of a range of declared and/or environmental weeds at the Casuarina campus of CDU as well as meeting obligations prescribed under relevant Northern Territory legislation (NT Weeds Management Act 2001, NT Fire and Emergency Act 2013). This plan, in association with the draft WMP (Metcalfe and Wingrave 2017) compiled and implemented in November 2017, provides a comprehensive and staged approach to weed management including detailed mapping of weeds, a schedule for control, recommendations regarding effective chemical treatments, buffer zone management and related advice which will contribute to the development of a new Master Plan for the campus.

An initial assessment of weed species present at the CDU Casuarina campus was conducted during three site visits between 2nd and 8th November 2017. A draft Weed Management Plan identifying priorities for weed control was compiled and submitted to CDU on 16 November for review and immediate implementation to ensure timely control of weeds prior to the wet season. In accordance with the Consultants Brief, the focus of the November 2017 survey was five previously identified Priority Weed Management Zones, located in the western section of the the site. The survey area also included the eight colour-coded university precincts - mainly comprising academic buildings, associated infrastructure, landscaped grounds and garden beds. The survey area also included the southern buffer zone, comprising bushland owned by other land holders, along the southern boundary of the campus. In April and May 2018, after completion of weed control for the 2017/18 season, the survey area was re-examined and revised mapping compiled for this final WMP detailing results of weed management during the 2017/18 season (Section 3 Results).

The Consultants Brief also identified four priority weed species which were the focus for data collection, control and management for this scope. The four priority weed species identified by CDU included two declared Class B weeds, gamba grass (*Andropogon gayanus*) and mission grass (*Cenchrus polystachion*) and two undeclared invasive species, coffee bush (*Leucaena leucocephala)* and Guinea grass (*Megathyrsus maximu*s). The distribution and density of these priority species was mapped within the survey area and detailed control plans and management schedules developed for the priority control areas (Zones 1 to 5) in the western section of the site and for the Southern Buffer Zone.

In the NT, all Class A weeds are to be eradicated, the growth and spread of Class B weeds are to be controlled, and Class C weeds are not to be introduced into the NT. All Class A or B weeds are automatically Class C. In accordance with the requirements of a legally compliant weed management plan, all Class A and B weeds recorded within the survey area were also documented with corresponding recommendations for control. A large variety of non-native species occur within the survey area, planted within gardens and landscaped areas of the campus, but information and data collection on these exotic species was limited to potentially invasive plants and environmental weeds causing significant management issues on campus.

The final field survey results and mapping of the distribution of all declared weed species during the April 2018 survey are provided in this report. No Class A weeds (to be eradicated) were detected but two Weeds of National Significance (gamba grass and lantana) were present within the survey area. Ten Class B species and a number of important invasive species including Coffee bush, were recorded and mapped to facilitate future control and to document progress in the reduction of weed distribution and abundance.

Gamba grass (Class B) was well established in the north west of the campus in early November 2017, with a density of 25% over approximately half of Zone 1 and a density of 50% over most of Zone 2. The focus of grassy weed control was to eradicate gamba in peripheral areas of Zones 1 and 2, creating either a 50 m buffer around less dense infestations, or a 30 m buffer in areas with dense, well-established stands. Timely and effective weed control involving several foliar

applications of glyphosate exceeded initial expectations and resulted in densities of less than 1% throughout both Zones 1 and 2 at the end of the control season in April 2018.

Elsewhere across campus isolated plants or clumps of gamba were successfully treated during repeated rounds of control. If similar strategic control is implemented during the 2018/19 season, gamba could be reduced to a level where eradication could be achieved within a few years. Although gamba grass produces copious quantities of seed, it only remains viable for one year, enabling effective control if a consistent approach is adopted.

Two mission grass species occur on campus, perennial (*Cenchrus polystachios)* and annual *(C. pedicellatus*). Perennial mission grass is a declared Class B weed. Although annual mission grass is not a declared weed in the Northern Territory, control of both species at the same time is highly recommended. As mission grass tends to co-occur with gamba grass infestations, these three species were typically mapped together as priority mixed grasses (PMG) and treated concomitantly during the 2017/18 season. The extent of mixed infestations has been substantially reduced across campus and it is recommended that control be continued as early as possible (i.e. soon after germination in November/December) in the 2018/19 season in order to further reduce the extent of mixed infestations.

The third priority grass species, Guinea grass (*Megathyrsus maximus*) was concentrated in a small infestation in the northwest corner of Zone 1 in November 2017. Guinea grass was also present in the Southern Buffer zone, but relatively absent from the remainder of the survey area. Guinea grass was successfully controlled during the 2017/18 season (it was not observed during the final survey) but this plan recommends inspection and early control of any Guinea grass germinating in areas occupied by previous infestations.

One highly evident outcome of weed control at Casuarina campus during the 2017/18 season was the clearing of dense, almost mono-specific thickets of the fourth priority weed coffee bush (*Leucaena leucocephala*) along the south-western boundary of the campus. Coffee bush is not a declared weed at either Territory or National level, but is recognised as a significant environmental weed in the NT as dense forests exclude native plants and reduce biodiversity. At the Casuarina campus coffee bush represents a major, long-term management issue not only because of the density, height and extent of well-established stands, but the longevity of the seed bank. The current control plan presents a staged, site-specific strategy for its eradication within the 8 university precincts and within Zones 1 to 5. Dense infestations within Zone 4 and remaining areas in the southern buffer require a long-term plan for gradual reduction, facilitated by involvement and co-operation of other groups such as Greening Australia, City of Darwin and NT Parks and Wildlife.

On 17 March 2018 Tropical Cyclone Marcus passed over Darwin causing considerable damage to trees and vegetation on the Casuarina campus. The category two storm had wind gusts to 130 km hr with sustained winds of 95 km hr near the centre causing significant destructive impacts including the loss of many canopy trees, particularly mature African mahogany and Eucalyptus species. Although reduction in the number of mahogany trees is of long-term benefit in terms of weed management at CDU, short-term terrain disturbance and widespread decline in canopy cover led to an immediate increase in target weeds, and will encourage weed establishment and proliferation during the 2018/19 season.

Overall, the objective for control of all priority grasses, including annual mission grass, is eventual eradication from the site through a focussed program conducted over several years. Recommendations for the 2018/19 season include continued clearing of priority grassy weeds back from weed-free edges (e.g. roads, tracks, lawns etc) in order to reduce spread and further establishment. These actions reduce the most significant sources of seed and effectively create a clear zone from which to resume follow-up control. The plan also aims to clear these weeds from tracks and firebreaks to reduce or stop their spread. To date, the plan to reduce populations of grassy weeds by 50% annually has been exceeded during 2017/18 and future management should include chemical control programs during late 2018, and well before flowering (i.e. prior to April 2019) in order to prevent any further seed production. This document reports major progress in the control of coffee bush in the southern buffer zone with recommendations for ongoing control of other dense infestations within the Casuarina campus.

Table of Contents

List of Tables

List of Figures

1 Introduction

This Weed Management Plan provides a comprehensive and staged approach to weed management including detailed mapping of weeds, information on weed diversity and density and a schedule for control. The plan presents recommendations regarding effective chemical treatments, buffer zone management and related advice which will contribute to the development of a new Master plan for the Casuarina campus of Charles Darwin University. This Weed Management Plan (WMP) provides a legally compliant plan and control program for an active management program required under the NT Weeds Act for all declared weed species at the CDU site.

Implementation of the plan should prevent spread of priority weed species through a strategic management program which eradicates isolated plants and reduces and contains established infestations. The focus of this weed management plan is eradication of all declared species in the short to medium term with a program of gradual control and eradication of other target species over the longer term.

1.1 Objectives

The primary objective of this weed management plan was to prevent the spread and further establishment of, and reduce the impact of, a range of declared and/or environmental weeds at CDU in addition to meeting obligations prescribed under relevant Northern Territory legislation (NT Weeds Management Act 2001, NT Fire and Emergency Act 2013).

In accordance with the Consultants Brief (Appendix A) specific objectives of the field survey were to:

- Conduct field surveys that identify the priority weed species present within CDU site and in adjacent areas
- Identify and map priority areas for control
- Map major infestations for containment
- Map isolated plants and outbreaks of priority species for eradication
- Identify and map high risk areas for weed spread
- Determine significant sources of weed seeds
- Delineate areas with low weed infestations and map any weed-free areas
- Examine adjacent property and identify areas where weed control requires co-ordination with land-holders

The objectives of the weed management plan were to:

- Describe the five priority weed management zones and identify priority weeds present
- Provide clear aims and objectives for each weed species and each priority control area
- Clearly describe a treatment strategy for priority species and priority control zones
- Prepare site maps which identify major infestations for containment as well as isolated plants and small outbreaks for control.
- Develop a weed control calendar that accounts for growth and reproductive cycles
- Provide a schedule for control of all weeds during the 2018/19 season that prevents the spread of weeds
- Compile mapping that enables changes in weed density and distribution to be tracked through time
- Map buffer zones and identify treatment for these areas
- Provide advice regarding best practice land management activities to reduce the introduction and spread of weeds and to assist in ongoing control.

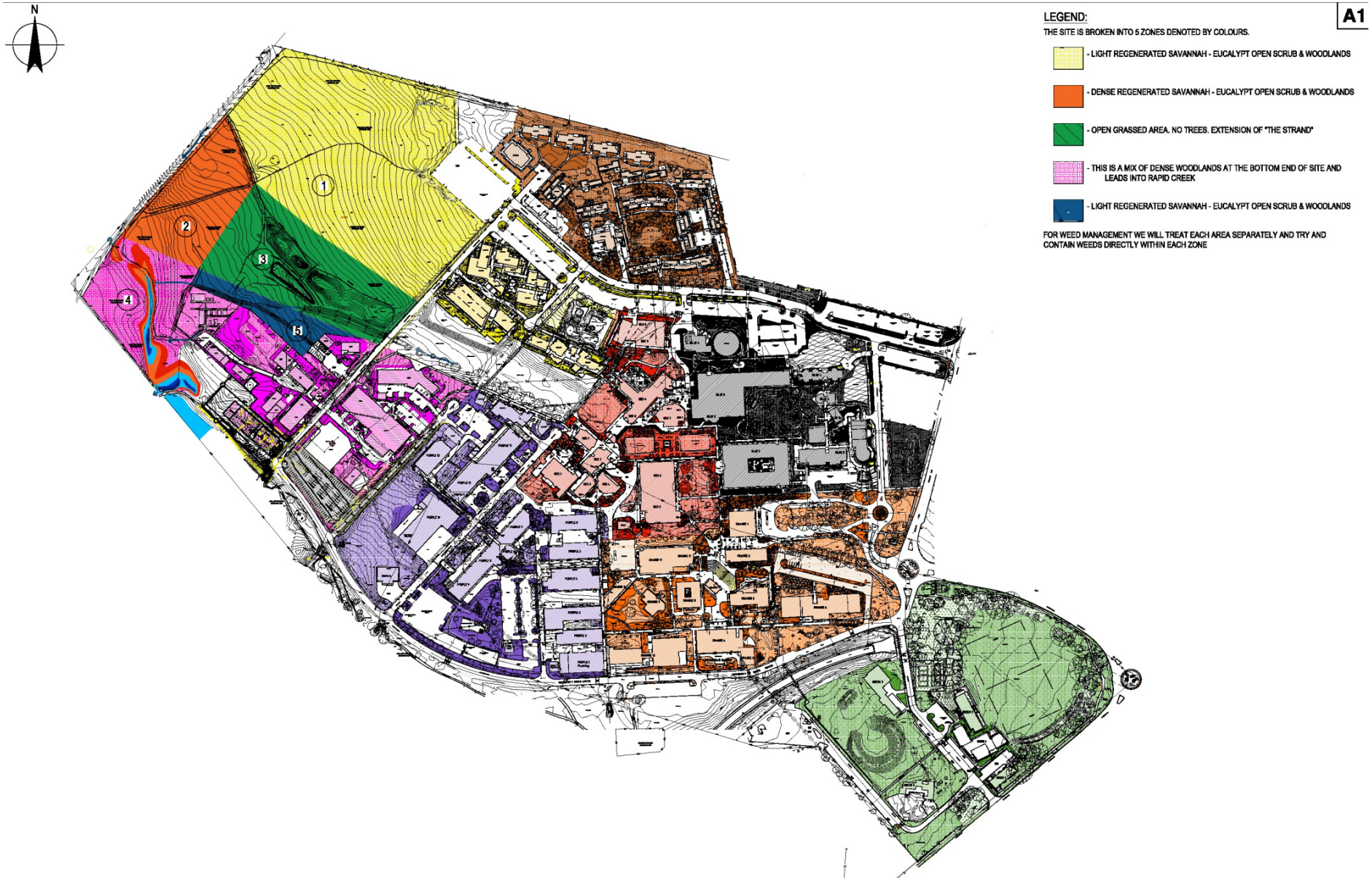

Figure 1-1 Overall weed management site plan of Casuarina campus indicating eight colour coded precincts (to east) and five priority weed management zones (to west)

1.2 Survey Area

The survey area comprised the Casuarina Campus of Charles Darwin University (CDU) in Darwin. It contains mainly flat to gently sloping upland terrain which forms part of the Rapid Creek catchment, which drains into Darwin Harbour. The survey area included eight well-established, colour-coded university precincts (comprising the green, orange, red, purple, blue, yellow, brown and pink precincts) in the eastern part of the site (Figure 1-1). The survey area also comprised an area of undeveloped remnant bushland identified for possible future expansion.

In accordance with the Consultants Brief, the focus of this survey was the undeveloped western section of the campus, previously divided into five zones, notionally identified as Priority Weed Management Zones (Figures 1-1). While these management zones were evidently delineated on the basis of existing vegetation - and to some extent the level of prior terrain disturbance and vegetation clearing - they also reflect the general level of weed infestation and have been retained throughout this project as the basis of the weed management program (Figure 1-2). The field survey focussed on these target areas but priority and declared weeds in each of the coloured precincts within the Casuarina campus were also mapped and presented in the draft and final WMP.

The survey area for this project also included some adjacent sites, particularly the linear corridor of vegetation located along the southern boundary of the campus that fringes the drainage canal and mangrove communities of Rapid Creek (Figure 1-1). This area, referred to as the southern buffer zone, mainly comprises degraded bushland comprising the interface of Sections 9260 and 9198 (owned by CDU) with vacant crown land in Section 8702 and mangroves and littoral woodland in Section 9375 which forms part of the Casuarina Coastal Reserve (NT Parks and Wildlife). Section 8640 owned/managed by the City of Darwin was examined during initial surveys but is not part of the current survey area (Figure 4-5). Weed management in relation to adjoining landholders is discussed in section 4.6 of this report.

1.3 Weed Management Zones 1 to 5

The focus of the plan was five previously identified Priority Weed Management Zones, located in the western section of the site. These areas, notionally mapped as management zones 1 to 5 as shown in Figure 1-2, were retained for weed management purposes and the boundaries of the five zones remain the same as provided by CDU.

The PMZ's were provided to the authors by CDU and relate broadly to existing vegetation type with the framework of historical site disturbance. For example, the main boundaries are defined by existing tracks, fencelines and infrastructure but the five zones also tend to reflect the level of prior terrain disturbance and vegetation clearing — which often determines the level of weed infestation. Although the zones may not align exactly with current vegetation community boundaries or recent land unit mapping (DENR, 2017), the focus of the WMP was management of weeds and the defined areas PMZ 1 to 5 have been adequate for this primary objective.

Indeed, historical aerial photos dating back to 1945 show that the whole of zone 1 (referred to as Light Regenerated Savannah) was cleared of vegetation, presumably strip-mined for topsoil. Gradual revegetation was evident in subsequent 1969 images but the boundary between zones 1 and 2 remained clearly visible. Aerial photographs from 1981 indicate the western section of the campus, including zones 1 to 5 was severely damaged by cyclone Tracey as well as being substantially disturbed by numerous tracks and clearings. Hence much of the existing vegetation represents regrowth within an area with a long history of disturbance. Revised descriptions of the existing vegetation, the distribution and density of weed infestations and the results of weed control during the 2017/18 season are provided in Section 3.2.

This weed management plan reflects the collaboration of staff, professionals, postgraduates and volunteers to document the environmental values of the remnant bushland at the Casuarina campus and to contribute to the sound environmental management and rehabilitation of vegetation in the area. The close proximity of this remnant bushland to the university adds to its inherent value as an ecological, scientific and educational resource.

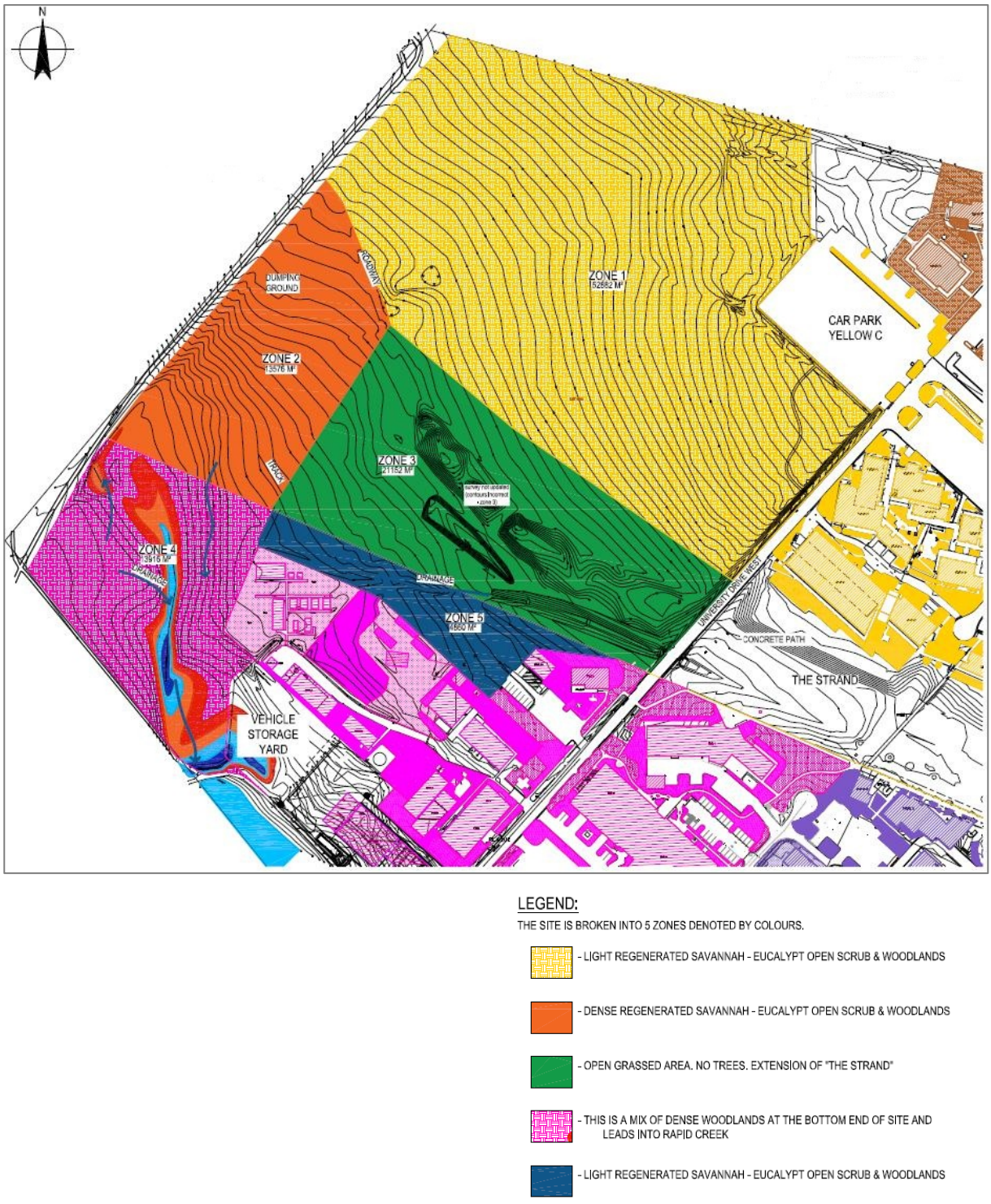

Figure 1-2 Detail of western end of Casuarina campus indicating weed management zones 1 to 5.

1.4 Priority Weed Species

Four priority weed species were identified in the consultants brief and information was collected in relation to these target species during the survey, including the density and size of infestations and their reproductive status. The four priority weed species identified by CDU included two declared Class B weeds gamba grass (*Andropogon gayanus*) and perennial mission grass (*Cenchrus polystachios*) and two undeclared invasive species, coffee bush (*Leucaena leucocephala)* and Guinea grass (*Megathyrsus maximus*).

The distribution and density of these priority species within the survey area was mapped and detailed control plans and management schedules developed within the priority control zones 1 to 5 in the western section of the site and for the southern buffer zone (see Section 3.5).

All other weeds declared under NT legislation (Section 3.1.1) occurring within the survey area were recorded, their distribution was mapped and appropriate weed control recommended for each species.

2 Methodology

Field methodology for the rapid assessment of key indicators was developed in accordance with project objectives. An initial assessment of weed species present at the CDU Casuarina campus was completed during three site visits between 2nd and 8th November 2017. A second survey of weeds present at the end of the 2017/18 control season was conducted in May-June 2018.

2.1 Field Survey

Field surveys comprised site-specific rapid assessment of weed presence and abundance to obtain a combination of qualitative, quantitative and semi-quantitative data and information. All areas of remnant bushland, garden beds and isolated plantings within the site were examined for the presence of weeds during both surveys.

Detailed survey of the five previously identified Priority Weed Management Zones, located in the western section of the site was conducted on foot, recording data in notebooks and using a hand-held Nautiz X7 PDA. Weed assessment of the eight colour-coded university precincts and the buffer zone along the southern boundary of the campus were conducted in the same way.

Field methodology derived from the Guidelines for Weed Data Collection in the Northern Territory and the Technical Manual for Weed Data Collection in the Northern Territory (NRETAS 2007; 2008) was applied during site inspections. Field data recorded included:

- GPS location
- Weed species present
- General location (e.g. minor track, disturbed area)
- Approximate number of plants
- Patch size (e.g. 1 m x 1 m)
- Density - estimated as % cover within each specific area, patch, or large infestation
- Population status (i.e. % seedlings (%S), % juveniles (%J) and % adults (%A)
- Presence/absence of seed either on plant or on the ground (yes/no);

Notes and photographs were taken during the field survey to record additional information on existing vegetation, other weeds present, weed control issues and recommended management for each specific section of the survey area.

2.2 Mapping

In accordance with standard techniques for recording weed distribution and density , the location of observed weeds were mapped using a hand-held Nautiz X7 PDA using ArcPad software.Weed species occurring in low densities were generally recorded as individual plants and the approximate number of plants was estimated. For larger infestations a linear strip or patch indicating distribution was recorded and the dimensions or patch size was estimated. Weeds in more extensive infestations were recorded as a polygon, where the extent was recorded by walking around the perimeter.

For each weed record, abundance was recorded by noting the density in terms of percentage (%) cover within the defined area, which may be an individual patch of weeds, or a polygon defining a larger infestation. Information was stored in Arc Catalogue and manipulation of data was done using ARCMap. Google Earth imagery was used as a baseline for overlay of cadastral information, weed distribution and density and for the presentation of weed management information.

3 Results

The draft WMP prepared in November 2017 (Metcalfe and Wingrave 2017) was implemented from mid-November to April 2018 by using integrated chemical and physical control to target priority weeds in management zones 1, 2 and 5 and along the southern boundary in CB1, 2 and 3. CDU office of Facilities Management conducted weed control within the orange and blue precincts and initiated clearing of dense coffee bush within the southern buffer zone as well as significant follow-up control of seedlings as they emerged.

Interim reporting on the success of control in priority zones 1 and 2 was provided to CDU in early January 2018 (Metcalfe and Wingrave 2018) documenting high initial success in controlling grassy weeds within native vegetation. Little Falcon Consulting conducted regular field inspections in zones 1 and 2 and completed on-going control of priority species to detect and manage any new and established weeds requiring treatment during the 2017/18 season. This plan provides the results for the end of season monitoring and presents corresponding revised priorities and recommendations for the 2018/19 season.

Overall, there has been a very significant reduction in targeted weeds across the Casuarina campus during the 2017/18 season. With the exception of neem (declared Class B but not identified as a priority species in this plan) an estimated 95 – 99% reduction in populations of all weeds was observed in June 2018. Detailed results are provided for control of priority weeds species in section 3.1 and the outcomes for priority management zones are presented in section 3.2. Information on weed management and control for each area of the Casuarina campus, including objectives, priorities and recommended actions for the 2018/19 season is contained in section 4.

3.1 Priority Weed Species

The Weeds Management Act 2001 (WMA) is administered by the Northern Territory Department of Land Resource Management. The NT Weeds Management Act applies to all owners, managers and occupiers of land, and all other land users in the NT. Once a weed is declared in accordance with section 7 of the Act there is a requirement for all land holders, land managers and land users to comply with the declaration classification.

Weeds are placed into classes based on the risk of harm they could cause and how difficult they are to control. In the NT there are three main categories of weeds defined Under the WMA. Class A weeds are to be eradicated, the growth and spread of Class B weeds are to be controlled, and Class C weeds are not to be introduced into the NT. All Class A and Class B weeds are also Class C weeds.

3.1.1 Class A Weeds

No Class A species were recorded within the survey area. However, although gamba grass (*Andropogon gayanus*) is classified as Class B in the Darwin region, elsewhere in the NT it is listed as Class A – to be eradicated.

A targeted search for pond apple (*Annona glabra)* a declared Class A and Class C species and Weed of National Significance was conducted along the hinterland margin of the mangroves fringing Rapid Creek within the Southern Buffer Zone. Approximately ten years ago, an outbreak of this species was detected in this area but on-ground control operations appear to have been successful in eradicating this species from the Rapid Creek. No further plants have been detected and pond apple was not evident in fringing mangroves during the November 2017 survey.

3.1.2 Class B Weeds

A total of ten Class B weeds were recorded within the survey area during field surveys in late 2017 and early 2018 (Table 3-1). The distribution of all declared Class B weeds within the survey area is mapped in Figure 3-1 with density categories for mixed stands of gamba and mission grass indicated by different coloured shading, where green denotes 5% cover, yellow 10%, orange 25% and red indicates 50 % cover. Section 4 of this management plan details how the growth and spread of each of these listed species is to be controlled in each of the different precincts and priority control areas of the Casuarina campus.

3.1.3 Weeds of National Significance

Weeds of National Significance (WoNS) are declared for the purpose of restricting spread and/or eradication from parts of Australia. It is a national approach managed by each state involved with the declared species. Thirty two Weeds of National Significance (WoNS) have been agreed by Australian governments based on their invasiveness, potential for spread and environmental, social and economic impacts. Two WoNS were recorded within the survey area during the 2017/18 season. Gamba grass (*Andropogon gayanus)* and lantana (*Lantana camara)* are both listed Class B weeds and classified as WoNS.

Gamba grass was mainly found in the north-west section of the survey area (Figure 3-1) where it was established throughout most of the remnant Eucalypt woodland communities in November 2017. Containment and reduction of gamba infestations represents a key objective of the current WMP (Section 4.3). Lantana had a much smaller distribution, occurring as isolated plants or small clumps within a garden area in Green Precinct and amongst vine-forest vegetation within Priority Management Zone 4 (Figure 3-1). Control of this species in accordance with the plan presented in section 4 should result in the eradication of lantana from the site in the short term.

Table 3-1 List of declared Class B weed species recorded at Casuarina campus during the 2017/18 season

Botanical name	Common name
Andropogon gayanus * ^	Gamba grass
Azadirachta indica	Neem
Cenchrus polystachios	Mission grass (perennial)
Hyptis suaveolens	Hyptis
Lantana camara *	Common lantana
Senna obtusifolia	Sicklepod
Sida acuta	Spinyhead sida
Sida cordifolia	Flannel weed
Sida rhombifolia	Paddy's lucerne
Stachytarpheta spp.	Snake weeds
* Weed of National Significance	
^ Class B in Darwin region, Class A elsewhere in the NT	

3.1.4 Undeclared non-native species

Annual Mission Grass

Annual mission grass (*Cenchrus pedicellatus*) has the same invasive characteristics as perennial mission grass and typically occurs in similar disturbed habitats, often in mixed stands with *C. polystachios* and *A. gayanus.* Although undeclared, this species was recorded and mapped in the same way as *C. polystachios* during this survey.

Coffee Bush

Although coffee bush (*Leucaena leucocephala)* is considered to pose a significant threat to biodiversity in tropical rangelands, it is not a declared weed at the State/Territory or National level. Coffee bush is listed as a high impact weed in the Field Guide to Assessing Australia's Tropical Riparian Zones (Dixon and Douglas 2007) and is recognised as a significant environmental weed in the Northern Territory Parks and Conservation Masterplan (DENR, 2005). Established stands of Coffee bush form dense thickets, which exclude wildlife and suppress recruitment of native plants, directly reducing local biodiversity. Coffee bush does not readily colonise undisturbed forests or woodlands, but it invades both disturbed and undisturbed riparian areas posing a serious threat to river systems and coastal wetlands.

Figure 3-1 Map of all declared Class B weeds recorded within the CDU survey area during the November 2017 field assessment, where PMG denotes perennial mission grass.

Within the CDU survey area coffee bush represents a major weed management issue, particularly along the canal and natural drainage lines in the southern buffer zone where extremely dense stands were recorded in November 2017 (Figure 3-3). Mature closed forests dominated by coffee bush are also present within other areas of the campus, particularly west of the pink precinct where they occupy much of PMZ 4 (Figure 3-3). Coffee bush is one of four priority weed species identified in this plan and in the short term, this species can be eradicated from all of the eight university precincts where it is present as isolated plants or small infestations. Eradication within the eight precincts is seen as the highest priority for coffee bush control.

In the medium term, coffee bush should be eradicated from Priority Management Zones 1, 2, 3 and 5 where it occurs in mid-dense stands that tend to be restricted to the fringes or disturbed areas of these zones. Control of low density coffee bush in these areas should be relatively straightforward if the correct physical and chemical treatment and regime of follow-up control is implemented (see Tables 4-2 and 4-3). The same approach needs to be applied to the north side of the southern buffer zone (i.e. between the bike path and campus) where targeted control will have a significant impact on eradication from small areas.

During the 2017-18 control season substantial progress was made by Facilities Management in removing coffee bush in the southern buffer zone, particularly between the canal and the campus (Figure 4-5). Detailed results for the three main sections of the southern buffer zone (CB1, CB2 and CB3) are presented in Section 3.3. Follow-up control (foliar application of Grazon Extra) was conducted and replanting with selected native species was undertaken in collaboration with Greening Australia and Green Army volunteers.

The use of a forestry mulcher to clear coffee bush delivered efficient results in this area which contained largely mono-specific stands and it is recommended that this technique be applied in other similar dense infestations. However, in areas where remnant vegetation is more prevalent, techniques to conserve valuable native trees should be employed where possible. In mixed stands , identification and marking of native trees to be retained combined with selective clearing is recommended, whereas the forestry mulcher is highly effective in clearing extensive stands of pure coffee bush.

Figure 3-2 Mature seed pods on coffee bush (left), dense infestation within Southern Buffer zone (centre) and multi-stemmed regrowth on cut stump in priority zone 4 (right)

It is vital to maintain any areas where initial control of coffee bush has been undertaken. During initial field surveys it was evident where previous attempts to control coffee bush had not received follow up treatment (e.g. in priority zone 4). In this area, cut stumps have now regrown into multi-stemmed large trees, effectively making control operations even more difficult and costly. Any control must be repeated and follow-up removal of any woody regrowth and seedlings and is critical for success. Furthermore, replanting must not be commenced prior to completion of chemical control of regrowth and germination.

The involvement of students in management of selected areas of the campus is valuable and would assist in the eventual eradication of coffee bush, but a consistent approach from year to year is important. It is recommended that each faculty involved should focus on a particular area in which annual foliar spraying of germinating seedlings and consistent control treatment of any regrowth is conducted.

The management of coffee bush at the Casuarina campus is a long term project, not only because of the very dense established infestations but due to the longevity of the seed bank. In contrast with gamba grass - whose seeds only persist for one year - seeds of coffee bush remain viable in the soil for many years, exacerbating attempts to control this species.

Figure 3-3 Map of coffee bush infestations within the CDU survey area in November 2017, indicating high density stands within the Southern buffer zone and Priority Management Zone 4

3.1.5 Other weeds of concern

Information on the presence of other introduced plant species was recorded, but the survey area contains a huge variety of exotic species planted in garden beds and numerous other undeclared weed species of low concern. Of necessity, data collection was limited to several invasive weed species and environmental weeds that pose significant current and potential future management issues on campus. Descriptions of these three undeclared potential environmental weeds are presented in Appendix B with corresponding recommended measures for control.

3.2 Priority Management Zones

The location of five priority management areas (PMZ's or zones 1 to 5) is shown in Figure 1-2 of this report. Descriptions and photographs of the five PMZ's illustrating vegetation condition, structure and composition were provided in the draft WMP (Metcalfe and Wingrave, 2017).

3.2.1 Zone 1 – Light Regenerated Savannah

Priority management zone 1 covers an area of 5.28 ha (yellow section in Figure 1-2) and contains remnant bushland comprising Darwin stringybark (*Eucalyptus tetrodonta*) mid open woodland to 16 m tall in the eastern section, with canopy cover and tree height diminishing to the west, where red paperbark (*Lophostemon lactifluus*) and kakadu plum (*Terminalia ferdinandiana*) become the dominant species. Zone 1 encompasses four different land units (7a, 7b1, 7b2 and 7c) which all occur on undulating, low broad rises on gravelly soils, with a minor central area subject to seasonal inundation (land unit 7c). The eastern section forms woodland to open woodland with a variety of upper and mid-stratum native trees including juvenile eucalypts, *Acacia* spp., *Terminalia carpentaria* and *Buchanania obovata*. Cycads (*Cycas armstrongii*) and sand palms (*Livistona humilus*) are common mid-stratum species.

Gamba and mission grass occupied at least 50% of zone 1 in November 2017 at densities from 25 to 50 % cover. The central section of this zone however, contained relatively few weeds and approximately one third of the total area remained in almost weed-free condition (see 3.5.4 Weed free areas of ecological value). Weeds had infiltrated zone 1 along lines of disturbance with the highest weed densities recorded along tracks, man-made drains and within areas of previous clearing and terrain disturbance. Repeated foliar treatment of grassy weeds from November 2017 to April 2018 successfully reduced these weed infestations by up to 95% with the following results:

PRIORITY MANAGEMENT ZONE 1 – 2017/18 WEED CONTROL RESULTS		
Target species	Management objective 2017/18	Management result
Coffee bush	- Eradication	Overall a very significant reduction in all targets at end of management season. Excellent result. • All mature coffee bush effectively treated • Emerging seedling/regrowth at < 1% density
Gamba grass + annual mission grass + perennial mission grass + Guinea grass	- Creation of 30 m wide grass weed free buffer along the western and southern edge of this site. - Creation of 50 m wide grass weed free buffer along the western and southern edge of this site.	Overall significant reduction in coffeebush at end of management season. Target grasses reduced significantly • Guinea grass reduced to zero • Gamba grass reduced to < 1% across site • Perennial mission grass at < 1% across site • Annual mission grass scattered through site in very low density, estimated at < 1%
Hyptis	- Eradication	• Zero hyptis detected at assessment

Eucalyptus woodland in zone 1 is the focus for numerous current and previous scientific experiments and educational projects including recent research on a population of Black-footed Tree Rats. Bushland in zone 1 also represents a valuable teaching facility and a list of current and previous research projects, students, academics and other stakeholders is provided (Appendix D). Interested parties should be contacted prior to any large scale control

operations (e.g. foliar application of herbicide) or should burning of this area ever be proposed. The ecological values of this area are particularly threatened by invasion of gamba and other introduced grasses, which reduce biodiversity and change fire regimes. The western section of this zone is more disturbed than the east and the level of weed infestation directly reflects this.

3.2.2 Zone 2 – Dense Regenerated Savannah

Priority Management Zone 2 covers an area of 1.36 ha (orange zone in Figure 1-2) and encompasses two land units (7b1 and 7c) associated with undulating low rises with well drained soils with open Eucalypt-dominated woodland (7b1) surrounding a central drainage way with abundant *Pandanus spiralis* and *Lophostemon lactifluus* - species associated with soils subject to seasonal waterlogging (7c). It is evident that zone 2 has experienced greater previous disturbance than zone 1 with former dumping areas, tracks, easements, drainage lines and minor clearings throughout this relatively small area of bushland.

In November 2017, well-established gamba and other priority grassy weed species formed dense infestations in highly disturbed areas with an average of 50% cover over all of zone 2. Due to the density and extent of grassy weeds in this area, a wet season burn was initially recommended in the draft WMP to reduce biomass and assist in follow-up control (Metcalfe and Wingrave 2017). However, timely and efficient control of grassy weeds in early December 2017 rapidly reduced infestations such that burning was no longer considered necessary or advisable. Several rounds of control, comprising targeted foliar application of Glyphosate during the 2017-18 season reduced the distribution of priority mixed grasses to <1% cover (Figure 3.4) with the following results:

PRIORITY MANAGEMENT ZONE 2 – 2017/18 WEED CONTROL RESULTS		
Target species	Management objective 2017/18	Management result
Coffee bush	- Eradication	Overall a very significant reduction in coffee bush at end of management season. Excellent result. • All mature coffeebush effectively treated • Emerging seedling/regrowth at < 1% density
Gamba grass + annual mission grass + perennial mission grass.	- Creation of 30 m wide grass weed free buffer along all edges of this site.	Overall significant reduction in all targets at end of management season. • Gamba grass: several scattered plants at assessment, reduced to < 1% across site • Perennial mission grass at zero at assessment • Annual mission grass scattered through site, some low density patches, overall very low density, estimated at < 1%

Similar management objectives should be sustained in zone 2 during the 2018/19 season through creation of weed free buffers and targeted control of any seedlings of gamba and mission grasses combined with eradication of coffee bush seedlings and regrowth (further detail in Section 4.4).

3.2.3 Zone 3 – Open Grassland

Priority management Zone 3 covers an area of 2.12 ha of Lot 9198 (green area in Figure 1-2) and mainly comprises a large grassed expanse with no mid or upper stratum vegetation. Forming an extension of the lawns and cleared expanse of 'the strand', the maintained lawns largely prevent the introduction or establishment of weed species. However, one declared weed species was recorded in a central location (*Sida rhombifilia*) during the November 2017 survey, which was subsequently eradicated during the season with the results summarised below.

PRIORITY MANAGEMENT ZONE 3 – 2017/18 WEED CONTROL RESULTS		
Target species	Management objective 2017/18	Management result
Sida rhombifolia (single plant found in centre of area)	- Eradication	• Zero sida detected at assessment

3.2.4 Zone 4 – Dense Woodland to Monsoon Vine Forest

Priority Management Zone 4 occupies 1.39 ha in the south western corner of the campus (pink area in Figure 1-2)and is characterised by dense coffee bush forests and a small patch of native vine forest. Zone 4 encompasses four different land units including upland communities (7c and 7b1), an alluvial drainage area with dense modified vegetation comprising coffee bush(9a) surrounded by native closed forest (12a) and mid-woodland (12 b).

Dense, closed canopy vegetation has developed in this area on alluvial soils associated with a seasonal drainage line, subject to inundation and seasonal waterlogging. Higher soil moisture levels are sufficient to support a small area of vine-forest of ecological value (see section 4.5). A central drainage way leads into intertidal habitat supporting mangroves that forms part of the Rapid Creek system.

Further upstream, this drainage way expands into an open area supporting vines and dense infestations of introduced grasses in November 2017. Aside from well-established, high density coffee bush infestations (Figure 3-13) priorities for control within Zone 4 include lantana (Class B, WoNS) within the vine-forest. Well-established population of the undeclared environmental weed ivy gourd (*Coccinea grandis*) was also recorded in this habitat (Appendix B). The draft WMP recommended that control of coffee bush infestations in this area be postponed until other areas in the southern buffer zone were adequately controlled, follow-up treatment and rehabilitation had been completed. Hence no coffee bush management was attempted and results for the 2017/18 season are summarised below.

PRIORITY MANAGEMENT ZONE 3 – 2017/18 WEED CONTROL RESULTS		
Target species	Management objective 2017/18	Management result
Lantana	- Eradication	No management action taken as at May/June 2018
Coffee bush	- Containment, draft WMP recommended postponing control	

Future control of coffee bush in this area will be complex due to uneven terrain, seasonal waterlogging, access difficulties, extremely dense infestations and a large seed bank. The balance between use of forestry mulcher and hand removal is also challenging due to the presence of valuable native trees. Preparation of a weed control and rehabilitation plan for this area, designed to meet multiple objectives and reduce the potential for seasonal erosion, may be useful for weed management in MZ. Table 4-1 provides detailed advice on chemical control options for coffee bush seedlings, saplings, small and large trees. In accordance with recommendations in the draft WMP control should be postponed until most other areas have been successfully managed and rehabilitated in order to ensure sufficient time and resources for consistent follow- up control in MZ4 (see section 4.4 for further detail regarding control).

3.2.5 Zone 5 – Disturbed Regenerating Woodland

Priority Management Zone 5 occupies a small linear area (0.48 ha) on the southern border of the grassed expanse of Zone 3 (blue section in Figure 1-2) comprising land unit 7b1 associated with undulating low rises supporting a low woodland of *Acacia*, eucalypt and mixed species. During the November 2017 survey this area was under remediation, with a recently constructed drain and stockpiled coffee bush timber and soil that had been cleared from adjacent Zone 4. The level of terrain disturbance leaves it vulnerable to weed invasion. Two declared weeds *S. acuta* and *Senna obtusifolia* were recorded in Zone 5 in November 2017 and end of season results are summarised below.

PRIORITY MANAGEMENT ZONE 5 – 2017/18 WEED CONTROL RESULTS		
Target species	Management objective 2017/18	Management result
Gamba grass, perennial mission grass, seedling and juvenile coffee bush and *Sida* spp.	- Eradication	Zero gamba grass detected at assessment. Zero perennial mission grass detected at assessment.
Coffee bush (adult)	- Eradication	Approx. 33% of the overall site effectively treated for coffee bush Remaining part of site unchanged

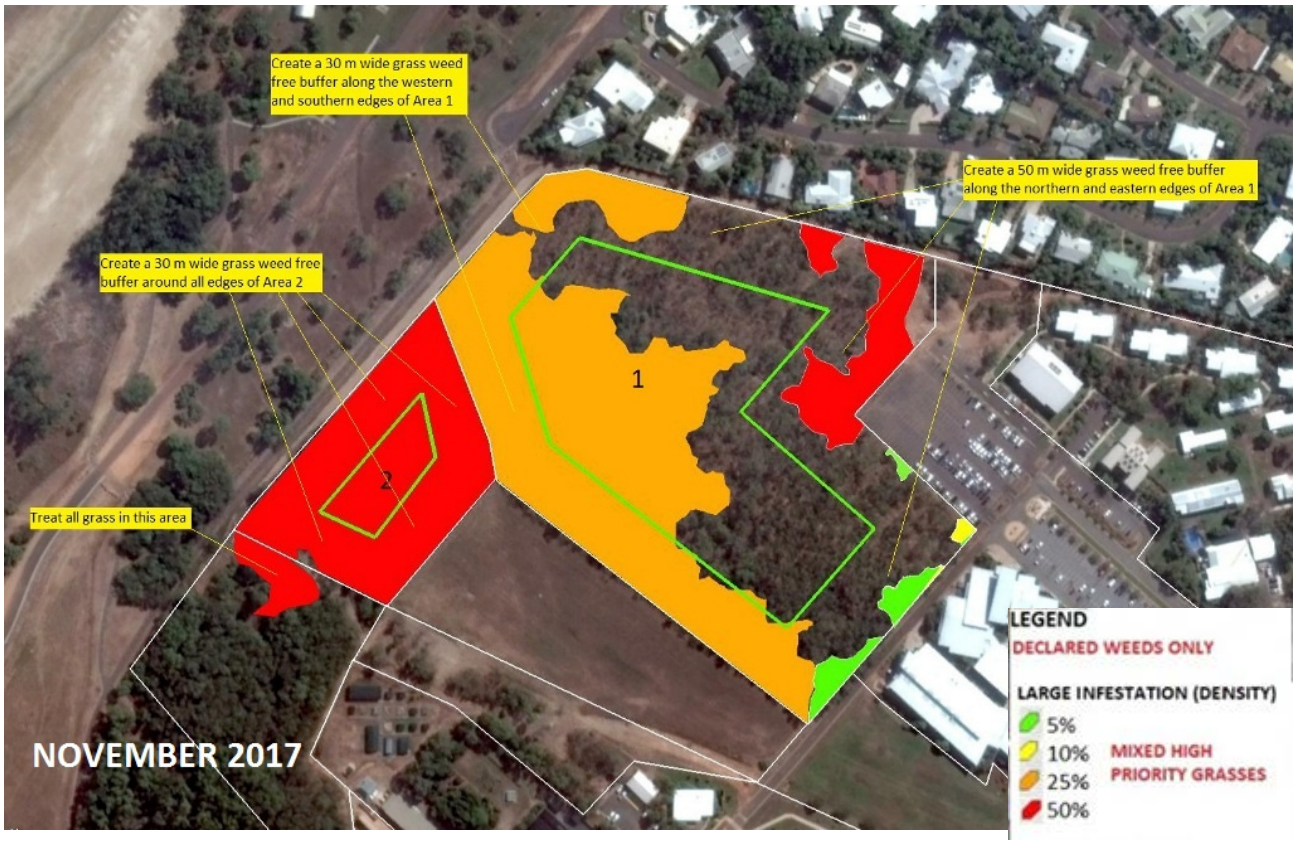

Figure 3-4 Distribution of mixed species of high priority grassy weeds in PMZ's 1 and 2 in November 2017 indicating strategy for control including widths of recommended weed-free buffers

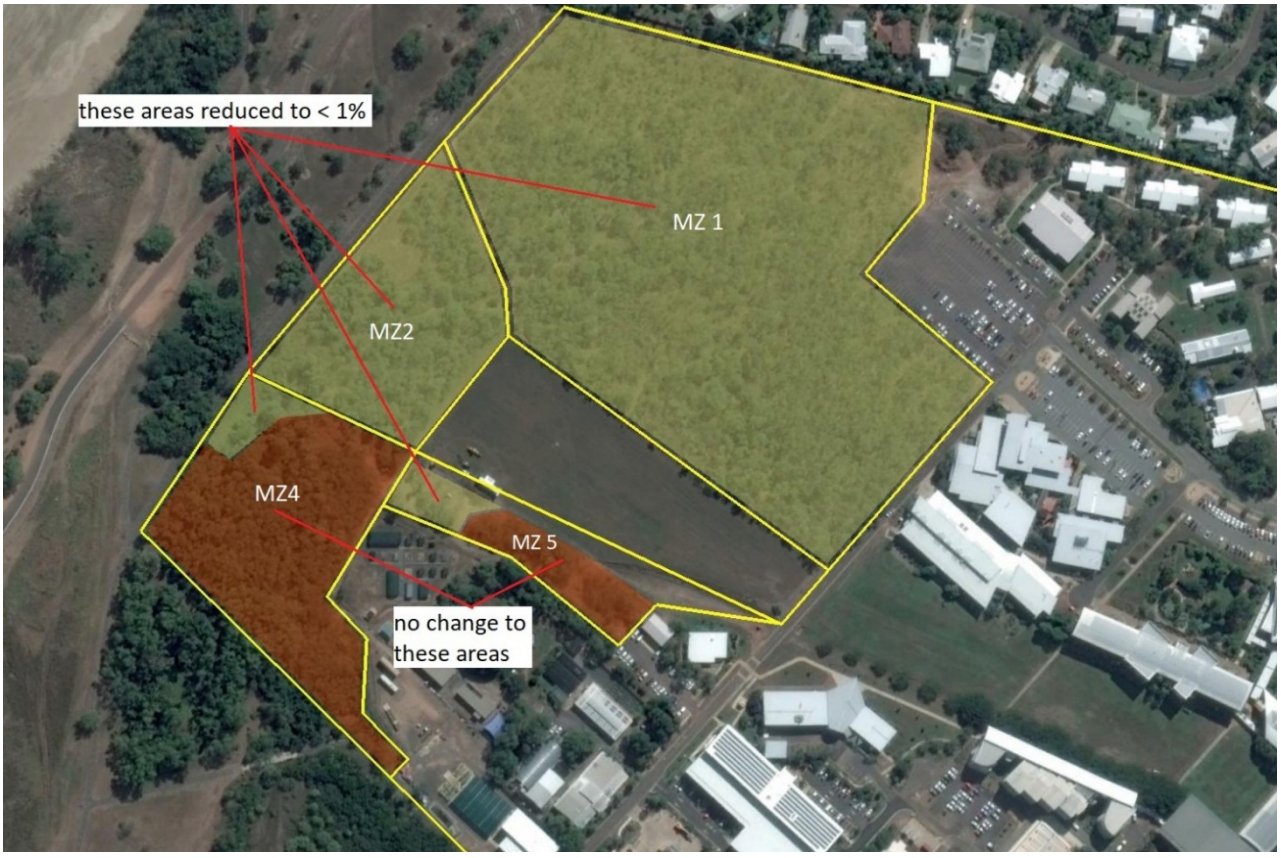

Figure 3-5 Results of weed control during 2017-18 season in priority management zones 1 to 5.

3.3 Southern Buffer Zone

The distribution and density of priority weeds in the southern buffer zone in November 2017 is mapped in Figure 3-6 which indicates the division of this management zone into three sections SB1, SB2 and SB3 and delineates the extent of high density weed infestations in three discrete areas surrounding the canal denoted CB1, CB2 and CB3.

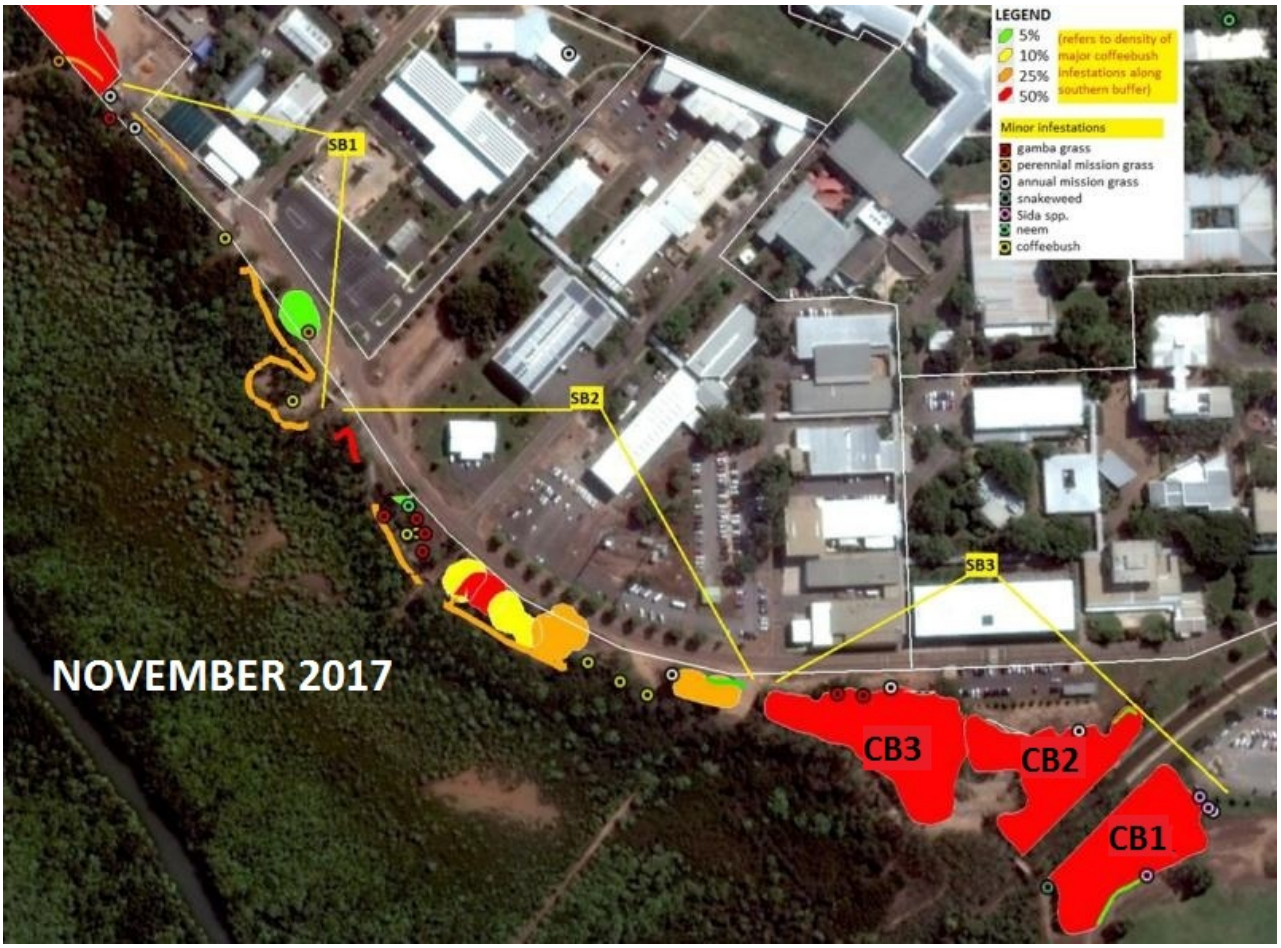

Figure 3-6 Map of the distribution, diversity and density of all priority and declared weeds within the southern buffer zone in November 2017, divided into three sections for strategic control

Results for weed management in the southern buffer zone during the 2017/18 season (Figure 3-7) are summarised below with revised priorities for control during the 2018/19 season for SB1, SB2 and SB3 listed in section 4 of this plan.

Figure 3-7 Areas where coffee bush was controlled in the southern buffer zone during the 2017/18 season

Southern Buffer Zone 1 – SB1

In November 2017 the SB1 section of the southern buffer zone, which extends from the open drain to a small bridge was characterised by dense stands of coffee bush with an average cover of 50% but with density up to 100% coffee bush in some places (Figure 3-5). Coffee bush extended all the way to the creek bank and around the fringes of dense stands several other declared weeds were recorded including sida species (*Sida cordifolia, S. acuta*) and snake weed. Grassy weeds including Guinea grass and annual mission grass were also recorded in SB1 at the beginning of the season (Figure 3-5).

SOUTHERN BUFFER ZONE 1 (SB1) – 2017/18 WEED CONTROL RESULTS		
Target species	**Management objective 2017/18**	**Management result**
Gamba + annual mission grass + perennial mission grass.	- Eradication	• Zero gamba detected at assessment • Zero annual mission grass detected at assessment • Zero perennial mission grass detected at assessment
Minor + isolated coffee bush sites	- Eradication of all plants prior to further on site establishment.	No management action taken as at May/June 2018
Major coffee bush site	- Initial containment and reduction of the more established infestations. - Eradication in longer term.	No management action taken as at May/June 2018

Targeted control using foliar application of Glyphosate between December 2017 and April 2018 resulted in no regrowth or seedling germination of priority grassy weeds during this control season in SB1. Control of coffee bush infestations in this area were not attempted during this season as the major focus of management in early 2018 was in SB3 (Figure 3-6).

Southern Buffer Zone 2 – SB2

In November 2017 both SB2 and SB3 sections of the southern buffer zone contained dense mono-specific stands of coffee bush in some areas, with occasional gamba grass, annual mission and abundant African mahogany seedlings (*Khaya senegalensis*). End of season monitoring results for SB2 and SB3 are presented below and mapped in Figure 3-6.

SOUTHERN BUFFER ZONE 2 (SB2) – 2017/18 WEED CONTROL RESULTS		
Target species	**Management objective 2017/18**	**Management result**
Gamba + annual mission grass + perennial mission grass.	- Eradication	• Zero gamba detected at assessment • Zero annual mission grass detected at assessment • Zero perennial mission grass detected at assessment
Neem	- Eradication	No management action taken as at May/June 2018
Minor + isolated coffee bush sites	- Eradication	No management action taken as at May/June 2018
Major coffee bush sites	- Initial containment and reduction of the more established infestations. - Eradication in longer term.	No management action taken as at May/June 2018

Southern Buffer Zone 3 – SB3

SOUTHERN BUFFER ZONE 3 (SB3) – 2017/18 WEED CONTROL RESULTS		
Target species	**Management objective 2017/18**	**Management result**
All gamba grass, annual & perennial mission grass, snakeweed, Sida & Senna spp. found around sites CB1, CB2 & CB3.	- Eradication	• Zero gamba grass, annual & perennial mission grass, snakeweed, Sida & Senna spp detected at assessment.
Neem	- Eradication	• Zero detected at assessment
Major coffee bush sites	- Containment and reduction of the more established infestations.	All sites under current/on-going active management. Emerging seedlings evident at assessment + extensive on-going follow-up control works. Appears to be on track for eradication. All areas approximately 75% coffee bush free at assessment. • CB1: approx. 1000 m² of seedlings at 10 – 50% density • CB2: approx. 100 m² of seedlings/regrowth all edge of drain at approx. 50 % density. • CB3: patchy seedling emergence, estimated at approx. 1300 m².

3.4 University Precincts

Descriptions and photographs of each of the precincts within the survey area (i.e. green, red, orange, purple, blue, yellow, brown and pink precincts) including the declared species present and priorities for control during the 2017/18 season were presented in the draft WMP (Metcalfe and Wingrave 2017). The distribution of existing declared and priority weeds in November 2017 is mapped in Figure 3-7 and a summary of declared and environmental weed species recorded in each precinct in late 2017 is compiled in Appendix C of this report.

Weed control within the university managed grounds from December 2017 to June 2018 concentrated on the Orange and Blue precincts only and results are tabulated below. Weed control in other areas, including declared neem and undeclared coffee bush in the Brown precinct have not been attempted this season (Figure 3-8).

UNIVERSITY PRECINCTS – 2017/18 WEED CONTROL RESULTS			
Area	Target species	Management objective 2017/18	Management result
Orange precinct	Gamba + annual mission grass + perennial mission grass	- Eradication	Overall significant reduction in all targets at end of management season. • Zero gamba grass detected at assessment. • Zero perennial mission grass detected at assessment. • Zero annual mission grass detected at assessment
	ALL Coffee bush + lantana + snakeweed + neem + *Sida* spp. + *Senna* spp.	- Eradication	Overall significant reduction in all targets at end of season. • Zero lantana, snakeweed, *Sida* spp. or *Senna* spp. detected at assessment. • Neem reduced to several scattered seedlings. • Coffeebush reduced to several scattered seedlings.
Blue precinct	Gamba + annual mission grass + perennial mission grass	- Eradication	Assessment indicated that part of Blue Precinct treated during management season. Minor follow up required. • 1 m X 1 m PMG at assessment (unchanged from initial assessment). • 2 minor AMG at assessment (unchanged from initial assessment) • Zero gamba grass detected at assessment.
	ALL Coffee bush + lantana + snakeweed + neem + *Sida* spp. + *Senna* spp.	- Eradication	Overall significant reduction in all targets at end of management season. • Very minor juvenile coffee bush detection at assessment. • Minor juvenile neem detected at assessment.
All others			No measurable management action taken as at May/June 2018.

Revised priorities for control and recommended treatment within each of the coloured precincts for the forthcoming 2018/19 season are listed in Section 4.4.1

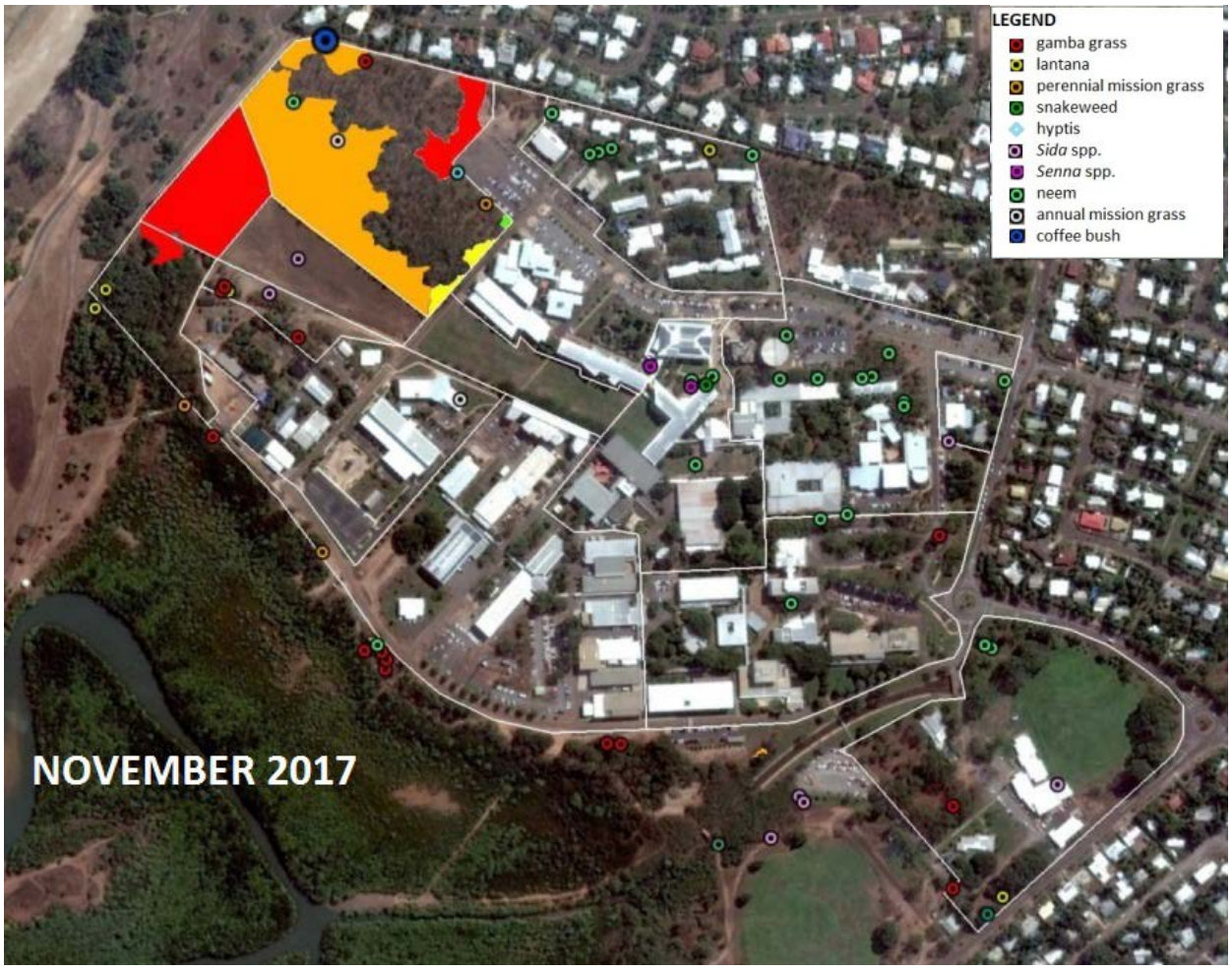

Figure 3-8 Map showing weed diversity and distribution recorded in all coloured precincts in November 2017

Figure 3-9 Map showing results of weed control in the orange and blue university precincts in June 2018 (yellow indicates weed management areas during 2017/18 season)

4 Weed Control and Management

This section contains weed management objectives, priorities for control, a schedule for control and required actions recommended for treatment in each of the management areas of the Casuarina campus during the 2018/19 season. It represents an updated Weed Management Plan that follows on from that provided in the Draft WMP for the 2017/18 season (Metcalfe and Wingrave, 2017). The weed management objectives identified for different areas of the Casuarina campus in late 2017 are summarised in Section 4.1.

The resources and timing allocated to weed control during each annual period will be determined by CDU on the basis of numerous factors including identified goals and priorities, budget, season and master planning considerations. The recommended priorities for control during the 2018-19 season are listed in decreasing order of importance in Table 4-1 while highlighting the broader long-term management objectives. As consistent and integrated weed control is implemented on an annual basis - and the eradication of declared weeds on campus is achieved - these objectives and priorities will change and the number of weed management actions will diminish.

4.1 Weed Management Objectives

Overall objectives for weed management at the Casuarina campus of CDU during the 2017/18 season focussed on control or eradication of declared species and developing a plan to prevent the spread of weeds. Specific objectives for each area of the campus are listed below.

1: Managed grounds/gardens + Management Zone 3

- effective control and ultimate eradication of all existing targets prior to further seeding events (includes all small isolated infestations of all target species)
- prevention of weed seed spread in managed grounds and gardens via management of mulching practices.
- prevention of weed seed spread within/between managed grounds/garden areas via management of target species prior to entry of mowing/slashing machinery.

2: Management Zones 1 and 2

- effective control and ultimate eradication of all small existing Guinea grass, lantana, neem and coffee bush with subsequent management of emerging seedlings and/or regrowth prior to further seeding events.
- prevention of weed seed spread through management of all target species along firebreaks/tracks prior to further seeding events.
- containment and reduction of existing high density grass weed infestations via development of clean grass weed free buffers around these areas and ultimate reduction and removal of infestations through continued/later control works.

3: Management Zone 4

- effective control and ultimate eradication of all small existing lantana and ivy gourd infestations with subsequent management of emerging seedlings and/or regrowth prior to further seeding events.
- prevention of weed seed spread through management of all target grass species along firebreaks/tracks at this site prior to further seeding events.
- containment of existing high density coffee bush infestation.

4: Management Zone 5

- effective control and ultimate eradication of all small existing coffee bush, gamba grass, perennial mission grass and Sida spp. infestations with subsequent management of emerging seedlings and/or regrowth prior to further seeding events.

5: Southern Buffer Zone

- effective control and ultimate eradication of all small existing gamba grass, annual and perennial mission grass, *Sida* and *Senna* spp., neem and coffee bush targets with subsequent management of emerging seedlings and/or regrowth prior to further seeding events.
- effective containment and reduction of existing high density coffee bush infestations via implementation of mechanical control programs followed by chemical control of emerging seedling and vegetative regrowth.

Weed control should be conducted according to current best practice observing the recommended timing for weed control for each of the target species (Table 4-2 Weed control calendar) using methods outlined in this plan developed for specific areas (see Section 4.4 Weed Management Actions). Any earthworks within weed infestations should be avoided during months when seed production and set occurs. Indeed access to weed infested areas should be limited and to further prevent spread, good hygiene practises (wash down of vehicles and other machinery in specific areas) should be implemented. The schedule in Table 4-2 provides information on the best timing for any earthworks within weed infestations of key weed species.

4.2 Weed Management Priorities

In accordance with the Weeds Management Act 2001 all landholders must control the growth and spread of Class B declared weeds and their management takes high priority within any WMP. Indeed the eradication of isolated or small infestations of declared weeds represents the objective with highest priority due to the potential to reduce spread into new areas. Weed species and recommended priorities for weed control at Casuarina campus are listed in Table 4-1

Table 4-1 Weed management priorities, obligations and broad management objectives for target weeds at CDU Casuarina campus during the 2017/18 season

Management Priority	Classification and Management Objectives
Priority 1: Gamba grass	**- declared a Class B/C weed (growth and spread to be controlled).**
	- active management program required under NT Weeds Act.
	- prevent spread, develop and implement strategic management program eradicating isolated plants and containing/reducing established infestations.
	- eradication in medium term.
Priority 2: Lantana	**- declared a Class B/C weed (growth and spread to be controlled).**
	- active management program required under NT Weeds Act.
	- eradicate all plants and prevent any further establishment across site.
Priority 3: Perennial mission grass	**- declared a Class B/C weed (growth and spread to be controlled)**
	- prevent further spread, implement strategic management program eradicating isolated plants and containing/reducing established infestations.
Priority 4: Coffee bush	
	- prevent further spread and establishment, develop and implement strategic management eradicating isolated plants and reducing established infestations.
Priority 5: Snake weed	**- declared a Class B/C weed (growth and spread to be controlled)**
	- prevent further spread and establishment, develop and implement strategic management eradicating isolated plants and reducing established infestations.
	- eradication in medium/long term.
Priority 6: Sida & Senna spp.	**- declared Class B/C weeds (growth and spread to be controlled)**
	- prevent further spread and establishment, develop and implement strategic management eradicating isolated plants and reducing established infestations.
	- eradication in medium term.
Priority 7: Annual mission grass	
	- prevent further spread and establishment, develop and implement strategic management program eradicating isolated plants and containing/reducing established infestations.
	- eradication in medium/long term.

4.3 Weed Management Schedule

A calendar indicating the growth and reproductive cycles of each of the priority weeds has been prepared (Table 4-2) providing a summary of information on the best timing for weed control, and the best methods/chemicals to be used for control of target species.

Table 4-2 Weed control calendar indicating annual cycle of weed growth and reproductive cycles

CALENDAR OF GROWTH CYCLE & CONTROL TIMES - PRIORITY & CLASS B WEEDS, CDU CASUARINA CAMPUS

Note: this indicates *general* growth cycle and control time patterns for the specified weeds. These times may vary with seasonal conditions and in accordance with the specifications of chemical labels and permits. Recommended control for specific areas of campus is presented in Tables 4.4.1 to 4.4.11

	Season	Wet Season						Dry Season					
	Month	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
GAMBA GRASS (Andropogon gayanus)													**CLASS A/B , WEED OF NATIONAL SIGNIFICANCE**
PRIORITY SP 1	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	FOLIAR APPLICATION OF GLYPHOSATE: SPOT / BROADACRE AFTER GERMINATION & PRIOR TO FLOWERING, APPLY IN NOV, FEB & APR											
	OTHER CONTROL	SPOT OR BROADACRE SPRAY GLYPHOSATE DURING ACTIVE GROWTH & BEFORE FLOWERING, LIMIT TRAFFIC & EARTHWORKS											
PERRENIAL MISSION GRASS (*Cenchrus polystachios*)													**CLASS B/C**
PRIORITY SP 2	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	FOLIAR APPLICATION OF GLYPHOSATE: SPOT / BROADACRE AFTER GERMINATION & PRIOR TO FLOWERING, APPLY IN NOV, FEB & APR											
	OTHER CONTROL	FOLIAR SPRAY GLYPHOSATE DURING ACTIVE GROWTH & BEFORE FLOWERING, REDUCE SPREAD - LIMIT TRAFFIC & EARTHWORKS											
GUINEA GRASS (Megathyrsus maxima)													**NOT DECLARED**
PRIORITY SP 3	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	FOLIAR APPLICATION OF GLYPHOSATE: SPOT / BROADACRE AFTER GERMINATION & PRIOR TO FLOWERING, APPLY IN NOV, FEB & APR											
	OTHER CONTROL	FOLIAR APPLICATION GLYPHOSATE WHEN ACTIVELY GROWING, REDUCE SPREAD -LIMIT TRAFFIC & EARTHWORKS											
COFFEE BUSH (Leucaena leucocephala)													**NOT DECLARED**
PRIORITY SP 4	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	BLACKBERRY KILLER (*TRICLOPYR*) IN MANAGED GROUNDS, *GRAZON EXTRA* IN MAJOR INFESTATIONS IN OTHER AREAS (NOV TO MAY)											
	OTHER CONTROL	SPOT / BROADACRE SPRAY, SELECTIVE CLEARING & BASAL BARK (*ACCESS*+DIESEL), FORESTRY MULCHER, REDUCE SPREAD											
ANNUAL MISSION GRASS (Cenchrus pedicellatum)													**NOT DECLARED**
	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	GLYPHOSATE: SPOT / BROADACRE FOLIAR APPLICATION											
	OTHER CONTROL	SPOT SPRAY GLYPHOSATE WHEN ACTIVELY GROWING & BEFORE FLOWERING, REDUCE SPREAD -LIMIT TRAFFIC & EARTHWORKS											
SPINYHEAD SIDA (Sida acuta)													**Class B/C**
	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	BLACKBERRY KILLER (*TRICLOPYR*) WITHIN MANAGED GROUNDS											
	OTHER CONTROL	MOWING/SLASHING PRIOR TO SEED SET, FOLIAR APPLICATION FOR JUVENILES, TREAT PRIOR TO FLOWERING & SEED PRODUCTION											
FLANNEL WEED (Sida cordifolia)													**Class B/C**
	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	BLACKBERRY KILLER (*TRICLOPYR*) WITHIN MANAGED GROUNDS											
	OTHER CONTROL	MOWING/SLASHING PRIOR TO SEED SET, FOLIAR APPLICATION FOR JUVENILES, TREAT PRIOR TO FLOWERING & SEED PRODUCTION											

Table 4-2 cont. Weed control calendar

NEEM (Azardirachta indica)													**Class B/C**
	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME					TRICLOPYR WITHIN MANAGED GROUNDS							
	OTHER CONTROL	FOLIAR APPLICATION FOR JUVENILES, BASAL BARK OR CUT STUMP FOR MATURE TREES. TREAT PRIOR TO FLOWERING & SEED SET											
	Season	**Wet Season**						**Dry Season**					
	Month	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
HYPTIS (Hyptis suaveolens)													**CLASS B/C**
	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	GLYPHOSATE DURING ACTIVE GROWTH & BEFORE FLOWERING											
	OTHER CONTROL	SLASHING WITH FOLLOW UP CHEMICAL CONTROL, TREAT PRIOR TO FLOWERING & SEED PRODUCTION											
PADDY'S LUCERNE (Sida rhombifolia)													**CLASS B/C**
	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	BLACKBERRY KILLER (*TRICLOPYR)* WITHIN MANAGED GROUNDS											
	OTHER CONTROL	FOLIAR APPLICATION OF *TRICLOPYR* FOR JUVENILES, TREAT PRIOR TO FLOWERING & SEED PRODUCTION											
LANTANA (Lantana camara)													**CLASS B/C, WEED OF NATIONAL SIGNIFICANCE**
	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME		TRICLOPYR WITHIN MANAGED GROUNDS										
	OTHER CONTROL	*TRICLOPYR* - FOLIAR FOR JUVENILES, BASAL BARK OR CUT STUMP FOR MATURE PLANTS.											
SICKLEPOD (Senna obtusifolia)													**CLASS B/C**
	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	FOLIAR APPLICATION FOR JUVENILES, TREAT PRIOR TO FLOWERING & SEED PRODUCTION											
	OTHER CONTROL	FOLIAR APPLICATION FOR JUVENILES & ACTIVELY GROWING PLANTS, TREAT PRIOR TO FLOWERING & SEED PRODUCTION											
SNAKEWEEDS (Stachytarpheta spp.)													**CLASS B/C**
	GERMINATION												
	FLOWERING												
	SEED FORMATION												
	SEED DROP												
	HERBICIDE & OPTIMUM TREATMENT TIME	FOLIAR APPLICATION FOR JUVENILES, TREAT PRIOR TO FLOWERING & SEED PRODUCTION											
	OTHER CONTROL	FOLIAR APPLICATION FOR JUVENILES & ACTIVELY GROWING PLANTS, TREAT PRIOR TO FLOWERING & SEED PRODUCTION											

In general, the best timing for any earthworks necessary within weed infestations is prior to flowering and seed set. Care should be taken in areas containing priority weeds to reduce spread, always limiting terrain disturbance to the minimum necessary and avoiding periods when weeds are fertile and producing seeds.

4.4 Weed Management Actions

Site specific recommendations for weed control for each area of the Casuarina campus were provided in Section 3.5.2 of the draft WMP (Metcalfe and Wingrave 2017) and included detailed instructions on the application of chemical control, appropriate sites for mechanical control (e.g. forestry mulcher) and timing in relation to weed reproductive cycles. Weed control within managed grounds and gardens is governed by permits regulating suitable chemicals safe for use in such areas and techniques may differ to those used less populated areas. Hence a site-specific approach, adopting control methods appropriate for each weed species present is necessary within the current survey area. The broad objectives for weed control outlined in late 2017 remain the same for the 2018/19 season but the recommended management actions required to achieve these goals have been revised on the basis of 2017/18 results and presented in Tables 4-3 to 4-11.

4.4.1 University Precincts

Table 4-3 - Weed control in all managed grounds/gardens in Green, Orange, Blue, Purple, Red, Brown and Yellow Precincts – 2018/19 Season

OBJECTIVE 1: ERADICATION OF ALL TARGET PLANTS WITHIN MANAGED GROUNDS/GARDENS ACROSS CDU SITE

Target species	Long term objective(s)	Action required + management tools	Milestones
Gamba + annual mission grass + perennial mission grass	- Eradication	- Foliar application of glyphosate prior to flowering. - Round 1 control prior to end of December. - Round 2 control by end of February. - Round 3 control prior to flowering at end of April.	- all plants treated prior to flowering/ seed production
ALL Coffee bush + lantana + snakeweed + neem + *Sida* spp. + *Senna* spp.	- Eradication	- Yates Tree and Blackberry Killer® (triclopyr) can be used as a foliar applied treatment for all seedlings/juveniles of all species listed as targets within managed grounds and/or gardens. - Yates Tree and Blackberry Killer® (triclopyr) can be used as a basal bark or cut stump treatment for any larger and/or mature neem trees or coffee bush within managed grounds and/or gardens.	- all plants treated prior to flowering/seed production.

IMPORTANT NOTE: It is recommended that glyphosate and Yates Tree and Blackberry Killer® be tank mixed together and used as the primary foliar applied herbicide mix for all weeds encountered within the managed grounds areas except juvenile and adult neem trees and coffee bush.
Juvenile and adult neem trees + juvenile and adult coffee bush can be effectively controlled using a cut stump treatment (or basal bark treatment) in managed grounds areas mixed at a ratio of 100 ml Yates Tree and Blackberry Killer® per 1 litre of kerosene.

See Appendix C for more detail regarding declared weeds recorded in gardens and landscaping in precincts in late 2017

4.4.2 Southern Buffer Zone

Table 4-4 - Weed control in Southern Buffer Zone: SB1 – 2018/19 Season

OBJECTIVE 1: EFFECTIVE CONTROL OF ALL GAMBA GRASS, ANNUAL & PERENNIAL MISSION GRASS PRIOR TO SEEDING
OBJECTIVE 2: EFFECTIVE CONTROL OF ALL MINOR COFFEE BUSH INFESTATIONS PRIOR TO FURTHER ESTABLISHMENT
OBJECTIVE 3: EFFECTIVE CONTAINMENT AND REDUCTION OF ESTABLISHED/MATURE COFFEE BUSH INFESTATIONS

Target species	Long term objective(s)	Action required + management tools	Milestones
Gamba + annual mission + perennial mission	- Eradication	- Foliar application of glyphosate prior to flowering. - Round 1 control prior to end of December. - Round 2 control by end of February. - Round 3 control prior to flowering at end of April.	- all plants treated prior to flowering/seed production.
Minor + isolated coffee bush sites	- Eradication of all plants prior to further on site establishment.	- Grazon Extra ® is recommended as a foliar applied treatment for all seedlings/juveniles. - Access® + diesel is recommended as a basal bark or cut stump treatment for any larger and/or mature plants.	- all plants treated prior to maturity.
Major coffee bush site	- Initial containment and reduction of the more established infestations. - Eradication in longer term.	-Treat any remaining mature high density sites with forestry mulcher to remove standing growth. - Recommend to follow up control of these areas with foliar application of Grazon Extra ® after sufficient level of regrowth has occurred. - Repeat foliar treatments will be required in order to manage emerging seedlings + any missed regrowth.	- site contained no further spread - infestation reduced - eradicated in longer term

Table 4-5 - Weed control in Southern Buffer Zone: SB2 – 2018/19 Season

OBJECTIVE 1: EFFECTIVE CONTROL OF ALL GAMBA GRASS, NEEM, ANNUAL & PERENNIAL MISSION GRASS PRIOR TO SEEDING/MATURITY.
OBJECTIVE 2: EFFECTIVE CONTROL OF ALL MINOR/SMALL COFFEE BUSH INFESTATIONS PRIOR TO FURTHER ESTABLISHMENT.
OBJECTIVE 3: EFFECTIVE CONTAINMENT AND REDUCTION OF ESTABLISHED/MATURE COFFEE BUSH INFESTATIONS.

Target species	Long term objective(s)	Action required + management tools	Milestones
Gamba + annual mission grass + perennial mission grass.	- Eradication	- Foliar application of glyphosate prior to flowering. - Round 1 control prior to end of December. - Round 2 control by end of February. - Round 3 control prior to flowering at end of April.	- All target plants controlled prior to flowering.
Neem	- Eradication	- Grazon Extra ® is recommended as a foliar applied treatment for all seedlings/juveniles. - Access® + diesel is recommended as a basal bark or cut stump treatment for any larger and/or mature plants within these areas.	- All target plants controlled prior to maturity.
Minor + isolated coffee bush sites	- Eradication	- Grazon Extra ® is recommended as a foliar applied treatment for all seedlings. - Access® + diesel is recommended as a basal bark or cut stump treatment for any larger and/or mature plants within these areas.	- all plants treated.
Major coffee bush sites	- Initial containment and reduction of the more established infestations. - Eradication in longer term.	- Recommended to initially treat mature high density sites with forestry mulcher to remove standing growth leaving as much native vegetation as possible. - Access® + diesel is recommended as a basal bark or cut stump treatment for any larger/mature plants missed with forestry mulcher. - Recommend to follow up control of these areas with foliar application of Grazon Extra ® after sufficient level of regrowth has occurred. - Repeat foliar treatments using Grazon Extra ® will be required in order to manage emerging seedlings + any missed regrowth.	- site contained and no further spread occurs. - area of infestation reduced. - area eradicated in longer term.

Table 4-6 - Weed control in Southern Buffer Zone: SB3 – 2018/19 Season

OBJECTIVE 1: PREVENTION OF FURTHER SPREAD OF SNAKEWEED, GAMBA GRASS, ANNUAL & PERENNIAL MISSION GRASS, SENNA & SIDA SPECIES
OBJECTIVE 2: EFFECTIVE CONTROL OF ALL GAMBA GRASS, ANNUAL & PERENNIAL MISSION GRASS, SENNA & SIDA SPECIES, SNAKEWEED & NEEM PRIOR TO SEEDING/MATURITY.
OBJECTIVE 3: EFFECTIVE CONTAINMENT AND REDUCTION OF ESTABLISHED/MATURE COFFEE BUSH INFESTATIONS.

Target species	Long term objective(s)	Action required + management tools	Milestones
All gamba grass, annual & perennial mission grass, snakeweed, Sida & Senna spp. found around sites CB1, CB2 & CB3.	- Eradication	- Foliar application of glyphosate + Grazon Extra® prior to mowing/slashing area surrounding major coffeebush infestations - Foliar application of glyphosate + Grazon Extra® prior to flowering	- all target plants controlled prior to mowing /slashing. - All targets controlled prior to flowering.

Weed control in SB3 cont.			
Target species	**Long term objective(s)**	**Action required + management tools**	**Milestones**
Neem	- Eradication	- Grazon Extra ® is recommended as a foliar applied treatment for all seedlings/juveniles. - Access® + diesel is recommended as a basal bark or cut stump treatment for any larger and/or mature plants within these areas.	- all plants controlled prior to maturity.
Major coffee bush sites	- Containment and reduction of the more established infestations.	- Recommended to initially treat mature high density sites with forestry mulcher to remove standing growth leaving as much native vegetation as possible. - Access® + diesel is recommended as a cut stump treatment for any larger/mature plants missed with forestry mulcher. - Recommend to follow up control of these areas with foliar application of Grazon Extra ® after sufficient level of regrowth has occurred. - Repeat foliar treatments using Grazon Extra ® will be required in order to manage emerging seedlings + any missed regrowth.	- site contained and no further spread occurs. - area of infestation reduced. - area eradicated in longer term.

4.4.3 Priority Management Zone 1

Table 4-7 - Weed control in Priority Management Zone 1 - 2018/19 Season

OBJECTIVE 1: ERADICATION OF COFFEE BUSH FROM SITE + PREVENTION OF RE-ESTABLISHMENT.
OBJECTIVE 2: EFFECTIVE CONTAINMENT AND REDUCTION OF ESTABLISHED AREA GAMBA & GUINEA GRASS, ANNUAL & PERENNIAL MISSION GRASS.
OBJECTIVE 3: ERADICATION OF GUINEA GRASS + HYPTIS FROM SITE

Target species	**Long term objective(s)**	**Action required + management tools**	**Milestones**
Hyptis	- Eradication	- Foliar Glyphosate prior to flowering.	
Coffee bush	- Eradication	- Access® + diesel is recommended as a cut stump treatment for any larger/mature single plants missed during 2017-18 season - Recommend follow up control of these areas with foliar application of Grazon Extra ® if a sufficient level of regrowth has occurred. - Repeat foliar treatments using Grazon Extra ® will be required in order to manage emerging seedlings + any missed regrowth.	- All plants treated. - Follow up work completed prior to further flowering and/or seed production.
Gamba grass + annual mission grass + perennial mission grass + Guinea grass	- Creation of **30 m** wide grass weed free buffer along the western and southern edge - Creation of **50 m** wide grass weed free buffer along the northern and eastern edge	- Foliar application of glyphosate prior to flowering. - Round 1 control prior to end of Dec - Round 2 control by end of February. - Round 3 control prior to flowering at end of April. **Inspect 50 m buffer on northern edge for any regrowth of Guinea grass**	- All plants within specified buffer(s) treated. - Follow up work completed within buffer prior to further flowering and/or seed production.

4.4.4 Priority Management Zone 2

Table 4-8 - Weed control in Priority Management Zone 2 – 2018/19 season			
OBJECTIVE 1: ERADICATION OF COFFEE BUSH FROM SITE + PREVENTION OF RE-ESTABLISHMENT. OBJECTIVE 2: EFFECTIVE CONTAINMENT AND REDUCTION OF ESTABLISHED AREA GAMBA GRASS, ANNUAL & PERENNIAL MISSION GRASS			
Target species	**Long term objective(s)**	**Action required + management tools**	**Milestones**
Coffee bush	- Eradication	- Access® + diesel is recommended as a cut stump treatment for any larger/mature single plants missed during 2017/18 season - Recommend to follow up control of these areas with foliar application of Grazon Extra ® when a sufficient level of regrowth has occurred. - Repeat foliar treatments using Grazon Extra ® will be required in order to manage emerging seedlings + any missed regrowth.	- All plants treated. - Follow up work completed prior to further flowering and/or seed production.
Gamba grass + annual mission grass + perennial mission grass.	- Creation of 30 m wide grass weed free buffer along all edges of this site.	- Foliar application of glyphosate after germination, prior to flowering. - Round 1 control prior to end of December. - Round 2 control by end of February. - Round 3 control prior to flowering at end of April.	- All plants within specified buffer(s) treated. - Follow up work completed within buffer prior to further flowering and/or seed production.

4.4.5 Priority Management Zone 4

Table 4-9 - Weed control in Priority Management Zone 4 – 2018/19 season			
OBJECTIVE: ERADICATION OF LANTANA FROM SITE			
Target species	**Long term objective(s)**	**Action required + management tools**	**Milestones**
Lantana	- Eradication	- Grazon Extra ® is recommended as a foliar applied treatment for lantana.	- All plants treated. - Follow up work conducted prior to further flowering and/or seed production.
IT IS RECOMMENDED THAT MANAGEMENT OF THE EXTENSIVE HIGH DENSITY COFFEE BUSH INFESTATION AT THIS SITE DOES NOT COMMENCE UNTIL ALL EXISTING COFFEE BUSH HAS BEEN EFFECTIVELY TREATED IN MANAGEMENT ZONES 1, 2, AND AFTER COMPLETION OF FOLLOW- UP CONTROL AND REPLANTING ALONG THE SOUTHERN BUFFER ZONE.			

4.4.6 Priority Management Zone 3

Table 4-10 - Weed control in Priority Management Zone 3- 2018/19 season			
OBJECTIVE: ERADICATION OF SIDA SPP. FROM SITE			
Target species	**Long term objective(s)**	**Action required + management tools**	**Milestones**
Sida rhombifolia	- Eradication	Yates Tree and Blackberry Killer® (triclopyr) be used as a foliar applied treatment	- All plants treated in 2017/18 - Follow up control advised if found

4.4.7 Priority Management Zone 5

Table 4-11 – Weed control in Priority Management Zone 5 – 2018/19 season

OBJECTIVE 1: ERADICATION OF COFFEE BUSH FROM SITE + PREVENTION OF RE-ESTABLISHMENT
OBJECTIVE 2: ERADICATION OF ALL GAMBA GRASS, ANNUAL & PERENNIAL MISSION GRASS + SIDA SPP FROM SITE PRIOR TO ANY FURTHER ESTABLISHMENT.

Target species	Long term objective(s)	Action required + management tools	Milestones
Gamba grass, perennial mission grass, seedling and juvenile coffee bush and *Sida* spp.	- Eradication	- Foliar application of glyphosate + Grazon Extra® prior to flowering.	- All plants treated. - Follow up work conducted prior to further flowering
Coffee bush (adult)	- Eradication	- Recommended to initially treat any mature higher density parts of this site with forestry mulcher to remove standing growth. - Access® + diesel is recommended as a cut stump treatment for any larger/mature single plants missed with forestry mulcher. - Recommend to follow up control of these areas with foliar application of Grazon Extra ® after sufficient level of regrowth occurred. - Repeat foliar treatments using Grazon will be required in order to manage emerging seedlings + any missed regrowth.	- All plants treated. - Follow up work conducted prior to further flowering and/or seed production.

It should be noted that clearing of dense stands of vegetation, including coffee bush generally requires a permit and the Planning Act controls clearing on land in the Darwin region, subject to the operation of other pieces of legislation listed below. The Act controls land clearing through the mechanism of assessing applications for development and by reference to the requirements of the NT Planning Scheme. Clearing may also be impacted by other legislation such as the Soil Conservation and Land Utilization Act, which provides for the prevention of soil erosion and for the conservation and reclamation of soil. For example a soil conservation order may be issued if clearing or other actions on an area of land might create a danger of soil erosion.

A land clearing permit was obtained by Facilities Management prior to removal of coffee bush in Lots 9260, 9375 and 8640 in January 2018 (red hatching in Figure 4-3) for the southern buffer zone area. On-going assistance with weed control and revegetation work during early 2018 was provided by Greening Australia, CDU staff, academics and students, the Green Army (volunteers) and horticulture students from Certificate 2 and 3 studying at CDU.

4.5 Significant sources of seed & prevention of spread

At the end of the 2017/18 control season, no significant sources of seed for the three priority species gamba, Guinea grass nor perennial and annual mission grasses remained within the Casuarina campus. It is expected that gamba and other grassy weeds may be eliminated from zone 2 (1.36 ha) this season and the time required to achieve the same result in zone 1 (5.28 ha) will be substantially less than expected at the commencement of this project. Seed from gamba grass will only remain viable in the soil for one year, which facilitates it's eradication from areas in which there is timely control and where seed introduction and spread has been is prevented.

By contrast, coffee bush infestations in the southern buffer zone (SB2 and SB3) and zone 4, still represent a significant source of seed. Coffee bush seed also has high longevity so germination in these areas will continue long after weed removal has occurred.

Populations of other Class B declared species that were not treated during the 207/18 season occur within the several precincts and represent a less significant source of weed seed. For example, numerous mature neem trees in brown precinct and some small infestations of hyptis at the interface of yellow precinct and PMZ 1 (Figure 3-7) may represent a source of seed during the 2018/19 season.

Minor sources of seed associated with single plants or small clumps of priority weeds are also present within a number of university precincts which were not treated for target species (particularly in green, red, brown and pink precincts). Further detail on the location and density of declared and environmental weeds recorded in these precincts is provided in Appendix C.

Overall, mapping of dense coffee bush infestations (Figure 3.3) delineates the most significant sources of seed at the end of the 2017/18 control season. Priorities for prevention of spread are listed in Section 4.2 and a detailed program to prevent spread with specific actions to be implemented in each area of the university are listed in Section 4.4. Where appropriate, these actions include

- the hygienic management of mulch to avoid the spread of coffee bush and the exotic ground orchid
- prevention or limiting access and earthworks within fertile weed infestations
- routine washdown of machinery and mowers after use in areas with high weed density or containing declared or priority species, and
- the creation of weed-free buffers as part of weed control for grassy weeds.

Several of these recommendations are summarised in the weed control calendar (Table 4-2) which provides key information on germination, flowering and fruiting for all target weeds to inform the timing of weed management and earthworks, along with optimum times for weed control. These recommendations represent good land management practice which will avoid the proliferation and spread of weeds on campus.

4.6 Weed-free areas of ecological value

Priority management zone 1 contains the most intact area of healthy native bushland within the Casuarina campus. The eastern section contains Stringy bark woodland with a mean height of 16 m over a diverse mid layer of low trees and shrubs including numerous cycads (*Cycas armstrongii)* which are listed as Vulnerable under NT legislation (Figure 4-1). The western section of zone 1 is dominated by *Corymbia polysciada* open woodland with a mean height of 11 m on poorly drained soils with areas of low woodland with *Terminalia ferdinandiana*.

Figure 4-1 Eucalyptus woodland in management zone 1 is the focus for numerous scientific experiments and is a valuable teaching facility (left) a central weed-free area with native plant species of ecological value including threatened species *Cycas armstrongii* (right)

Weed surveys conducted in November 2017 found the perimeter of this area had relatively dense infestations of declared Class B weeds gamba and mission grass which covered approximately two thirds of the area with an average

density of 25 % cover. The central section of this management zone was however, relatively free of introduced grasses and other weeds (Figure 4-2). During November 2017 this central area contained target grasses in very low density but they were not very evident at the time and in comparison with the remainder of Zones 1 and 2, was relatively weed free. The high scientific, educational and natural values of this area are particularly threatened by invasion of gamba and other introduced grasses, which exclude native species, change water relations in forests, reduce biodiversity and dramatically change fire regimes.

The ecological value of this bushland increases with the diminishing area of remnant bushland remaining in the Darwin region. These woodland communities are valuable habitats, of importance for biodiversity conservation and as a fauna corridor. The area's importance as a valuable educational and scientific resource is underscored by its proximity to the CDU science building and the prevalence of ecological studies and research projects that have been conducted in this area. Recent research includes PhD studies on the Black-footed Tree Rat including the monitoring of nest boxes specifically designed for this species which have been attached to forest trees in this area.

Given the importance of this area for current and previous scientific research and teaching (refer to Appendix D for details) it is imperative that the evident invasion of exotic grasses is curtailed and a vigilant weed control program is maintained in this area until it is weed-free. The current program of chemical control during the 2017/18 season has reduced grassy weeds to less than 1% throughout, when assessed in May – June 2018 (Figure 3-5, Section 3.2.1) representing substantial progress in this regard. The area of weed free native vegetation on campus will undoubtedly expand in future with consistent integrated weed control and monitoring .

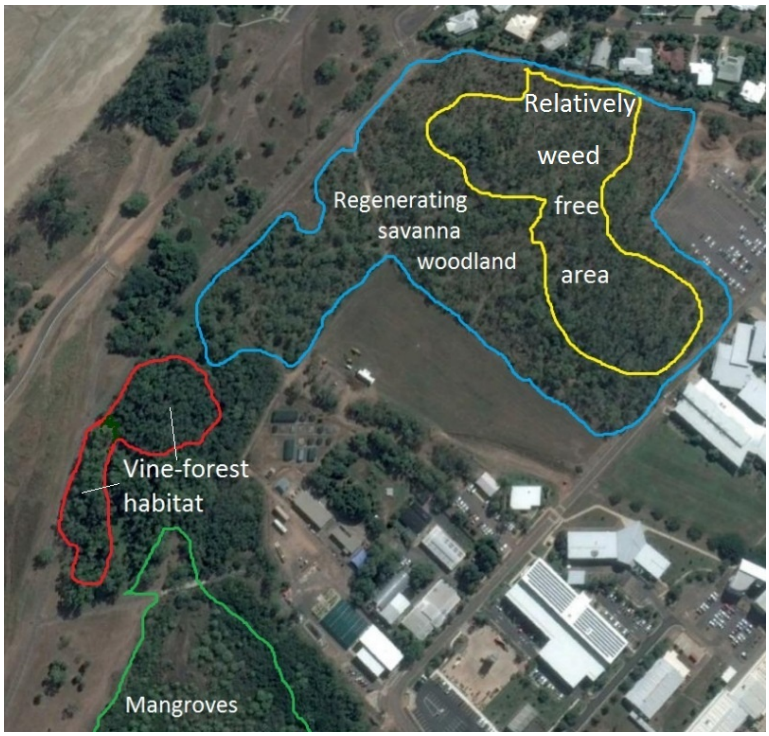

Figure 4-2 Map of western section of Casuarina campus showing approximate distribution of relatively weed free area in November 2017 (yellow outline) and native vegetation of ecological value including regenerating savannah woodland (blue). Areas of vine-forest habitat (red) occur within the university campus while mangrove vegetation (green) occurs within the adjacent Casuarina coastal reserve

Monsoon vine forest vegetation comprising low closed forest with Pongamia (*Millettia pinnata*), *Micromelum minutum* with emergent Black Wattle (*Acacia auriculiformis*) occurs on deep organic sandy soils, situated partly within zone 4 and extending into the adjoining Casuarina Coastal Reserve (Figure 4-2). A range of other vine forest species occur within this community including *Bombax ceiba, Flueggea virosa, Ganophyllum falcatum, Wrightia pubescens, Sterculia quadrifida* and *Smilax australis*. The area is subject to flooding and poorly drained conditions during the wet season and the vegetation had been unburnt for a long time (DENR, 2017). As many vine forest species are fire sensitive, this area represents a valuable refuge for vegetation that has a naturally patchy distribution and is very limited in extent across the Top End.

The Northern Territory Government Planning Scheme (NTG, 2010) defines vine-forest habitat as a 'sensitive and significant' vegetation community. Monsoon vine forest habitat naturally occurs as small, disjunct patches within the landscape (Russell Smith and Bowman 1992, Panton 1993). Research by Price et al. (1998) and Russell-Smith et al. (1992) stresses the importance of conserving each small area as it forms part of an important network in the landscape. So the conservation of discrete isolates such as that found in at CDU are important for maintaining the diversity and integrity of the interrelated network of Top End vine forests – particularly as a habitat and resource for fruit eating birds and bats. It also represents a valuable refuge and fauna corridor that links with other woodland vegetation in zones 1 and 2 as well as other closed forests within the mangrove corridor lining Rapid Creek.

The small area of vine-forest is unfortunately surrounded by extremely dense forests of coffee bush that pose significant challenges for initial clearing and follow-up control (see Section 3.2.4). Several other weeds also occur within the native vine forest including Class B weed *Lantana camara* and several well established large ivy gourd vines. Although the latter may be a naturalised species, it can rapidly increase in density and smother host vegetation (Appendix C) and should be removed from this habitat. Weed control in zone 4 has been deliberately postponed until other areas have been treated and rehabilitated. Complex control operations in this area will benefit from the insight and experience gained elsewhere on campus in protecting native vegetation while attempting to eradicate coffee bush from the site.

4.7 Tropical Cyclone Marcus

On 17 March 2018 category two storm Tropical Cyclone Marcus passed over Darwin with wind gusts to 130 km hr with sustained winds of 95 km hr near the centre. The cyclone caused considerable damage to trees and vegetation all across the Casuarina campus. It was presumably the most severe storm to damage vegetation on campus since Cyclone Tracey in 1974. Significant destructive impacts included the loss of many canopy trees, particularly mature African mahogany and Eucalyptus species, wind sway, root damage, branch and trunk damage and partial defoliation. Understorey species exposed by the loss of tree canopy were also affected by increased sun exposure.

TC Marcus immediately resulted in a significant increase in germination of target grasses. It is anticipated that the short-term disturbance created by the cyclone – particularly terrain associated with lifting of root systems of fallen trees and widespread decline in canopy cover across the site - will significantly encourage the establishment and proliferation of weeds during the 2018-19 season. The reduction in the number of mahogany trees is of long-term benefit for weed management at CDU however, as the cyclone resulted in a substantial decline in sources of seed.

4.8 Adjoining lands

The Charles Darwin University campus site is comprised of sections 9260 and 9198 and occupies an area of approximately 57 hectares. Along the southern boundary the site is adjoined by Vacant Crown Land (section 8702), Casuarina Coastal Reserve (section 9375) and also land (section 8640) owned/managed by City of Darwin (Figure 4-3). Field survey of section 8702 indicated there were no significant weed issues requiring consideration in relation to the development and implementation of a strategic weed management program for the Charles Darwin University site.

Survey of the land adjoining the southern edge of the CDU campus however indicated the presence of significant established high density infestations of coffee bush with additional minor areas affected by a range of species including gamba grass, snakeweed, *Sida* spp. and annual and perennial mission grass (Figure 3-5). Control of coffee bush in this area would benefit from a joint approach to management and follow up control. These areas interface with section 9375 (Casuarina Coastal Reserve) and section 8640 (Darwin City Council). However, coffee bush is not a declared weed in the NT and as such, these adjoining landholders do not have an obligation to undertake any level of management relating to these species.

It is recommended that during the forthcoming season CDU continue management of all minor infestations of gamba grass, snakeweed, *Sida* spp. and mission grass on these lands as minimal resource inputs are required and the strategic benefit gained in regard to the broader weed management program at CDU is immediate and significant.

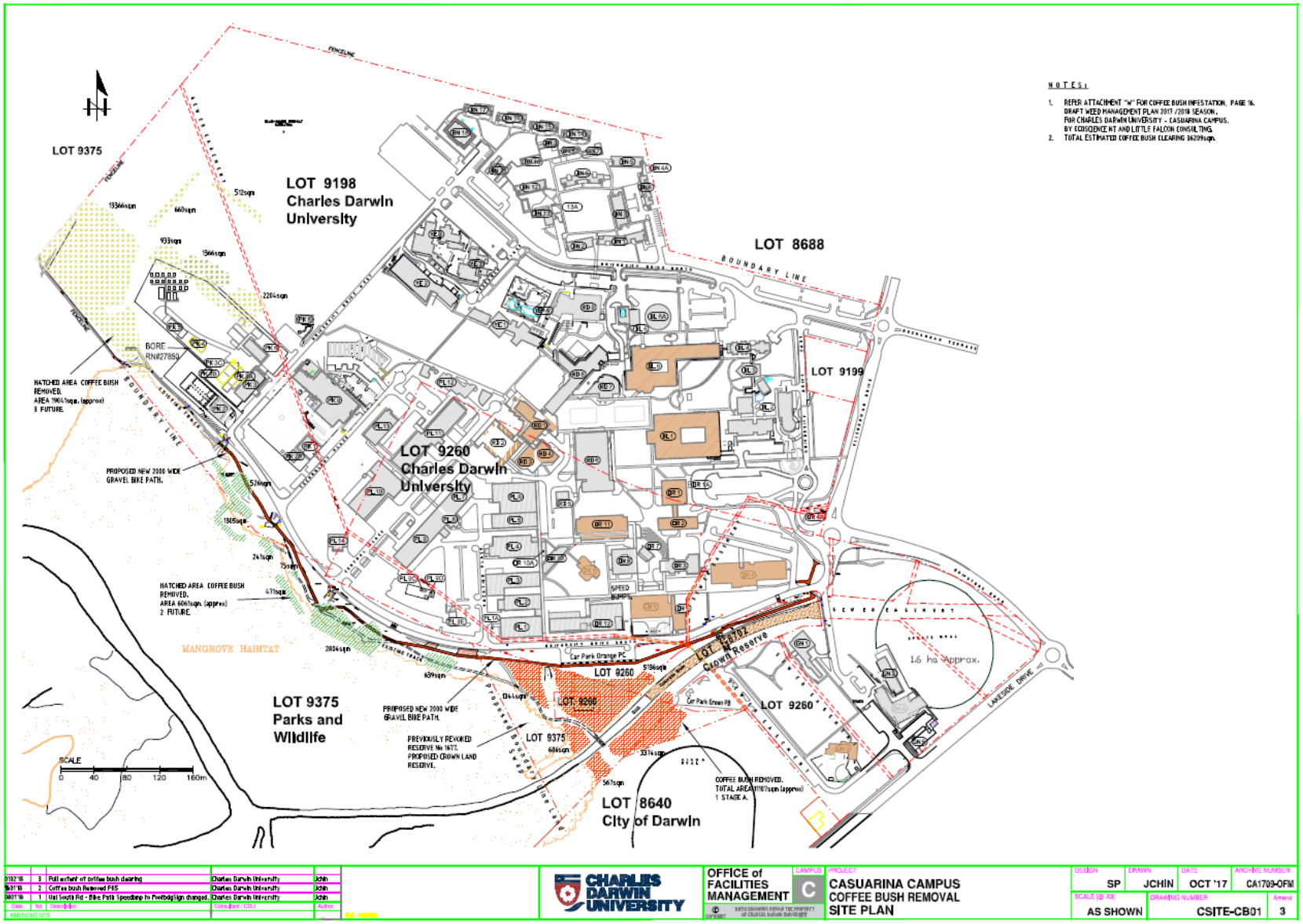

Figure 4-3: Map showing coffee bush removal areas and cadastral boundaries indicating land ownership for properties adjoining the southern boundary of Casuarina campus

4.8.1 Options for co-ordinating weed control with neighbouring land-holders

Liaison with neighbouring land-holders, including City of Darwin and Northern Territory Government Department of Parks and Wildlife revealed several mutually beneficial approaches to weed control within the southern buffer zone. These were explored during the 2017/18 season in regard to the more significant infestations of coffee bush in these areas. A Trees for Wildlife landholders agreement was signed between CDU and NT Parks and Wildlife Commission on 8 January 2018. In February 2018, after initial management of high density coffee bush, CDU in collaboration with Greening Australia developed and implemented a native revegetation plan (with a particular focus on creating habitat for the Black-footed Tree Rat).

In order to develop and implement an effective weed management program at CDU it is recommended that all neighbouring landowners are approached in order to gain the benefit of their participation. This will reduce the occurrence of repeated reinfestation of previously treated areas within the CDU project area.

4.8.2 Future Monitoring

In order to allow for on-going fine-tuning of the weed management program at Charles Darwin University it is recommended that a program monitoring process be developed and implemented.

This process should involve the gathering of information in relation to weed species density, distribution and reproductive status at the pre- and post- treatment stages of the program in addition to an assessment of the overall effectiveness of on-ground management efforts. This information can then be considered in conjunction with other information including all labour input, herbicide input and equipment usage for the purpose of program review.

This information can be used to assess whether the aims and objectives for each species and/or priority management area are being met and to identify where improvements can be made. As such it is recommended that this program is subjected to a mid-season (checking on-site progress) and post-control season assessment (considering all program results and inputs). It is then recommended that the operational program for the 2018/19 management season be updated accordingly as required.

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APPENDIX A - CONSULTANTS BRIEF

Consultants Brief: Development of a Weed Management Plan and related advice for CDU Casuarina site

The Weed Management Plan should provide an understanding of the issues relating to weeds on the Casuarina Campus as per the deliverables below. It should also contribute to the development of a new Master plan for the campus.

Step 1: Assess your situation

What are your:	**Response**	**Deliverables**
Priority weed species	Gamba grass Coffee bush Mission Guinea	Define the scope – relative to magnitude.
Priority control areas	These are notionally been identified as zones 1 to 5	Review current CDU thinking and provide advice.
High risk areas for weed spread	Yet to be identified	Assess site and identify – show won map
Significant weed seed sources	Yet to be identified	Identify and consider implications – show on map if possible
Clean and valuable areas	Yet to be identified	Advice required regarding relative value (why are they valuable?) – show on map.
Options for co-ordinating weed control with neighbours	Yet to be identified	Could be useful – stakeholder NTG and DCC. How would this be done?

Step 2: Develop a Plan

Tasks	**Response**	**Deliverables**
Draw a property map	CDU has existing plan	Provide to consultant. CDU will amend on advice.
Identify isolated plants and outbreaks for eradication	Yet to be identified	Areas identified, treatment strategy. To be shown on map.

Identify major infestations for containment	Yet to be identified	Areas identified, treatment strategy. To be shown on map.
Determine necessary buffer zones	Review existing	Identify need for additional of existing to remain. To be shown on map.
Develop a weed control calendar taking into account weed growth and reproductive cycles	Yet to be done	Draft calendar
Design a weed spread prevention program	Yet to be done	Draft program developed
Cost all planned control works, including follow up	Yet to be done	Annual follow – Ref Step 4

Step 3: Plan implementation

Task	Response	Deliverables
Undertake integrated weed control activities. • Physical • Chemical • Grazing • Fire • Biocontrol	Yet to be identified	Provide advice on control activities as applicable. Specifically use of chemicals and any biocontrol's.
Complement with good land management techniques to avoid weed germination and spread.	Yet to be identified	Provide advice best practice land management practices.

Step 4: Monitor and Review

Task	Response	Deliverables
Regularly conduct surveys to detect new and re-establishing weeds	Yet to be identified	Consultants to provide indicative price for annual follow up.
Record/photograph control results (success and failure)	Internal	
Document costs and resources	Internal	
Review your plan		

APPENDIX B - OTHER WEED SPECIES

A number of weed species that are not declared under NT or Commonwealth legislation were recorded within the survey area during the 2017/18 season. These species are described here as they are of some concern due to their potential as environmental weeds that may become invasive, or represent a significant future management issue on the Casuarina campus. Figure 5-4 shows the distribution of these species in November 2017.

Exotic Ground Orchid (*Eluophia graminea*)

Eulophia graminea is an exotic ground orchid without a common name, native to tropical and subtropical parts of Asia including India, Southeast Asia and Sothern China. In the NT this species is recognised as a potentially invasive plant that was first collected in 2001 and is currently only known from the Darwin region. In and around Darwin the orchid is typically found growing in woodchip mulched garden beds (Macrae 2002). It has also been reported from Queensland (PIER 2008).

E. graminea is classified as a newly naturalized ground orchid in Florida, where it is still rare but becoming more of a problem. It favors open, sunny habitats where it is often seen partially buried in a thick woodchip mulch layer. The naturalized orchid plants can spread by airborne seeds and pseudobulbs moved in mulch and soil. The orchid may become a future pest problem so it is recommended that control measures be adopted now. Exotic ground orchid was observed in low densities in gardens in Orange, Purple and Red Precincts (Figure 5-1)

Figure 5-1 Exotic ground orchid showing pseudobulb (left) typical growth habit in mulched garden beds (centre) and isolated plant observed in orange precinct (right)

Ivy gourd (Coccinea grandis)

C. grandis is believed to be native to central Africa, India and Asia. However, its long history of use, cultivation and transportation by people has obscured its origin. In Australia, ivy gourd is not a prohibited or restricted invasive plant under the Biosecurity Act 2014 as it may have been introduced to Australia prior to European settlement (Technigro, 2011). The origin of C. grandis is confused and some early literature listed this species as native to Australia. However, the Queensland Herbarium currently lists this species as 'naturalised' (not native).

There is considerable evidence in the literature to suggest that *C. grandis* has the potential to become a significant weed in Queensland and the Northern Territory (DAF, 2016). In particular, it has a history as a significant weed in Hawaii and Fiji and has naturalised in numerous other countries (PIER, 2017). Its impact in Hawaii was sufficient to justify listing as a noxious weed and biological control research.

An aggressive vine, which climbs over and envelops shrubs and trees, it can totally smother riparian vegetation forming a dense canopy that impedes light penetration and prevents the growth and regeneration of native plants. Across northern Australia, ivy gourd is found in the Kimberley region of Western Australia, in Arnhem Land, Darwin

and the Gulf region in the Northern Territory. North Queensland currently has small, scattered populations. Ivy gourd can smother vegetation and other objects, forming a dense canopy (Figure 5-2). It has the potential to spread if not controlled. Within the survey area Ivy gourd was found amongst vegetation surrounding the horticultural compound and in vine-forest vegetation in the far south western corner of the campus.

Figure 5-2 Images of ivy gourd showing flowers, fruit and growth habit of this smothering vine which potentially represents a significant management issue and environmental weed

Ivy gourd has been described as very difficult to control, as all roots and stem fragments must be removed or plants will regrow from tuberous root system. Seeds can also be dispersed by birds and feral pigs. No herbicide is currently registered for control of ivy gourd in Queensland and in Hawaii, foliar application has proved successful only on small, young plants. Cut-stump application of herbicides will be more effective. Ivy gourd was recorded in Priority Control Zones 4 and 5 in dense vine-forest and disturbed woodland respectively (Figure 5-4).

Figure 5-3 Distribution of other weed species of concern recorded within the CDU campus during the 2017/18 season

Ogiera or Eleutheranthera

Ogiera (*Eleutheranthera ruderalis*) is a weed of agriculture and disturbed places that has become naturalised in western Australia, NT, Cape York Peninsula and North-east Queensland. In the Darwin region Eleutheranthera forms dense carpets in lawns, garden beds, along tracks, roadsides and other disturbed places. It appears to spread rapidly from seed and potentially represents a maintenance issue and reputed to be a pest species at the Territory Wildlife Park (Figure 5-3).

Figure 5-4 Eleutheranthera forms dense ground cover in some areas of Green precinct (far left) and in garden beds near the gym (far right) and bordering the strand.

Eleutheranthera was recorded in several locations within the survey area with the most notable infestations in garden beds within the Green and Red precincts (Figure 5-4).

APPENDIX C – UNIVERSITY COLOURED PRECINCTS
WEED DIVERSITY, DISTRIBUTION & RECOMMENDED CONTROL

	GREEN PRECINCT
Description	Green Precinct is located in the SE corner of campus and is bordered by Lakeside drive and Dripstone Road. It contains one large oval (grassed and weed free) a smaller playing field and is contains a number buildings (including gym and childcare centre), carparks with garden beds.
Weeds	Five declared weed species, sicklepod, lantana, snake weed, neem tree and gamba grass were recorded in November 2017. Sicklepod was recorded in garden beds (*Senna obtusifolia*), two isolated clumps of gamba were recorded near the small playing field and lantana near Lakeside Drive. Other invasive species included coffee bush and annual mission grass.
Priorities for Control	Eradicate the five declared species from this precinct as they occur in small discrete populations. Secondary priority for control is treat coffee bush in all areas with aim to eradicate. Long term goal would be to remove the african mahogany trees (major source of seed) to reduce maintenance burden. They are also a recognized HSE risk.
Management Issues	Extremely dense regeneration of african mahogany seedlings in garden beds. Other introduced species of concern present in green precinct (near Childcare centre) are Yellow Oleander, Mother-in-laws Tongue (*Sanserviera* sp) and Curry Tree
Weed Management Objectives 2018/19	➢ **Eradicate Lantana from this area - highest priority for control** ➢ **Eradicate isolated gamba grass clumps from this precinct - high priority for control** ➢ **Control coffee bush to prevent spread, aim to eradicate from Green Precinct** ➢ **Garden beds near gym contain declared *Senna obtusifolia* (Sicklepod) and invasive species Itch Grass *(Rottboellia cochinchinensis*)** ➢ **Green Precinct contains many mature African Mahogany trees - significant seed source**
	ORANGE PRECINCT
Description	Orange precinct is located in the SE section of campus and is bordered by University Drive South. It contains numerous buildings, two main carparks, with new and established garden beds.
Weeds	Two declared weed species neem tree and gamba grass were recorded within orange precinct in November 2017. Other invasive species included coffee bush and annual mission grass.
Priorities for Control	Orange precinct is largely free of declared weed infestations. Weed management priorities include eradicating the two declared species from this precinct as they occur in small discrete populations. Secondary priority is to control coffee bush in all areas with aim to eradicate from this area.
Management Issues	New garden beds are relatively weed free. Older garden beds often have extremely dense regeneration of African mahogany seedlings. Important to remove Mahogany seedlings before they become mature trees. Other introduced species of concern present in orange precinct include dense seedlings of fishtail palm (*Caryota mitis*), Chinese Ground Orchid (*Eulophia graminea*) and seedlling Poinciana trees (*Delonix regia*)
Weed Management Objectives 2018/19	➢ **Eradicate isolated gamba grass clumps from this precinct - high priority for control** ➢ **Eradicate neem trees from garden beds - high priority for control** ➢ **Treat isolated clumps/plants of coffee bush to prevent spread, aim to eradicate from orange precinct**

	PURPLE PRECINCT
Description	Purple precinct, located in the SW section of campus is bordered by University Drive South. It contains numerous buildings and large carparks, grassed areas and a number of small well-established gardens
Weeds	No declared species were observed in Purple precinct in November 2017. Seedlings of annual mission grass were observed near drain outfall in southern section
Priorities for Control	Recommended control of coffee bush and exotic ground orchid to eradicate these species from this area.
Management Issues	Ensure machinery and use of mulch does not introduce or spread weed seed.
Weed Management Objectives 2018/19	➢ **Control isolated plants of annual mission grass within purple precinct** ➢ **Control four recorded infestations of coffee bush** ➢ **Remove medium density infestation of chinese ground orchid**

	RED PRECINCT
Description	Centrally located, red precinct contains the Library and Student Square, the eastern end of the strand (extensive grassed area) and a variety of courtyards, lawns, ornamental and ceremonial gardens
Weeds	Three declared weed species recorded within Red Precinct in November 2017. These include snakeweed - in garden bed in Library courtyard, and sicklepod *Senna obtusifolia* - in gardens between the Library and Menzies school of health. Isolated neem tree seedlings were recorded, including one in Boab Court.
Priorities for Control	Eradicate declared species from red precinct. All in occur in small populations and can be effectively eliminated.
Management Issues	It appears both coffee bush and chinese ground orchid (*Eulophia graminea*) may have been introduced within mulch to garden beds in this precinct. Strict hygenic management of mulching practices is recommended in future.
Weed Management Objectives 2018/19	➢ **Eradicate declared species snake weed (*Stachytarpheta cayennensis*) from Library courtyard garden** ➢ **Eradicate declared sicklepod (*Senna obtusifolia*) from garden near Menzies building** ➢ **Eradicate isolated neem plant from Boab Court** ➢ **Eradicate isolated coffee bush plants (see mapping)** ➢ **Remove ground orchid (*Eulophia graminea*) infestation**

	BLUE PRECINCT
Description	Blue Precinct, located in the NE section of campus is bordered by Ellengowan Drive. It contains a range of buildings, several large carparks, limited grassed areas and numerous well-established gardens
Weeds	Two declared Class B weed species (Neem and *Sida acuta*) were recorded within blue precinct. Other invasive species included isolated plants of coffee bush and annual mission grass.
Priorities for Control	Eradicate declared species. All in occur in small populations and can be effectively eliminated. Remove isolated coffee bush plants to prevent spread and re-spray patches of annual mission grass regrowth.
Management Issues	Juvenile annual mission grass observed on adjacent properties (NARU). Important these plants are controlled prior to seed production to avoid spread into CDU grounds.
Weed Management Objectives 2018/19	➢ **Eradicate seedlings and sapling neem trees present within gardens in Blue Precint** ➢ **Eradicate young neem trees near courtyard garden** ➢ **Spot control of coffee bush in mulch in median strip of carpark in blue precinct (see mapping)** ➢ **Control regrowth of annual mission grass in area with previous control of grassy weeds** ➢ **Control annual mission grass seedlings in grounds of neighbouring property NARU**

	YELLOW PRECINCT
Description	Yellow Precinct is located on the western edge of campus, bordered by University Drive West. It contains the western section of the open grassed Strand, small ornamental gardens and the Chinese Garden.
Weeds	No declared weed species recorded.
Priorities for Control	No priorites for control
Management Issues	Maintain routine weed control to prevent weed establishment
Weed Management Objectives 2018/19	Maintain weed free status for target and environmental weeds through regular monitoring and control

	BROWN PRECINCT
Description	Brown Precinct is located on the northwest corner of campus and contains student housing. Grassed areas and garden beds surround numerous small buildings. It merges with bushland to the northwest and intergrades with Zone 1 priority weed management zone.
Weeds	Two declared species recorded within brown precinct - neem and perrenial mission grass
Priorities for Control	Remove all large neem trees in brown precinct - which represents the largest source of seed on campus.
Management Issues	Maintain regular weed control to kill regrowth and recruitment of neem and perrenial mission grass.
Weed Management Objectives 2018/19	➢ Eradicate declared species perrenial mission grass (*Cenchrus pedicellatum*) from garden beds near boundary with Brinkin ➢ Eradicate declared neem seedlings and remove all mature neem trees
	PINK PRECINCT
Description	Pink Precinct, occupies the SW section of campus and is bordered by Rapid Creek to the south. It contains the horticultural compound, several new buildings and abuts a large sections of remnant bushland (Priority management zone 4).
Weeds	No declared weed species observed within the Pink Precinct. Other weed species included isolated plants of coffee bush and annual mission grass.
Priorities for Control	Remove isolated coffee bush plants to prevent spread and eradicate any annual mission grass.
Management Issues	Pink precinct abuts priority management zone 4 which has stands of very dense coffee bush - this will be a significant source of seed until it is controlled. Similarly dense stands of coffee bush as well as gamba grass and mission grass occured in the southern buffer zone in November 2017 and represent a seed source for pink precinct until they are eradicated.
Weed Management Objectives 2018/19	➢ Eradication of coffee bush from precinct ➢ Eradicate annual mission grass ➢ Maintain declared weed-free status and control all undeclared species

APPENDIX D – RESEARCH & EDUCATIONAL PROJECTS CONDUCTED IN REMNANT VEGETATION, CDU CASUARINA

Researcher	Research/ Experiment Topic	Current/Past (Year)
RESEARCH PROJECTS		
Dr Leigh-Ann Woolley Cara Penton	Black-footed Tree rat, PhD research	Current
Dr A O'Grady	Water use (sap flow) in trees – student experiment	Past
Prof Derek Eamus, Prof Lindsay Hutley	Root biomass and root fractal analyses of an open Eucalyptus forest in a savanna of north Australia- Field sampling site	Past (https://doi.org/10.1071/BT01054)
Dr Philipp A. Nauer, Prof Lindsay B. Hutley Prof Stefan K. Arndt	Microbial methane oxidation in termite mounds mitigates half of termite methane emissions	Current, *paper in review* Proceedings of the National Academy of Sciences of the United States of America
Dr Philipp A. Nauer, Dr Eleonora Chiri, Dr David de Souza, Prof Lindsay B. Hutley, Prof Stefan K. Arndt	Rapid image-based field methods improve the quantification of termite mound structures and greenhouse-gas fluxes	Past, (https://doi.org/10.5194/bg-15-3731-2018)
Prof Lindsay Hutley	Water relations in savanna trees	Past (https://doi.org/10.1046/j.1365-2435.2000.00416.x)
Muhammad Salman Quddus	Ecological weed control of disturbed lands by native species (PhD project) - Test field sampling methods prior to implementation at field sites off campus	Past (2009)
Evi Saragih	Vegetation development in gold mine rehabilitation in relation with cattle grazing and fire in the Northern Territory Australia (PhD project) - Test field sampling methods prior to implementation at field sites off campus	Past (2012)
Hanna Markones	Understanding the pollination biology of *Terminalia ferdinandiana* (MEM research project)- Field sampling site	Past (2015)
Julian Gorman	Indigenous enterprise development, population ecology and phenotype variation of the tropical tree, *Terminalia ferdinandiana*, in the Northern Territory, Australia (PhD research project) - Field sampling site	Past (2016)
Leigh-Ann Woolley, Brett Murphy, Mike Lawes	Arresting declines of arboreal mammals in the tropical savannas (ARC Linkage Project) - Radio-tracking black-footed tree-rats and brushtail possums to determine denning sites	Past (2016) to present

TEACHING		
Dr Brett Murphy	Student mammal trapping surveys	Past, current
CDU, RIEL	Ethnobotany – Aboriginal uses of native plants	Current
School of Horticulture	Weed control techniques – demonstration of coffee bush treatment	Current
Bellairs, Rossiter-Rachor, Hutley, Murphy et al.	Various courses and topics	Teaching (past, current)
Samantha Saynor	AHCPCM201A Recognise plants AHCPCM502A Collect and classify plants - Field sampling site AHCLPW405A Monitor biodiversity AHCNAR502 Conduct biological surveys - Practice aspects of field sampling	2013 to present
Miki Ensby, Mila Bristow, Sean Bellairs, Brett Murphy, Alison Stobo-Wilson	ENV203 Environmental survey and monitoring skills	2013 to present
Carla Eisemberg, Erica Garcia, Penny Wurm	ENV201 Introductory ecology – teaching	2012 to present

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