



DEPARTMENT OF LAND RESOURCE MANAGEMENT

Vegetation communities and plant biodiversity values of the seasonally saturated lands of the Howard Sand Plains Site of Conservation Significance in the Northern Territory of Australia.

D.T. Liddle, P. Harkness, J. Westaway, D.L. Lewis and I.D. Cowie

October 2013



CARING
FOR
OUR
COUNTRY



Flora and Fauna Division
Department of Land Resource Management
PO Box 496
Palmerston NT 0831

© Northern Territory of Australia

Report to the Australian Government Caring for our Country initiative.

This project is partially funded by the Northern Territory Government Department of Land Resource Management and the Australian Government's Caring for our Country initiative.

Citation

D.T. Liddle, P. Harkness, J. Westaway, D.L. Lewis and I.D. Cowie (2013) Vegetation communities and plant biodiversity values of the seasonally saturated lands of the Howard Sand Plains Site of Conservation Significance in the Northern Territory of Australia. Report to the Australian Government Caring for our Country initiative. Northern Territory Government Department of Land Resource Management. Palmerston.

Cover photograph: .The carnivorous bladderwort *Utricularia dunstaniae* on the Howard Sand Plains. Photo: D.T. Liddle.

Executive summary

The Howard Sand Plains Site of Conservation Significance is located 30 km east of Darwin and supports a diverse array of vegetation communities. These communities include sensitive sandsheet heath and the area is recognised as being of international significance due to the concentration of threatened species. The area has come under pressure due to changes in land use, particularly the extraction of sand resources to support demand from the expanding city of Darwin. This study addresses a gap in mapping of vegetation at a scale appropriate for land use decisions, along with an analysis to identify patches of particularly high biological significance within the landscape. A focus of the study is to identify areas that are important for conservation of the carnivorous plant genus *Utricularia*, and threatened herb *Typhonium taylori*. The study is one component of a project titled “Extractive Industry improved response to biodiversity for Howard Sand Plains” co-ordinated by the Extractive Industry Association of the Northern Territory and supported by the Australian Government’s Caring for Our Country initiative.

Visual interpretation of aerial photography flown in June 2010 was undertaken to delineate vegetation communities in the seasonally saturated “floodplains” of the Howard River catchment. An iterative process of image interpretation and field survey to ground truth the observed patterns was carried out in the late wet season and early dry season. Vegetation was quantified in 20 m by 20 m plots to provide floristic and structural data. These data were combined with pre-existing plot data held by the Northern Territory Herbarium to compile descriptions of the vegetation communities. Records of *Utricularia* and the herbaceous *Typhonium* group were analysed to highlight the significance of the Howard Sand Plains and identify vegetation communities of particular note for the occurrence of threatened species and diversity of *Utricularia*.

Twenty-one vegetation communities are described and mapped. The mapping provides a foundation for identifying those parts of the landscape that support a concentration of species of conservation significance. The community analysis has been further refined to identify priority areas for conservation of the threatened *Typhonium taylori*, *Utricularia dunstaniae* and the rainforest palm *Ptychosperma macarthurii*. Identification of high priority areas provides a basis for land use decisions and focus for on-ground management to look after the habitat on which these species depend.

More broadly, a description of the seasonally saturated vegetation communities and mapping of their distribution within the Howard Sand Plains Site of Conservation Significance provides an improved understanding on which to base land use and management decisions. For example, knowledge of the characteristics and variation in the natural vegetation communities can be useful in establishing mine site rehabilitation criteria. The sand sheet communities are one component of a complex mosaic of vegetation within the landscape and their existence is closely related to adjoining communities.

A significant gap in knowledge to manage the mosaic of vegetation on the seasonally saturated plains is an understanding of hydrologic processes in the landscape. Sensitive sand sheet communities supporting prime *Utricularia* habitat are often located towards the margin of the floodplain where seepage of groundwater from nearby woodlands for a month or two into the dry season appears to be crucial factor in the maintenance of these communities. Existence of these high biodiversity value patches appears intimately linked to management of the adjoining lands through the flow of water in the landscape. The Howard Sand Plains Site of Conservation Significance has outstanding biodiversity value, particularly with regard to the diversity of *Utricularia* species supported within the landscape.

CONTENTS

Executive summary	iii
1. Introduction.....	1
1.1.1. Background and objectives	1
1.1.2. Location and extent of survey	2
2. Methods.....	3
2.1. Vegetation communities.....	3
2.1.1. Collation of pre-existing information	3
2.1.2. Field survey	3
2.1.3. Site data analysis and classification.....	4
2.1.4. Vegetation community mapping.....	4
2.2. Identification of biodiversity values.....	5
2.2.1. Target species	5
2.2.2. Utricularia species diversity.....	5
2.2.3. Identification of priority sites.....	6
3. Results.....	7
3.1. Vegetation communities.....	7
3.1.1. Existing information.....	7
3.1.2. Field survey	8
3.1.3. Vegetation communities.....	8
3.2. Vegetation community descriptions.....	8
3.2.1. Map Unit 1: <i>Lophostemon lactifluus</i> (red swamp mahogany), +/- <i>Erythrophleum chlorostachys</i> (ironwood) mid open forest with a mid open tussock grassland understorey	8
3.2.2. Map Unit 2a: <i>Melaleuca viridiflora</i> (broad-leaved paperbark) mid open woodland with a mid open tussock grassland understorey	13
3.2.3. Map Unit 2b: <i>Melaleuca viridiflora</i> low woodland with <i>Fimbristylis</i> mid open sedgeland understorey	16
3.2.4. Map Unit 3a: <i>Melaleuca nervosa</i> +/- <i>Pandanus spiralis</i> (screw palm) low open woodland with a <i>Sorghum intrans</i> , <i>Eriachne trisetata</i> mid tussock grassland understorey	19
3.2.5. Map Unit 3b <i>Melaleuca nervosa</i> , <i>Grevillea pteridifolia</i> (fern-leaved grevillea) low open woodland with <i>Dapsilanthus spathaceus</i> low open sedgeland ground layer	24
3.2.6. Map Unit 4a: <i>Verticordia cunninghamii</i> (Cunningham's featherflower) and <i>Banksia dentata</i> mid open heathland with an emergent <i>Melaleuca nervosa</i> and <i>Grevillea pteridifolia</i> (fern-leaved grevillea) low open woodland and with <i>Dapsilanthus spathaceus</i> mid open sedgeland ground layer.....	29
3.2.7. Map Unit 4b: <i>Grevillea pteridifolia</i> (fern-leaved grevillea) +/- <i>Melaleuca nervosa</i> low open woodland with or without a mid layer of <i>Pandanus spiralis</i> (screw palm) and <i>Verticordia cunninghamii</i> (Cunningham's featherflower) low isolated trees or heath shrubs and a <i>Dapsilanthus spathaceus</i> mid open sedgeland understorey	33
3.2.8. Map Unit 4c: <i>Grevillea pteridifolia</i> (fern-leaved grevillea) +/- <i>Melaleuca viridiflora</i> (broad-leaved paperbark) +/- <i>Melaleuca nervosa</i> low open woodland with a mid layer of <i>Banksia dentata</i> +/- <i>Pandanus spiralis</i> (screw palm) +/- <i>Verticordia cunninghamii</i> (Cunningham's	

featherflower) tall sparse heathland and a <i>Dapsilanthus spathaceus</i> mid sedgeland understorey	37
3.2.9. Map Unit 4d: <i>Grevillea pteridifolia</i> and/or <i>Lophostemon lactifluus</i> mid open woodland with or without a <i>Banksia dentata</i> low open woodland mid layer and mid tussock grassland/sedgeland ground layer	41
3.2.10. Map Unit 5 <i>Melaleuca dealbata</i> low open forest with a low sparse sedgeland understorey	45
3.2.11. Map Unit 6: <i>Lophostemon lactifluus</i> +/- <i>Melaleuca viridiflora</i> mid open woodland over a tall tussock grassland	48
3.2.12. Map Unit 7: <i>Acacia plectocarpa</i> , <i>Acacia latescens</i> low open woodland with a low open tussock grassland ground storey	51
3.2.13. Map Unit 8: <i>Melaleuca viridiflora</i> , <i>Acacia latescens</i> , <i>Pandanus spiralis</i> low open woodland with a low open tussock grassland or sedgeland ground storey	54
3.2.14. Map Unit 9: <i>Pandanus spiralis</i> (screw palm) +/- <i>Melaleuca viridiflora</i> low open woodland with a mid tussock grassland / sedgeland ground story.....	58
3.2.15. Map Unit 10: <i>Sorghum intrans</i> , <i>Alloteropsis semialata</i> , +- <i>Eriachne burkittii</i> tussock grassland with isolated <i>Acacia latescens</i> and <i>Grevillea pteridifolia</i> (fern-leaved grevillea) 62	
3.2.16. Map Unit 11: <i>Hakea arborescens</i> and <i>Terminalia grandiflora</i> low open woodland with <i>Fimbristylis pauciflora</i> and <i>Eriachne burkittii</i> mixed low sedgeland or tussock grassland ground layer.....	65
3.2.17. Map Unit 12: <i>Lophostemon lactifluus</i> (Red Swamp Mahogany) +/- <i>Banksia dentata</i> and <i>Grevillea pteridifolia</i> (fern-leaved grevillea) low open woodland over <i>Dapsilanthus spathaceus</i> mid sedgeland understory with heath shrubs and tussock grasses 68	
3.2.18. Map Unit 13: Tussock grassland with isolated <i>Melaleuca nervosa</i>	72
3.2.19. Map Unit 14: Aquatic bed with <i>Nymphoides</i> and <i>Eleocharis</i>	74
3.2.20. Map Unit 15: <i>Melaleuca cajuputi</i> mid open forest with <i>Pandanus spiralis</i> (screw palm) low open woodland mid stratum and sedgeland or grassland ground stratum. 77	
3.2.21. Map Unit 16: <i>Acacia auriculiformis</i> and <i>Carpentaria acuminata</i> closed forest 80	
3.3. Other map unit descriptions	83
3.3.1. Cleared Eucalypt woodland	83
3.3.2. Disturbed	84
3.3.3. Farming or forestry.....	85
3.3.4. Rural residential.....	86
3.3.5. Map Unit W: Eucalypt woodland	87
3.4. Biodiversity values	88
3.4.1. Target species	88
3.4.2. <i>Utricularia</i> species diversity.....	89
3.4.3. Identification of priority vegetation sites.....	94
4. Discussion.....	98
5. Acknowledgements	101

6. References 102

List of Tables

TABLE 1: COMMUNITY 1 STRUCTURAL SUMMARY.....	8
TABLE 2: COMMUNITY 1 SPECIES COVER AND OCCURRENCE	10
TABLE 3: COMMUNITY 2A STRUCTURAL SUMMARY.....	13
TABLE 4: COMMUNITY 2A SPECIES COVER AND OCCURRENCE.....	14
TABLE 5: COMMUNITY 2B STRUCTURAL SUMMARY	16
TABLE 6: COMMUNITY 2B SPECIES COVER AND OCCURRENCE.....	17
TABLE 7: COMMUNITY 3A STRUCTURAL SUMMARY.....	19
TABLE 8: COMMUNITY 3A SPECIES COVER AND OCCURRENCE.....	21
TABLE 9: COMMUNITY 3B STRUCTURAL SUMMARY	24
TABLE 10: COMMUNITY 3B SPECIES COVER AND OCCURRENCE.....	26
TABLE 11: COMMUNITY 4A STRUCTURAL SUMMARY.....	29
TABLE 12: COMMUNITY 4A SPECIES COVER AND OCCURRENCE.....	31
TABLE 13: COMMUNITY 4B STRUCTURAL SUMMARY	33
TABLE 14: COMMUNITY 4B SPECIES COVER AND OCCURRENCE.....	35
TABLE 15: COMMUNITY 4C STRUCTURAL SUMMARY	37
TABLE 16: COMMUNITY 4C SPECIES COVER AND OCCURRENCE.....	39
TABLE 17: COMMUNITY 4D STRUCTURAL SUMMARY.....	41
TABLE 18: COMMUNITY 4D SPECIES COVER AND OCCURRENCE	42
TABLE 19: COMMUNITY 5 STRUCTURAL SUMMARY.....	45
TABLE 20: COMMUNITY 5 SPECIES COVER AND OCCURRENCE	46
TABLE 21: COMMUNITY 6 STRUCTURAL SUMMARY.....	48
TABLE 22: COMMUNITY 6 SPECIES COVER AND OCCURRENCE	49
TABLE 23: COMMUNITY 7 STRUCTURAL SUMMARY.....	51
TABLE 24: COMMUNITY 7 SPECIES COVER AND OCCURRENCE	52
TABLE 25: COMMUNITY 8 STRUCTURAL SUMMARY.....	54
TABLE 26: COMMUNITY 8 SPECIES COVER AND OCCURRENCE	56
TABLE 27: COMMUNITY 9 STRUCTURAL SUMMARY.....	58
TABLE 28: COMMUNITY 9 SPECIES COVER AND OCCURRENCE	59
TABLE 29: COMMUNITY 10 STRUCTURAL SUMMARY.....	62
TABLE 30: COMMUNITY 10 SPECIES COVER AND OCCURRENCE	63
TABLE 31: COMMUNITY 11 STRUCTURAL SUMMARY.....	65
TABLE 32: COMMUNITY 11 SPECIES COVER AND OCCURRENCE	66
TABLE 33: COMMUNITY 12 STRUCTURAL SUMMARY.....	68
TABLE 34: COMMUNITY 12 SPECIES COVER AND OCCURRENCE	70
TABLE 35: COMMUNITY 13 SPECIES OCCURRENCE.....	72
TABLE 36: COMMUNITY 14 STRUCTURAL SUMMARY.....	74
TABLE 37: COMMUNITY 14 SPECIES COVER AND OCCURRENCE	75
TABLE 38: COMMUNITY 15 STRUCTURAL SUMMARY.....	77
TABLE 39: COMMUNITY 15 SPECIES COVER AND OCCURRENCE	78
TABLE 40: COMMUNITY 16 STRUCTURAL SUMMARY.....	80
TABLE 41: COMMUNITY 16 SPECIES COVER AND OCCURRENCE	81
TABLE 42: DIVERSITY OF <i>UTRICULARIA</i> SPECIES AND OCCURRENCE OF <i>UTRICULARIA DUNSTANIAE</i> POPULATIONS IN THE VEGETATION COMMUNITIES. COLOUR CODING REFLECTS THE CATEGORIES ILLUSTRATED IN FIGURES 31 AND 32.	90

List of Figures

FIGURE 1: HOWARD SAND PLAINS SITE OF CONSERVATION SIGNIFICANCE AND DISTRIBUTION OF SAND-SHEET HEATHLAND MAPPED FROM SATELLITE IMAGERY BY HEMPEL (2003).....	2
FIGURE 2: MAP UNIT 1 DISTRIBUTION MAP.	12
FIGURE 3: MAP UNIT 2A DISTRIBUTION MAP.....	15

FIGURE 4: MAP UNIT 2B DISTRIBUTION MAP.....	18
FIGURE 5: MAP UNIT 3A DISTRIBUTION MAP.....	23
FIGURE 6: MAP UNIT 3B DISTRIBUTION MAP.....	28
FIGURE 7: MAP UNIT 4A DISTRIBUTION MAP.....	32
FIGURE 8: MAP UNIT 4B DISTRIBUTION MAP.....	36
FIGURE 9: MAP UNIT 4C DISTRIBUTION MAP.....	40
FIGURE 10: MAP UNIT 4D DISTRIBUTION MAP.	44
FIGURE 11: MAP UNIT 5 DISTRIBUTION MAP.	47
FIGURE 12: MAP UNIT 6 DISTRIBUTION MAP.	50
FIGURE 13: MAP UNIT 7 DISTRIBUTION MAP.	53
FIGURE 14: MAP UNIT 8 DISTRIBUTION MAP.	57
FIGURE 15: MAP UNIT 9 DISTRIBUTION MAP.	61
FIGURE 16: MAP UNIT 10 DISTRIBUTION MAP.	64
FIGURE 17: MAP UNIT 11 DISTRIBUTION MAP.	67
FIGURE 18: MAP UNIT 12 DISTRIBUTION MAP.	71
FIGURE 19: MAP UNIT 13 DISTRIBUTION MAP.	73
FIGURE 20: MAP UNIT 14 DISTRIBUTION MAP.	76
FIGURE 21: MAP UNIT 15 DISTRIBUTION MAP.	79
FIGURE 22: MAP UNIT 16 DISTRIBUTION MAP.	82
FIGURE 23: DISTRIBUTION OF LANDS MAPPED AS CLEARED EUCALYPT WOODLAND.	83
FIGURE 24: DISTRIBUTION OF LANDS MAPPED AS DISTURBED.....	84
FIGURE 25: DISTRIBUTION OF LANDS MAPPED AS FARMING OR FORESTRY.	85
FIGURE 26: DISTRIBUTION OF LANDS MAPPED AS RURAL RESIDENTIAL.	86
FIGURE 27: DISTRIBUTION OF LANDS MAPPED AS EUCALYPT WOODLAND.	87
FIGURE 28: OCCURRENCE OF THE VULNERABLE <i>UTRICULARIA DUNSTANIAE</i> AGAINST A BACKDROP OF <i>UTRICULARIA</i> RECORDS IN THE NORTHERN TERRITORY.....	88
FIGURE 29: OCCURRENCE OF THE ENDANGERED <i>TYPHONIUM TAYLORI</i> AGAINST A BACKDROP OF <i>TYPHONIUM</i> RECORDS IN THE NORTHERN PART OF THE NORTHERN TERRITORY.....	88
FIGURE 30: OCCURRENCE OF THE ENDANGERED <i>PTYCHOSPERMA MACARTHURII</i> IN THE NORTHERN TERRITORY.....	89
FIGURE 31: MAXIMUM SPECIES DIVERSITY OF <i>UTRICULARIA</i> IN 20 M BY 20 M PLOTS WITHIN VEGETATION COMMUNITIES.	91
FIGURE 32: AVERAGE SPECIES DIVERSITY OF <i>UTRICULARIA</i> IN 20 M BY 20 M PLOTS WITHIN VEGETATION COMMUNITIES.	92
FIGURE 33: THE NUMBER OF <i>UTRICULARIA</i> SPECIES RECORDED IN 20 M BY 20 M FLORISTIC PLOTS ACROSS THE NORTHERN TERRITORY.....	93
FIGURE 34: THE NUMBER OF <i>UTRICULARIA</i> SPECIES RECORDED IN 25 KM BY 25 KM CELLS ACROSS THE NORTHERN TERRITORY.....	93
FIGURE 35: HIGHEST PRIORITY AREAS FOR BIODIVERSITY VALUE ASSOCIATED WITH <i>UTRICULARIA</i> SPECIES IN THE HOWARD SAND PLAINS SITE OF CONSERVATION SIGNIFICANCE.	95
FIGURE 36: HIGHEST PRIORITY AREAS FOR BIODIVERSITY VALUE ASSOCIATED WITH <i>TYPHONIUM TAYLORI</i> IN THE HOWARD SAND PLAINS SITE OF CONSERVATION SIGNIFICANCE.	96
FIGURE 37: HIGHEST PRIORITY AREAS FOR BIODIVERSITY VALUE ASSOCIATED WITH <i>PTYCHOSPERMA MACARTHURII</i> IN THE HOWARD SAND PLAINS SITE OF CONSERVATION SIGNIFICANCE.	97

List of Plates

PLATE 1: VEGETATION COMMUNITY 1 (SITE 52)	9
PLATE 2: VEGETATION COMMUNITY 2A (SITE 15)	13
PLATE 3: VEGETATION COMMUNITY 3A (SITE 18)	19
PLATE 4: VEGETATION COMMUNITY 3B (SITE 44) WITH NO MID STRATUM EVIDENT	24
PLATE 5: VEGETATION COMMUNITY 3B (SITE 2) WITH HEATH SHRUB MID STRATUM.....	25
PLATE 6: VEGETATION COMMUNITY 4A (SITE 26)	29
PLATE 7: VEGETATION COMMUNITY 4B (SITE 42).....	33
PLATE 8: VEGETATION COMMUNITY 4C (SITE 29).....	37
PLATE 9: VEGETATION COMMUNITY 4D (SITE 45)	41
PLATE 10: VEGETATION COMMUNITY 8 (SITE 37)	54
PLATE 11: VEGETATION COMMUNITY 9 (SITE 36)	58
PLATE 12: VEGETATION COMMUNITY 12 (SITE 27)	68

1. Introduction

1.1.1. Background and objectives

The Howard Sand Plains Site of Conservation Significance (SOCS) is recognised as being of international significance due to the concentration of threatened species within the site. These include a suite of species associated with the extensive broad floodplains adjacent to the Howard River or associated drainage systems. Threatened species occurring within the seasonally saturated parts of the landscape not dominated by rainforest include the Howard Toadlet, *Uperoleia daviesae*, and plants *Typhonium taylori* and *Utricularia dunstaniae* (Kerrigan and Cowie 2007a, 2007b; Ward 2007). More generally, the sandy heaths support a high diversity of small carnivorous bladderworts of the genus *Utricularia*.

Within the diverse array of vegetation communities that occupy the Howard Sand Plains SOCS, sensitive vegetation types include sand-sheet heath and rainforest (NRETAS 2010, DLRM 2013a, 2013b). Species of conservation significance within the spring-fed rainforest include the threatened Darwin Palm, *Ptychosperma macarthurii* (Kerrigan *et al.* 2007).

The Howard Sand Plains have come under increasing pressure due to changes in land use, particularly with the extraction of sand resources to support demand for the expanding city of Darwin. In recognition of the competing demands upon the landscape and the desirability of advancing the balance between maintaining biodiversity values and providing sand resources, this study was conducted as part of a collaborative project with the Extractive Industry Association of the Northern Territory, EcOz Environmental Services, Conservation Volunteers and the Northern Territory Government Department of Land Resource Management, formerly the Department of Natural Resources, Environment, the Arts and Sport. This study was partially funded by the Northern Territory Government and the Australian Government's Caring for Our Country initiative.

This study addresses a gap in mapping of vegetation at a scale appropriate for land use decisions along with an analysis to identify the most biologically significant patches for plants within the landscape. The priority objectives were to:

- Collate existing information, particularly pertaining to *Utricularia* and *Typhonium*;
- Undertake field survey to identify range of habitats as recognised by extant vegetation communities;
- Relate vegetation communities (habitats) to occurrence of species of conservation significance; and
- Identify priority areas for conservation of species of conservation significance.

1.1.2. Location and extent of survey

The Howard Sand Plains SOCS is located 30 km east of Darwin (Figure 1) and occupies an area of 264 km². The SOCS extends 27 km north to south and 16 km east to west. The site is one of a series of internationally significant sites in the coastal areas of the north-west of the Top End (Harrison *et al.* 2009). Shoal Bay SOCS abuts to the north-west of the Howard Sand Plains and the Adelaide River Coastal Floodplain SOCS abuts midway along the eastern side.

Given the floodplains are the part of the landscape that both provide habitat for a suite of threatened species and are the focus for sand mining, these seasonally saturated areas are the focus of this study. The concentration of seasonally saturated sand-sheet habitat within the Howard Sand Plains SOCS is evident as heathland in land cover mapping in the greater Darwin region based upon Landsat satellite imagery (Hempel 2003) (Figure 1). At the time of commencing this study the mapping by Hempel was the best information available about the spatial extent of seasonally saturated sand-sheet heath near Darwin.

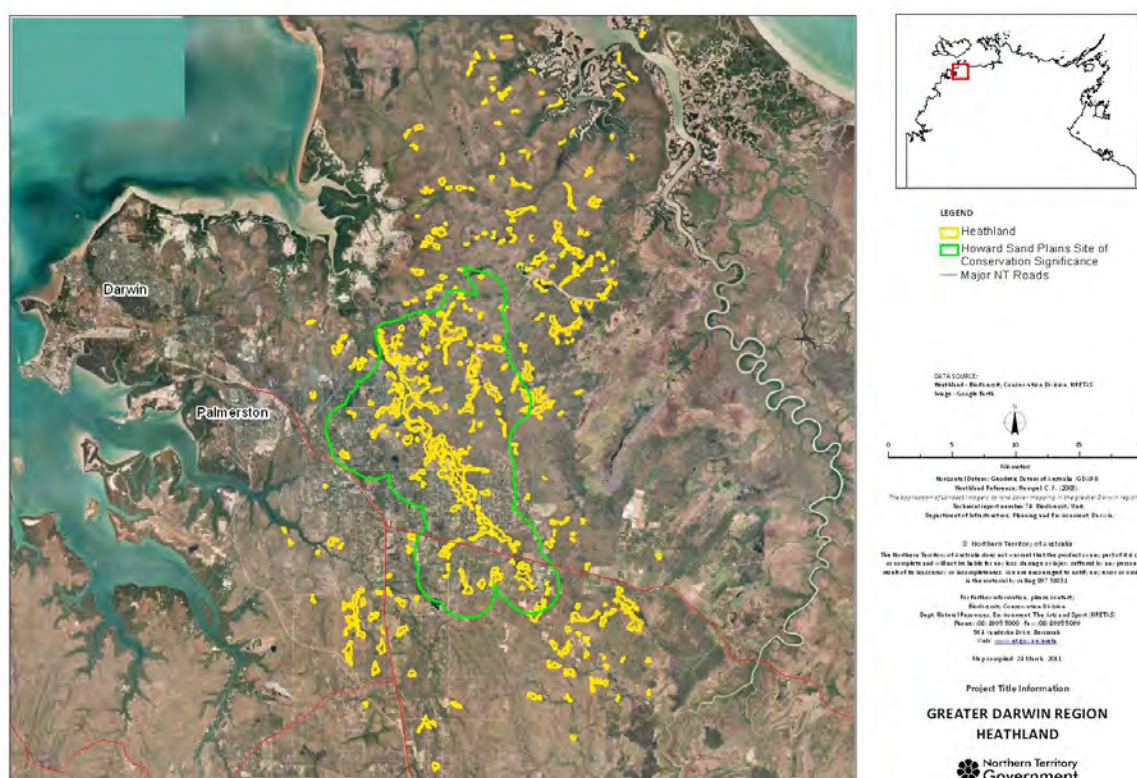


Figure 1: Howard Sand Plains Site of Conservation Significance and distribution of sand-sheet heathland mapped from satellite imagery by Hempel (2003).

2. Methods

2.1. Vegetation communities

2.1.1. Collation of pre-existing information

The study built upon existing data, particularly that collected by the Northern Territory Herbarium with a focus on *Utricularia* in the Howard River and Shoal Bay area (Cowie 2002). Point data on the occurrence of *Utricularia* and other species was derived from the NT Herbarium specimen and plot databases. Information about individual species was obtained from a variety of sources including advice from staff of the Northern Territory Herbarium, threatened species information sheets (DLRM 2013c), a guide to *Utricularia* (NT Herbarium 2013) and other works addressing either the area or species (Cowie *et al.* 2000, Brock 2001, Holmes *et al.* 2005, Liddle and Trikojus 2010).

An overview of the vegetation of the study area was available from land unit and remnant vegetation mapping (Fogarty *et al.* 1984, Conservation and Natural Resources Group 2002, Hempel 2003). Land unit mapping at a scale of 1:25,000 (Fogarty *et al.* 1984) was available from the spatial data libraries held by the Northern Territory Government (NTLIS 2000). The units with a severe level of seasonal soil waterlogging or inundation for extended periods within the Howard Sand Plains SOCS approximate the lands that are the focus of this mapping and conservation assessment.

A visual inspection of recent satellite imagery and aerial photography available for the study area revealed the Darwin Region 30 cm 2010 aerial photography to be the most suitable imagery for mapping the vegetation communities. This imagery was flown on 1st June 2010 with a horizontal resolution of 0.3 m (NTLIS 2010).

2.1.2. Field survey

Field survey was based on the methodologies of Brocklehurst *et al.* (2007) and the National Committee on Soil and Terrain (2009) with surveys conducted between April 2011 and August 2012. The primary survey activity was timed to coincide with the flowering of floodplain herbs, including *Utricularia*, that flower at the end of and immediately following the wet season. This group of plants is only identifiable to species when flowering.

Full floristics was recorded for 20 m by 20 m plots at 53 sites within the Howard Sand Plains SOCS, a density of approximately one site per 5 km², or one site per 1.3 km² within the key focus area consisting mainly of undisturbed sand-sheet, floodplain or other wetlands. Sites were selected in the office from the aerial imagery displayed with ArcMap Geographic Information System (GIS) (ESRI 2012) to represent the geographic and environmental range within the focus area while taking into account site accessibility. Co-ordinates for the target

sites were recorded from the imagery in the office and uploaded to a GPS for location in the field.

2.1.3. Site data analysis and classification

Field data used for classification of map units combined pre-existing data and field sites assessed during this study. Interrogation of the Herbarium plot database provided data from 43 previously assessed 20 m by 20 m plots that contained 10 or more plant species and were located in the seasonally saturated lands that were the focus of this study. Plots with less than 10 species were excluded due to a possibility these may represent plots for which a full floristic survey had not been undertaken. These data had been collected between July 1998 and May 2001, with the majority (41 plots) sampled between March and May 2001 as part of a survey focused on *Utricularia* habitat (Cowie 2002). The data from these plots included plant occurrence and were suitable for analyses based upon presence or absence of species.

With the addition of 45 plots sampled during this study, floristic data from a total of 88 plots were available. A subset of 65 plots was classified into floristic groups by conducting a multivariate analysis using Primer (Clarke and Gorley 2006). A cluster analysis was conducted on species presence/absence data using a Bray Curtis similarity measure with no transformation of the data. The remaining 23 plots were reserved for future further analyses.

2.1.4. Vegetation community mapping

Visual inspection of the aerial imagery displayed on a computer screen with ArcMap GIS was undertaken to build up familiarity with the area and the vegetation patterns evident. Interpretation of the imagery on the computer screen was carried out with the scale set at 1:2,000 with a view to production of a community map at a scale of 1:10,000. Preliminary line work was drawn to separate vegetation units and ground truthing conducted in the field to confirm the units identified were meaningful. The one operator (PH) undertook all the line work and participated in many of the field trips when ground truthing was undertaken. In the field a combination of inspection at points of interest and assessment of vegetation at sites was used to build confidence in recognition of patterns and quantify vegetation characteristics. The process of line work and ground truthing was iterative with field experience crucial to refining the line work drawn in the office.

The mapping of vegetation communities was undertaken in relatively unmodified seasonally saturated parts of the landscape. Seasonally saturated areas that had been extensively modified by the building of infrastructure or mining along with upland areas within the Howard Sand Plains SOCS were broadly classified within the following classes: cleared Eucalypt woodland; disturbed; farming or forestry; rural residential; or Eucalypt woodland. A description of structural formations and associations were compiled for vegetation communities in accord with the National Vegetation Information System (NVIS), version 6 (ESCAVI 2003).

2.2. Identification of biodiversity values

2.2.1. Target species

Plant taxa listed as threatened under Northern Territory or Australian Government legislation that occur on the seasonally saturated lands provided a primary focus for the identification of plant biodiversity values of the Howard Sand Plains SOCS. These species include: the herb *Typhonium taylori* which is listed as endangered under both the Australian Government *Environment Protection and Biodiversity Conservation Act 1999* and Northern Territory *Government Territory Parks and Wildlife Conservation Act 2000*; the carnivorous herb *Utricularia dunstaniae* which is listed as vulnerable under Territory legislation; and the rainforest palm *Ptychosperma macarthurii*. Following a review which merged the Northern Territory entity, previously known as *Ptychosperma bleeseri* with the Queensland species *Ptychosperma macarthurii* (Dixon *et al.* 2003) it appears likely *Ptychosperma bleeseri* will be removed from the Australian Government list of threatened species. Independent of listing at the national level, the entity has retained the status of endangered in the Northern Territory under the name *Ptychosperma macarthurii*.

2.2.2. *Utricularia* species diversity

Given the international and national recognition of the high diversity of *Utricularia* species occurring near Darwin within the area now recognised as the Howard Sand Plains SOCS (Taylor 1989, Harrison *et al.* 2009), the diversity within this taxonomic group was examined to augment the focus on the threatened *Utricularia dunstaniae*. The maximum and average numbers of *Utricularia* species recorded in 20 m by 20 m plots within each vegetation unit were calculated to provide measures of local diversity. The count of *Utricularia* species per plot was arbitrarily assigned into 5 classes: nil species recorded, 1 or 2 species, 3 or 4 species, 5 or 6 species and 7 or more species. For ease of discussion, the class with 7 or more species has been referred to as very high and 5 or 6 species as high for maximum plot diversity. Similarly, the average number of *Utricularia* species per plot was arbitrarily assigned into 5 classes: nil species recorded, present with up to 2 species, more than 2 and up to 4 species, more than 4 and up to 6 species, and more than 6 species. For ease of discussion, the class with more than 6 species has been referred to as very high and more than 4 and up to 6 species as high for average plot diversity.

Furthermore, a count of the number of *Utricularia* species recorded from each vegetation community was compiled by intercepting all available *Utricularia* records from both plot and point data, with the mapped vegetation polygons. These data provide a measure of diversity at the scale of the mapped vegetation community polygons.

The regional significance of the Howard Sand Plains SOCS was investigated by two approaches. Firstly, the number of *Utricularia* species recorded within 20 m by 20 m floristic plots was charted across the Northern Territory. These data were sourced from the Northern Territory Herbarium plot database which is the most extensive and taxonomically

reliable source of floristic plot data in the Northern Territory. The 20 m by 20 m plots have been assessed by experienced botanists and the assessment protocol had a common theme of recording all vascular plant species that can be identified within a plot. Secondly, to expand the analysis to include data from point samples and vouchered specimens, both vouchered and non-vouchered records held by the Northern Territory Herbarium were mapped in 25 km by 25 km cells to illustrate the diversity of *Utricularia* species recorded across the Northern Territory.

2.2.3. Identification of priority sites

Priority sites for the conservation of plant biodiversity values within the Howard Sand Plains SOCS were identified by combining data of known localities for threatened species, mapped vegetation polygons and in the case of *Utricularia*, species diversity recorded in 20 m by 20 m plots. The steps taken for identifying the priority sites for each of the target taxa follow.

Utricularia

- 1) Identify mapped vegetation polygons known to support populations of *U. dunstaniae*.
- 2) Confirm each *U. dunstaniae* record occurs in a vegetation community representative of the mapped polygon. Small unrepresentative areas occur within mapped communities as the result of the scale of mapping in heterogeneous landscapes. Confirmation was achieved by use of aerial photographic interpretation in combination with field inspection to categorise the vegetation community at the location of the record.
- 3) Identify vegetation communities known to support very high or high maximum diversity of *Utricularia* species. Very high maximum diversity communities were subjectively defined as those supporting an occurrence of 7 or more species in a 20 m by 20 m plot (see 2.2.2).
- 4) Identify vegetation communities known to support very high or high average diversity of *Utricularia* species. Very high average diversity communities were subjectively defined as those supporting on average more than 6 species in a 20 m by 20 m plot (see 2.2.2).
- 5) Allocate the highest priority for biodiversity values associated with *Utricularia* to polygons that satisfy all of:
 - a) *U. dunstaniae* present (step 1);
 - b) *U. dunstaniae* occurrence representative of mapped polygon (step 2);
 - c) very high maximum diversity (step 3); and
 - d) very high average diversity (step 4).
- 6) Allocate the next highest priority for biodiversity values associated with *Utricularia* to polygons where:
 - a) *U. dunstaniae* present (step 1);
 - b) *U. dunstaniae* occurrence representative of mapped polygon (step 2); and
 - c) high maximum diversity (step 3) or high average diversity (step 4).
- 7) Also allocate the next highest priority for biodiversity values associated with *Utricularia* to point localities where:
 - a) *U. dunstaniae* present (step 1); and
 - b) *U. dunstaniae* occurrence unrepresentative of mapped polygon (step 2).
- 8) Identify a buffer zone around the priority polygons by selecting nearby seasonally saturated vegetation polygons that are considered to be integral to maintaining the

hydrologic characteristics of the locality and buffer by 500 m. Buffer around priority point localities by 500 m. Truncate buffers at major roads.

Typhonium taylori

- 1) Identify mapped vegetation polygons known to support populations of *T. taylori*.
- 2) Identify the vegetation communities known to support the species.
- 3) Identify *T. taylori* populations that comprise 50 or more individuals (Liddle and Trikojus 2010). This encompasses the three largest known populations.
- 4) Identify *T. taylori* populations that comprise 25 to 49 individuals (Liddle and Trikojus 2010).
- 5) Identify the primary occupied vegetation community polygon within the three largest populations. A population may extend across adjacent mapped vegetation polygons. The primary occupied vegetation community polygon within each of the three largest populations supports between 65% and 98% of the known individuals of the respective population.
- 6) Identify the secondary occupied vegetation community polygon within the three largest populations and all polygons occupied by the populations identified in step 4.
- 7) Allocate highest priority for biodiversity values associated with *T. taylori* to polygons identified in step 5.
- 8) Allocate next highest priority for biodiversity values associated with *T. taylori* to polygons identified in step 6.
- 9) Identify a buffer zone of 500 m around the highest and next highest priority polygons. Truncate the buffer at major roads downstream of the population.

Ptychosperma macarthurii

- 1) Select vegetation community polygons known to support a population of *P. macarthurii*. This incorporates the two occurrences of the closed forest vegetation community occurring in the Howard Sand Plains SOCS.
- 2) Allocate highest priority for biodiversity values associated with *P. macarthurii* to both polygons identified in step 1.
- 3) Identify a buffer zone of 500 m around the selected polygons.

3. Results

3.1. Vegetation communities

3.1.1. Existing information

Data from 43 previously assessed 20 m by 20 m plots located in the seasonally saturated lands of the Howard Sand Plains SOCS provided a total of 1062 individual plant records with an average of 25 species per plot. Interrogation of floristic data sampled in 20 m by 20 m plots held by the Northern Territory Herbarium yielded 489 plots with *Utricularia* present across the Top End. These records occurred across a latitudinal range from 19.27° south to 11.27° south.

All 11 known populations of *T. taylori* occur within the Howard Sand Plains SOCS. Records of 1197 individual plants were available with population counts ranging from a single individual to over 500 plants at two localities (Liddle and Trikojus 2010). The palm *P. macarthurii* is known from 8 rainforests in the Northern Territory with all patches located within the Howard River or Adelaide River catchments (Liddle *et al.* 2006).

3.1.2. Field survey

Floristic data, vegetation structure and environmental attributes were collected at 45 plots during the course of the field survey.

3.1.3. Vegetation communities

Twenty-one vegetation communities were identified and mapped in the seasonally saturated lands of the Howard Sand Plains SOCS.

3.2. Vegetation community descriptions

3.2.1. *Map Unit 1: Lophostemon lactifluus (red swamp mahogany), +/- Erythrophleum chlorostachys (ironwood) mid open forest with a mid open tussock grassland understorey*

Table 1: Community 1 structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	52 (35 – 60)	12 (8 – 15)	100	T7c
Mid M1	Tree	15 (5 – 25)	2.05 (1.6 – 2.5)	67	T6i
Ground G1	Grass	20 (5 – 35)	0.97 (0.5 – 1.3)	100	G2i



Plate 1: Vegetation community 1 (site 52)

NVIS Association

U+ *Lophostemon lactifluus*, *Erythrophleum chlorostachys*, *Corymbia polycarpa* \^tree\7\c; M
Lophostemon lactifluus, *Erythrophleum chlorostachys* \^tree\6\i; G *Eriachne trisetata*, *Mnesithea*
rottboellioides, *Sorghum intrans* \^tussock grass\2\i

Description:

The upper stratum is a mid open forest dominated by *Lophostemon lactifluus* (red swamp mahogany), with or without *Erythrophleum chlorostachys* (ironwood) and *Corymbia polycarpa* (long-fruited bloodwood) as subdominant species.

A mid stratum forming a low open woodland with or without *Pandanus spiralis* (screw palm), *Alphitonia excelsa* (red ash) and *Melaleuca nervosa*.

The ground stratum forms a mid open tussock grassland dominated by *Eriachne trisetata*, *Mnesithea rottboellioides* and *Sorghum intrans*.

Distribution: Occurs in isolated patches on the flood plain and in bands along the floodplain/woodland ecotone.

Surface soils: Sandy loam (2 plots) and clay loam (1 plot).

Rare or significant species/community: There are no records of listed threatened plants from this community.

Comments:

Area: 0.87 km²

Sites: Count = 3; Howard Sand Plains Survey 11, 20, 52.

Table 2: Community 1 species cover and occurrence

Stratum	Species	Average Cover (%) within 3 sites	Occurrence (%) within 3 sites
Upper	<i>Lophostemon lactifluus</i>	28.3	100
	<i>Erythrophleum chlorostachys</i>	11.3	67
	<i>Corymbia polycarpa</i>	5	67
	<i>Terminalia ferdinandiana</i>	3.4	67
	<i>Planchonia careya</i>	3.3	33
	<i>Cochlospermum fraseri</i> , <i>Ipomoea abrupta</i> , <i>Pandanus spiralis</i> , <i>Terminalia grandiflora</i>	<1	33
Mid	<i>Alphitonia excelsa</i> , <i>Buchanania obovata</i> , <i>Melaleuca nervosa</i> , <i>Pandanus spiralis</i>	<1	67
	<i>Lophostemon lactifluus</i>	3.3	33
	<i>Erythrophleum chlorostachys</i>	2.7	33
	<i>Antidesma ghesaembilla</i> , <i>Cochlospermum fraseri</i> , <i>Corymbia polycarpa</i> , <i>Flagellaria indica</i> , <i>Ipomoea abrupta</i> , <i>Livistona humilis</i> , <i>Smilax australis</i> , <i>Syzygium eucalyptoides</i>	<1	33
Lower	<i>Eriachne trisetia</i>	7.3	100
	<i>Mnesithea rottboellioides</i>	3.3	100
	<i>Sorghum intrans</i>	1.7	100
	<i>Grewia retusifolia</i> , <i>Scleria annularis</i> ,	<1	100
	<i>Lophostemon lactifluus</i>	4	67
	<i>Heteropogon triticeus</i>	2	67
	<i>Alloteropsis semialata</i> , <i>Fimbristylis acuminata</i>	1.7	67
	<i>Whiteochloa capillipes</i>	1.3	67
	<i>Eriachne schultzeana</i>	1	67

Stratum	Species	Average Cover (%) within 3 sites	Occurrence (%) within 3 sites
	<i>Ampelocissus acetosa</i> , <i>Breynia cernua</i> , <i>Dioscorea bulbifera</i> , <i>Limnophila fragrans</i> , <i>Scleria caricina</i> , <i>Smilax australis</i> , <i>Terminalia grandiflora</i>	<1	67
	<i>Scleria rugosa</i>	1.3	33
	<i>Alphitonia excelsa</i> , <i>Asparagus racemosus</i> , <i>Byblis aquatica</i> , <i>Cartonema parviflorum</i> , <i>Cassytha filiformis</i> , <i>Ceratopteris thalictroides</i> , <i>Chlorophytum laxum</i> , <i>Commelina ensifolia</i> , <i>Crotalaria brevis</i> , <i>Cyperus javanicus</i> , <i>Cyperus tenuiculmis</i> , <i>Eragrostis cumingii</i> , <i>Eragrostis rigidiuscula</i> , <i>Eriocaulon tortuosum</i> , <i>Erythrophleum chlorostachys</i> , <i>Fimbristylis furva</i> , <i>Fimbristylis pallida</i> , <i>Flemingia involucrata</i> , <i>Grevillea pteridifolia</i> , <i>Hibbertia candicans</i> , <i>Imperata cylindrica</i> , <i>Ipomoea abrupta</i> , <i>Melaleuca nervosa</i> , <i>Microstachys chamaelea</i> , <i>Murdannia cryptantha</i> , <i>Murdannia graminea</i> , <i>Pandanus spiralis</i> , <i>Panicum mindanaense</i> , <i>Persoonia falcata</i> , <i>Planchonia careya</i> , <i>Pseudopogonatherum irritans</i> , <i>Rotala mexicana</i> , <i>Sacciolepis indica</i> , <i>Syzygium eucalyptoides</i> , <i>Syzygium suborbiculare</i> , <i>Tabernaemontana orientalis</i> , <i>Tacca leontopetaloides</i> , <i>Utricularia minutissima</i> , <i>Vigna lanceolata</i> , <i>Vigna vexillata</i>	<1	33

Distribution Map:

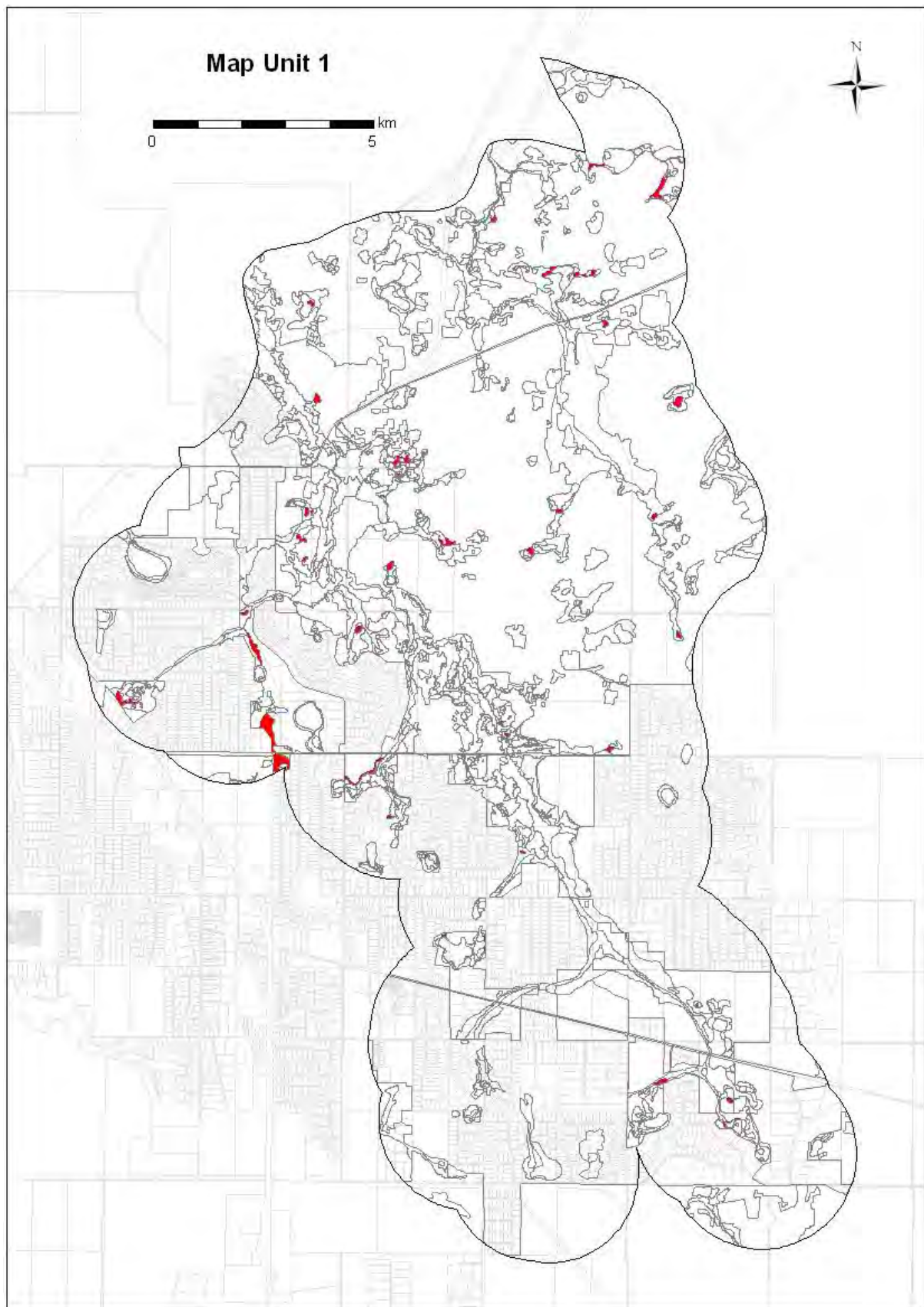


Figure 2: Map Unit 1 distribution map.

3.2.2. Map Unit 2a: *Melaleuca viridiflora* (broad-leaved paperbark) mid open woodland with a mid open tussock grassland understorey

Table 3: Community 2a structural summary

Stratum	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	15	14	100	T7r
Ground G1	Grass	35	0.6	100	G2c



Plate 2: Vegetation community 2a (site 15)

NVIS association

U+ ^*Melaleuca viridiflora*, *Pandanus spiralis*, *Eucalyptus alba* \^tree\7\r; G ^*Chrysopogon oliganthus*, ^*Eriocaulon setaceum*, *Ischaemum australe* \^tussock grass, herb\2\c

Description:

The upper stratum is mid open woodland strongly dominated by *Melaleuca viridiflora* (broad-leaved paperbark) with scattered *Pandanus spiralis* (screw palm) and *Eucalyptus alba* (white gum).

The tussock grassland ground stratum is dominated by the grass *Chrysopogon oliganthus* along with the herb *Eriocaulon setaceum* and with the grass *Ischaemum australe* sub-dominant.

Distribution: More common in the north and south-west of the Howard Sand Plains SOCS. Often in bands towards the margin of the floodplain or where the floodplain is relatively narrow and in proximity to adjoining uplands.

Surface soils: Loam (1 plot).

Rare or significant species/community: There are no records of listed threatened plants from this community.

Comments: Swamp with standing and flowing water for a significant proportion of the year.

Area: 4.28 km²

Sites: Count = 1; Howard Sand Plains Survey 15.

Table 4: Community 2a species cover and occurrence

Stratum	Species	Average Cover (%) within 1 site	Occurrence (%) within 1 site
Upper	<i>Melaleuca viridiflora</i>	15	100
	<i>Eucalyptus alba</i> , <i>Pandanus spiralis</i>	<1	100
Lower	<i>Chrysopogon oliganthus</i> , <i>Eriocaulon setaceum</i>	10	100
	<i>Ischaemum australe</i> , <i>Melaleuca viridiflora</i>	5	100
	<i>Pandanus spiralis</i> , <i>Sacciolepis indica</i>	<1	100

Distribution Map:

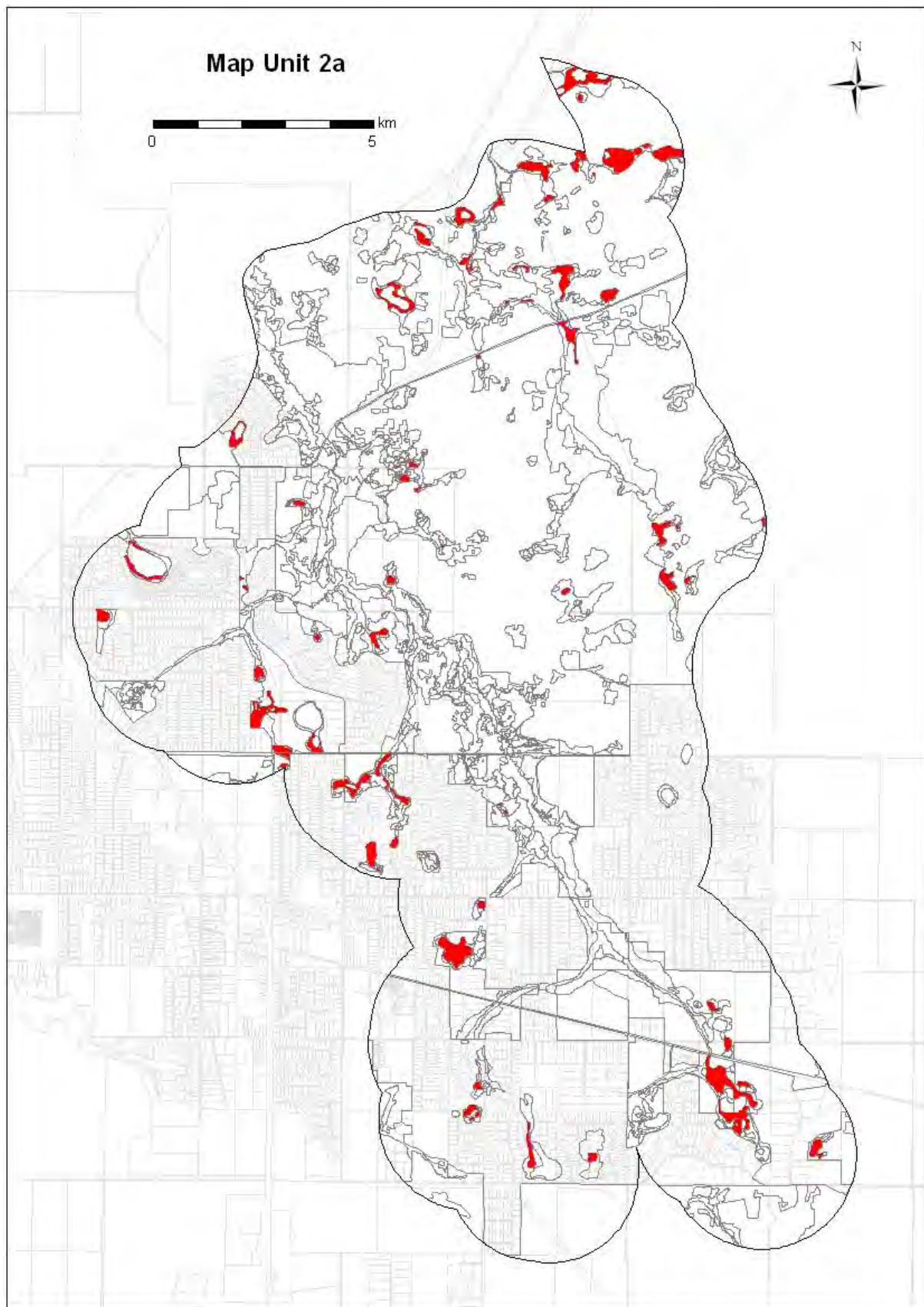


Figure 3: Map Unit 2a distribution map.

3.2.3. Map Unit 2b: *Melaleuca viridiflora* low woodland with *Fimbristylis* mid open sedgeland understorey

Table 5: Community 2b structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	40	8	100	T6i
Ground G1	Sedge	30	0.5	100	V2i

NVIS association

U+ ^*Melaleuca viridiflora*, *Melaleuca dealbata* \^tree\6\i; G ^*Fimbristylis acuminata*, *Fimbristylis tristachya*, *Eriachne burkittii* \^sedge, tussock grass\2\i

Description:

The upper stratum is a low woodland strongly dominated by *Melaleuca viridiflora* (broad-leaved paperbark) with sub-dominant *Melaleuca dealbata* (blue-leaved paperbark).

The mid open sedgeland ground stratum is dominated by the sedges *Fimbristylis acuminata* and *Fimbristylis tristachya* with sub-dominant tussock grass *Eriachne burkittii*.

Distribution: Scattered pockets throughout the seasonally saturated lands.

Surface soils: Light clay (1 plot).

Rare or significant species/community: There are no records of listed threatened plants from this community.

Comments: Swamp.

Area: 1.18 km²

Sites: Count = 1; Howard Sand Plains Survey 33.

Table 6: Community 2b species cover and occurrence

Stratum	Species	Average Cover (%) within 1 sites	Occurrence (%) within 1 sites
Upper	<i>Melaleuca viridiflora</i>	35	100
	<i>Melaleuca dealbata</i>	5	100
Lower	<i>Fimbristylis acuminata</i>	10	100
	<i>Fimbristylis tristachya</i>	8	100
	<i>Eriachne burkittii</i>	5	100
	<i>Fimbristylis acicularis</i> , <i>Fimbristylis furva</i>	2	100
	<i>Ficus aculeate</i>	1	100
	<i>Drosera indica</i> , <i>Eriocaulon setaceum</i> , <i>Fimbristylis pallida</i> , <i>Goodenia purpurascens</i> , <i>Goodenia symonii</i> , <i>Limnophila</i> <i>fragrans</i> , <i>Lindernia scapigera</i> , <i>Murdannia gigantea</i> , <i>Nymphoides subacuta</i> , <i>Sacciolepis myosuroides</i> , <i>Salomonina</i> <i>ciliata</i> , <i>Scleria annularis</i> , <i>Scleria laxa</i> , <i>Stylidium fissilobum</i> , <i>Utricularia gibba</i> , <i>Utricularia involvens</i> , <i>Utricularia lasiocaulis</i> , <i>Utricularia leptoplectra</i> , <i>Xyris complanata</i> , <i>Xyris indica</i>	<1	100

Distribution Map:

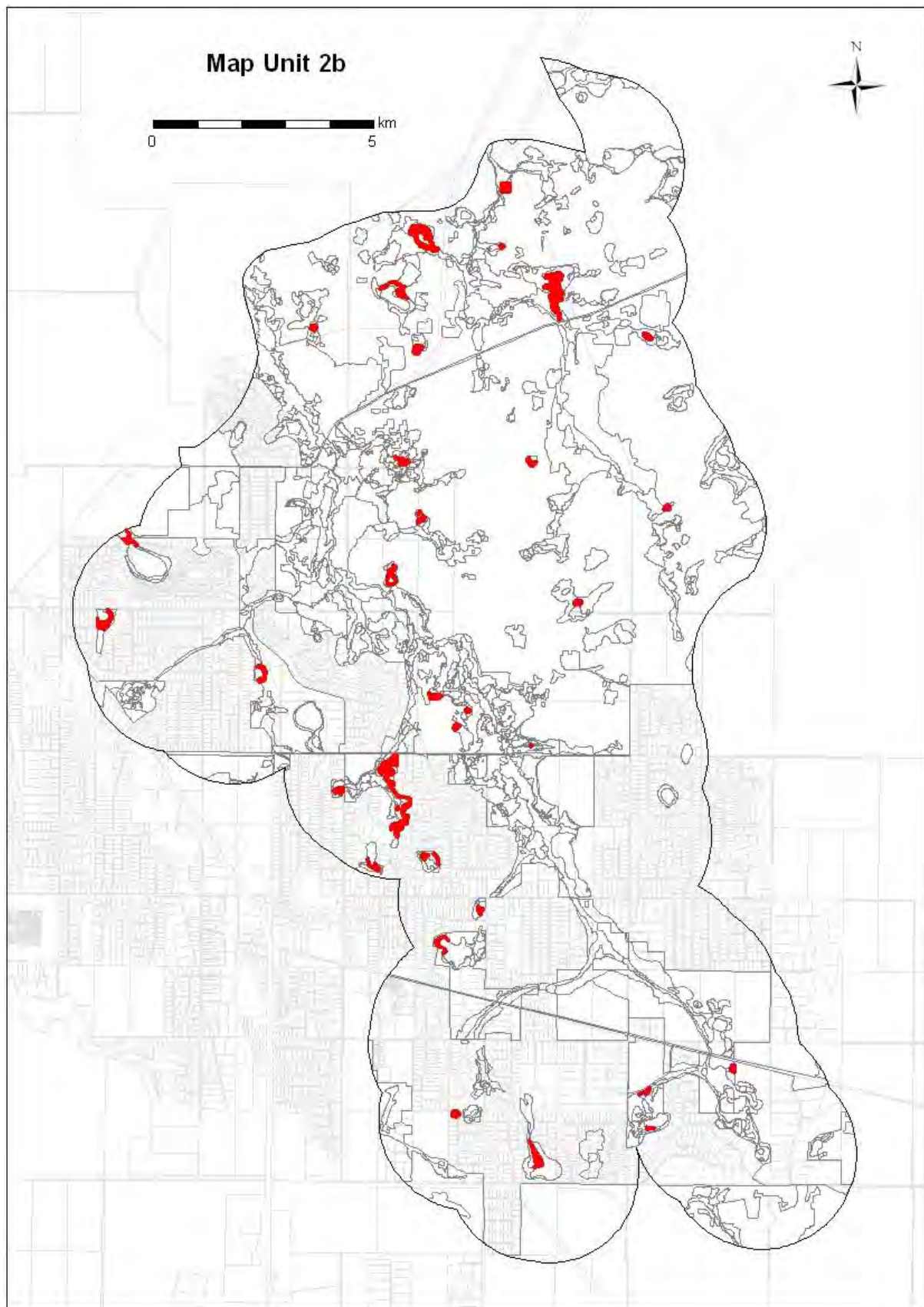


Figure 4: Map Unit 2b distribution map.

3.2.4. *Map Unit 3a: Melaleuca nervosa +/- Pandanus spiralis (screw palm) low open woodland with a Sorghum intrans, Eriachne trisetata mid tussock grassland understorey*

Table 7: Community 3a structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	13 (3 – 20)	7 (4 – 11)	100	T6r
Mid M1	Tree	2 (1 – 8)	2.2 (1.2 – 3)	71	T6r
Ground G1	Grass	31 (25 – 60)	0.6 (0.1 – 1.4)	100	G2c



Plate 3: Vegetation community 3a (site 18)

NVIS association

U+ ^*Melaleuca nervosa*, *Pandanus spiralis*, *Grevillea pteridifolia* \^tree, palm\6\r; M ^*Pandanus spiralis*, *Grevillea pteridifolia*, *Planchonia careya* \^tree, palm\6\r; G ^*Sorghum intrans*, *Eriachne trisetata*, *Xyris complanata* \ ^tussock grass, herb\2\c

Description:

The upper stratum is a low open woodland dominated by *Melaleuca nervosa*, *Pandanus spiralis* is common and *Hakea arborescens* may also occur.

A low open woodland mid stratum of *Pandanus spiralis* is sometimes evident, possibly with *Planchonia careya* and *Grevillea pteridifolia* present.

The ground stratum features a mid tussock grassland dominated by *Sorghum intrans* and *Eriachne trisetata* with *Lindernia lobelioides*, *Buchnera gracilis* present. *Xyris complanata* and *Cartonema trigonospermum* are also common.

Distribution: Occurs predominately in the central and northern part of the Howard Sand Plains SOCS.

Surface soils: Sand (2 plots), loamy sand (2 plots) and clayey sand (3 plots).

Rare or significant species/community: The two largest known populations of the endangered herb *Typhonium taylori* occur in this community. The near threatened herb *Rhamphicarpa australiensis* has been recorded in this community.

Comments:

Area: 5.18 km²

Sites: Count = 7; Howard Sand Plains Survey 4, 6, 8, 9, 10, 13, 18.

Table 8: Community 3a species cover and occurrence

Stratum	Species	Average Cover (%) within 7 sites	Occurrence (%) within 7 sites
Upper	<i>Melaleuca nervosa</i>	10.4	100
	<i>Pandanus spiralis</i>	1.6	71
	<i>Grevillea pteridifolia</i>	<1	43
	<i>Hakea arborescens</i>	<1	29
	<i>Acacia latescens, Ipomoea abrupta</i>	<1	14
Mid	<i>Pandanus spiralis</i>	<1	43
	<i>Grevillea pteridifolia, Planchonia careya</i>	<1	29
	<i>Acacia dimidiata</i>	<1	14
Lower	<i>Sorghum intrans</i>	7.1	100
	<i>Eriachne trisetia</i>	5.6	100
	<i>Lindernia lobelioides, Buchnera gracilis</i>	<1	100
	<i>Xyris complanata</i>	2.4	86
	<i>Cartonema trigonospermum</i>	1.9	86
	<i>Goodenia symonii, Sacciolepis indica,</i>	<1	86
	<i>Fimbristylis punctata</i>	1	71
	<i>Cartonema parviflorum, Eriocaulon fistulosum, Mimulus uvedaliae, Spermacoce calliantha, Utricularia chrysantha</i>	<1	71
	<i>Drosera fulva</i>	1.9	57
	<i>Fimbristylis sp. Howard River</i>	1.6	57
	<i>Calandrinia gracilis, Cyperus pulchellus, Huxleya linifolia, Murdannia cryptantha, Rhynchospora longisetis, Sowerbaea alliacea, Thaumastochloa major, Utricularia lasiocaulis</i>	<1	57
	<i>Eriocaulon schultzei</i>	2.3	43
	<i>Dapsilanthus spathaceus</i>	2	43
	<i>Limnophila fragrans</i>	1.7	43
	<i>Whiteochloa capillipes</i>	1	43
	<i>Desmodium trichostachyum, Dimeria ornithopoda, Eriocaulon cinereum, Fimbristylis acuminata, Murdannia graminea, Murdannia vaginata, Utricularia capilliflora, Utricularia sp. small white</i>	<1	43

Stratum	Species	Average Cover (%) within 7 sites	Occurrence (%) within 7 sites
	<i>Scleria laxa</i>	1	29
	<i>Alloteropsis semialata</i> , <i>Byblis aquatica</i> , <i>Cartonema tenue</i> , <i>Fimbristylis furva</i> , <i>Mitrasacme subvolubilis</i> , <i>Pandanus spiralis</i> , <i>Polygala exsuarrosa</i> , <i>Schoenus punctatus</i> <i>Scleria annularis</i> , <i>Scleria pygmaea</i> , <i>Scleria rugosa</i> , <i>Utricularia hamiltonii</i>	<1	29
	<i>Aristida holathera</i> , <i>Bergia pusilla</i> , <i>Cassytha filiformis</i> , <i>Centrolepis exserta</i> , <i>Chamaecrista mimosoides</i> , <i>Cleome tetrandra</i> , <i>Corynotheca lateriflora</i> , <i>Cyanotis axillaris</i> , <i>Cyclocarpa stellaris</i> , <i>Drosera dilatatopetiolaris</i> , <i>Drosera indica</i> , <i>Empusa habenarina</i> , <i>Eriocaulon tortuosum</i> , <i>Eriocaulon tricornum</i> , <i>Euphorbia muelleri</i> , <i>Ficus aculeata</i> , <i>Fimbristylis dunlopii</i> , <i>Fimbristylis pallida</i> , <i>Fimbristylis pauciflora</i> , <i>Fimbristylis pilifera</i> , <i>Fimbristylis pterygosperma</i> , <i>Fimbristylis rara</i> , <i>Fimbristylis squarrulosa</i> , <i>Fimbristylis tetragona</i> , <i>Germania grandiflora</i> , <i>Gomphrena diffusa</i> , <i>Goodenia purpurea</i> , <i>Ipomoea abrupta</i> , <i>Lipocarpha microcephala</i> , <i>Ludwigia perennis</i> , <i>Melaleuca nervosa</i> , <i>Melochia corchorifolia</i> , <i>Mitrasacme laevis</i> , <i>Murdannia gigantea</i> , <i>Panicum mindanaense</i> , <i>Persoonia falcata</i> , <i>Phyllanthus minutiflorus</i> , <i>Ptilotus corymbosus</i> , <i>Rhamphicarpa australiensis</i> , <i>Rotala mexicana</i> , <i>Salomonina ciliata</i> , <i>Scleria novae-hollandiae</i> , <i>Selaginella pygmaea</i> , <i>Thecanthes punicea</i> , <i>Utricularia leptoplectra</i> , <i>Utricularia minutissima</i> , <i>Xyris oligantha</i>	<1	14

Distribution Map:

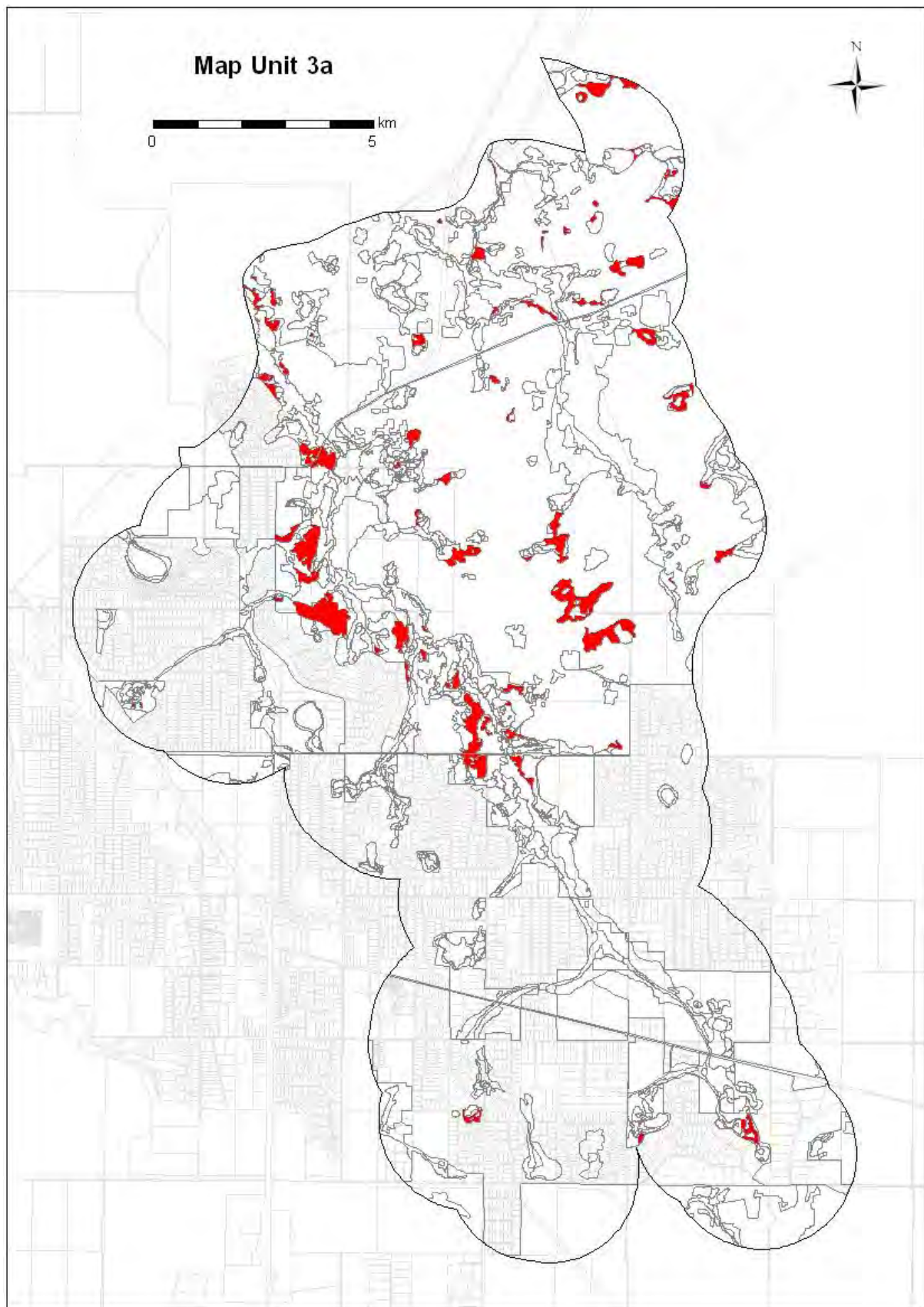


Figure 5: Map Unit 3a distribution map.

3.2.5. *Map Unit 3b* *Melaleuca nervosa*, *Grevillea pteridifolia* (*fern-leaved grevillea*) *low open woodland with Dapsilanthus spathaceus low open sedgeland ground layer*

Table 9: Community 3b structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	9 (5 – 17)	7.1 (5.5 – 9)	100	T6r
Mid M1	Heath Shrub	0.7	2.5	17	Z4r
Ground G1	Sedge	31 (15 – 50)	0.4 (0.2 – 0.5)	100	V1c



Plate 4: Vegetation community 3b (site 44) with no mid stratum evident



Plate 5: Vegetation community 3b (site 2) with heath shrub mid stratum

NVIS association

U+ ^*Melaleuca nervosa*, *Grevillea pteridifolia* , *Hakea arborescens* \ ^tree\6\r; M ^*Verticordia cunninghamii*, *Banksia dentata* \ ^heath shrub\4\r; G ^*Dapsilanthus spathaceus*, *Sorghum intrans*, *Alloteropsis semialata* \ ^sedge, tussock grass\1\c

Description:

The upper stratum is a low open woodland dominated by *Melaleuca nervosa* with or without *Grevillea pteridifolia* and *Hakea arborescens*.

Where evident, the mid stratum is a tall sparse heathland of *Verticordia cunninghamii* and *Banksia dentata* may be present.

The ground layer is a low open sedgeland dominated by *Dapsilanthus spathaceus* and a variable prominence of tussock grasses with widespread occurrence of *Sorghum intrans* and *Alloteropsis semialata*.

Distribution: Concentrated on broad floodplains in the central part of the Howard Sand Plains SOCS.

Surface soils: Loamy sand (4 plots) and clayey sand (2 plots).

Rare or significant species/community: The endangered herb *Typhonium taylori* occurs in this community.

Comments:

Area: 2.72 km²

Sites: Count = 7; Howard Sand Plains Survey 1, 2, 5, 28, 38, 44; Herbarium 3054.

Table 10: Community 3b species cover and occurrence

Stratum	Species	Average Cover (%) within 6 sites	Occurrence (%) within 6 sites
Upper	<i>Melaleuca nervosa</i>	7.7	100
	<i>Grevillea pteridifolia</i>	1.7	33
	<i>Hakea arborescens</i> , <i>Planchonia careya</i> , <i>Wrightia saligna</i>	<1	17
Mid	<i>Verticordia cunninghamii</i>	<1	33
	<i>Banksia dentata</i>	<1	17
Ground	<i>Dapsilanthus spathaceus</i>	11.8	100
	<i>Sorghum intrans</i>	2.2	100
	<i>Alloteropsis semialata</i>	1.4	100
	<i>Cartonema trigonospermum</i>	<1	100
	<i>Eriachne trisetia</i>	3.5	83
	<i>Buchnera gracilis</i> , <i>Drosera dilatatopetiolaris</i> , <i>Euphorbia muelleri</i> , <i>Lindernia lobelioides</i> , <i>Xyris complanata</i>	<1	83
	<i>Eriocaulon schultzei</i>	1	67
	<i>Cyperus pulchellus</i> , <i>Eriocaulon fistulosum</i> , <i>Fimbristylis pallida</i> , <i>Huxleya linifolia</i> , <i>Sacciolepis indica</i> , <i>Scleria pygmaea</i> , <i>Spermacoce calliantha</i>	<1	67
	<i>Centrolepis exserta</i> , <i>Drosera fulva</i> , <i>Fimbristylis punctata</i> , <i>Melaleuca nervosa</i> , <i>Mimulus uvedaliae</i> , <i>Thaumastochloa major</i> , <i>Utricularia</i> sp. small white	<1	50
	<i>Fimbristylis pauciflora</i>	1.5	33
	<i>Centrolepis banksii</i> , <i>Dimeria ornithopoda</i> , <i>Drosera indica</i> , <i>Eriosema chinense</i> , <i>Fimbristylis dunlopiae</i> , <i>Fimbristylis furva</i> , <i>Goodenia purpurea</i> , <i>Goodenia symonii</i> , <i>Grevillea pteridifolia</i> , <i>Haemodorum ensifolium</i> , <i>Mitrasacme subvolubilis</i> , <i>Oldenlandia leptocaulis</i> , <i>Phyllanthus virgatus</i> , <i>Rhynchospora longisetis</i> , <i>Salomonina ciliata</i> , <i>Scleria novae-hollandiae</i> , <i>Scleria rugosa</i> , <i>Sowerbaea alliacea</i> , <i>Stylidium cordifolium</i> , <i>Utricularia chrysantha</i>	<1	33

<i>Aristida holathera</i>, <i>Bacopa floribunda</i>, <i>Bergia pusilla</i>, <i>Buchnera linearis</i>, <i>Byblis liniflora</i>, <i>Cartonema tenue</i>, <i>Drosera brevicornis</i>, <i>Drosera burmanni</i>, <i>Drosera</i> <i>petiolaris</i>, <i>Ectrosia leporina</i>, <i>Empusa habenarina</i>, <i>Eriachne agrostidea</i>, <i>Eriachne burkittii</i>, <i>Eriocaulon</i> <i>cinereum</i>, <i>Eriocaulon pusillum</i>, <i>Eriocaulon tortuosum</i>, <i>Fimbristylis acicularis</i>, <i>Fimbristylis acuminata</i>, <i>Fimbristylis macassarensis</i>, <i>Fimbristylis</i> <i>pterygosperma</i>, <i>Fimbristylis</i> sp. Howard River, <i>Germainia grandiflora</i>, <i>Goodenia porphyrea</i>, <i>Grevillea dimidiata</i>, <i>Haemodorum brevicaule</i>, <i>Hakea</i> <i>arborescens</i>, <i>Limnophila fragrans</i>, <i>Lipocarpa</i> <i>microcephala</i>, <i>Mitrasacme gentianeae</i>, <i>Murdannia</i> <i>graminea</i>, <i>Phyllanthus minutiflorus</i>, <i>Pleurocarpaea</i> <i>denticulata</i>, <i>Rotala mexicana</i>, <i>Sauropus stenocladus</i>, <i>Scleria annularis</i>, <i>Scleria laxa</i>, <i>Scleria</i> sp. Oenpelli, <i>Stylidium adenophorum</i>, <i>Stylidium turbinatum</i>, <i>Utricularia hamiltonii</i>, <i>Utricularia lasiocaulis</i>, <i>Utricularia odorata</i>, <i>Wrightia saligna</i>, <i>Xyris oligantha</i>, <i>Xyris pauciflora</i>	<1	17
--	----	----

Distribution Map:

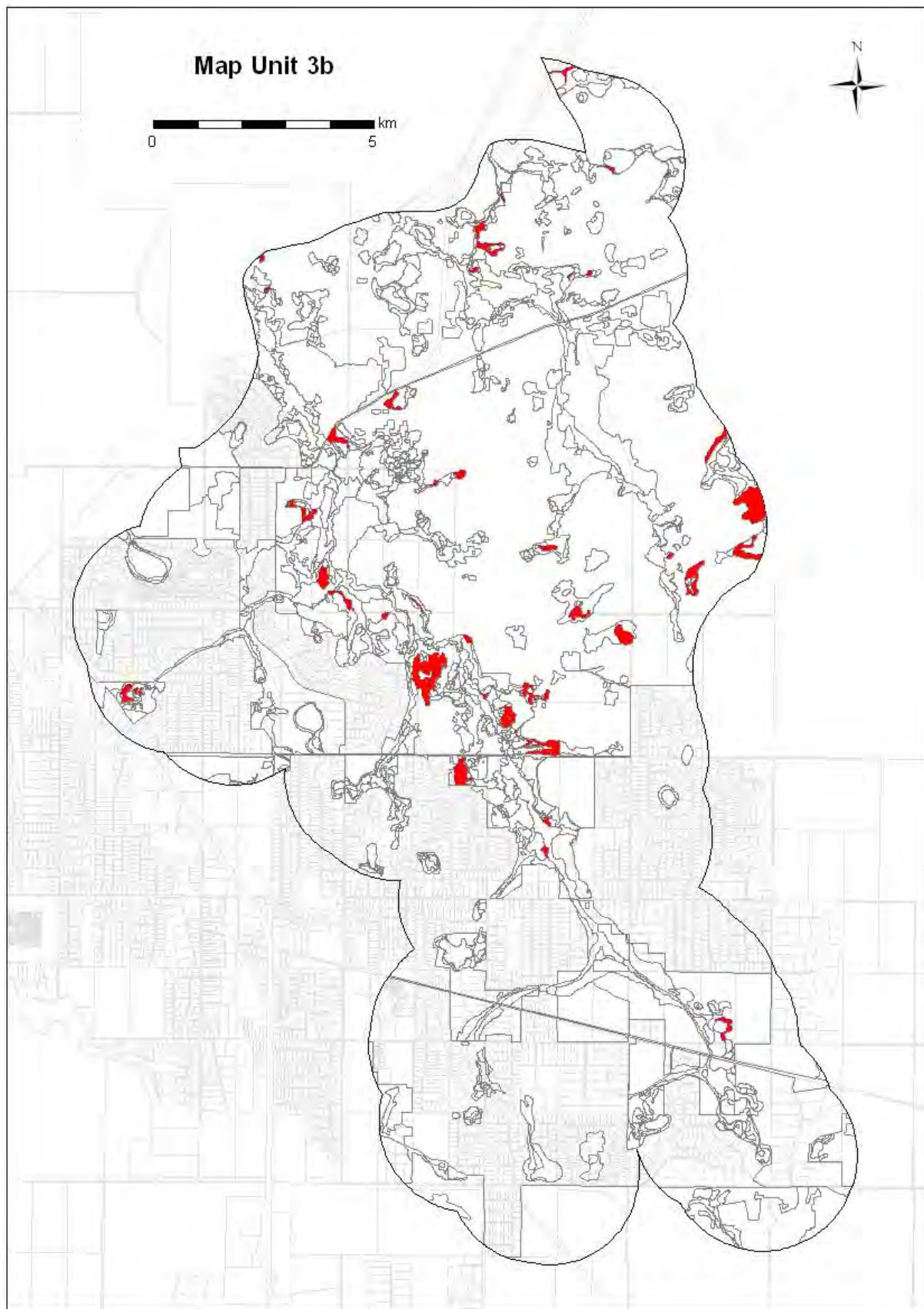


Figure 6: Map Unit 3b distribution map.

3.2.6. *Map Unit 4a: Verticordia cunninghamii (Cunningham's featherflower) and Banksia dentata mid open heathland with an emergent Melaleuca nervosa and Grevillea pteridifolia (fern-leaved grevillea) low open woodland and with Dapsilanthus spathaceus mid open sedgeland ground layer*

Table 11: Community 4a structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	2.6 (1.5 – 4.5)	5.3 (5 – 6)	100	T6r
Mid M1	Heath Shrub	16 (13 – 20)	1.9 (1.9 – 2)	100	Z3i
Ground G1	Sedge	23 (15 – 35)	0.6 (0.5 – 0.8)	100	V2i



Plate 6: Vegetation community 4a (site 26)

NVIS association

U ^*Melaleuca nervosa*, *Grevillea pteridifolia*, *Banksia dentata* /^tree/6/r; M+ ^*Verticordia cunninghamii*, *Banksia dentata*, *Melaleuca nervosa* /^heath shrub/3/i; G ^*Dapsilanthus spathaceus*, *Eriocaulon fistulosum*, *Tricostularia undulata* /^sedge, herb, tussock grass/2/i

Description:

The upper stratum is an emergent low open woodland dominated by *Melaleuca nervosa* and *Grevillea pteridifolia* (fern-leaved grevillea) with or without *Banksia dentata*.

The middle stratum comprises the dominant woody component of the community and is a mid open heathland dominated by *Verticordia cunninghamii* (Cunningham's featherflower) and *Banksia dentata*.

The ground layer is a mid open sedgeland dominated by *Dapsilanthus spathaceus*, with common occurrence of *Eriocaulon fistulosum*, *Tricostularia undulate* and *Cartonema trigonospermum*, with or without *Eriachne trisetata*.

Distribution: Occurs predominately in the south of the Howard Sand Plains SOCS.

Surface soils: Loamy sand (1 plot) or clayey sand (2 plots).

Rare or significant species/community: The endangered *T. taylori* and vulnerable *U. dunstaniae* have been recorded in this community. A high maximum and high average number of *Utricularia* species recorded in 20 m by 20 m plots.

Comments:

Area: 2.38 km²

Sites: Count = 5; Howard Sand Plains 22, 25, 26; Herbarium 3076, 3077.

Table 12: Community 4a species cover and occurrence

Stratum	Species	Average Cover (%) within 3 sites	Occurrence (%) within 3 sites
Upper	<i>Melaleuca nervosa</i>	1.6	100
	<i>Grevillea pteridifolia</i>	<1	100
	<i>Banksia dentata</i>	<1	67
Mid	<i>Verticordia cunninghamii</i>	14.7	100
	<i>Banksia dentata</i>	1	100
	<i>Melaleuca nervosa</i>	<1	67
	<i>Grevillea pteridifolia</i>	<1	33
Lower	<i>Dapsilanthus spathaceus</i>	16.7	100
	<i>Eriocaulon fistulosum</i>	1.7	100
	<i>Tricostularia undulata</i>	1.3	100
	<i>Cartonema trigonospermum</i>	<1	100
	<i>Eriachne trisetia</i>	1.7	67
	<i>Buchnera gracilis</i> , <i>Byblis aquatica</i> , <i>Centrolepis exserta</i> , <i>Fimbristylis lanceolata</i> , <i>Germainia grandiflora</i> , <i>Scleria</i> <i>pygmaea</i> , <i>Scleria</i> sp. <i>Oenpelli</i> , <i>Sowerbaea alliacea</i> , <i>Utricularia lasiocaulis</i> , <i>Utricularia</i> sp. <i>small white</i>	<1	67
	<i>Fimbristylis pallida</i>	1.7	33
	<i>Banksia dentata</i> , <i>Calandrinia gracilis</i> , <i>Cassytha capillaris</i> , <i>Drosera brevicornis</i> , <i>Drosera dilatatopetiolaris</i> , <i>Drosera</i> <i>falconeri</i> , <i>Drosera fulva</i> , <i>Eriachne avenacea</i> <i>Eriocaulon</i> <i>schultzei</i> , <i>Euphorbia muelleri</i> , <i>Fimbristylis macassarensis</i> , <i>Grevillea pteridifolia</i> , <i>Lindernia lobelioides</i> , <i>Melaleuca</i> <i>nervosa</i> , <i>Salomonina ciliata</i> , <i>Stylidium ericksoniae</i> , <i>Stylidium</i> <i>turbinatum</i> , <i>Utricularia capilliflora</i> , <i>Utricularia chrysantha</i> , <i>Utricularia kamienskii</i> , <i>Verticordia cunninghamii</i> , <i>Xyris</i> <i>cheumatophila</i> , <i>Xyris complanata</i> , <i>Xyris oligantha</i>	<1	33

Distribution Map:

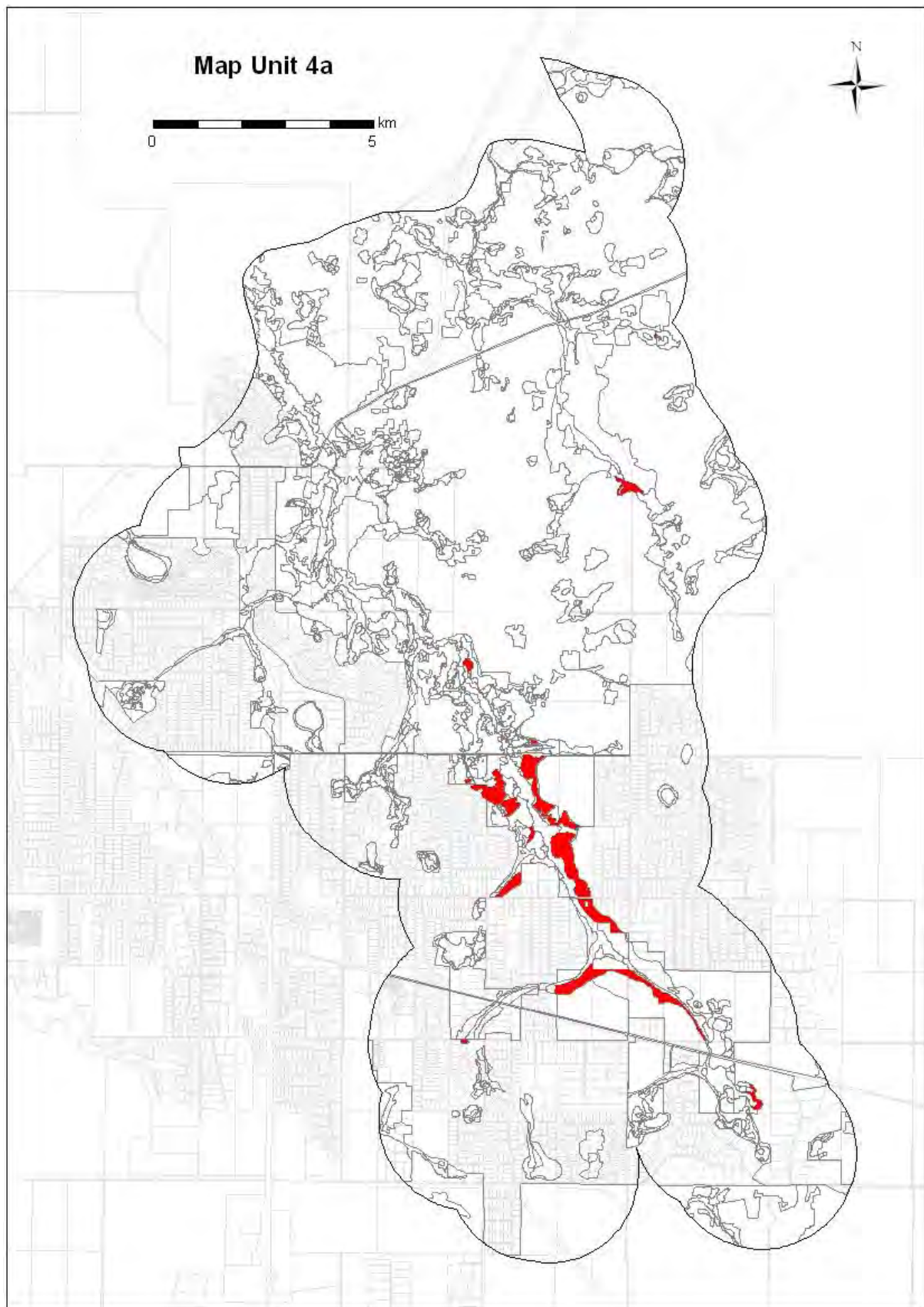


Figure 7: Map Unit 4a distribution map.

3.2.7. *Map Unit 4b: Grevillea pteridifolia (fern-leaved grevillea) +- Melaleuca nervosa low open woodland with or without a mid layer of Pandanus spiralis (screw palm) and Verticordia cunninghamii (Cunningham's featherflower) low isolated trees or heath shrubs and a Dapsilanthus spathaceus mid open sedgeland understorey*

Table 13: Community 4b structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	9 (6 – 12)	8.5 (8 – 9)	100	T6r
Mid M1	Palm (Pandanus)	<1	3	50	P6bi
Ground G1	Sedge	20 (15 – 25)	0.7 (0.7 – 0.7)	100	R2c



Plate 7: Vegetation community 4b (site 42)

NVIS association

U+ ^*Grevillea pteridifolia*, *Melaleuca nervosa* \^tree\6\r; M ^*Pandanus spiralis*, *Verticordia cunninghamii* \^palm\6\bi; G ^*Dapsilanthus spathaceus*, *Eriachne trisetata*, *Drosera dilatatopetiolaris* \^sedge, tussock grass, forb \2\i

Description:

The upper stratum is a low open woodland dominated by *Grevillea pteridifolia* (fern-leaved grevillea) with or without *Melaleuca nervosa*.

A mid stratum of *Pandanus spiralis* (screw palm) low isolated trees and *Verticordia cunninghamii* (Cunningham's featherflower) isolated heath may be evident.

The ground stratum is a mid open sedgeland dominated by *Dapsilanthus spathaceus* with common occurrence of the grass *Eriachne trisetia* and forb *Drosera dilatatopetiolaris*.

Distribution: Mostly occurs to the east of the main channel of the Howard River with a concentration in the central part of the Howard Sand Plains SOCS. This community is often in proximity to slightly elevated woodlands that abut the seasonally saturated floodplains.

Surface soils: Clayey sand (2 plots).

Rare or significant species/community: The vulnerable *U. dunstaniae* have been recorded in this community. A very high maximum and very high average number of *Utricularia* species recorded in 20 m by 20 m plots.

Comments:

Area: 0.93 km²

Sites: Count = 5; Howard Sand Plains Survey 40, 42; Herbarium 3066, 3069, 3070.

Table 14: Community 4b species cover and occurrence

Stratum	Species	Average Cover (%) within 2 sites	Occurrence (%) within 2 sites
Upper	<i>Grevillea pteridifolia</i>	7	100
	<i>Melaleuca nervosa</i>	2	50
Mid	<i>Pandanus spiralis</i> , <i>Verticordia cunninghamii</i>	<1	50
Ground	<i>Dapsilanthus spathaceus</i>	8	100
	<i>Eriachne trisetia</i>	4.5	100
	<i>Drosera dilatatopetiolaris</i>	1.5	100
	<i>Eriachne burkittii</i> , <i>Xyris complanata</i>	1	100
	<i>Byblis aquatic</i> , <i>Cartonema trigonospermum</i> , <i>Drosera indica</i> , <i>Eriocaulon fistulosum</i> , <i>Eriocaulon schultzei</i> , <i>Goodenia symonii</i> , <i>Lindernia lobelioides</i> , <i>Utricularia chrysantha</i> , <i>Utricularia</i> <i>hamiltonii</i> , <i>Utricularia holtzei</i> , <i>Utricularia kamienskii</i> , <i>Utricularia leptoplectra</i> , <i>Utricularia odorata</i>	<1	100
	<i>Fimbristylis acuminata</i>	1.5	50
	<i>Aristida holathera</i> , <i>Buchnera gracilis</i> , <i>Calandrinia gracilis</i> , <i>Eriocaulon tortuosum</i> , <i>Fimbristylis furva</i> , <i>Fimbristylis pallida</i> , <i>Germania grandiflora</i> , <i>Melaleuca nervosa</i> , <i>Oldenlandia</i> <i>leptocaulis</i> , <i>Pandanus spiralis</i> , <i>Salomonina ciliata</i> , <i>Scleria sp.</i> <i>Oenpelli</i> , <i>Sorghum intrans</i> , <i>Sowerbaea alliacea</i> , <i>Spermacoce</i> <i>calliantha</i> , <i>Tricostularia undulate</i> , <i>Utricularia capilliflora</i> , <i>Utricularia dunstanii</i> , <i>Utricularia lasiocaulis</i> , <i>Utricularia sp.</i> <i>small white</i> , <i>Verticordia cunninghamii</i>	<1	50

Distribution Map:

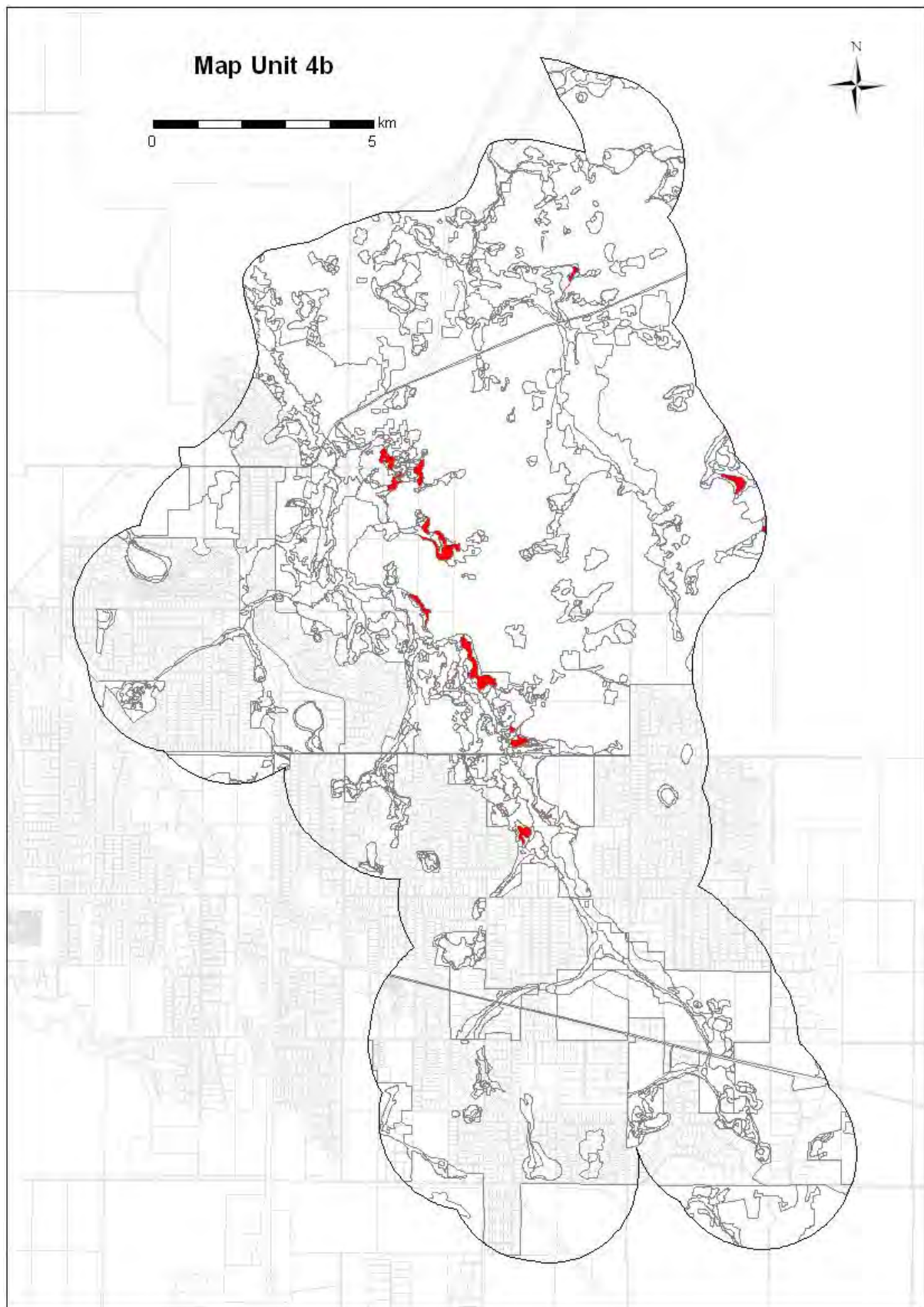


Figure 8: Map Unit 4b distribution map.

3.2.8. *Map Unit 4c: Grevillea pteridifolia (fern-leaved grevillea) +- Melaleuca viridiflora (broad-leaved paperbark) +- Melaleuca nervosa low open woodland with a mid layer of Banksia dentata +- Pandanus spiralis (screw palm) +- Verticordia cunninghamii (Cunningham's featherflower) tall sparse heathland and a Dapsilanthus spathaceus mid sedgeland understorey*

Table 15: Community 4c structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	9.7 (4 – 13)	8.3 (7 – 9)	100	T6r
Mid M1	Heath Shrub	10 (10 – 10)	3.2 (2 – 4.5)	100	Z4r
Ground G1	Sedge	48.3 (40 – 60)	0.5 (0.4 – 0.6)	100	V2c



Plate 8: Vegetation community 4c (site 29)

NVIS Association

U+ ^*Grevillea pteridifolia*, *Melaleuca viridiflora*, *Melaleuca nervosa* \^tree\6\r; M ^*Banksia dentata*, *Pandanus spiralis*, *Verticordia cunninghamii* \^heath shrub\4\r; G ^*Dapsilanthus spathaceus*, *Eriachne trisetia*, *Ischaemum decumbens* \^sedge, tussock grass, forb\2\c

Description:

The upper stratum is a low open woodland dominated by *Grevillea pteridifolia* (fern-leaved grevillea) with or without *Melaleuca viridiflora* (broad-leaved paperbark) and *Melaleuca nervosa*.

A mid stratum of tall sparse heathland dominated by *Banksia dentata* with or without *Pandanus spiralis* (screw palm) and *Verticordia cunninghamii* (Cunningham's featherflower).

The ground stratum is a mid sedgeland dominated by *Dapsilanthus spathaceus* with common occurrence of the grasses *Eriachne trisetia* and *Ischaemum decumbens*.

Distribution: Small patches scattered throughout with the major concentration to the south of the Howard Sand Plains SOCS.

Surface soils: Clayey sand (2 plots) and sandy loam (1 plot).

Rare or significant species/community: The endangered *T. taylori* has been recorded in this community. A high maximum number of *Utricularia* species recorded in 20 m by 20 m plots.

Comments:

Area: 2.34 km²

Sites: Count = 4; Howard Sand Plains Survey 29, 30, 46; Herbarium 3046.

Table 16: Community 4c species cover and occurrence

Stratum	Species	Average Cover (%) within 3 sites	Occurrence (%) within 3 sites
Upper	<i>Grevillea pteridifolia</i>	4	100
	<i>Melaleuca viridiflora</i>	2.7	33
	<i>Melaleuca nervosa</i>	2	33
	<i>Pandanus spiralis</i>	<1	33
Mid	<i>Banksia dentata</i>	2.7	100
	<i>Pandanus spiralis</i>	3.7	67
	<i>Verticordia cunninghamii</i>	2.7	67
	<i>Lophostemon lactifluus</i> , <i>Melaleuca nervosa</i> , <i>Melaleuca viridiflora</i>	<1	33
Ground	<i>Dapsilanthus spathaceus</i>	18.3	100
	<i>Eriachne trisetia</i>	7	100
	<i>Ischaemum decumbens</i>	6.7	100
	<i>Xyris cheumatophila</i>	5.7	100
	<i>Alloteropsis semialata</i>	2.3	100
	<i>Sorghum intrans</i>	2	100
	<i>Fimbristylis furva</i>	1.4	100
	<i>Fimbristylis pallida</i>	1	100
	<i>Cartonema trigonospermum</i> , <i>Drosera indica</i> , <i>Eriocaulon fistulosum</i> , <i>Eriocaulon setaceum</i> , <i>Lindernia scapigera</i> , <i>Salomonina ciliate</i> , <i>Scleria pygmaea</i> , <i>Sowerbaea alliacea</i> , <i>Utricularia leptoplectra</i>	<1	100
	<i>Tricostularia undulata</i>	4	67
	<i>Germainia grandiflora</i>	2	67
	<i>Fimbristylis pauciflora</i>	1.3	67
	<i>Fimbristylis lanceolata</i>	1	67
	<i>Cassytha filiformis</i> , <i>Pandanus spiralis</i> , <i>Sacciolepis indica</i> , <i>Selaginella pygmaea</i> , <i>Xyris complanata</i>	<1	67
	<i>Fimbristylis acuminata</i>	1.7	33
	<i>Banksia dentata</i> , <i>Buchnera linearis</i> , <i>Byblis aquatic</i> , <i>Calandrinia gracilis</i> , <i>Chrysopogon setifolius</i> , <i>Drosera burmanni</i> , <i>Drosera dilatatopetiolaris</i> , <i>Eriachne burkittii</i> , <i>Eriocaulon schultzei</i> , <i>Gonocarpus leptothecus</i> , <i>Goodenia elaiosoma</i> , <i>Goodenia purpurea</i> , <i>Goodenia symonii</i> , <i>Grevillea pteridifolia</i> , <i>Limnophila fragrans</i> , <i>Lophostemon lactifluus</i> , <i>Melaleuca nervosa</i> , <i>Melaleuca viridiflora</i> , <i>Murdannia gigantea</i> , <i>Oldenlandia largiflorens</i> , <i>Osbeckia australiana</i> , <i>Rhynchospora heterochaeta</i> , <i>Scleria laxa</i> , <i>Scleria</i> sp. <i>Oenpelli</i> , <i>Stylidium tenerimum</i> , <i>Utricularia chrysantha</i> , <i>Utricularia hamiltonii</i> , <i>Utricularia holtzei</i> , <i>Utricularia kamienskii</i> , <i>Utricularia leptorhyncha</i> , <i>Utricularia odorata</i> , <i>Verticordia cunninghamii</i> , <i>Whiteochloa capillipes</i> , <i>Xyris indica</i>	<1	33

Distribution Map:

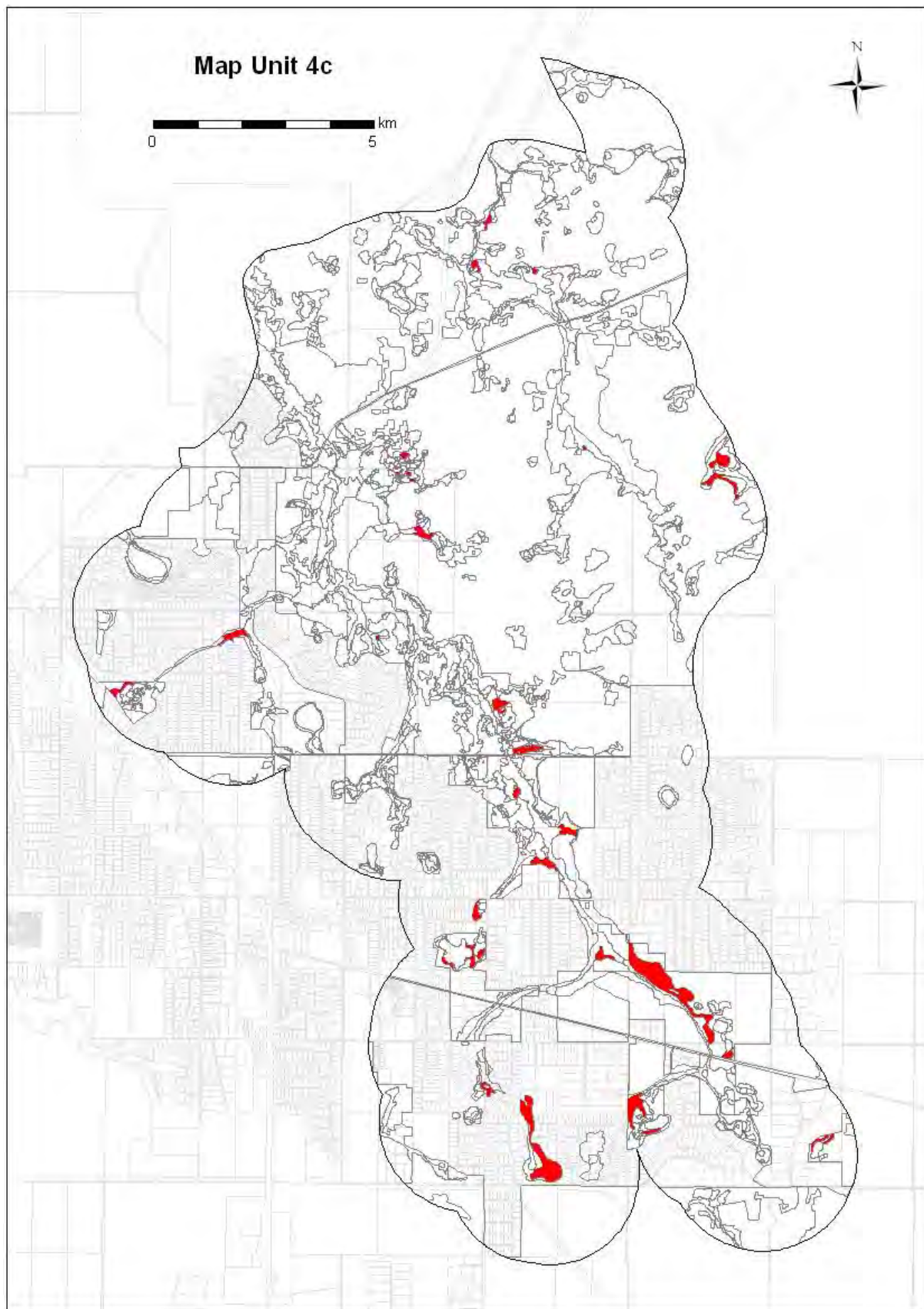


Figure 9: Map Unit 4c distribution map.

3.2.9. *Map Unit 4d: Grevillea pteridifolia and/or Lophostemon lactifluus mid open woodland with or without a Banksia dentata low open woodland mid layer and mid tussock grassland/sedgeland ground layer*

Table 17: Community 4d structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	10.7 (4 – 25)	10.7 (6 – 16)	100	T7r
Mid M1	Tree	7.3 (6 – 15)	3.9 (1.8 – 6)	75	T6r
Ground G1	Grass	55 (45 – 70)	0.6 (0.5 – 0.8)	100	G2c



Plate 9: Vegetation community 4d (site 45)

NVIS Association

U+ ^*Grevillea pteridifolia*, *Lophostemon lactifluus*, *Acacia latescens* \^tree\7\r; M ^*Banksia dentata*, *Pandanus spiralis*, *Melaleuca nervosa* \^tree, palm\6\r; G ^*Eriachne trisetata*, *Dapsilanthus spathaceus*, *Fimbristylis acuminata* \^grass, sedge\2\c

Distribution: Scattered throughout the Howard Sand Plains SOCS, often located towards the margin of the seasonally saturated floodplain.

Surface soils: Loamy sand (1 plot), clayey sand (3 plots) and sandy loam (1 plot).

Rare or significant species/community: The vulnerable *U. dunstaniae* has been recorded in this community. A high maximum number of *Utricularia* species recorded in 20 m by 20 m plots.

Comments:

Area: 2.88 km²

Sites: Count = 5; Howard Sand Plains Survey 14, 16, 19, 21, 45.

Table 18: Community 4d species cover and occurrence

Stratum	Species	Average Cover (%) within 5 sites	Occurrence (%) within 5 sites
Upper	<i>Grevillea pteridifolia</i>	3.2	60
	<i>Lophostemon lactifluus</i>	3	60
	<i>Acacia latescens</i>	4.4	40
	<i>Melaleuca nervosa</i>	1	40
	<i>Eucalyptus alba</i>	2	20
	<i>Syzygium eucalyptoides</i>	1	20
	<i>Banksia dentata</i> , <i>Erythrophleum chlorostachys</i> , <i>Pandanus spiralis</i>	<1	20
Mid	<i>Banksia dentata</i>	4.2	80
	<i>Pandanus spiralis</i>	<1	60
	<i>Cassytha filiformis</i> , <i>Melaleuca nervosa</i> , <i>Planchonia careya</i>	<1	40
	<i>Acacia leptocarpa</i> , <i>Alphitonia excelsa</i> , <i>Asteromyrtus symphyocarpa</i> , <i>Buchanania obovata</i> , <i>Erythrophleum chlorostachys</i> , <i>Grevillea pteridifolia</i> , <i>Lophostemon lactifluus</i> , <i>Melaleuca viridiflora</i> , <i>Terminalia ferdinandiana</i>	<1	20
Lower	<i>Fimbristylis acuminata</i>	4.4	100
	<i>Xyris complanata</i>	4	100
	<i>Scleria pygmaea</i>	2.8	100
	<i>Drosera dilatatopetiolaris</i> , <i>Eriocaulon fistulosum</i> , <i>Scleria novae-hollandiae</i> , <i>Sowerbaea alliacea</i>	<1	100
	<i>Eriachne trisetia</i>	10	80

	<i>Dapsilanthus spathaceus</i>	5.6	80
	<i>Germainia grandiflora</i>	4.2	80
	<i>Sorghum intrans</i> , <i>Whiteochloa capillipes</i>	3	80
	<i>Cartonema trigonospermum</i> , <i>Melaleuca nervosa</i> <i>Pandanus spiralis</i> , <i>Sacciolepis indica</i> , <i>Spermacoce calliantha</i>	<1	80
	<i>Tricostularia undulata</i>	1.4	60
	<i>Scleria rugosa</i>	1	60
	<i>Goodenia purpurea</i> , <i>Limnophila fragrans</i> , <i>Phyllanthus virgatus</i> , <i>Utricularia lasiocaulis</i>	<1	60
	<i>Alloteropsis semialata</i>	2.6	40
	<i>Fimbristylis furva</i>	1	40
	<i>Buchnera gracilis</i> , <i>Byblis aquatica</i> , <i>Corynotheca lateriflora</i> , <i>Desmodium trichostachyum</i> , <i>Eriachne schultzeana</i> , <i>Eriosema chinense</i> , <i>Fimbristylis pallida</i> , <i>Heteropogon triticeus</i> , <i>Huxleya linifolia</i> , <i>Lindernia lobelioides</i> , <i>Mimulus uvedaliae</i> , <i>Mitrasacme subvolubilis</i> , <i>Murdannia cryptantha</i> , <i>Stylidium cordifolium</i> , <i>Thaumastochloa major</i> , <i>Utricularia chrysantha</i> , <i>Waltheria indica</i>	<1	40
	<i>Chrysopogon oliganthus</i>	1.2	20
	<i>Mnesithea rottboellioides</i>		0
	<i>Rhynchospora longisetis</i>		0
	<i>Verticordia cunninghamii</i>		0
	<i>Aristida holathera</i> , <i>Blumea saxatilis</i> , <i>Breynia cernua</i> , <i>Cassytha filiformis</i> , <i>Drosera indica</i> , <i>Ectrosia leporina</i> , <i>Empusa habenarina</i> , <i>Eragrostis spartinoides</i> , <i>Eriocaulon pusillum</i> , <i>Eriocaulon schultzei</i> , <i>Fimbristylis dunlopiae</i> , <i>Fimbristylis pilifera</i> , <i>Fimbristylis punctata</i> , <i>Fuirena ciliaris</i> , <i>Goodenia symonii</i> , <i>Isachne myosotis</i> , <i>Ischaemum decumbens</i> , <i>Lindernia scapigera</i> , <i>Ludwigia hyssopifolia</i> , <i>Melaleuca viridiflora</i> , <i>Microstachys chamaelea</i> , <i>Mitrasacme aggregata</i> , <i>Mitrasacme exserta</i> , <i>Mnesithea rottboellioides</i> , <i>Murdannia gigantea</i> , <i>Murdannia graminea</i> , <i>Murdannia vaginata</i> , <i>Persoonia falcata</i> , <i>Pseudopogonatherum irritans</i> , <i>Rhynchospora longisetis</i> , <i>Sacciolepis myosuroides</i> , <i>Salomonina ciliata</i> , <i>Sauropus paucifolius</i> , <i>Stemona prostrata</i> , <i>Stylidium ceratophorum</i> , <i>Tacca leontopetaloides</i> , <i>Terminalia ferdinandiana</i> , <i>Utricularia hamiltonii</i> , <i>Utricularia holtzei</i> , <i>Utricularia involvens</i> , <i>Utricularia kamienskii</i> , <i>Utricularia leptoplectra</i> , <i>Utricularia odorata</i> , <i>Utricularia sp. small white</i> , <i>Verticordia cunninghamii</i> , <i>Vigna lanceolata</i>	<1	20

Distribution Map:

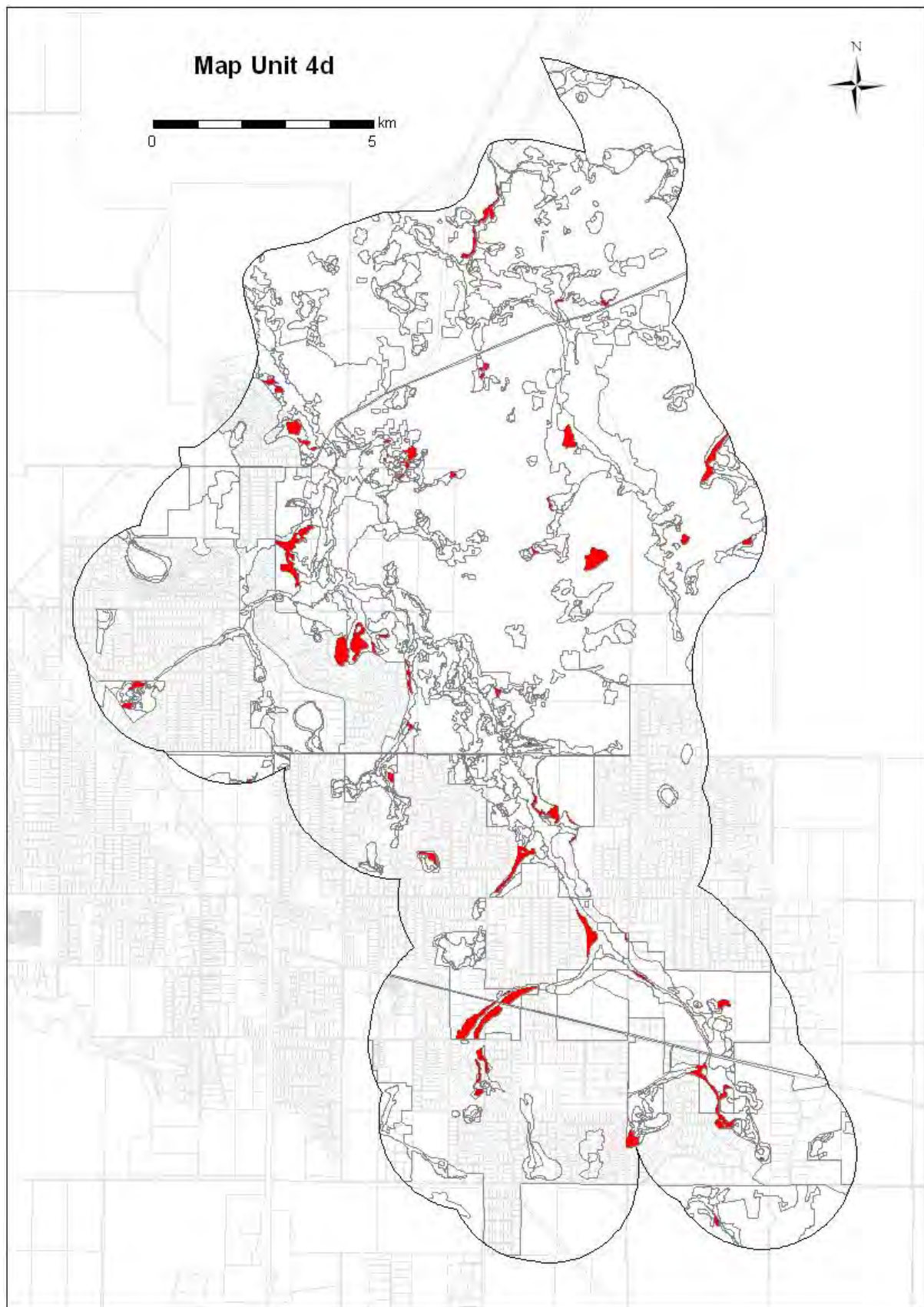


Figure 10: Map Unit 4d distribution map.

3.2.10. *Map Unit 5 Melaleuca dealbata low open forest with a low sparse sedgeland understorey*

Table 19: Community 5 structural summary

Stratum	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	65	5	100	T6c
Ground G1	Sedge	5	0.4	100	V1r

NVIS Association

U+ ^*Melaleuca dealbata*, *Melaleuca viridiflora* \^tree\6\c; G ^*Fimbristylis acuminata*, *Nymphoides subacuta*, *Goodenia purpurascens* \^sedge, herb\1\r

Description:

The upper stratum consists of a *Melaleuca dealbata* low open forest with infrequent *Melaleuca viridiflora*.

The ground stratum is a low sparse sedgeland dominated by *Fimbristylis acuminata*, *Nymphoides subacuta*, with less frequent *Goodenia purpurascens* and other scattered sedges and forbs.

Distribution: A small number of patches, mostly towards the southern end of the Howard Sand Plains SOCS.

Surface soils: Medium clay (1 plot).

Rare or significant species/community: There are no records of listed threatened plant species in this community.

Comments:

Area: 0.59 km²

Sites: Count = 1; Howard Sand Plains Survey 32.

Table 20: Community 5 species cover and occurrence

Stratum	Species	Average Cover (%)	Occurrence (%)
Upper	<i>Melaleuca dealbata</i>	60	100
	<i>Melaleuca viridiflora</i>	1	100
Lower	<i>Fimbristylis acuminata</i> , <i>Nymphoides subacuta</i>	2	100
	<i>Goodenia purpurascens</i>	1	100
	<i>Byblis aquatica</i> , <i>Cassytha filiformis</i> , <i>Crinum uniflorum</i> , <i>Eriachne burkittii</i> , <i>Eriocaulon setaceum</i> , <i>Fimbristylis pallida</i> , <i>Murdannia gigantea</i> , <i>Oldenlandia largiflorens</i> , <i>Scleria</i> <i>rugosa</i> , <i>Utricularia leptoplectra</i> , <i>Xyris indica</i>	<1	100

Distribution Map:

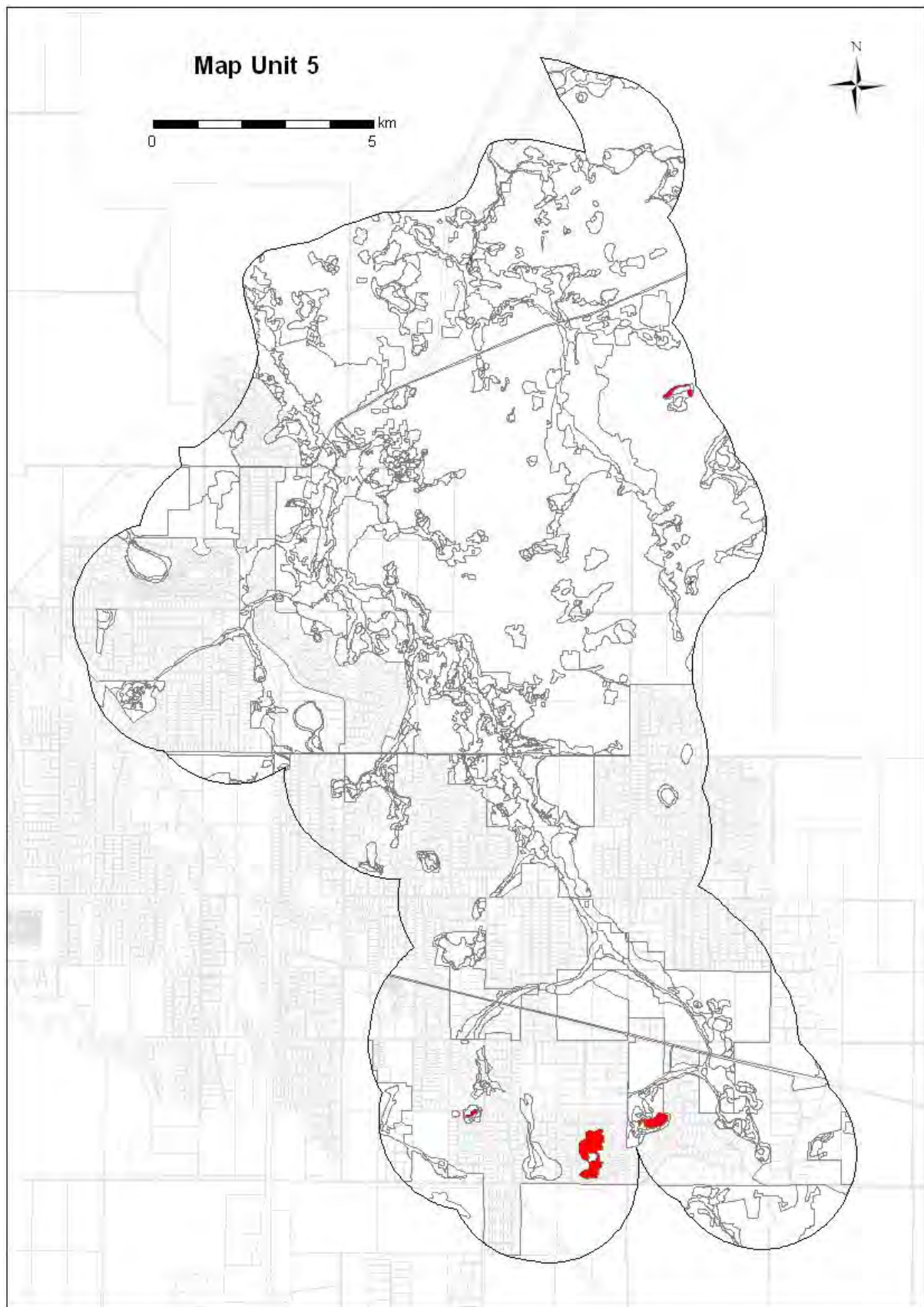


Figure 11: Map Unit 5 distribution map.

3.2.11. *Map Unit 6: Lophostemon lactifluus +/- Melaleuca viridiflora mid open woodland over a tall tussock grassland*

Table 21: Community 6 structural summary

Stratum	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	17 (5 – 40)	11.2 (6 – 15)	100	T7r
Mid M1	Tree	2.6 (2 – 5)	2.0 (1.7 – 4)	80	T6r
Ground G1	Grass	57.8 (25 – 92)	0.8 (0.5 – 1.6)	100	G2c

NVIS Association

U+ ^*Lophostemon lactifluus*, *Melaleuca viridiflora*, *Pandanus spiralis* \^tree, palm\7\r; M ^*Melaleuca viridiflora*, *Pandanus spiralis*, *Lophostemon lactifluus* \^tree, palm\6\r; G ^*Eriachne burkittii*, *Germainia grandiflora*, *Sorghum intrans* \^tussock grass\2\c

Description:

The upper stratum consists of a mid open woodland dominated by *Lophostemon lactifluus* with or without *Melaleuca viridiflora*, *Pandanus spiralis* or *Eucalyptus alba*.

A mid stratum of low open woodland with *Melaleuca viridiflora*, *Pandanus spiralis* or *Lophostemon lactifluus* may be present.

The ground stratum is a tall tussock grassland dominated by *Eriachne burkittii* and *Germainia grandiflora*. *Utricularia leptoplectra*, *Sacciolepis indica*, *Fimbristylis pauciflora* and *Eriachne trisetata* are common. A second ground stratum with emergent *Sorghum intrans* may be present.

Distribution: Scattered throughout, however, a markedly greater occurrence in the northern part of the Howard Sand Plains SOCS.

Surface soils: Loam (3 plots), sandy clay loam (1 plot) and light clay (1 plot).

Rare or significant species/community: There are no records of listed threatened plant species in this community.

Comments:

Area: 5.31 km²

Sites: Count = 5; Howard Sand Plains Survey 31, 41, 47, 48, 49.

Table 22: Community 6 species cover and occurrence

Stratum	Species	Average Cover (%) within 5 sites	Occurrence (%) within 5 sites
Upper	<i>Lophostemon lactiflorus</i>	7.4	100
	<i>Melaleuca viridiflora</i>	6.6	60
	<i>Pandanus spiralis</i>	<1	60
	<i>Eucalyptus alba</i>	2.2	40
	<i>Banksia dentata</i>	<1	20
Mid	<i>Melaleuca viridiflora</i>	<1	60
	<i>Pandanus spiralis</i>	1	40
	<i>Lophostemon lactiflorus</i>	<1	40
	<i>Grevillea pteridifolia</i> , <i>Melaleuca nervosa</i> , <i>Osbeckia australiana</i>	<1	20
Lower	<i>Eriachne burkittii</i>	15	100
	<i>Utricularia leptoplectra</i>	<1	100
	<i>Germainia grandiflora</i>	15	80
	<i>Sorghum intrans</i>	4	80
	<i>Sacciolepis indica</i>	1.4	80
	<i>Fimbristylis pauciflora</i>	3.6	60
	<i>Eriachne trisetia</i> , <i>Lophostemon lactiflorus</i>	1.2	60
	<i>Eriocaulon setaceum</i> , <i>Limnophila chinensis</i> , <i>Nymphoides minima</i> , <i>Pandanus spiralis</i> , <i>Sacciolepis myosuroides</i>	<1	60
	<i>Ischaemum fragile</i>	4	40
	<i>Alloteropsis semialata</i> , <i>Cassytha capillaries</i> , <i>Eragrostis potamophila</i> , <i>Fimbristylis nutans</i> , <i>Limnophila fragrans</i> , <i>Melaleuca viridiflora</i> , <i>Paspalum scrobiculatum</i> , <i>Tricostularia undulate</i> , <i>Utricularia limosa</i> , <i>Xyris complanata</i> ,	<1	40
	<i>Osbeckia chinensis</i> , <i>Xyris cheumatophila</i>	2	20
	<i>Stylidium dunlopianum</i>	3	20
	<i>Fimbristylis acicularis</i> , <i>Mnesithea rottboellioides</i>	2	20
	<i>Aristida holathera</i> , <i>Buchnera linearis</i> , <i>Burmannia coelestis</i> , <i>Cartonema trigonospermum</i> , <i>Cassytha filiformis</i> , <i>Cyperus haspan</i> , <i>Drosera indica</i> , <i>Eriocaulon cinereum</i> , <i>Eriocaulon fistulosum</i> , <i>Eriocaulon schultzei</i> , <i>Eriocaulon tortuosum</i> , <i>Fimbristylis acicularis</i> , <i>Fimbristylis furva</i> , <i>Fimbristylis lanceolata</i> , <i>Fimbristylis modesta</i> , <i>Goodenia purpurascens</i> , <i>Lindernia scapigera</i> , <i>Lindsaea ensifolia</i> , <i>Melaleuca nervosa</i> , <i>Mitrasacme nummularia</i> , <i>Mnesithea rottboellioides</i> , <i>Murdannia graminea</i> , <i>Scleria laxa</i> , <i>Scleria levis</i> , <i>Scleria pygmaea</i> , <i>Scleria rugosa</i> , <i>Selaginella pygmaea</i> , <i>Spermacoce calliantha</i> , <i>Stylidium dunlopianum</i> , <i>Utricularia aurea</i> , <i>Utricularia caerulea</i> , <i>Utricularia holtzei</i> , <i>Utricularia sp. small white</i> , <i>Xyris oligantha</i>	<1	20

Distribution Map:

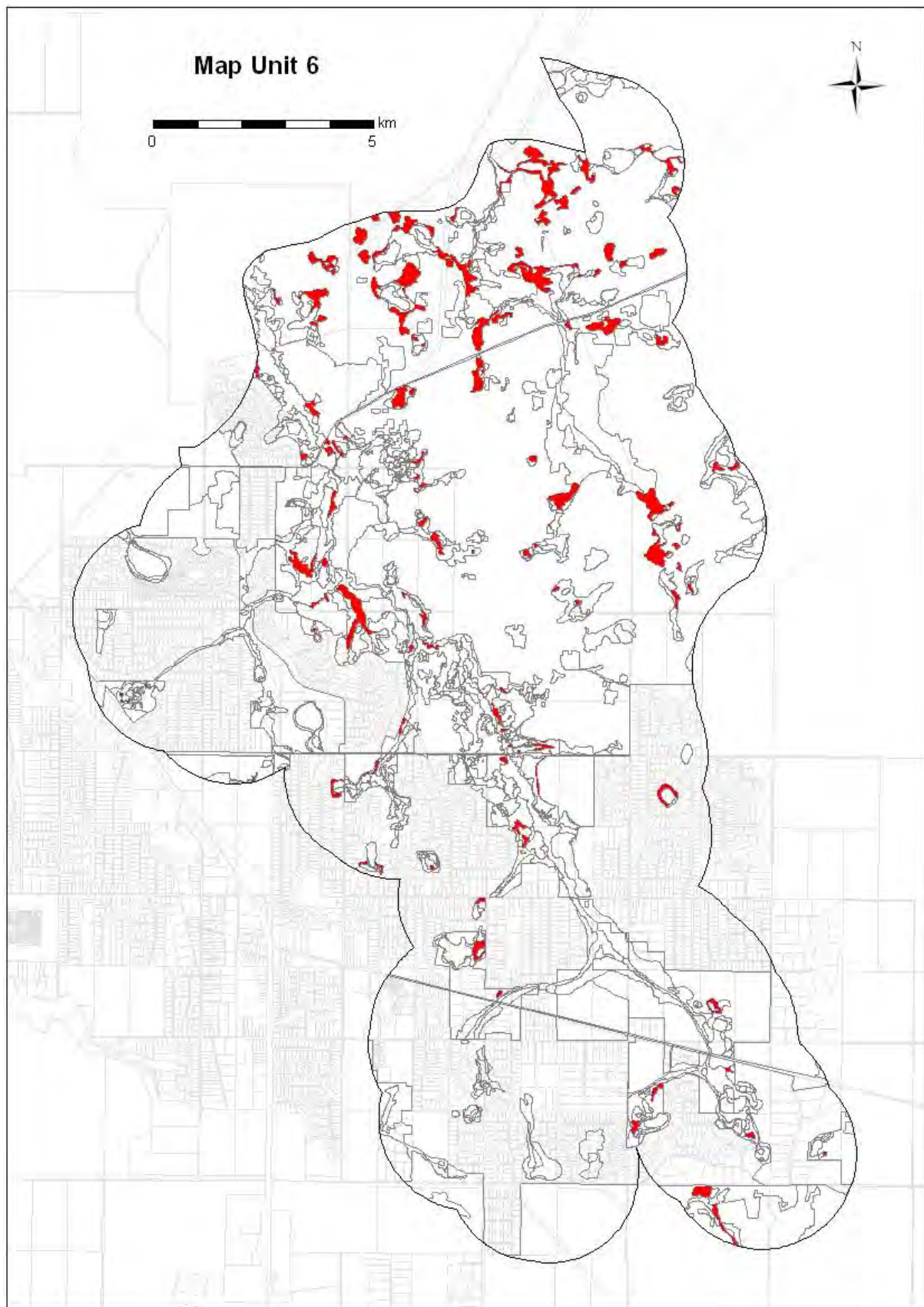


Figure 12: Map Unit 6 distribution map.

3.2.12. *Map Unit 7: Acacia plectocarpa, Acacia latescens low open woodland with a low open tussock grassland ground storey*

Table 23: Community 7 structural summary

Stratum	Modal Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	7	5.5	100	T6r
Mid M1	Tree	11	2.5	100	T6r
Ground G1	Grass	13	0.3	100	G1i

NVIS Association

U+ ^*Acacia plectocarpa*, *Acacia latescens*, *Terminalia grandiflora* \^tree\6\r; M ^*Acacia plectocarpa*, *Acacia latescens*, *Pandanus spiralis* \^tree, palm\6\r; G ^*Pandanus spiralis*, *Heteropogon triticeus*, *Scleria novae-hollandiae* \^grass, palm\1\i

Description:

The upper stratum consists of a low open woodland dominated by *Acacia plectocarpa* and *Acacia latescens* with less frequent *Terminalia grandiflora*.

The mid stratum is a low open woodland dominated by *Acacia plectocarpa* and *Acacia latescens* with a mix of other woody species.

The ground stratum is a low open tussock grassland dominated by *Pandanus spiralis*, *Heteropogon triticeus* and *Scleria novae-hollandiae*, with other scattered sedges, grasses and forbs.

Distribution: A small number of patches principally occurring on the periphery of the main Howard River floodplain.

Surface soils: Clayey sand (1 plot).

Rare or significant species/community: There are no records of listed threatened plant species in this community.

Comments:

Area: 0.44 km²

Sites: Count = 1; Howard Sand Plains Survey 3.

Table 24: Community 7 species cover and occurrence

Stratum	Species	Average Cover (%) within 1 site	Occurrence (%) within 1 site
Upper	<i>Acacia plectocarpa</i>	4	100
	<i>Acacia latescens</i>	2	100
	<i>Terminalia grandiflora</i>	1	100
	<i>Hakea arborescens</i> , <i>Melaleuca nervosa</i>	<1	100
Mid	<i>Acacia plectocarpa</i>	5	100
	<i>Acacia latescens</i>	2	100
	<i>Hakea arborescens</i> , <i>Pandanus spiralis</i> , <i>Petalostigma pubescens</i> , <i>Terminalia grandiflora</i>	1	100
	<i>Calytrix exstipulata</i> , <i>Cassytha filiformis</i> , <i>Grevillea pteridifolia</i> , <i>Melaleuca nervosa</i> , <i>Melaleuca viridiflora</i> , <i>Passiflora foetida</i> *, <i>Planchonia careya</i> , <i>Terminalia pterocarya</i>	<1	100
Lower	<i>Pandanus spiralis</i>	3	100
	<i>Heteropogon triticeus</i> , <i>Scleria novae-hollandiae</i>	2	100
	<i>Fimbristylis dichotoma</i> , <i>Waltheria indica</i>	1	100
	<i>Ampelocissus acetosa</i> , <i>Cartonema parviflorum</i> , <i>Cartonema trigonospermum</i> , <i>Corynotheca lateriflora</i> , <i>Cyperus pulchellus</i> , <i>Desmodium trichostachyum</i> , <i>Dimeria ornithopoda</i> , <i>Drosera dilatatopetiolaris</i> , <i>Eriachne trisetia</i> , <i>Fimbristylis dunlopilii</i> , <i>Fimbristylis tetragona</i> , <i>Goodenia purpurea</i> , <i>Hibbertia juncea</i> , <i>Lindernia lobelioides</i> , <i>Microstachys chamaelea</i> , <i>Mitrasacme laevis</i> , <i>Murdannia graminea</i> , <i>Scleria laxa</i> , <i>Scleria rugosa</i> , <i>Sorghum intrans</i> , <i>Sowerbaea alliacea</i> , <i>Spermacoce calliantha</i> , <i>Stemona prostrate</i> , <i>Tacca leontopetaloides</i> , <i>Tephrosia remotiflora</i> , <i>Terminalia grandiflora</i> , <i>Thysanotus banksii</i>	<1	100

Distribution Map:

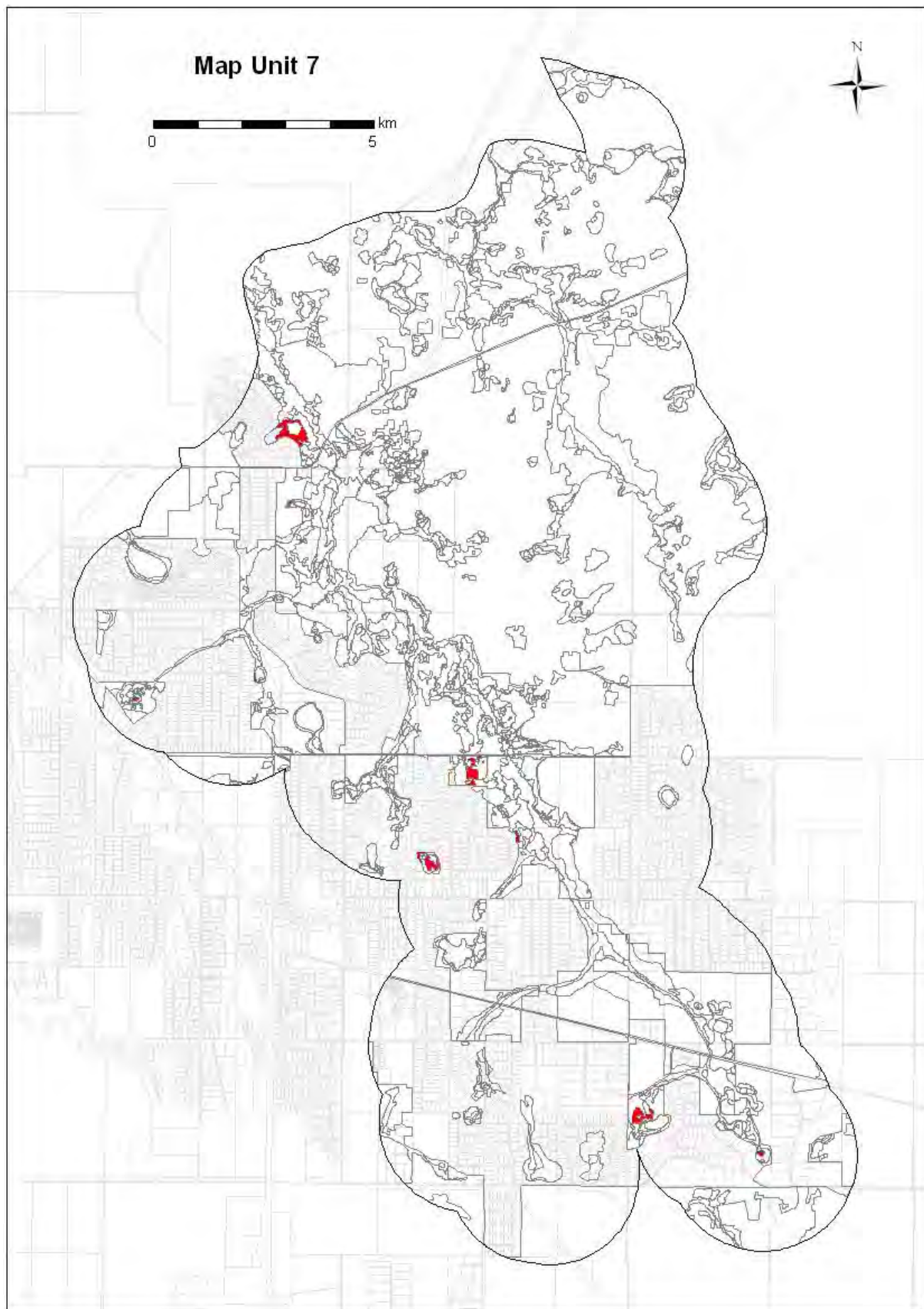


Figure 13: Map Unit 7 distribution map.

3.2.13. *Map Unit 8: Melaleuca viridiflora, Acacia latescens, Pandanus spiralis low open woodland with a low open tussock grassland or sedgeland ground storey*

Table 25: Community 8 structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	16 (7 – 25)	3 (2 – 4)	100	T6r
Ground G1	Grass/Sedge	16.5 (8 – 25)	0.45 (0.4 – 0.5)	100	G1i/V1i



Plate 10: Vegetation community 8 (site 37)

NVIS Association

U+ ^ *Melaleuca viridiflora*, *Acacia latescens*, *Pandanus spiralis* \^tree, palm\6\r; G ^ *Eriachne trisetata*, *Pandanus spiralis*, *Dapsilanthus spathaceus*, \^grass, sedge\1\i

Description:

The upper stratum is a low open woodland featuring *Melaleuca viridiflora*, *Acacia latescens* and *Pandanus spiralis* with or without *Hakea arborescens* and *Acacia auriculiformis*.

The ground stratum is a low open tussock grassland or sedgeland featuring *Eriachne trisetata*, *Dapsilanthus spathaceus*, *Pandanus spiralis* and *Sorghum intrans*.

Distribution: Occurs as a series of patches principally in the central part of the Howard Sand Plains SOCS.

Surface soils: Loamy sand (1 plot) and clayey sand (1 plot).

Rare or significant species/community: The endangered *T. taylori* has been recorded in this community.

Comments:

Area: 0.25 km²

Sites: Count = 2; Howard Sand Plains Survey 37, 39.

Table 26: Community 8 species cover and occurrence

Stratum	Species	Average Cover (%) within 2 sites	Occurrence (%) within 2 sites
Upper	Melaleuca viridiflora	4.5	100
	Acacia latescens	3.5	100
	Pandanus spiralis	1.6	100
	Hakea arborescens	5	50
	Acacia auriculiformis	1	50
	Calytrix exstipulata, Planchonia careya, Terminalia pterocarya	<1	50
Ground	Eriachne trisetata	5	100
	Pandanus spiralis	3.5	100
	Dapsilanthus spathaceus	3	100
	Sorghum intrans	2.2	100
	Terminalia pterocarya	1	100
	Buchnera gracilis, Calytrix exstipulata, Cartonema trigonospermum, Centrolepis exserta, Cyperus pulchellus, Drosera indica, Eriocaulon tricornum, Evolvulus alsinoides, Fimbristylis rara, Hakea arborescens, Lindernia lobelioides, Melaleuca viridiflora, Rhynchospora heterochaeta, Utricularia chrysantha, Waltheria indica, Xyris complanata, Xyris pauciflora	<1	100
	Eriachne burkittii	1.5	50
	Alloteropsis semialata	3	50
	Acacia latescens, Buchanania obovata, Byblis aquatica, Cassytha capillaris, Drosera brevicornis, Eriachne avenacea, Eriocaulon cinereum, Eriocaulon fistulosum, Fimbristylis furva, Fimbristylis macassarensis, Fimbristylis pilifera, Fimbristylis pterygosperma, Fimbristylis recta, Fimbristylis sp. Howard River, Goodenia porphyrea, Goodenia purpurea, Heteropogon triticeus, Lipocarpa microcephala, Microstachys chamaelea, Mimulus uvedaliae, Mitrasacme gentianeae, Mitrasacme multicaulis, Mitrasacme subvolubilis, Murdannia graminea, Oldenlandia leptocaulis, Planchonia careya, Polymeria ambigua, Scleria annularis, Sowerbaea alliacea, Stylidium turbinatum, Thysanotus banksia, Utricularia lasiocaulis, Utricularia leptorhyncha, Wrightia saligna	<1	50

Distribution Map:

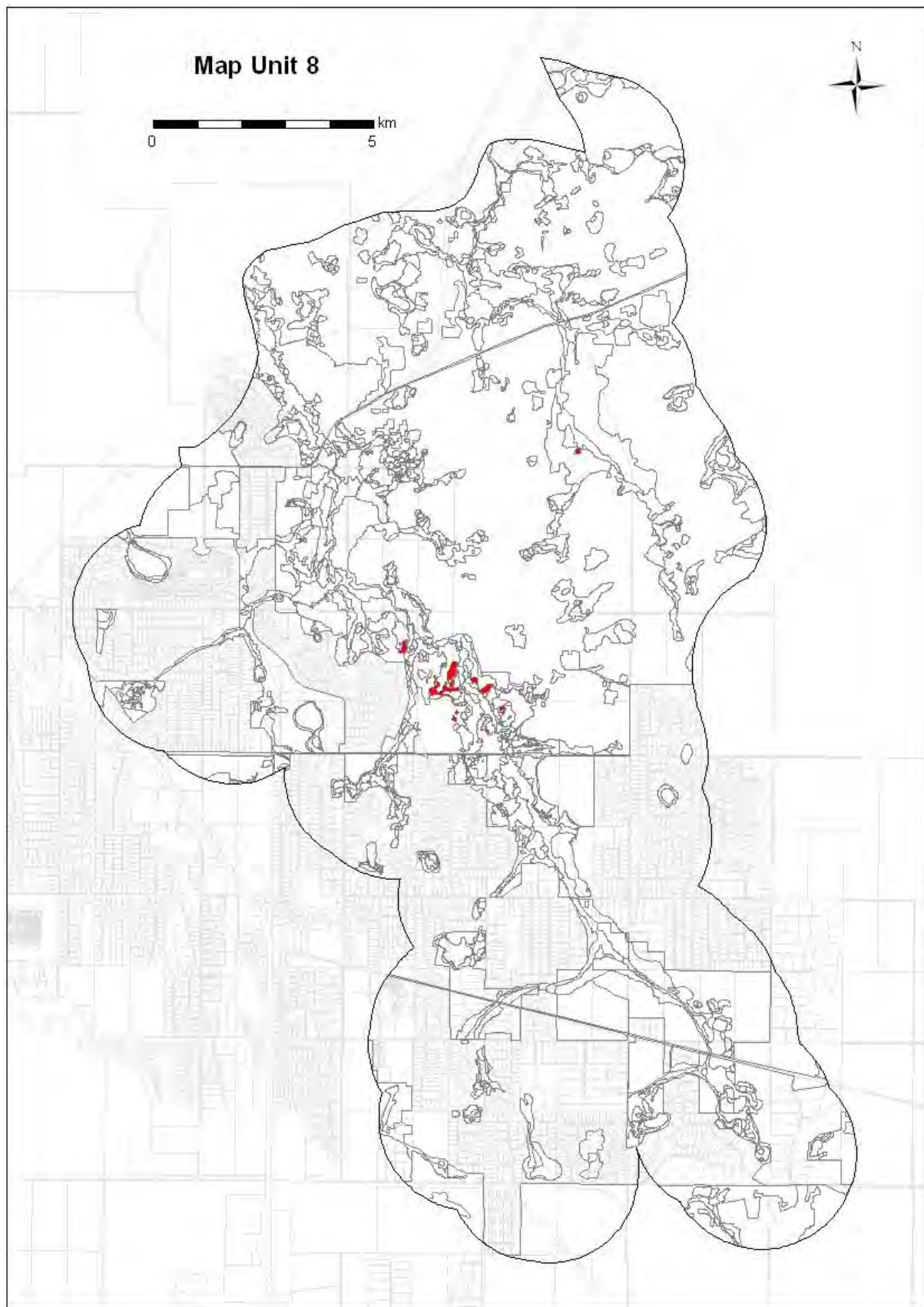


Figure 14: Map Unit 8 distribution map.

3.2.14. *Map Unit 9: Pandanus spiralis (screw palm) +/- Melaleuca viridiflora low open woodland with a mid tussock grassland / sedgeland ground story*

Table 27: Community 9 structural summary

Stratum	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	8.8 (5 – 20)	6.9 (5 – 11)	100	T6r
Mid M1	Palm (Pandanus)	3.8	2.5	25	T6r
Ground G1	Grass/Sedge	48.8 (30 – 75)	0.7 (0.3 – 1.2)	100	G2c/V2c



Plate 11: Vegetation community 9 (site 36)

NVIS Association

U+ ^*Pandanus spiralis*, +-*Melaleuca viridiflora*, +-*Eucalyptus alba* \^tree\6\r; M ^+-*Acacia auriculiformis*, +-*Pandanus spiralis* \^tree, palm\6\r; G ^*Eriachne burkittii*, *Pandanus spiralis*, *Fimbristylis acuminata* \^grass\2\c

Description:

The upper stratum forms a low open woodland dominated by *Pandanus spiralis* with or without sub-dominant *Melaleuca viridiflora* and *Eucalyptus alba*.

A low open woodland mid stratum consisting of *Acacia auriculiformis* and *Pandanus spiralis* may be present.

The ground stratum consists of a mid tussock grassland dominated by *Eriachne burkittii*, and or sedgeland dominated by *Fimbristylis acuminata*. The ground stratum is also characterised by the presence of *Pandanus spiralis*.

Distribution: An extensive community of the broad floodplains principally in the centre and north of the Howard Sand Plains SOCS.

Surface soils: Sand (1 plot), clayey sand (1 plot) and sandy clay loam (2 plots).

Rare or significant species/community: The endangered herb *Typhonium taylori* occurs in this community.

Comments:

Area: 3.93 km²

Sites: Count = 5; Howard Sand Plains Survey 23, 24, 35, 36; Herbarium 3035.

Table 28: Community 9 species cover and occurrence

Stratum	Species	Average Cover (%) within 4 sites	Occurrence (%) within 4 sites
Upper	<i>Pandanus spiralis</i>	5.8	100
	<i>Melaleuca viridiflora</i>	1.2	50
	<i>Eucalyptus alba</i>	2.5	25
	<i>Melaleuca nervosa</i>	1	25
	<i>Banksia dentata</i> , <i>Grevillea pteridifolia</i> , <i>Lophostemon lactiflorus</i>	<1	25
Mid	<i>Acacia auriculiformis</i>	6.2	25
	<i>Pandanus spiralis</i>	2.5	25
	<i>Melaleuca viridiflora</i>	<1	25

Ground	<i>Eriachne burkittii</i>	10.8	100
	<i>Pandanus spiralis</i>	5.5	100
	<i>Fimbristylis acuminata</i>	4	100
	<i>Desmodium trichostachyum</i> , <i>Mitrasacme subvolubilis</i> , <i>Murdannia gigantea</i> , <i>Salomonina ciliate</i> , <i>Scleria annularis</i>	<1	100
	<i>Fimbristylis pallida</i>	2.5	75
	<i>Alloteropsis semialata</i> , <i>Calandrinia gracilis</i> , <i>Cartonema trigonospermum</i> , <i>Drosera indica</i> , <i>Euphorbia muelleri</i> , <i>Huxleya linifolia</i> , <i>Mimulus uvedaliae</i> , <i>Oldenlandia leptocaulis</i> , <i>Sacciolepis myosuroides</i> , <i>Scleria caricina</i> , <i>Utricularia leptoplectra</i> , <i>Xyris complanata</i> , <i>Xyris indica</i>	<1	75
	<i>Dapsilanthus spathaceus</i>	2.8	50
	<i>Fimbristylis furva</i> , <i>Sacciolepis indica</i>	1.3	50
	<i>Eriocaulon schultzei</i>	1.2	50
	<i>Buchnera gracilis</i> , <i>Dimeria ornithopoda</i> , <i>Eriocaulon cinereum</i> , <i>Eriocaulon fistulosum</i> , <i>Fimbristylis macassarensis</i> , <i>Fimbristylis tetragona</i> , <i>Goodenia porphyria</i> , <i>Goodenia symonii</i> , <i>Grevillea pteridifolia</i> , <i>Ipomoea graminea</i> , <i>Ischaemum decumbens</i> , <i>Limnophila fragrans</i> , <i>Lindernia lobelioides</i> , <i>Ludwigia octovalvis</i> , <i>Melaleuca viridiflora</i> , <i>Rhynchospora heterochaeta</i> , <i>Scleria pygmaea</i> , <i>Sorghum intrans</i> , <i>Utricularia chrysantha</i>	<1	50
	<i>Chrysopogon oliganthus</i>	11.2	25
	<i>Germainia grandiflora</i>	1.2	25
	<i>Acacia auriculiformis</i> , <i>Byblis aquatic</i> , <i>Capillipedium parviflorum</i> , <i>Cassytha filiformis</i> , <i>Centrolepis banksii</i> , <i>Cyperus haspan</i> , <i>Drosera brevicornis</i> , <i>Eragrostis potamophila</i> , <i>Eriachne trisetia</i> , <i>Eriocaulon concretum</i> , <i>Fimbristylis acicularis</i> , <i>Fimbristylis modesta</i> , <i>Fimbristylis pilifera</i> , <i>Fimbristylis</i> sp. Howard River, <i>Fuirena umbellata</i> , <i>Goodenia purpurea</i> , <i>Heteropogon triticeus</i> , <i>Isachne confusa</i> , <i>Lindernia aplectra</i> , <i>Lindernia scapigera</i> , <i>Lophostemon lactifluus</i> , <i>Melaleuca cajuputi</i> , <i>Mitrasacme prolifera</i> , <i>Murdannia cryptantha</i> , <i>Nymphoides minima</i> , <i>Oldenlandia galioides</i> , <i>Paspalum scrobiculatum</i> , <i>Planchonia careya</i> , <i>Scleria laxa</i> , <i>Scleria</i> sp. Oenpelli, <i>Selaginella ciliaris</i> , <i>Stylidium cordifolium</i> , <i>Stylidium fissilobum</i> , <i>Tricostularia undulate</i> , <i>Utricularia aurea</i> , <i>Utricularia capilliflora</i> , <i>Utricularia circumvoluta</i> , <i>Utricularia gibba</i> , <i>Utricularia lasiocaulis</i> , <i>Utricularia</i> sp. small white, <i>Vigna lanceolata</i> , <i>Xyris oligantha</i>	<1	25

Distribution Map:

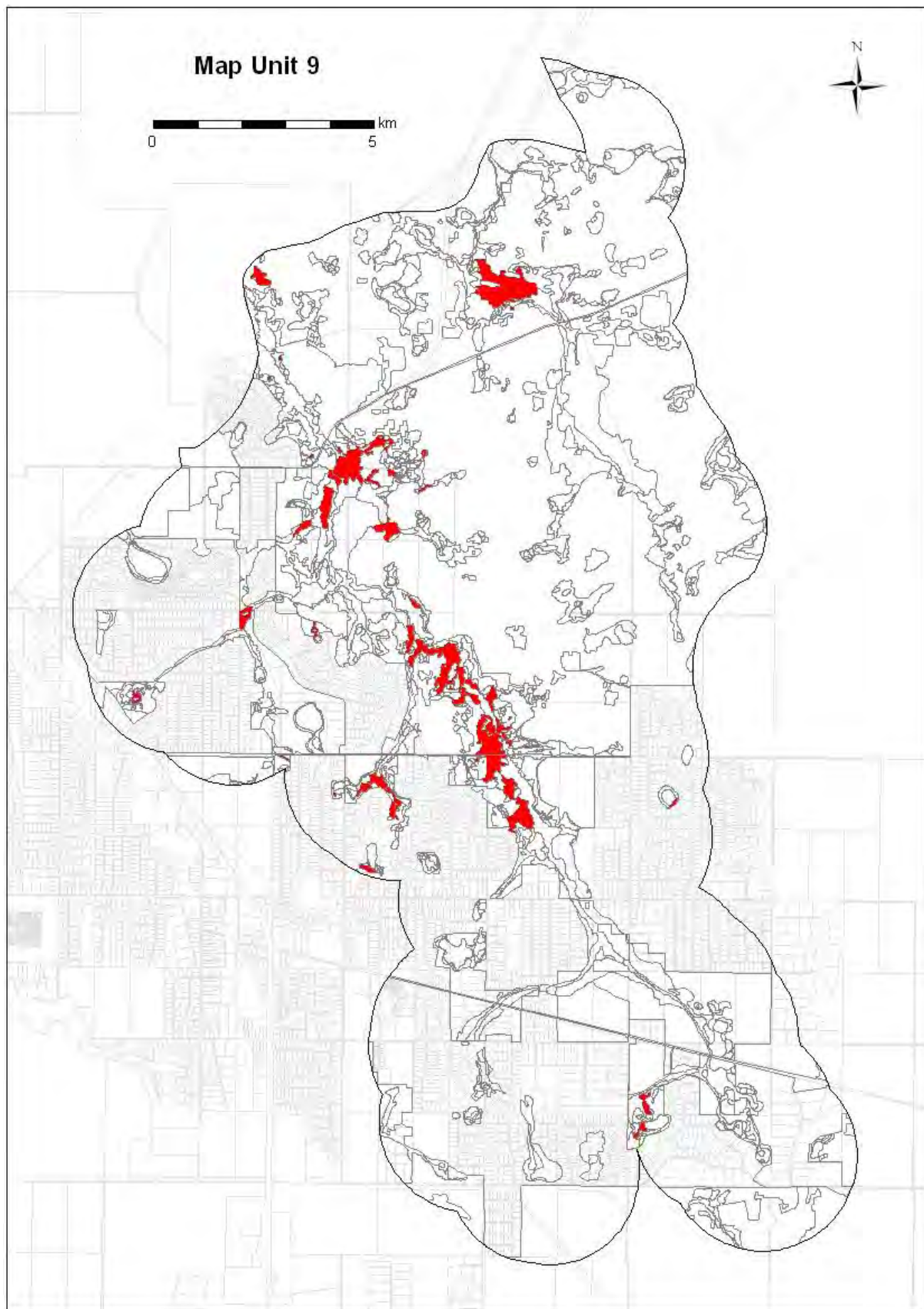


Figure 15: Map Unit 9 distribution map.

3.2.15. *Map Unit 10: Sorghum intrans, Alloteropsis semialata, +-Eriachne burkittii tussock grassland with isolated Acacia latescens and Grevillea pteridifolia (fern-leaved grevillea)*

Table 29: Community 10 structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	<1	6	33	T6bi
Ground G1	Grass	28 (25 – 30)	0.6 (0.4 – 0.9)	100	G2i
Ground G2	Grass	11.7	2	33	G3i

NVIS Association

U ^*Acacia latescens*, *Grevillea pteridifolia* \^tree\6\bi; G+ ^*Sorghum intrans*, *Alloteropsis semialata*, *Eriachne burkittii* \^grass\2\i

Description:

The upper stratum of isolated trees of *Acacia latescens* and *Grevillea pteridifolia*.

The ground stratum is a tussock grassland dominated by *Sorghum intrans* and *Alloteropsis semialata* with or without *Eriachne burkittii*.

Distribution: An extensive floodplain community principally in the north-west of the Howard Sand Plains SOCS.

Surface soils: Clayey sand (1 plot), sandy loam (1 plot) and medium clay (1 plot).

Rare or significant species/community: The endangered herb *T. taylori* has been recorded in this community.

Comments:

Area: 2.66 km²

Sites: Count = 6; Howard Sand Plains Survey 7, 12, 51; Herbarium 2432, 3087, 3045.

Table 30: Community 10 species cover and occurrence

Stratum	Species	Average Cover (%) within 3 sites	Occurrence (%) within 3 sites
Upper	<i>Acacia latescens</i> , <i>Grevillea pteridifolia</i>	<1	33
Lower	<i>Sorghum intrans</i>	12.7	100
	<i>Alloteropsis semialata</i>	5	100
	<i>Melaleuca nervosa</i>	<1	100
	<i>Eriachne burkittii</i>	7.7	67
	<i>Xyris complanata</i>	2.3	67
	<i>Scleria annularis</i>	1	67
	<i>Fimbristylis furva</i> , <i>Goodenia purpurea</i> , <i>Goodenia symonii</i>	<1	67
	<i>Verticordia cunninghamii</i>	3.3	33
	<i>Dapsilanthus spathaceus</i>	2.7	33
	<i>Fimbristylis acuminata</i>	2.3	33
	<i>Eriachne trisetia</i>	1.7	33
	<i>Schoenus punctatus</i>	1.3	33
	<i>Fimbristylis pauciflora</i> , <i>Spermacoce breviflora</i>	1	33
	<i>Acacia latescens</i> , <i>Aristida holathera</i> , <i>Buchnera gracilis</i> , <i>Byblis aquatic</i> , <i>Capillipedium parviflorum</i> , <i>Cartonema trigonospermum</i> , <i>Centrolepis banksia</i> , <i>Chrysopogon setifolius</i> , <i>Corymbia polycarpa</i> , <i>Crinum angustifolium</i> , <i>Cyanotis axillaris</i> , <i>Drosera dilatatopetiolaris</i> , <i>Drosera indica</i> , <i>Euphorbia vachellii</i> , <i>Germainia grandiflora</i> , <i>Grevillea pteridifolia</i> , <i>Haemodorum ensifolium</i> , <i>Limnophila fragrans</i> , <i>Ludwigia octovalvis</i> , <i>Ludwigia perennis</i> , <i>Murdannia gigantea</i> , <i>Nelsonia campestris</i> , <i>Nymphoides spongiosa</i> , <i>Panicum trachyrhachis</i> , <i>Paspalum scrobiculatum</i> , <i>Phyllanthus urinaria</i> , <i>Polymeria ambigua</i> , <i>Rhynchospora longisetis</i> , <i>Salomonina ciliata</i> , <i>Schizachyrium crinizonatum</i> , <i>Scleria laxa</i> , <i>Scleria sp.</i> McMinns Lagoon, <i>Spermacoce calliantha</i> , <i>Utricularia leptoplectra</i> , <i>Utricularia sp. small white</i> , <i>Xyris oligantha</i>	<1	33

Distribution Map:

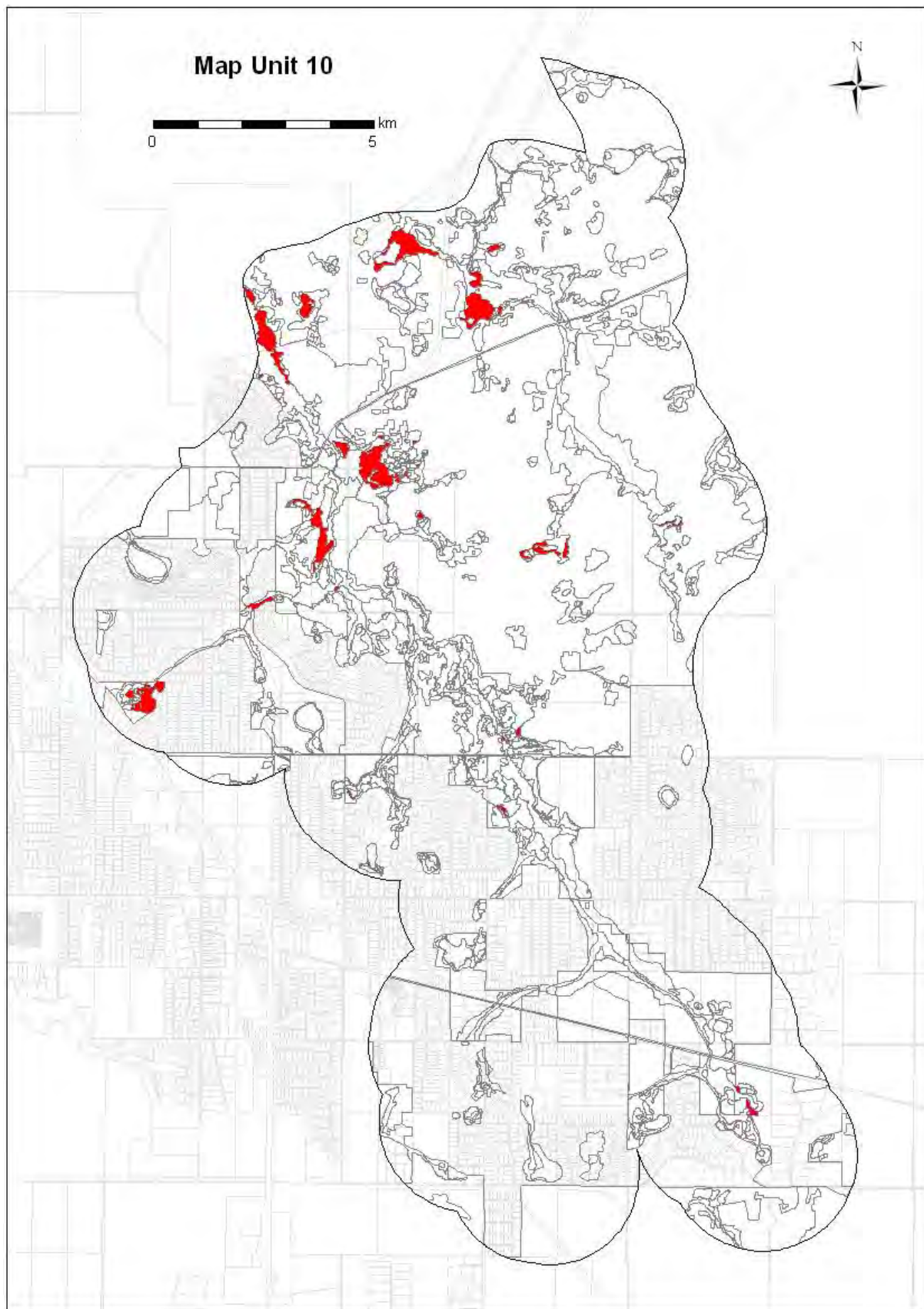


Figure 16: Map Unit 10 distribution map.

3.2.16. *Map Unit 11: Hakea arborescens and Terminalia grandiflora low open woodland with Fimbristylis pauciflora and Eriachne burkittii mixed low sedgeland or tussock grassland ground layer.*

Table 31: Community 11 structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	45	8	100	T6i
Ground G1	Sedge	50	0.4	100	V1c

NVIS Association

U+ ^*Hakea arborescens*, ^*Terminalia grandiflora*, *Pandanus spiralis* \^tree, palm\6\i; G ^*Fimbristylis pauciflora*, *Eriachne burkittii*, *Sorghum plumosum* \^sedge, tussock grass\1\c

Description:

The upper stratum is a low open woodland dominated by *Hakea arborescens* and *Terminalia grandiflora* with subdominant *Melaleuca viridiflora* and *Pandanus spiralis*.

The ground stratum is a mixed low sedgeland or low tussock grassland dominated by *Fimbristylis pauciflora* with subdominant *Eriachne burkittii* and *Sorghum plumosum*.

Distribution: A community of restricted extent principally occurring on the western side of the Howard River system.

Surface soils: Sandy loam (1 plot).

Rare or significant species/community: The endangered herb *T. taylori* has been recorded in this community.

Comments:

Area: 0.56 km²

Sites: Count = 1; Howard Sand Plains Survey 34.

Table 32: Community 11 species cover and occurrence

Stratum	Species	Average Cover (%) within 1 site	Occurrence (%) within 1 site
Upper	<i>Hakea arborescens</i> , <i>Terminalia grandiflora</i>	15	100
	<i>Melaleuca viridiflora</i> , <i>Pandanus spiralis</i>	5	100
Lower	<i>Fimbristylis pauciflora</i>	30	100
	<i>Eriachne burkittii</i>	10	100
	<i>Sorghum plumosum</i>	5	100
	<i>Scleria laxa</i>	3	100
	<i>Fimbristylis furva</i> , <i>Scleria rugosa</i> , <i>Whiteochloa capillipes</i>	2	100
	<i>Alloteropsis semialata</i> , <i>Ampelocissus acetosa</i> , <i>Breynia cernua</i> , <i>Commelina agrostophylla</i> , <i>Drosera indica</i> , <i>Eriachne trisetata</i> , <i>Eriocaulon</i> <i>concretum</i> , <i>Eriocaulon tortuosum</i> , <i>Eriocaulon tricornum</i> , <i>Fimbristylis</i> <i>pallida</i> , <i>Fimbristylis recta</i> , <i>Goodenia symonii</i> , <i>Heteropogon triticeus</i> , <i>Limnophila fragrans</i> , <i>Melaleuca nervosa</i> , <i>Mitrasacme subvolubilis</i> , <i>Nelsonia campestris</i> , <i>Phyllanthus virgatus</i> , <i>Planchonia careya</i> , <i>Rhynchospora pterochaeta</i> , <i>Sacciolepis indica</i> , <i>Scleria pygmaea</i> , <i>Sorghum intrans</i> , <i>Spermacoce calliantha</i> , <i>Utricularia chrysantha</i> , <i>Utricularia leptorhyncha</i> , <i>Utricularia limosa</i> , <i>Utricularia sp. small</i> <i>white</i> , <i>Waltheria indica</i>	<1	100

Distribution Map:

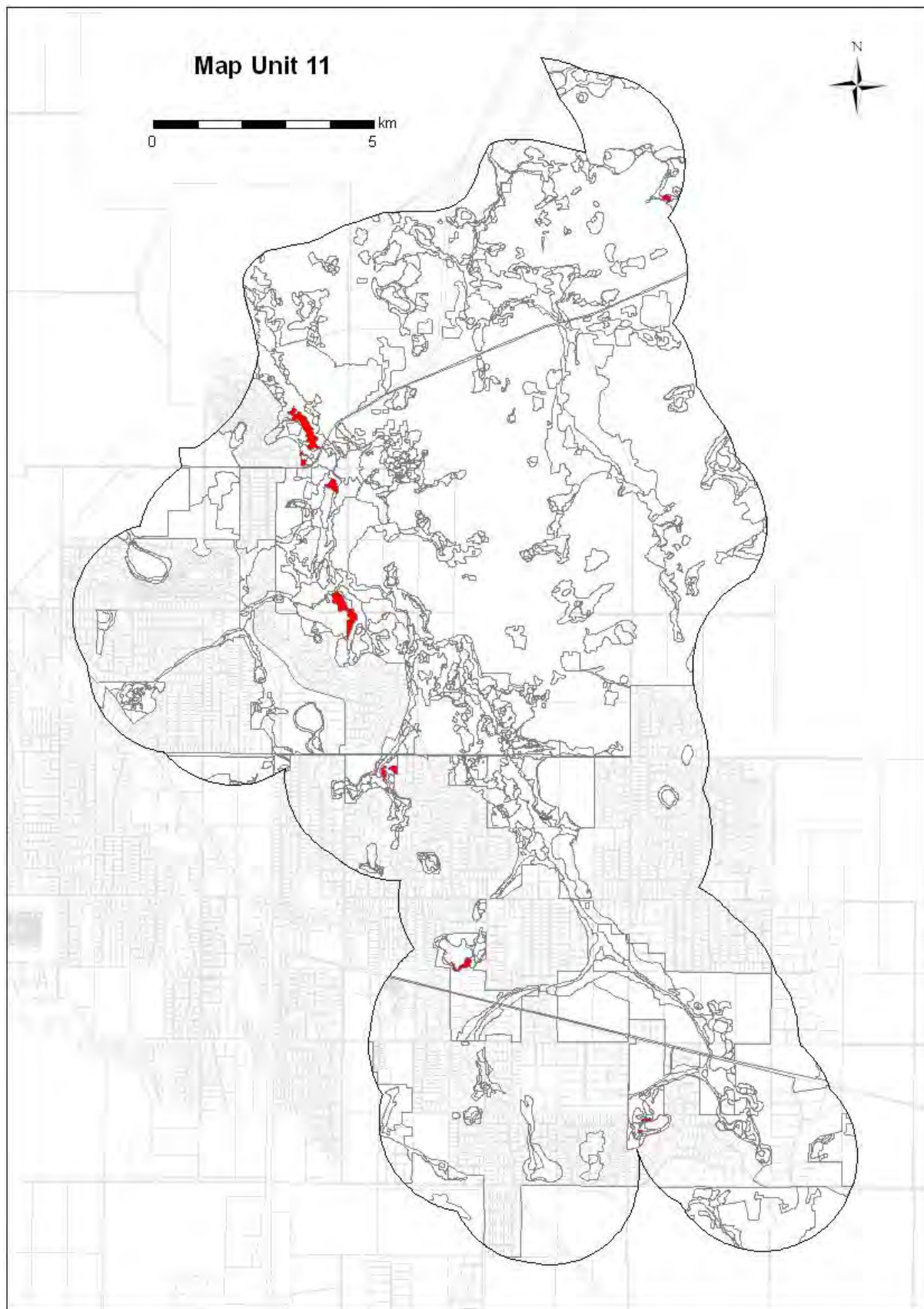


Figure 17: Map Unit 11 distribution map.

3.2.17. *Map Unit 12: Lophostemon lactifluus (Red Swamp Mahogany) +/- Banksia dentata and Grevillea pteridifolia (fern-leaved grevillea) low open woodland over Dapsilanthus spathaceus mid sedgeland understory with heath shrubs and tussock grasses*

Table 33: Community 12 structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	4 (1-7)	5 (5 – 5)	100	T6r
Ground G1	Sedge	35 (35 - 35)	0.8 (0.3-1.2)	100	V2c



Plate 12: Vegetation community 12 (site 27)

NVIS Association

U+ ^*Lophostemon lactifluus*, +- *Banksia dentata*, +- *Grevillea pteridifolia* \^tree\6\r; G ^*Dapsilanthus spathaceus*, *Verticordia cunninghamii*, *Sorghum intrans* \^sedge, shrub, tussock grass\2\c

Description:

The upper stratum is a low open woodland of *Lophostemon lactifluus* (Red Swamp Mahogany) with or without *Banksia dentata* and *Grevillea pteridifolia* (fern-leaved grevillea).

A mid stratum is not present.

The lower stratum is a mid sedgeland dominated by *Dapsilanthus spathaceus* and includes the heath shrub *Verticordia cunninghamii* and tussock grass *Sorghum intrans*.

Distribution: Primarily occurs as extensive patches on the floodplains in the central north of the Howard Sand Plains SOCS.

Surface soils: Sandy loam (2 plots).

Rare or significant species/community: The endangered *T. taylori* and vulnerable *U. dunstaniae* have been recorded in this unit, however, the recorded occurrence of *U. dunstaniae* has been on small patches of country that are not representative of the broader vegetation community. A high maximum and high average number of *Utricularia* species have been recorded in 20 m by 20 m plots.

Comments:

Area: 2.71 km²

Sites: Count = 2; Howard Sand Plains Survey 27, 50.

Table 34: Community 12 species cover and occurrence

Stratum	Species	Average Cover (%) within 2 sites	Occurrence (%) within 2 sites
Upper	<i>Lophostemon lactifluus</i>	3.5	100
	<i>Banksia dentata</i>	2.5	50
	<i>Grevillea pteridifolia</i>	1.2	50
	<i>Corymbia polycarpa</i> , <i>Melaleuca nervosa</i> , <i>Melaleuca viridiflora</i> , <i>Verticordia cunninghamii</i>	<1	50
Lower	<i>Dapsilanthus spathaceus</i>	8.5	100
	<i>Verticordia cunninghamii</i>	6	100
	<i>Sorghum intrans</i>	3	100
	<i>Eriachne trisetia</i>	1.5	100
	<i>Alloteropsis semialata</i>	1	100
	<i>Buchnera gracilis</i> , <i>Cartonema trigonospermum</i> , <i>Drosera dilatatopetiolaris</i> , <i>Grevillea pteridifolia</i> , <i>Lophostemon lactifluus</i> , <i>Salomonina ciliate</i> , <i>Sowerbaea alliacea</i> , <i>Stylidium ericksoniae</i> , <i>Utricularia holtzei</i> , <i>Utricularia kamienskii</i> , <i>Utricularia leptoplectra</i>	<1	100
	<i>Eriachne obtuse</i>	7.5	50
	<i>Fimbristylis lanceolata</i>	3.5	50
	<i>Xyris cheumatophila</i>	1.5	50
	<i>Fimbristylis pauciflora</i>	1	50
	<i>Banksia dentata</i> , <i>Cassytha capillaries</i> , <i>Drosera brevicornis</i> , <i>Eriocaulon tortuosum</i> , <i>Fimbristylis punctata</i> , <i>Fimbristylis tetragona</i> , <i>Goodenia purpurea</i> , <i>Melaleuca nervosa</i> , <i>Melaleuca viridiflora</i> , <i>Utricularia capilliflora</i> , <i>Utricularia chrysantha</i> , <i>Utricularia quinqueidentata</i> , <i>Xyris complanata</i> , <i>Xyris oligantha</i> , <i>Xyris pauciflora</i>	<1	50

Distribution Map:

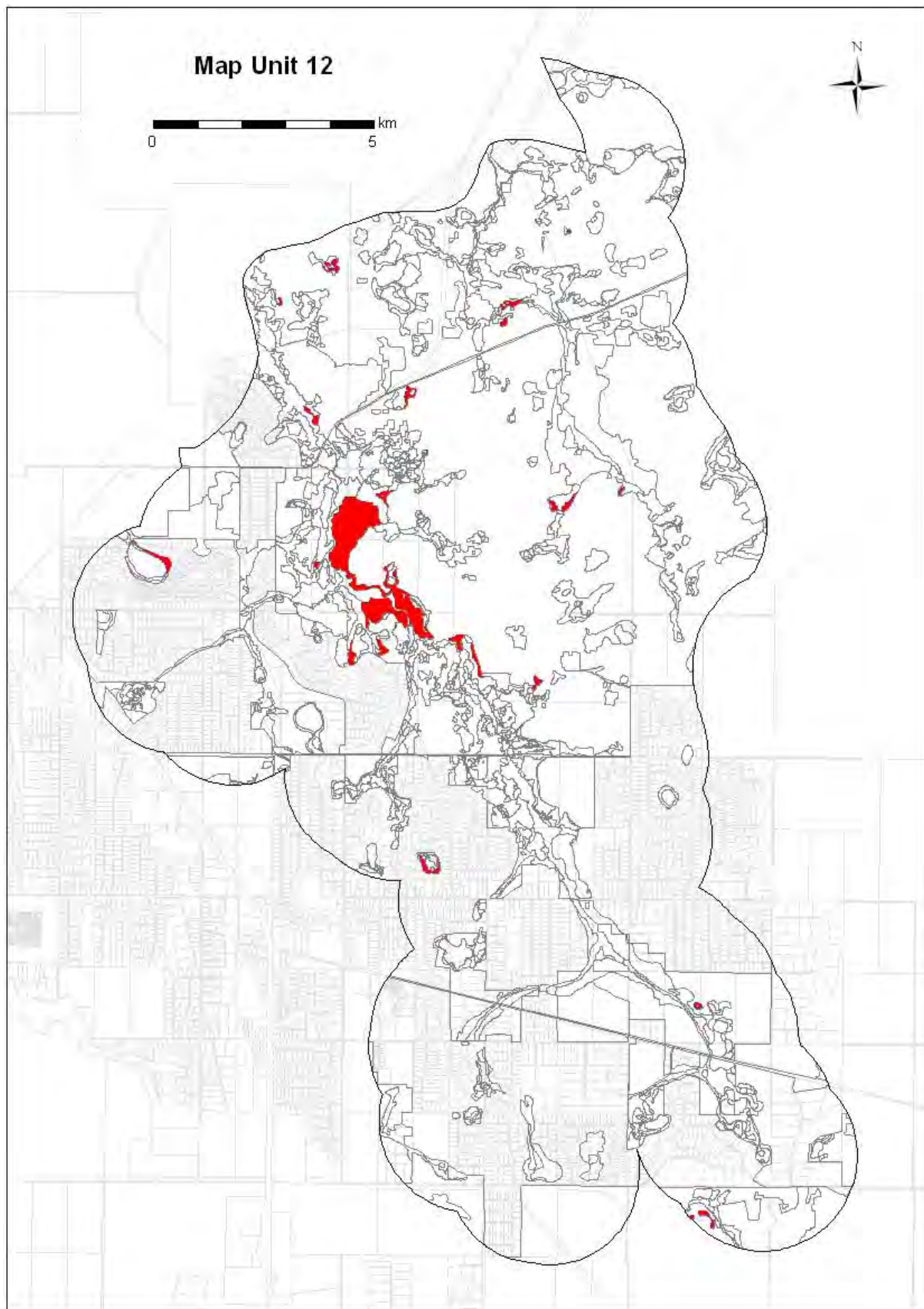


Figure 18: Map Unit 12 distribution map.

3.2.18. Map Unit 13: Tussock grassland with isolated *Melaleuca nervosa*

Description:

Based upon species occurrence the ground layer is composed of a mix of grassland and sedgeland species.

Distribution: Occurs as small scattered patches towards the margin of the floodplain.

Surface soils: No data.

Rare or significant species/community: The endangered *T. taylori* has been recorded in this unit.

Comments: No data on vegetation structure are available for this community.

Area: 1.69 km²

Sites: Count = 4; Herbarium 3041, 3043, 3058, 3068.

Table 35: Community 13 species occurrence

Species	Occurrence (%) within 4 plots
<i>Cartonema trigonospermum</i> , <i>Drosera petiolaris</i> , <i>Melaleuca nervosa</i> , <i>Sorghum intrans</i> , <i>Utricularia capilliflora</i> , <i>Utricularia limosa</i> , <i>Xyris complanata</i>	100
<i>Dapsilanthus spathaceus</i> , <i>Fimbristylis simplex</i>	75
<i>Alloteropsis semialata</i> , <i>Buchnera gracilis</i> , <i>Cassytha filiformis</i> , <i>Eriachne obtuse</i> , <i>Eriocaulon fistulosum</i> , <i>Eriocaulon setaceum</i> , <i>Fimbristylis lanceolata</i> , <i>Lindernia aplectra</i> , <i>Lophostemon lactifluus</i> , <i>Rhynchospora longisetis</i> , <i>Utricularia leptoplectra</i> , <i>Utricularia minutissima</i> , <i>Utricularia sp. small white</i> , <i>Verticordia cunninghamii</i>	50
<i>Aristida holathera</i> , <i>Asteromyrtus symphyocarpa</i> , <i>Centrolepis exserta</i> , <i>Corymbia confertiflora</i> , <i>Ectrosia leporine</i> , <i>Eriachne burkittii</i> , <i>Eriachne trisetia</i> , <i>Eriocaulon cinereum</i> , <i>Fimbristylis macassarensis</i> , <i>Fimbristylis nutans</i> , <i>Fimbristylis pallid</i> , <i>Fuirena ciliaris</i> , <i>Germainia grandiflora</i> , <i>Grevillea pteridifolia</i> , <i>Haemodorum ensifolium</i> , <i>Nymphoides minima</i> , <i>Nymphoides parvifolia</i> , <i>Nymphoides spongiosa</i> , <i>Ophioglossum gramineum</i> , <i>Pandanus spiralis</i> , <i>Paspalum scrobiculatum</i> , <i>Rhynchospora wightiana</i> , <i>Salomonina ciliate</i> , <i>Scleria annularis</i> , <i>Scleria laxa</i> , <i>Scleria novae-hollandiae</i> , <i>Scleria pygmaea</i> , <i>Scleria rugosa</i> , <i>Sowerbaea alliacea</i> , <i>Stylidium cordifolium</i> , <i>Stylidium pedunculatum</i> , <i>Syzygium eucalyptoides</i> subsp. <i>bleeseri</i> , <i>Trithuria lantern</i> , <i>Utricularia gibba</i> , <i>Utricularia holtzei</i> , <i>Utricularia quinquedentata</i>	25

Distribution Map:

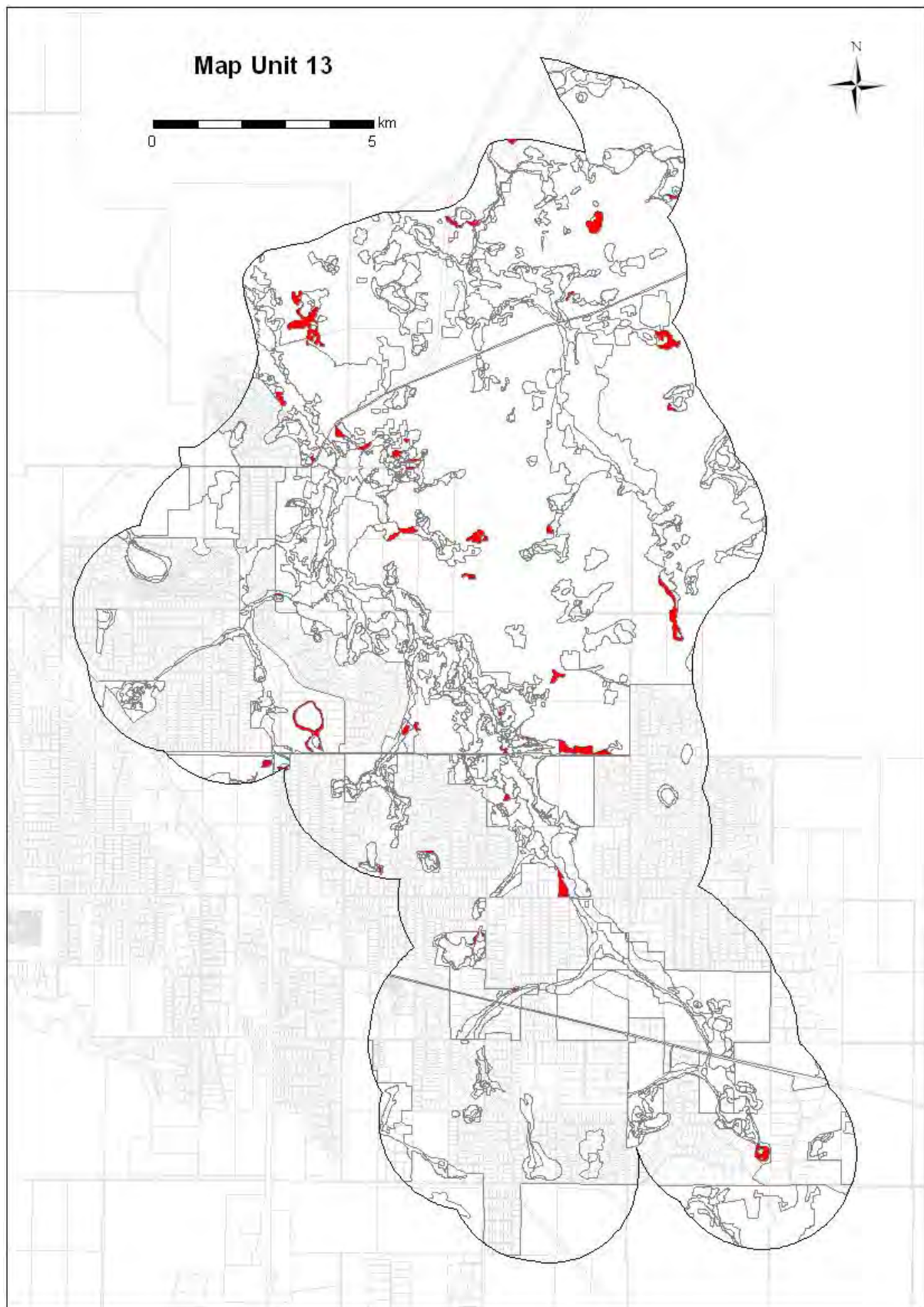


Figure 19: Map Unit 13 distribution map.

3.2.19. Map Unit 14: Aquatic bed with *Nymphoides* and *Eleocharis*

Table 36: Community 14 structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Ground G1	Aquatic	80	0.1	100	Q1c

NVIS Association

G ^*Nymphoides*, *Eleocharis* \^aquatic\1\c

Description:

A treeless aquatic bed dominated by *Nymphoides* with sparse *Eleocharis* and surface water persisting until late in the dry season if not all year. Vegetation zonation is evident in some wetlands grading through closed aquatic beds dominated by aquatic forbs or sedges to permanent open water. In the single site sampled, water depth in the dry season (late August) averaged 0.35 m with a maximum depth of 0.6 m.

Distribution: This community often occurs in wetlands that are somewhat isolated from the main floodplain of the Howard River.

Surface soils: (1 plot).

Rare or significant species/community: There are no records of listed threatened plants from this community.

Comments:

Area: 2.03 km²

Sites: Count = 1; Howard Sand Plains Survey 57.

Table 37: Community 14 species cover and occurrence

Stratum	Species	Average Cover (%) within 1 site	Occurrence (%) within 1 site
Ground	<i>Nymphoides</i>	71	100
	<i>Eleocharis</i>	5	100
	<i>Utricularia gibba</i>	3	100
	<i>Caldesia oligococca</i> , <i>Pseudoraphis spinescens</i>	<1	100

Distribution Map:

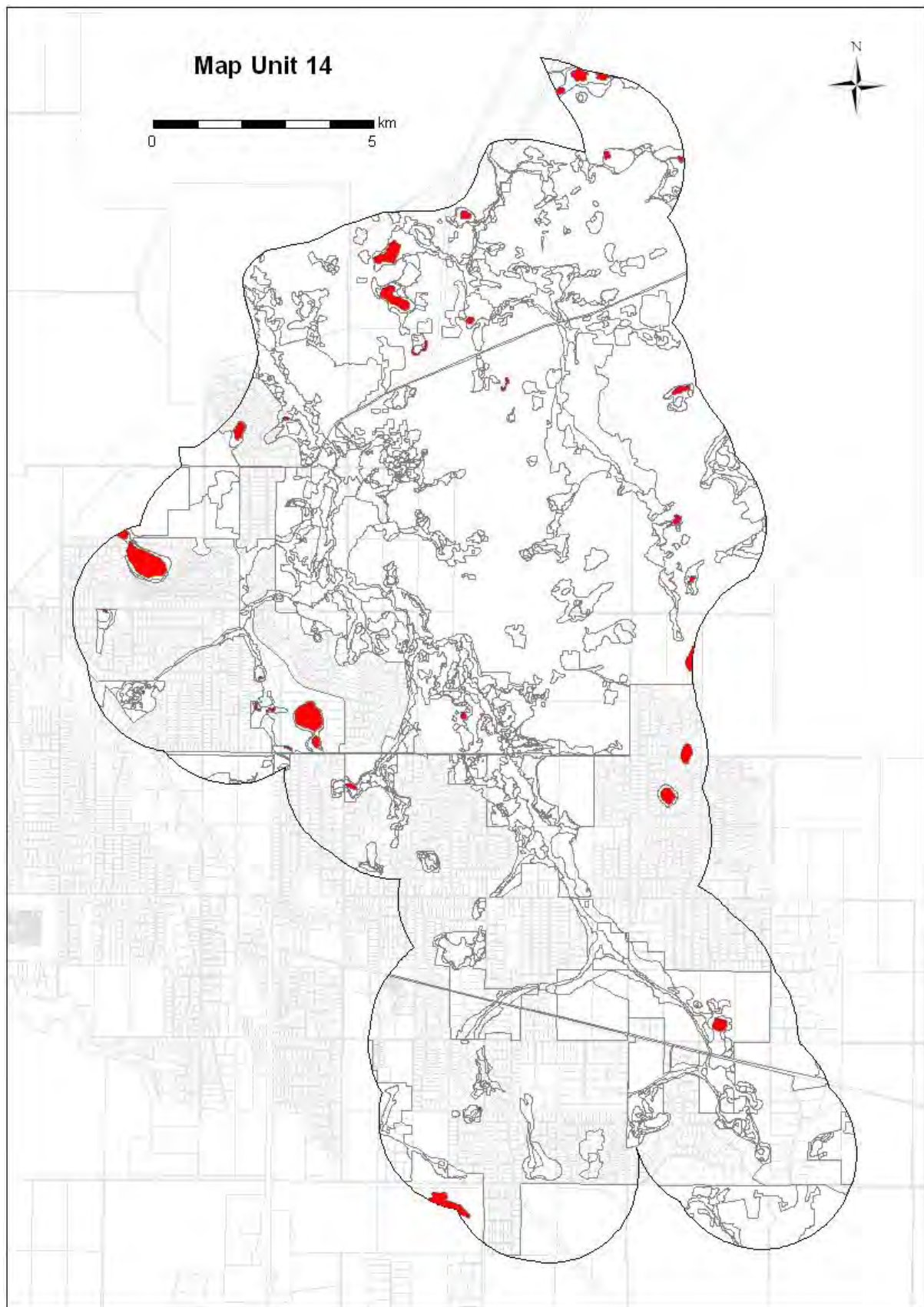


Figure 20: Map Unit 14 distribution map.

3.2.20. *Map Unit 15: Melaleuca cajuputi mid open forest with Pandanus spiralis (screw palm) low open woodland mid stratum and sedgeland or grassland ground stratum.*

Table 38: Community 15 structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	50 (30 -70)	19 (18 – 20)	100	T7c
Mid M1	Palm (Pandanus)	6.5 (3 - 10)	6.5 (4 – 9)	100	P6r
Ground G1	Sedge/Tussock Grass	40 (30 - 50)	1.0 (0.5-1.5)	100	V2c/G2c

NVIS Association

Description:

The upper stratum is a mid open forest of *Melaleuca cajuputi*.

The mid stratum is low open woodland dominated by *Pandanus spiralis* (screw palm).

The lower stratum is a tall sedgeland dominated by *Scleria* or mid open tussock grassland.

Distribution: This community often occurs as the forested riparian zone associated with the main channel of the Howard River.

Surface soils: (2 plots).

Rare or significant species/community: There are no records of listed threatened plants from this community.

Comments:

Area: 6.47 km²

Sites: Count = 2; Howard Sand Plains Survey 58, 60.

Table 39: Community 15 species cover and occurrence

Stratum	Species	Average Cover (%) within 2 sites	Occurrence (%) within 2 sites
Upper	<i>Melaleuca cajuputi</i>	45	100
	<i>Timonius timon</i>	1.5	100
	<i>Carpentaria acuminata</i>	2.5	50
	<i>Terminalia sp.</i>	1	50
Mid	<i>Pandanus spiralis</i>	5	100
	<i>Timonius timon</i>	<1	100
	<i>Acacia auriculiformis</i> , <i>Cayratia sp.</i> , <i>Melaleuca cajuputi</i> , <i>Passiflora foetida*</i> , <i>Sesbania formosa</i> , <i>Terminalia sp.</i>	<1	50
Ground	<i>Pandanus spiralis</i>	5	100
	<i>Barringtonia acutangula</i>	2	100
	<i>Carallia brachiata</i>	1	100
	<i>Acacia auriculiformis</i> , <i>Carpentaria acuminata</i> , <i>Flagellaria indica</i> , <i>Livistona benthamii</i> , <i>Melaleuca cajuputi</i> , <i>Mnesithea rotti-boellioides</i> , <i>Terminalia microcarpa</i> , <i>Timonius timon</i>	<1	100
	<i>Scleria</i>	17.5	50
	<i>Poaceae</i>	5	50
	<i>Chrysopogon sp.</i> , <i>Ischaemum sp.</i>	1.5	50
	<i>Passiflora foetida*</i>	1	50
	<i>Alphitonia excelsa</i> , <i>Antidesma ghesaembilla</i> , <i>Breynia cernua</i> , <i>Cayratia sp.</i> , <i>Crinum angustifolium</i> , <i>Fuirena sp.</i> , <i>Glochidion sp.</i> , <i>Grewia retusifolia</i> , <i>Heteropogon triticeus</i> , <i>Planchonia careya</i> , <i>Smilax australis</i> , <i>Syzygium armstrongii</i> , <i>Terminalia sp.</i>	<1	50

Distribution Map:

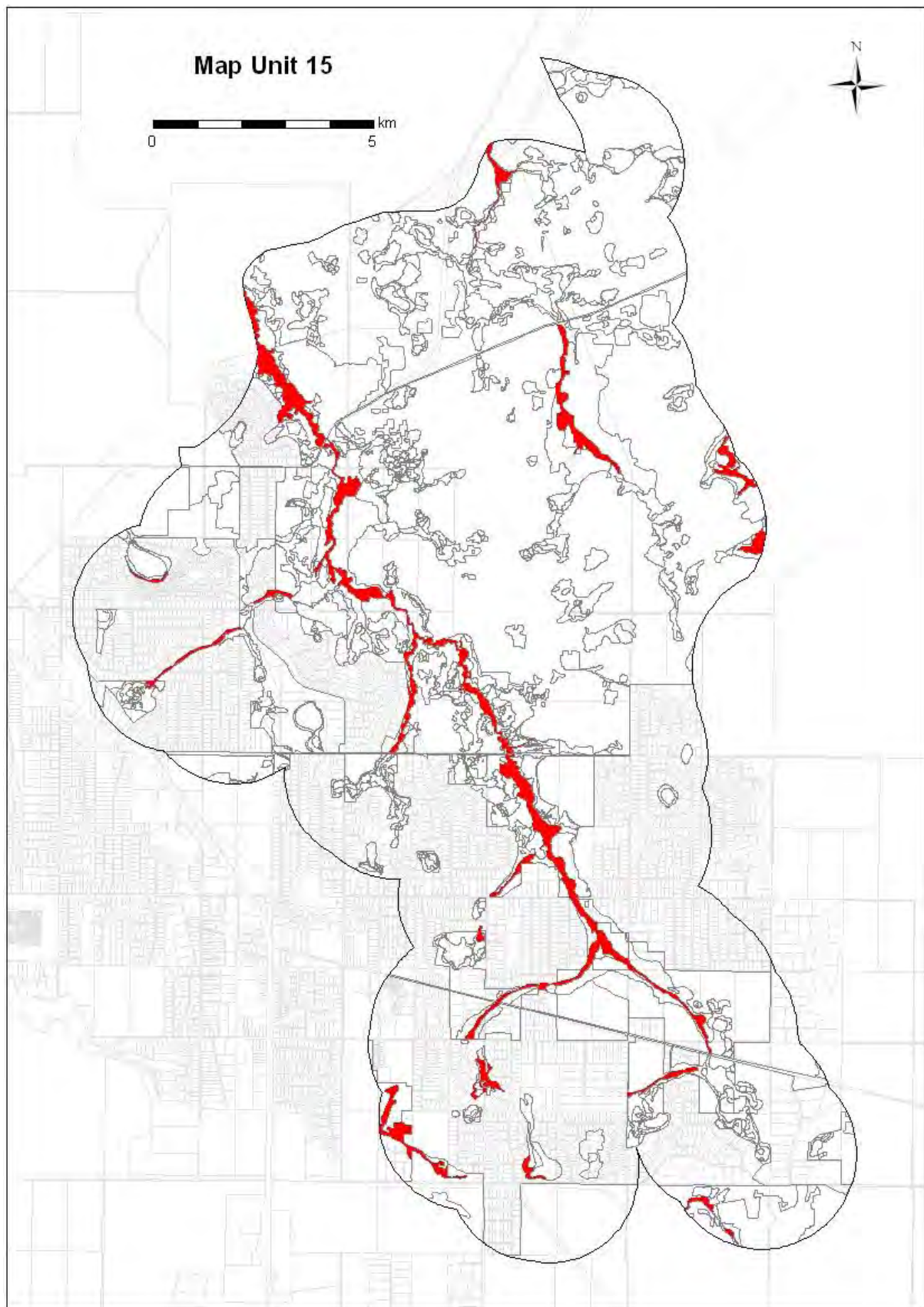


Figure 21: Map Unit 15 distribution map.

3.2.21. Map Unit 16: *Acacia auriculiformis* and *Carpentaria acuminata* closed forest

Table 40: Community 16 structural summary

Strata	Growth Form	Mean Cover (%)	Mean Height (m)	Occurrence (%)	NVIS Code
Upper U1	Tree	70	20	100	T7c
Mid M1	Palm	30	5	100	P6i
Ground G1	Palm	5	0.3	100	P6r

NVIS Association

Description:

The upper stratum is an open forest of dominated by *Acacia auriculiformis* (Black Wattle) and *Carpentaria acuminata* (Carpentaria Palm) with sub-dominant *Nauclea orientalis* (Leichhardt Tree), *Syzygium nervosum* and *Terminalia microcarpa*. The closed forest dominated by rainforest species grades into a *Melaleuca* dominated forest away from the springs or wetter drainage lines.

The mid stratum is low open woodland dominated by *Carpentaria acuminata* (Carpentaria Palm) with sub-dominant *Syzygium nervosum*.

The lower stratum is low open woodland.

Distribution: Within the Howard Sand Plains SOCS there are two patches of this community both of which are associated with springs.

Surface soils: (1 plot).

Rare or significant species/community: An uncommon vegetation community within the Howard Sand Plains SOCS. Rainforest is recognised as sensitive vegetation and both of these patches provide habitat for the endangered palm *P. macarthurii*. The mosaic of rainforest patches provide an important network of habitat for mobile fauna such as birds and fruit bats.

Comments: These spring-fed rainforests fall within floristic group 2 recognised by Russell-Smith (1991). The patch at the eastern end of Whitewood Road relies on ground water from surface layers and deeper aquifers (Boggs *et al.* 2008). The occurrence on the north-eastern edge of the SOCS is part of a series of spring-fed rainforest patches that occur along the margin of the Adelaide River floodplain.

Area: 0.52 km²

Sites: Count = 1; Howard Sand Plains Survey 59.

Table 41: Community 16 species cover and occurrence

Stratum	Species	Average Cover (%) within 1 site	Occurrence (%) within 1 site
Upper	<i>Acacia auriculiformis</i>	26	100
	<i>Carpentaria acuminata</i>	15	100
	<i>Nauclea orientalis</i> , <i>Terminalia microcarpa</i>	9	100
	<i>Syzygium nervosum</i>	5	100
	<i>Alphitonia excelsa</i> , <i>Carallia brachiata</i> , <i>Gmelina schlechteri</i>	2	100
Mid	<i>Carpentaria acuminata</i>	17	100
	<i>Syzygium nervosum</i>	7	100
	<i>Gmelina schlechteri</i> , <i>Macaranga involucrata</i>	2	100
	<i>Buchanania arborescens</i> , <i>Carallia brachiata</i>	1	100
	<i>Caryota mitis</i> *, <i>Flagellaria indica</i> , <i>Nauclea orientalis</i>	<1	100
Ground	<i>Carpentaria acuminata</i>	2	100
	<i>Macaranga involucrata</i>	1	100
	<i>Acacia auriculiformis</i> , <i>Barringtonia acutangula</i> , <i>Breynia cernua</i> , <i>Buchanania arborescens</i> , <i>Carallia brachiata</i> , <i>Caryota mitis</i> *, <i>Cayratia sp.</i> , <i>Ficus sp.</i> , <i>Flagellaria indica</i> , <i>Gmelina schlechteri</i> , <i>Ichnocarpus frutescens</i> , <i>Ixora timorensis</i> , <i>Livistona benthamii</i> , <i>Morinda citrifolia</i> , <i>Nauclea orientalis</i> , <i>Ptychosperma macarthurii</i> , <i>Stenochlaena palustris</i> , <i>Stephania japonica</i> , <i>Sterculia holtzei</i> , <i>Syzygium sp.</i> , <i>Syzygium nervosum</i> , <i>Terminalia microcarpa</i>	<1	100

Distribution Map:

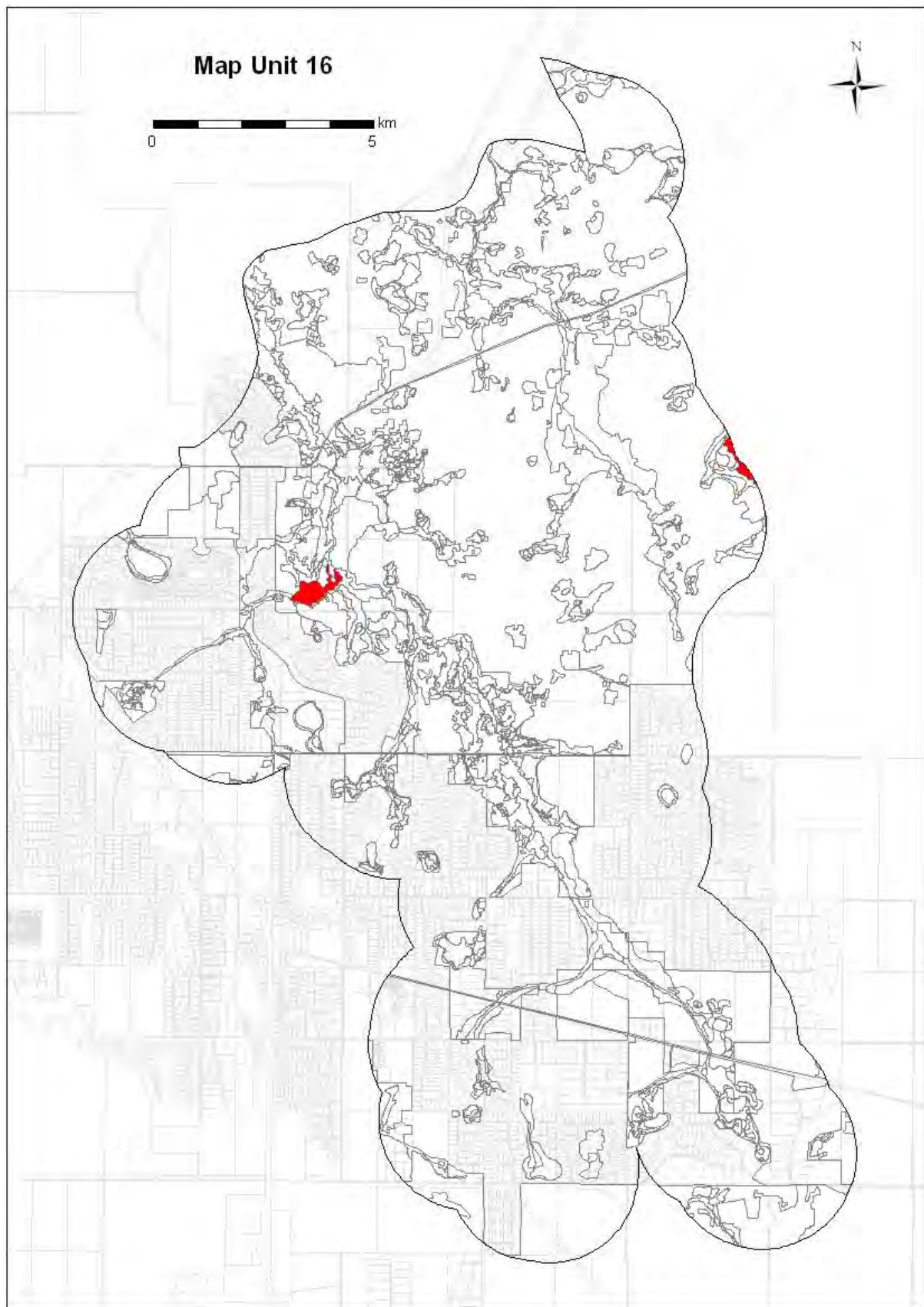


Figure 22: Map Unit 16 distribution map.

3.3. Other map unit descriptions

3.3.1. *Cleared Eucalypt woodland*

Area: 4.90 km² comprising 1.9% of the Howard Sand Plains SOCS.

Distribution Map:

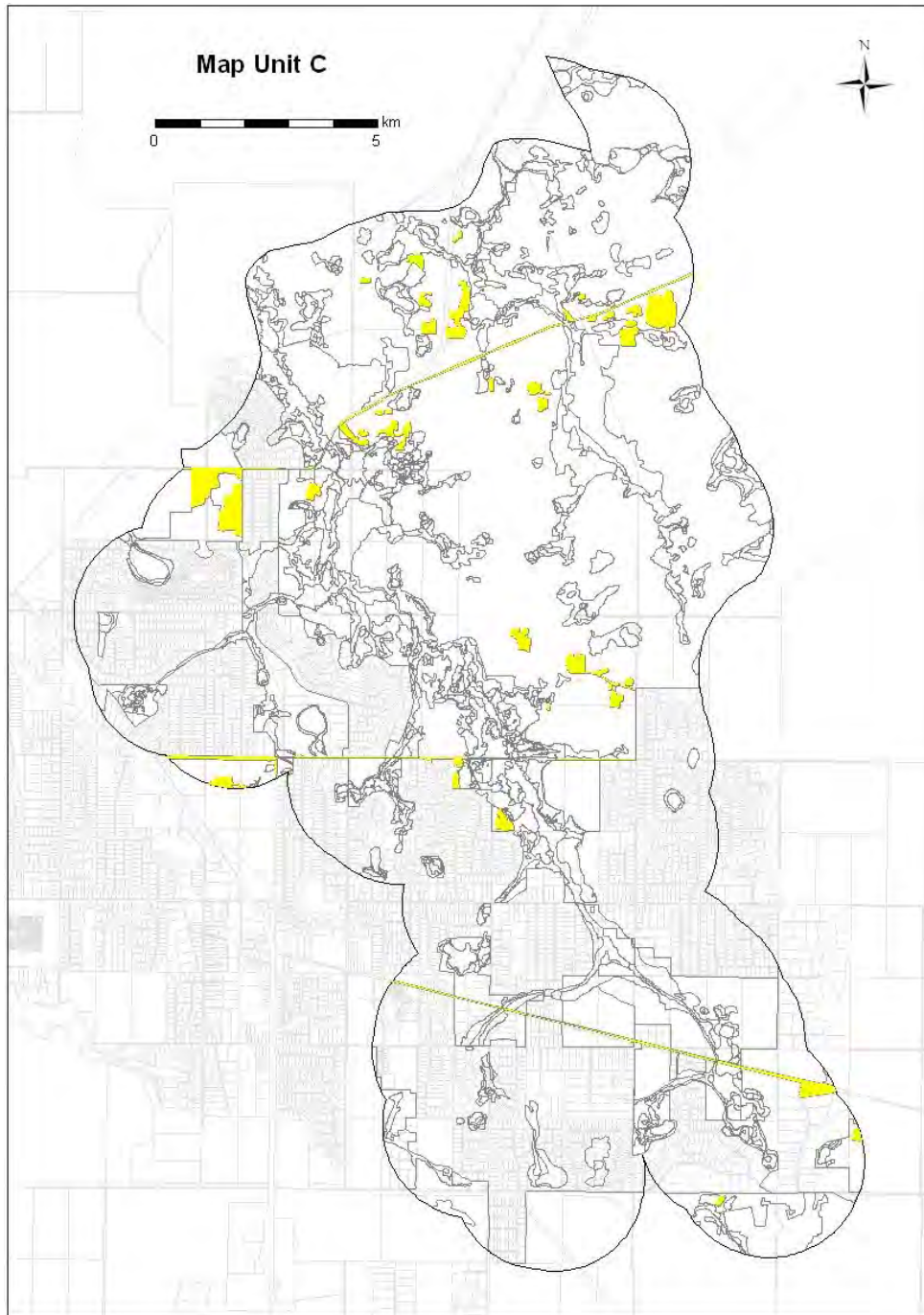


Figure 23: Distribution of lands mapped as cleared eucalypt woodland.

3.3.2. *Disturbed*

Area: 10.82 km² comprising 4.1% of the Howard Sand Plains SOCS.

Distribution Map:

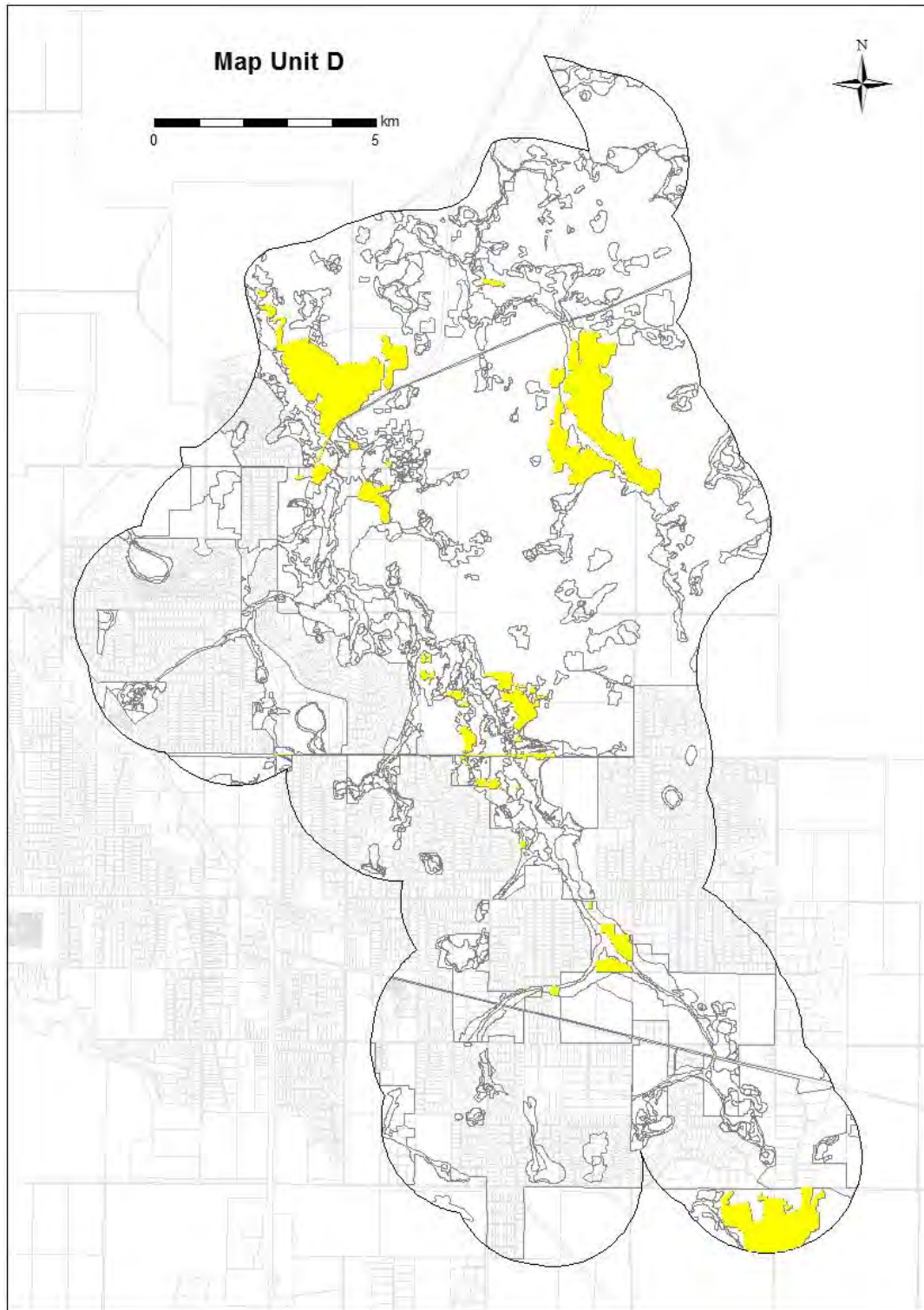


Figure 24: Distribution of lands mapped as disturbed.

3.3.3. Farming or forestry

Area: 9.13 km² comprising 3.5% of the Howard Sand Plains SOCS.

Distribution Map:

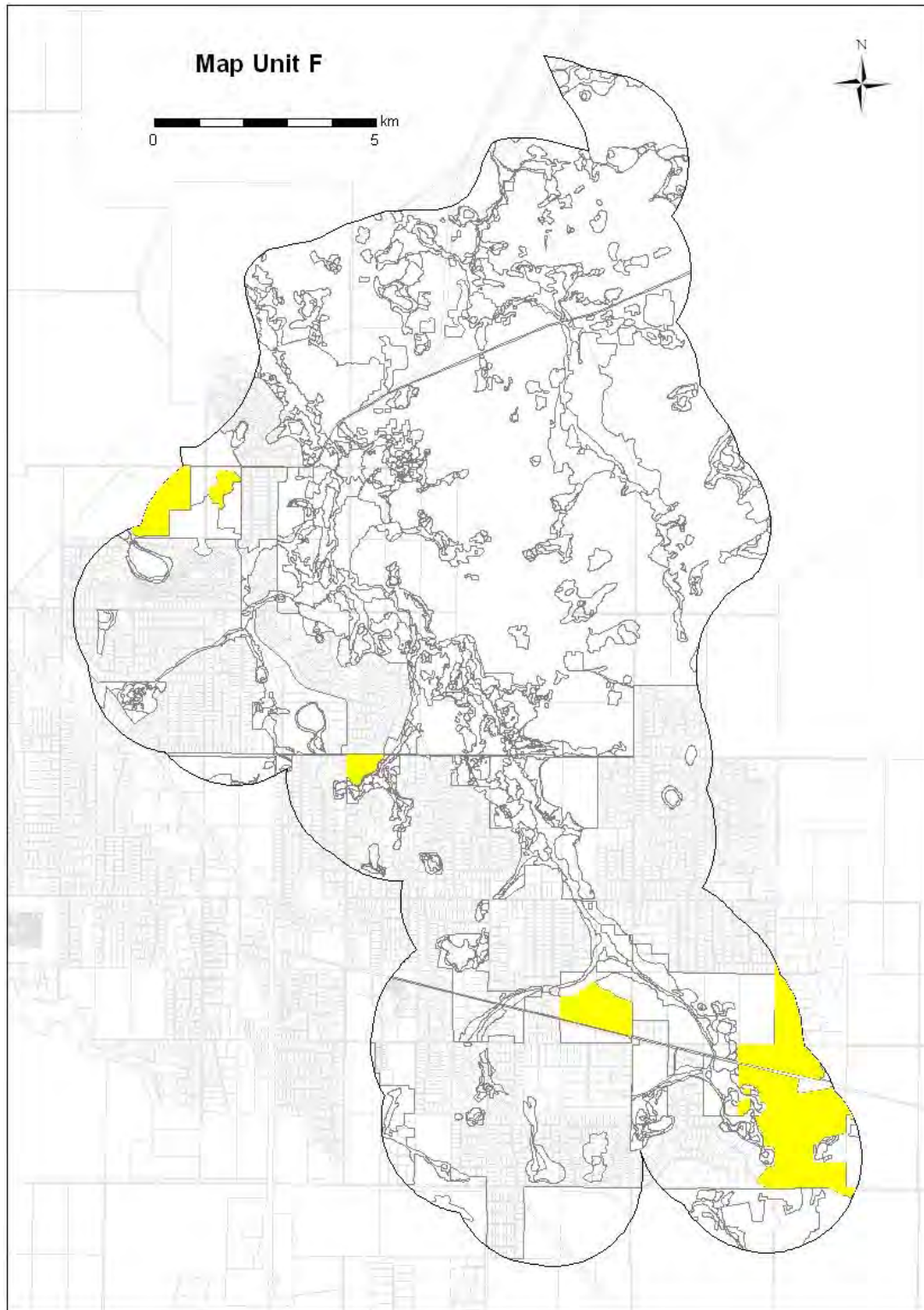


Figure 25: Distribution of lands mapped as farming or forestry.

3.3.4. Rural residential

Area: 83.75 km² comprising 31.8% of the Howard Sand Plains SOCS.

Distribution Map:

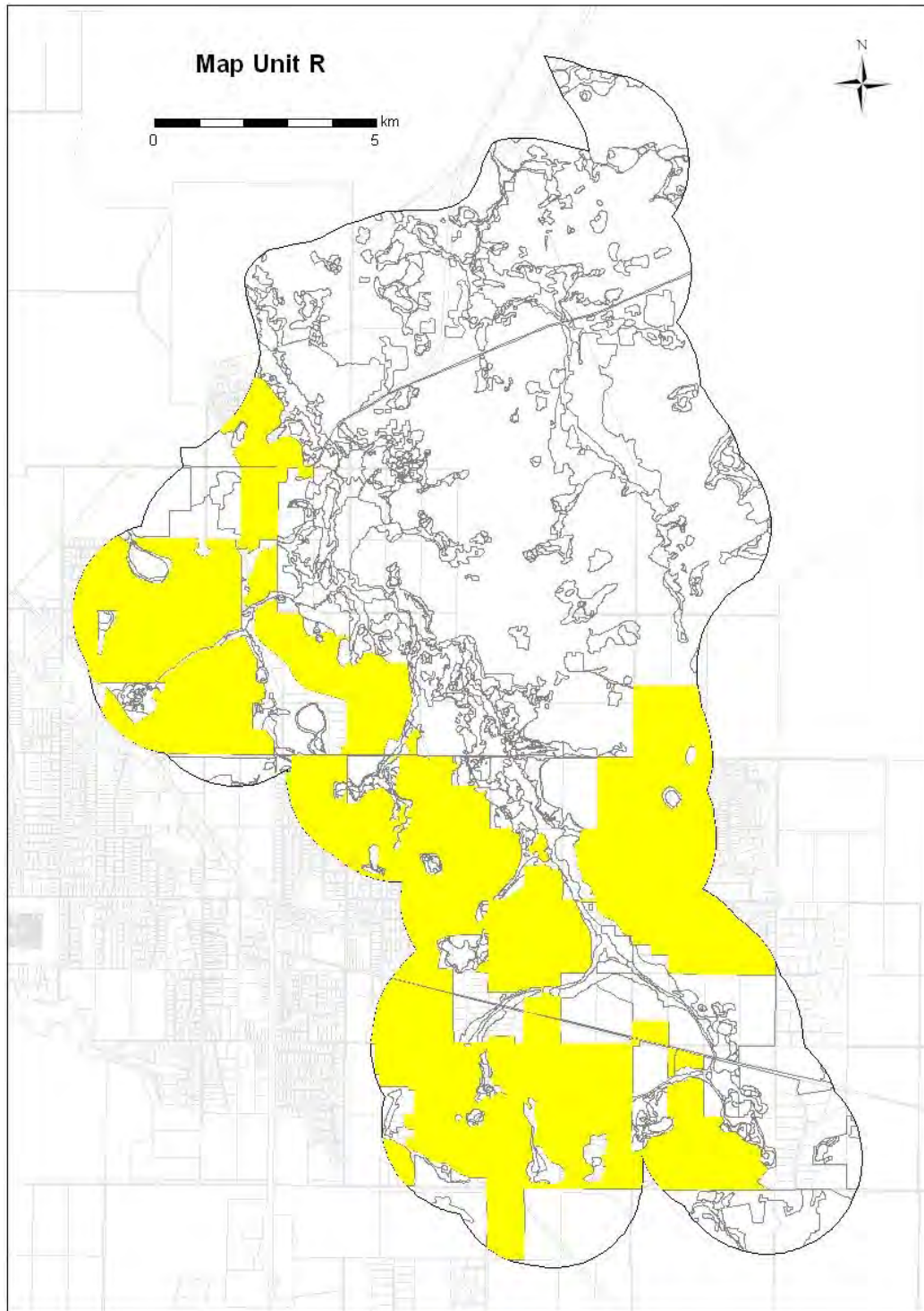


Figure 26: Distribution of lands mapped as rural residential.

3.3.5. Map Unit W: *Eucalypt* woodland

Area: 105.15 km² comprising 39.9% of the Howard Sand Plains SOCS.

Distribution Map:

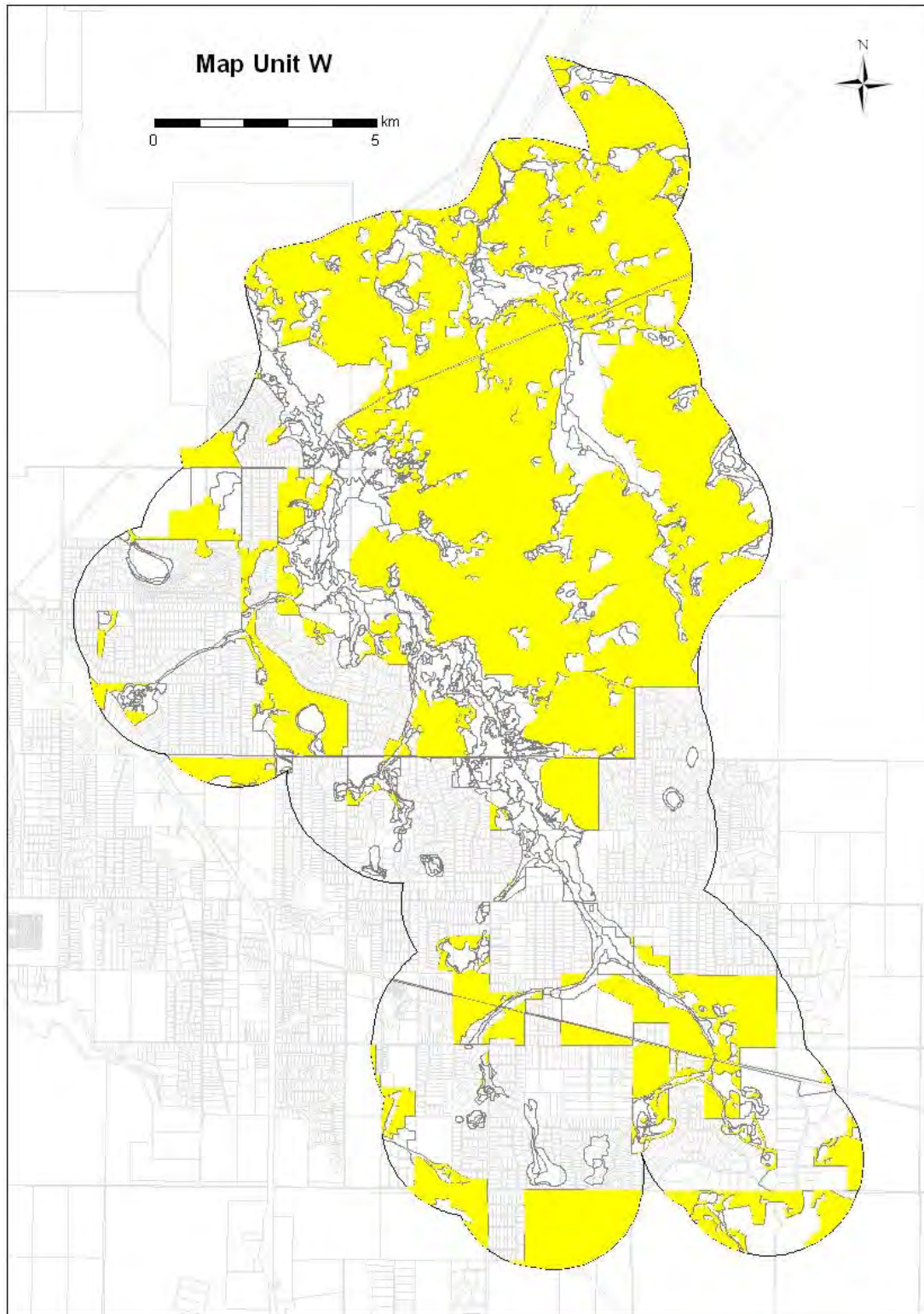


Figure 27: Distribution of lands mapped as eucalypt woodland.

3.4. Biodiversity values

3.4.1. Target species

The distributions of *Utricularia dunstaniae*, *Typhonium taylori*, and *Ptychosperma macarthurii* in the Northern Territory are provided in Figures 28 to 30.

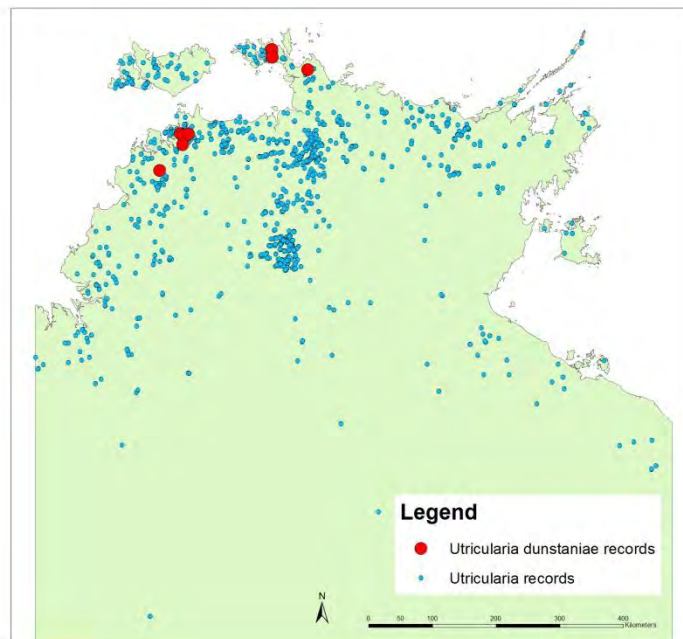


Figure 28: Occurrence of the vulnerable *Utricularia dunstaniae* against a backdrop of *Utricularia* records in the Northern Territory.

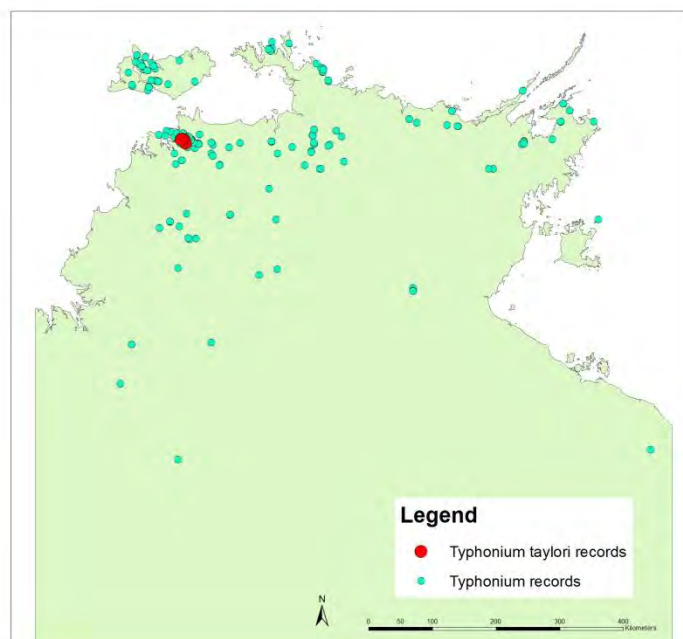


Figure 29: Occurrence of the endangered *Typhonium taylori* against a backdrop of *Typhonium* records in the northern part of the Northern Territory.

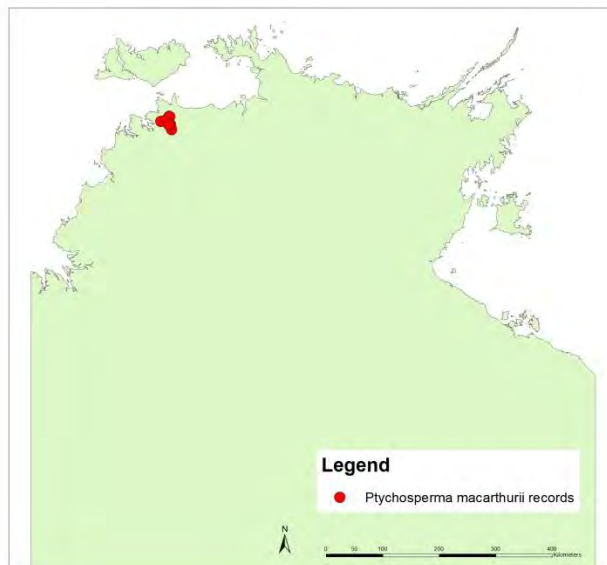


Figure 30: Occurrence of the endangered *Ptychosperma macarthurii* in the Northern Territory

3.4.2. *Utricularia* species diversity

Within the Howard Sand Plains SOCS the number of *Utricularia* species recorded in the vegetation communities ranged from zero to 16 species while the number recorded in individual 20 m by 20 m sample plots ranged from zero to 12 species (Table 42). Vegetation community 4b which is dominated by *Grevillea pteridifolia* in the upper story and *Dapsilanthus spathaceus* and *Eriachne trisetia* in the ground story, stands out with the highest maximum and average count of *Utricularia* species per sample plot. The spatial arrangement of communities supporting nil to very high diversity of *Utricularia* species within 20 m by 20 m sample plots is provided in Figure 31 and Figure 32.

Across the Northern Territory a maximum of 12 *Utricularia* species have been recorded within a 20 m by 20 m floristic plot. In a sample of 376 plots with *Utricularia* present, 67% of plots (253) contained 1 or 2 species, 19% (73) contained 3 or 4 species, 11% (43) contained 5 or 6 species and 2% (7) contained 7 or more species (Figure 33). All of the plots with 7 or more species were located within the Howard Sand Plains SOCS. All records of *Utricularia* within the Northern Territory occurred north of latitude 19° south.

The count of *Utricularia* species recorded within 25 km by 25 km cells across the Northern Territory ranges from nil to 25 species (Figure 34). The highest diversity occurs in the near Darwin area which incorporates the Howard Sand Plains SOCS. Other high diversity localities include Kakadu National Park, Nitmiluk National Park and Cobourg Peninsular.

Table 42: Diversity of *Utricularia* species and occurrence of *Utricularia dunstaniae* populations in the vegetation communities. Colour coding reflects the categories illustrated in Figures 31 and 32.

Vegetation Community	Number of 20 m by 20 m plots	Maximum number of <i>Utricularia</i> species in a plot	Average number of <i>Utricularia</i> species per plot	Number of <i>Utricularia</i> species recorded	Number of <i>Utricularia dunstaniae</i> populations	Occurrence of <i>Utricularia dunstaniae</i> representative
1	3	1	0.3	1	0	na*
2a	1	0	0	3	0	na
2b	1	4	4.0	10	0	na
3a	7	6	2.7	11	0	na
3b	7	4	1.7	16	0	na
4a	5	8	4.3	13	1	Yes
4b	5	12	8.4	13	2	Yes
4c	4	6	3.5	14	0	na
4d	5	5	2.4	12	1	Yes
5	1	1	1.0	1	0	na
6	5	4	2.2	11	0	na
7	1	0	0	0	0	na
8	2	2	2.0	4	0	na
9	5	5	2.8	10	0	na
10	6	4	1.7	14	0	na
11	1	4	4.0	4	0	na
12	2	5	4.5	10	1	No
13	4	5	4.2	14	0	na
14	1	1	1.0	1	0	na
15	2	0	0	0	0	na
16	1	0	0	0	0	na

*not applicable as *Utricularia dunstaniae* not recorded in the community.

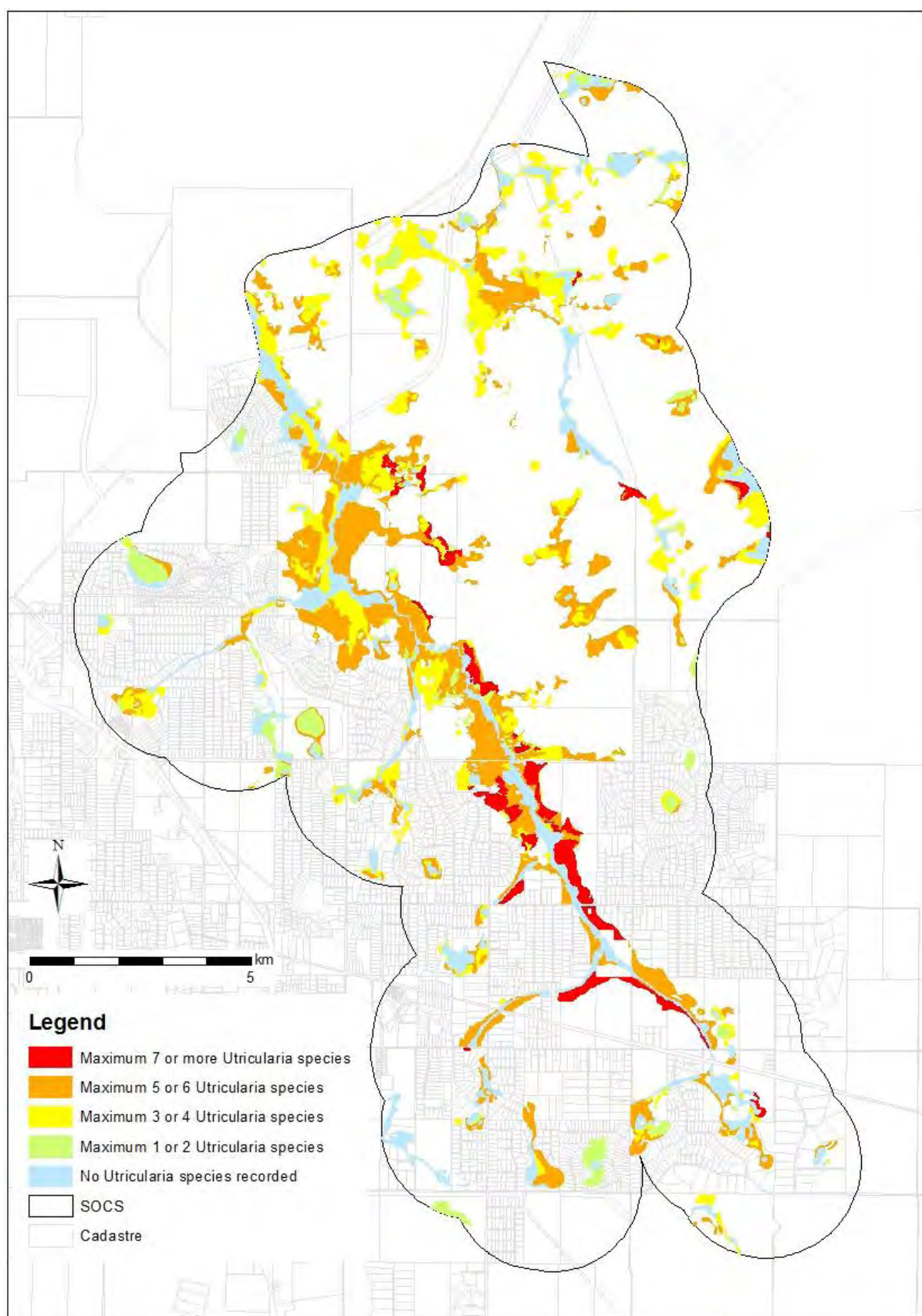


Figure 31: Maximum species diversity of *Utricularia* in 20 m by 20 m plots within vegetation communities.

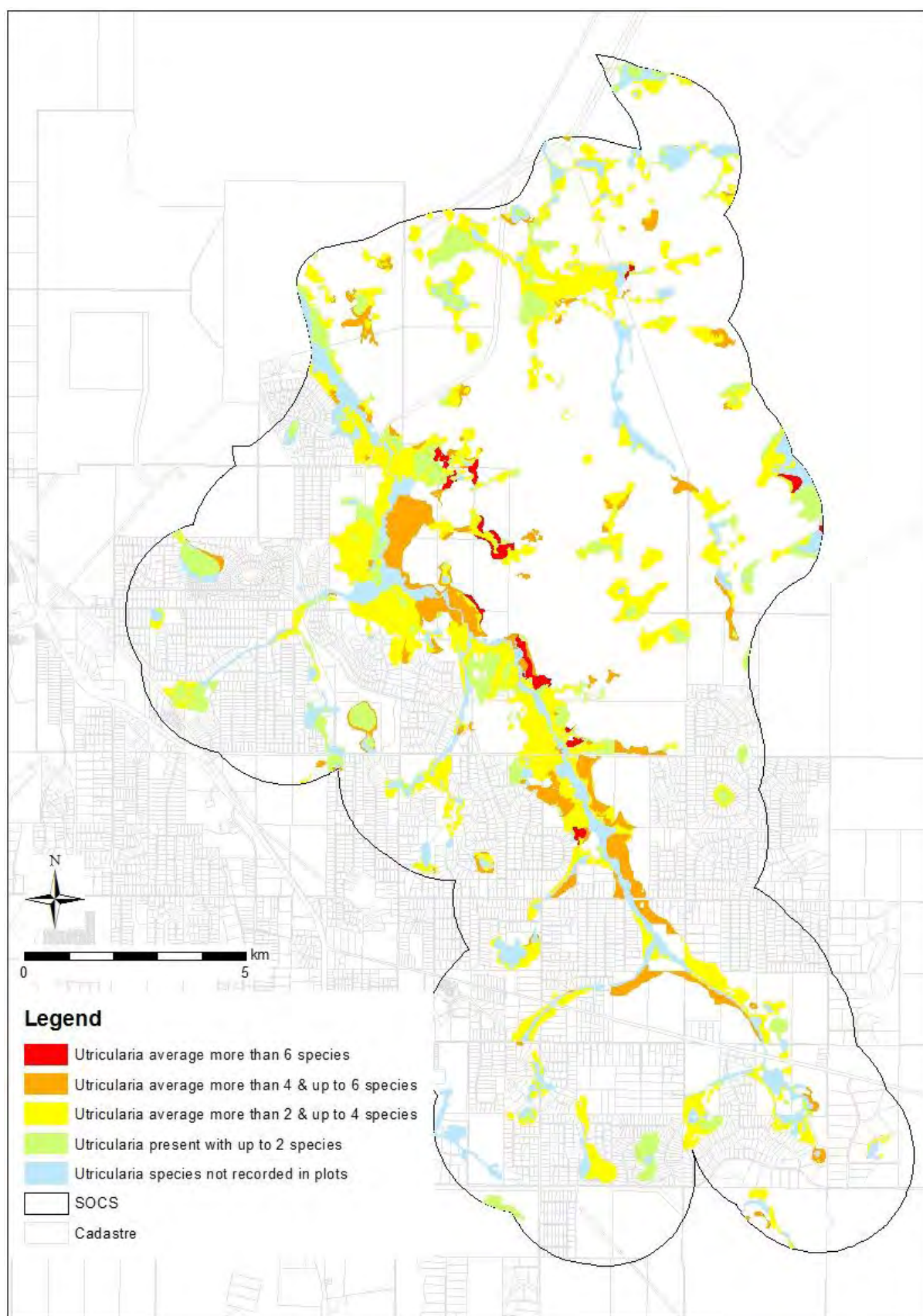


Figure 32: Average species diversity of *Utricularia* in 20 m by 20 m plots within vegetation communities.

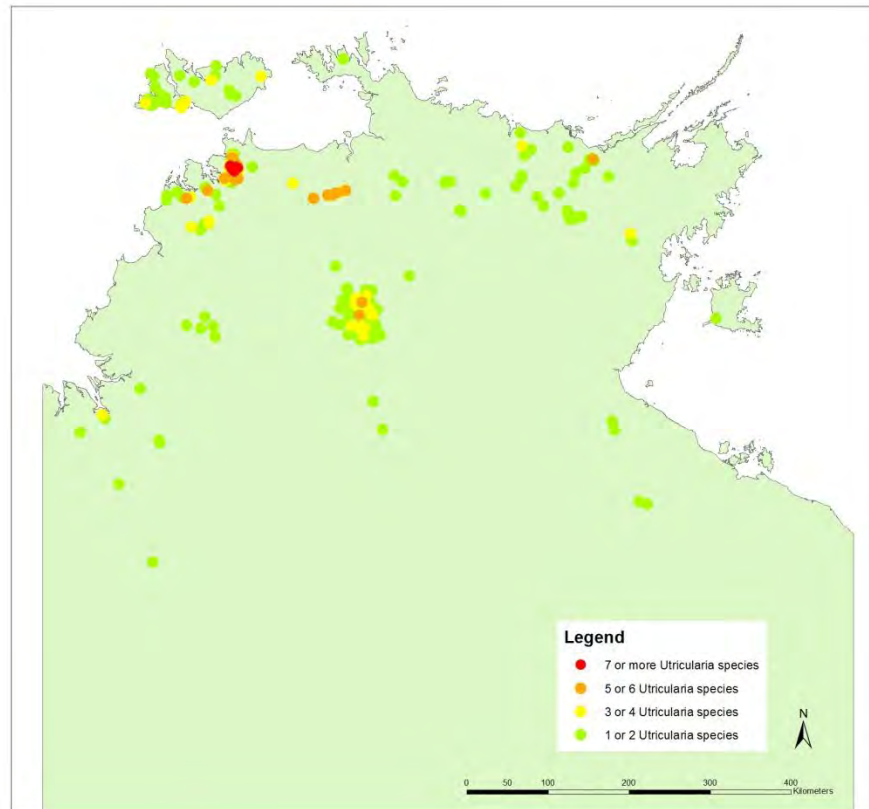


Figure 33: The number of *Utricularia* species recorded in 20 m by 20 m floristic plots across the Northern Territory.

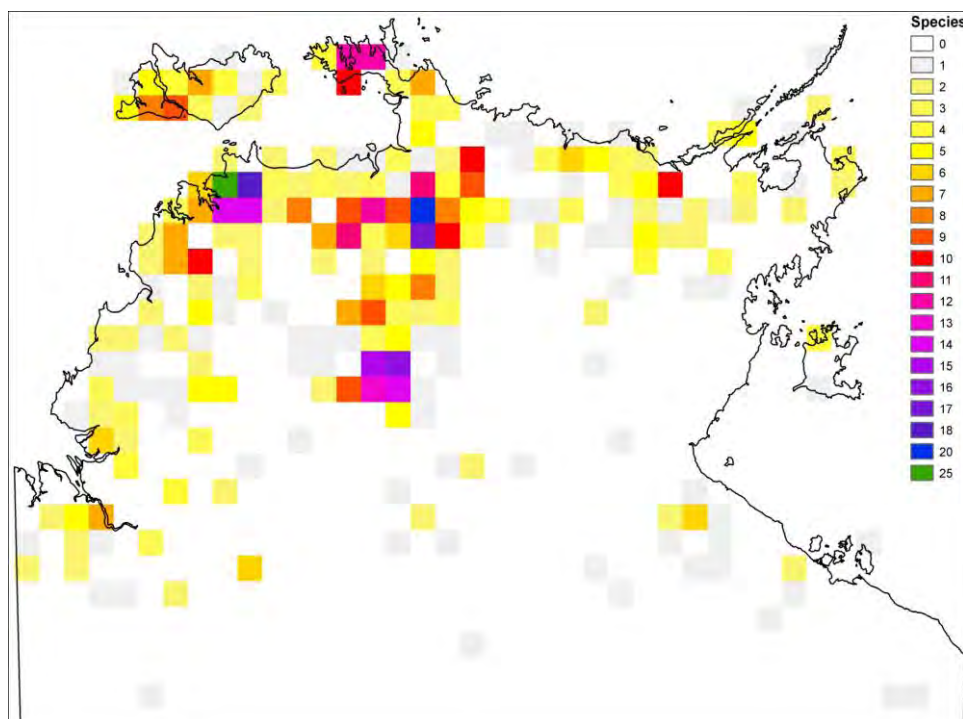


Figure 34: The number of *Utricularia* species recorded in 25 km by 25 km cells across the Northern Territory.

3.4.3. Identification of priority vegetation sites

Five mapped vegetation polygons within the Howard Sand Plains SOCS contain records of the endangered *U. dunstaniae*. Two were identified as the core of the highest priority sites and the others provide a focus for the next highest priority sites (Figure 35, refer section 2.2.3 for identification of priority sites). All sites are located to the east of the main watercourse of the Howard River, with four in the Howard River catchment and one within the watershed of the Adelaide River. Both highest priority sites have a core of vegetation community 4b while the southern next highest priority site has a core of community 4a and the northern next highest priority site a core of community 4d. The next highest priority site abutting the northern most of the highest priority sites is centred on point records for *Utricularia dunstaniae*. This population is comprised of 2 records of the species logged prior to the commencement of this project, which occur within a polygon mapped as community 12. Interpretation of aerial photographs and field inspection revealed small patches of high quality *Utricularia* habitat located towards the margin of this polygon, however, these small patches were not representative of the broader vegetation community occurring within the mapped polygon.

Three vegetation polygons were identified as highest priority sites for *T. taylori* (Figure 36). At two of these sites adjacent vegetation polygons have been classified as next highest priority for biodiversity value. A further two populations have also been recognised as next highest priority sites. Collectively these sites encompass five of the 11 recorded populations for the species (Liddle and Trikojus 2010).

The two patches of closed forest occurring within the Howard Sand Plains SOCS and both score a highest priority rating for biodiversity value associated with the occurrence of the endangered *P. macarthurii* (Figure 37).

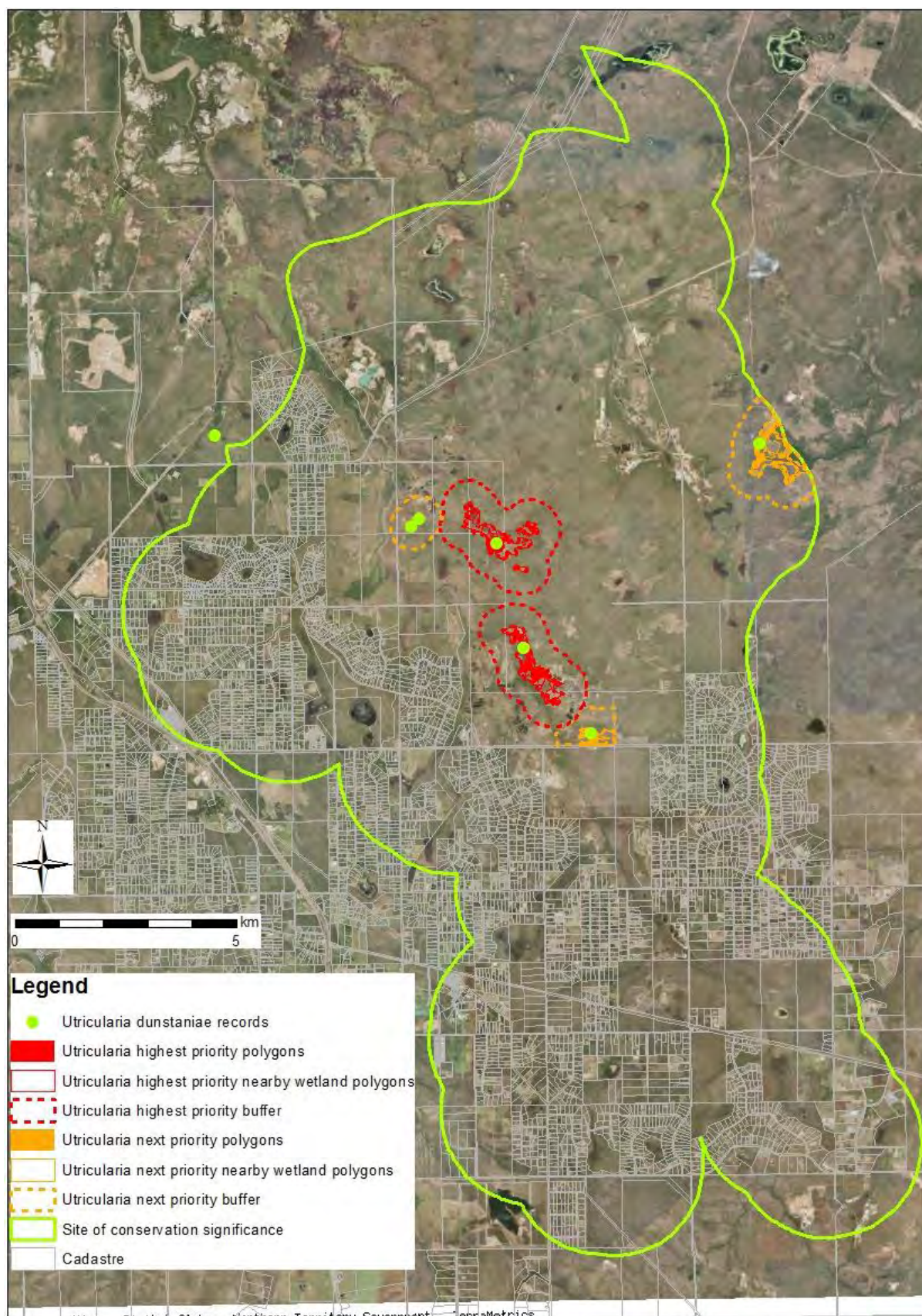


Figure 35: Highest priority areas for biodiversity value associated with *Utricularia* species in the Howard Sand Plains Site of Conservation Significance.

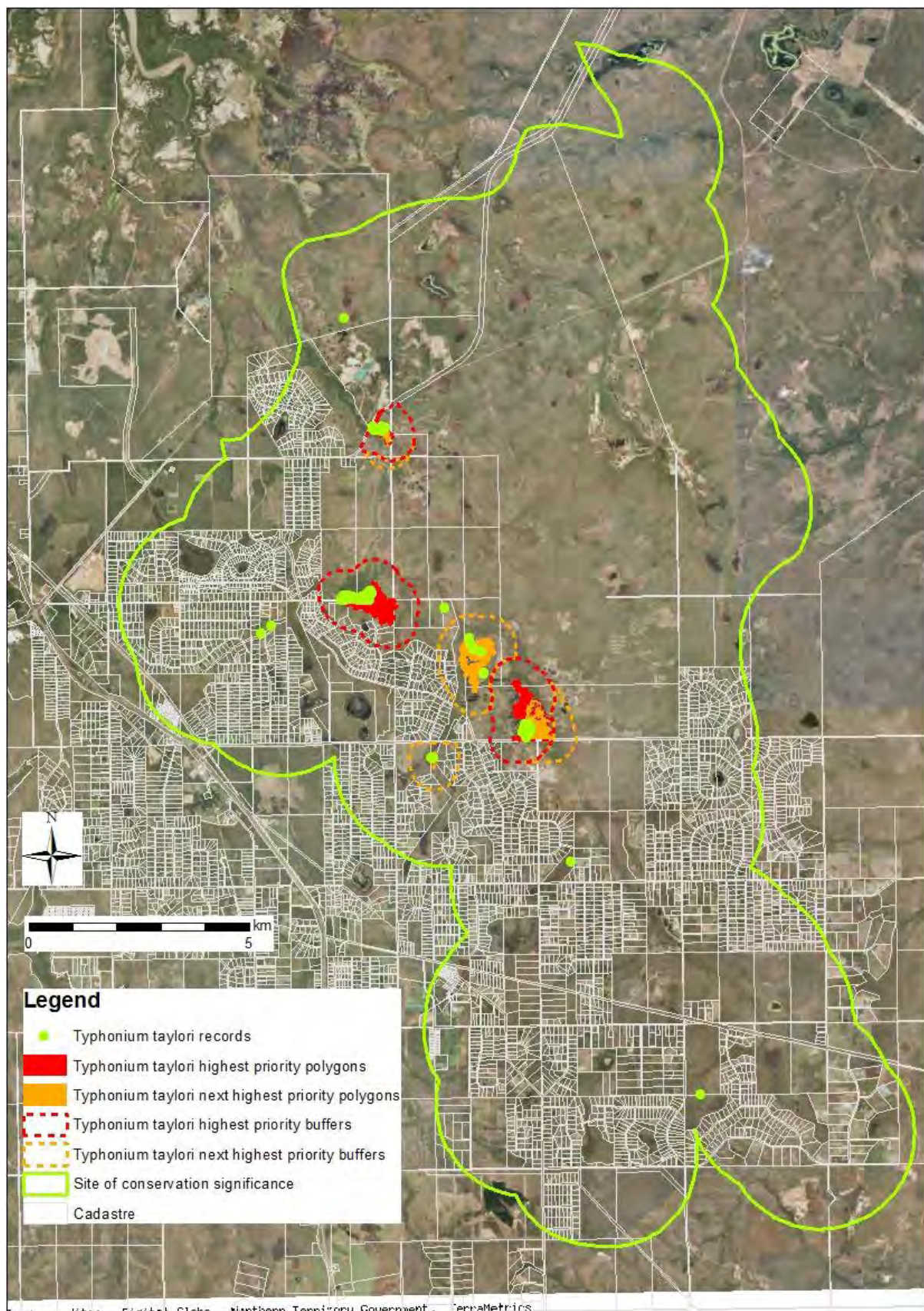


Figure 36: Highest priority areas for biodiversity value associated with *Typhonium taylori* in the Howard Sand Plains Site of Conservation Significance.

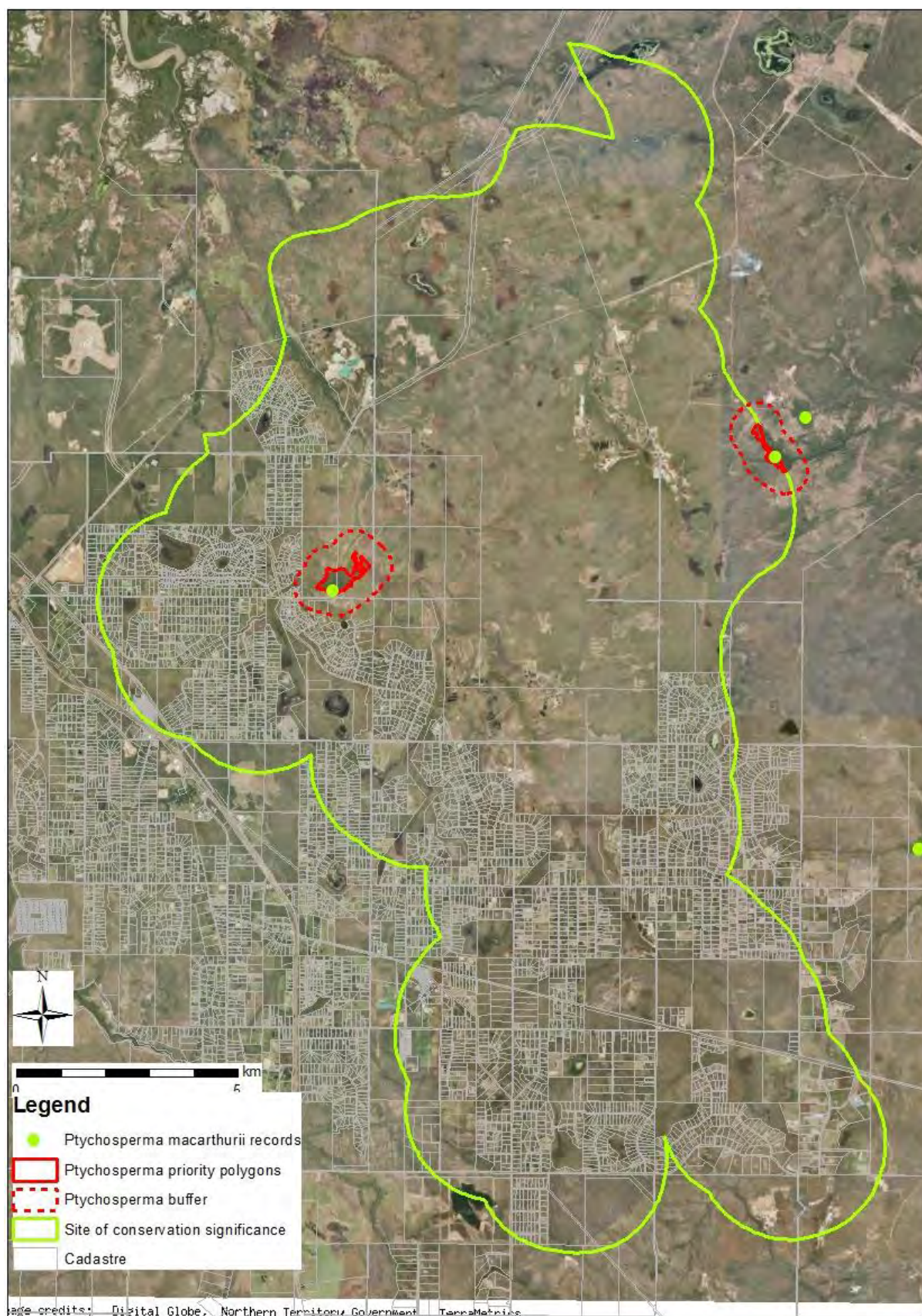


Figure 37: Highest priority areas for biodiversity value associated with *Ptychosperma macarthurii* in the Howard Sand Plains Site of Conservation Significance.

4. Discussion

The diversity of *Utricularia* within the Howard Sand Plains SOCS is outstanding. The high number of *Utricularia* species recorded within 20 m by 20 m plots and vegetation communities reinforce the previous international and national recognition as an area of high diversity for the genus (Taylor 1989, Harrison *et al.* 2009). In accord with this extra-jurisdictional significance, the area supports the highest diversity recorded for *Utricularia* in any part of the Northern Territory (Figures 33 and 34). Survey intensity near Darwin is likely to provide a positive bias towards the recording of *Utricularia* species in the Howard Sand Plains SOCS and it is expected that the number of *Utricularia* species recorded from more remote areas of the Northern Territory will increase over time. Despite the incomplete picture of occurrence of the genus across the Northern Territory, the records from 20 m by 20 m floristic plots where sampling effort is similar within each plot, provide evidence that the habitats of the Howard Sand Plains support an exceptional diversity of *Utricularia*.

The value for plant biodiversity is not restricted to *Utricularia*, with all known populations of the nationally endangered herb *T. taylori* located within the Howard Sand Plains SOCS (Liddle and Trikojus 2010) and two out of eight Northern Territory populations of the endangered rainforest palm *P. macarthurii* within the SOCS. The other six populations of *P. macarthurii* occur in the adjacent Adelaide River Coastal Floodplain SOCS (Liddle *et al.* 2006, Harrison *et al.* 2009). Along with *U. dunstaniae*, these species occur in seasonally saturated parts of the landscape.

The seasonally wet areas are part of a mosaic of interconnected vegetation communities linked by the flow of water. There are obvious flows of surface water in the wet season, however, the less obvious and less well understood flow of groundwater appears crucial to the maintenance of at least some of these vegetation communities. This is particularly the case for the prime areas of *Utricularia* habitat and for the spring-fed rainforest habitat of *P. macarthurii*.

There is a recurring pattern of the most diverse *Utricularia* habitat occurring towards the margin of the floodplain as indicated by the distribution of the vegetation communities supporting the highest diversity of *Utricularia* species (Figure 31). Field experience supports the contention that sandy substrates near the junction of broad shallow watercourses also provide prime habitat for diverse assemblages of *Utricularia* species. Many of the 'sand sheet' species appear to be at their peak when water is seeping out of the ground (Cowie 2002) and many of the richest areas occur on sandy substrates with an open ground layer, for example; as often occurs in vegetation communities 4a and 4b. Seepage across these areas extends for a month or two after the wet season rains have finished. The adjacent slightly elevated woodlands appear to act as a sponge, soaking up the wet season rain. This store of water seeps onto the adjoining sand sheets as the dry season advances. Eventually these seepages dry up and the sand sheets become dry and parched. This produces a characteristic and uncommon habitat varying from seasonally waterlogged to parched, occurring on low-nutrient sandy substrates. The seasonal extremes appear to contribute to the sparse tree over-story and prominence of annual herbs, specifically carnivorous herbs that supplement their nutritional requirements by their association with insects.

The hydrologic relationships of these seasonally ground-water dependent vegetation communities are poorly understood. However, field observations reveal a clear association between seepage of water from the adjoining slightly elevated woodlands, with sites supporting a very high diversity of *Utricularia*. The flow of water between adjoining floodplain vegetation communities is also poorly understood. Given the paucity of understanding of the hydrologic flows between prime *Utricularia* habitat and nearby vegetation communities, a 500 m buffer has been adopted in defining the priority sites identified in this report. The adequacy of a 500 m buffer is unknown and even this distance may not be sufficient to maintain water flows where there is extensive modification of the landscape. Potential changes could include drawing surface and/or groundwater flow away from the *Utricularia* habitat as may occur with lowering of the land surface through mining; or a diminished water supply through reduced infiltration and recharge that may occur with compaction of the land surface as an outcome of urban or industrial development. Improved understanding of the surface and groundwater flows of the seasonally saturated lands and adjoining habitats is a high priority in the quest for further knowledge to support maintenance of these high biodiversity value habitats. The Howard Sand Plains are recognised at a national level as a High Ecological Value Aquatic Ecosystem (Australian Government 2010) yet there is sparse knowledge about the water flows required to maintain the ecological values.

In contrast, there is a greater understanding of the water supply that supports the closed forest habitat of *Ptychosperma macarthurii*. Whitewood Road Rainforest is one of the two habitat patches supporting *Ptychosperma macarthurii* in the Howard Sand Plains SOCS and was a field site for a study of water use by closed forest vegetation (Boggs *et al.* 2008). Around half the water used by the vegetation in the late dry season was sourced from underlying aquifers and half from near the surface. Thus maintenance of this habitat requires continuity of water supply from both the underlying dolomite aquifer system and from the surface layers. The dynamics of water movement through the surface layers and the impact of removing the surface substrate to a depth of two meters through extractive mineral operations on nearby habitats have not been documented for the Howard Sand Plains SOCS.

A focus of this study has been to identify key sites for plant species of conservation significance, with a project activity to identify a minimum of 5 hectares for the conservation of *Utricularia* and *Typhonium taylori*. Including buffers, a total 1359 ha of priority lands have been identified for *Utricularia* and 1189 ha for *Typhonium taylori*. Respectively, these areas comprise 5.1% and 4.5% of the Howard Sand Plains SOCS (Figures 35 and 36). The focus has been on identifying the highest priority sites based upon the available information as opposed to an assessment of what may be required to maintain the biodiversity values of the Howard Sand Plains SOCS. Ten of the 21 communities identified support high or very high diversity of *Utricularia* with communities 4b and 4a at the forefront of maximum plot diversity scores (Table 42, Figures 8, 7 and 31). These two communities both fall within the spectrum of what is colloquially recognised as sand-sheet heath in the near Darwin area. These communities, along with 4c and 12 include the term heath in the community descriptions derived by application of the NVIS Association protocols. In addition, heath shrubs appear as a dominant life form in the mid-stratum of community 3b. These units collectively provide a preliminary description of the range of sand-sheet heath communities, however, further analysis of the data is required to provide a more comprehensive description of sand-sheet heath in the study area. Furthermore, the identification of highest and next highest priority areas does not diminish the responsibilities elsewhere to reduce or mitigate impacts on these species or the communities they occupy. Future surveys may reveal other areas with diversities of species or population sizes above the thresholds used in this study, such that those areas will also qualify as of highest priority.

The understanding of prime *Utricularia* habitat may be refined through a study to identify areas with sandy substrates that are fed by ground-water as the dry season advances. A series of satellite images captured at the end of the wet season and periodically throughout the dry season may provide the data to identify areas fed by seepage from adjoining woodlands. The seepage areas are expected to stay wet for longer than nearby non-seepage areas.

Limitations of the current study include reliance upon a low number of floristic plots for describing the vegetation communities. Sampling of additional plots would add to the understanding of the variation within the communities described and assist an assessment of the accuracy of the mapping undertaken. The majority of the field sampling was undertaken in the late wet season and early dry season of 2011. The vegetation response varies from year to year in the strongly seasonal environment and there is no measure available to compare the response in 2011 with other years. The growth response of *Utricularia* is seasonal (Cowie 2002) and thus timing of field sampling is important with regard to which species are likely to be encountered. Establishment of a series of periodically assessed reference sites would both assist in understanding the seasonal variation and provide a baseline against which to compare the occurrence or lack thereof, of species observed during field surveys.

The endangered geophytic orchid *Habenaria rumphii* has been reported from the Howard Sand Plains SOCS, however, the single record has geo-coordinates that do not match with the seasonally saturated lands. This is inconsistent with the specimen information that describes the locality as the edge of a spring fed jungle in sandplain. Field survey has failed to relocate the population. Should this population be refound, the locality may provide a further focus for conservation priority.

The seasonally waterlogged, infertile, sandy soils of the monsoonal portion of the Northern Territory support a diverse assemblage of specialist plant species (Cowie 2005). Many taxa are endemic to the Northern Territory and have relatively restricted distributions. Along with rare and threatened species; endemic taxa, in particular those with restricted range, deserve special attention regards conservation priority. If not looked after in their local area they will not be looked after elsewhere. Two areas of particular note for their diverse assemblage of such species are the lowlands associated with the Koolpinyah Surface (Williams 1969), a part of which has been the focus of this study, and the Western Arnhem Land Plateau (Woinarski et al. 2006). The species composition of this diverse flora appears to vary in response to subtle changes in soil texture, drainage and period of inundation. A substantial task lies ahead to gain an understanding of how the different species and diversity of taxa respond to the varying hydrologic and substrate conditions.

Priorities for further endeavour, listed by topic rather than priority include:

Hydrologic flows, both surface and sub-surface within the seasonally saturated lands and between the seasonally saturated lands and adjoining habitats.

The width of buffers requiring sympathetic management to maintain sites of high biodiversity value.

Identification of seepage areas important for *Utricularia*.

Modelling the relationship between the margin of the floodplain and the occurrence of important *Utricularia* habitat.

Modelling the habitat for *Typhonium* and *Utricularia* to gain insight as to important environmental correlates.

Establish and periodically assess a series of reference sites for *Utricularia* and *Typhonium*.

Conservation planning, incorporating both flora and fauna priorities.

Expansion of the knowledge base of the occurrence of significant species in the landscape. Specifically the occurrence or otherwise of significant species on disturbed sites including previously mined sites.

Improved rehabilitation techniques for disturbed areas.

The constructive collaboration of people with disparate interests has been a positive aspect of this project supported by the Australian Government's Caring for our Country initiative and co-ordinated by the Extractive Industry Association of the Northern Territory. There are multiple competing land uses in the Howard Sand Plains SOCS and conflict between competing interest groups has the potential to increase as Darwin expands. A collaborative approach between interest groups will assist in minimising such conflict. The conflicting demands and capacity for single-purpose-use to preclude future options adds weight to the urgent need to develop a land use plan that addresses the maintenance of the biodiversity values of the Howard Sand Plains SOCS. The documentation of biodiversity values undertaken in this project provides improved baseline data on which to develop a land use plan.

5. Acknowledgements

Partially funding of this project by the Australian Government's Caring for our Country initiative is gratefully acknowledged along with co-ordination of the grant by the Extractive Industry Association of the Northern Territory, in particular the support from Sandra Johnson, June Lurssen, Tom Harris and Ann Grattidge. Permission of landholders for access to country for field assessment is acknowledged along with assistance in the field by Ben Stuckey, Sarah Hirst, and Charmaine Tynan. Ann Grattidge and Steve Reynolds from EcOz Environmental Services have engaged in many interesting discussions about sand-plain country.

The Northern Territory Herbarium provided plant distribution and plot data along with information on species and assistance with plant identification. Advice on vegetation mapping has been generously provided by Nick Cuff and Peter Brocklehurst from the Land Assessment Branch of the Department of Land Resource Management. From Flora and Fauna Division: Matthew Fegan has been generous with advice on GIS operation and map production; and Simon Ward provided comments on a draft of this report.

6. References

- Australian Government (2010). Caring for our Country business plan 2010-11. Department of the Environment, Water, Heritage and the Arts; and the Department of Agriculture, Fisheries and Forestry, Canberra.
- Boggs, D., L. Hutley, P.G. Cook, D.T. Liddle and L.P. Elliott (2008). Chapter 3: Patterns of water use and water sources of spring-fed monsoon vine forest ecosystems. In Biophysical modelling of water quality in a Darwin rural area groundwater dependent ecosystem. D.T. Liddle, D. Boggs, L. Hutley, D. Yin Foo, G. Boggs, D. Pearson, P.G. Cook and L.P. Elliott (eds.). Report to Natural Resource Management Board (NT), NHT Project 2005/133. Northern Territory Government Department of Natural Resources, Environment, The Arts and Sport, Palmerston: 60-78.
- Brock, J. (2001). Native Plants of Northern Australia. Reed New Holland.
- Brocklehurst, P., D. Lewis, D. Napier and D. Lynch (2007). Northern Territory guidelines and field methodology for vegetation survey and mapping. Palmerston. Northern Territory Government, Department of Natural Resources Environment and the Arts.
- Clarke, K.R. and R.N. Gorley (2006). PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.
- Conservation and Natural Resources Group (2002). Litchfield Shire Remnant Vegetation. Northern Territory Government, Department of Infrastructure, Planning and Environment.
- Cowie, I. (2002). Preliminary report on a survey of *Utricularia* (LENTIBULARIACEAE) in the Howard River - Shoal Bay area.
- Cowie, I. D. (2006). *Goodenia elaiosoma* I.D. Cowie (Goodeniaceae), a new species from the Top End of the Northern Territory and a key to the northern species. *Austrobaileya* 7: 205-213.
- Cowie, I.D., P.S. Short and M. Osterkamp Madsen (2000). *Floodplain flora : a flora of the coastal floodplains of the Northern Territory, Australia*. Australian Biological Resources Study, Canberra/ Parks and Wildlife Commission of the Northern Territory, Darwin.
- Dixon, D., I. Cowie and R. Kerrigan (2003). *Ptychosperma macarthurii* or *P. bleeseri*? The taxonomic status of *P. bleeseri* reconsidered. *The Beagle, Records of the Museums and Art Galleries of the Northern Territory* 19: 81-86
- DLRM (2013a). Sensitive vegetation in the Northern Territory, Monsoon Rainforest. Department of Land Resource Management, Northern Territory Government. http://www.lrm.nt.gov.au/data/assets/pdf_file/0003/5349/Sensitive-Veg-Factsheets_Monsoon_Feb2013.pdf Accessed 10 October 2013.

- DLRM (2013b). Sensitive vegetation in the Northern Territory, Sandsheet Heath. Department of Land Resource Management, Northern Territory Government.
http://www.lrm.nt.gov.au/data/assets/pdf_file/0015/5352/Sensitive-Veg-Factsheets_Sandsheet_Feb2013.pdf Accessed 10 October 2013.
- DLRM (2013c). Threatened species list. <http://www.lrm.nt.gov.au/plants-and-animals/home/specieslist> Accessed 10 October 2013.
- ESCAVI (2003). Australian vegetation attribute manual: National Vegetation Information System Version 6.0. Executive Steering Committee for Australian Vegetation Information. Department of the Environment and Heritage. Canberra.
- ESRI (2012). ArcMap 10.1 <http://www.esri.com/>
- Fogarty, P. J., B. Lynch and B. Wood (1984). The land resources of the Elizabeth, Darwin and Blackmore Rivers. Land Conservation Unit, Conservation Commission of the Northern Territory.
- Harrison, L., L. McGuire, S. Ward, A. Fisher, C. Pavey, M. Fegan and B. Lynch (2009). An inventory of sites of international and national significance for biodiversity values in the Northern Territory. Department of Natural Resources, Environment, the Arts and Sport, Darwin, NT.
- Hempel, C.J. (2003). The application of Landsat imagery to land cover mapping in the greater Darwin region. Darwin, Biodiversity Unit, Department of Infrastructure, Planning and Environment: 39.
- Holmes, J., D. Bisa, A. Hill and B. Crase (2005). *Threatened and data-deficient plants in the Litchfield Shire of the Northern Territory*. Sydney, WWF-Australia.
- Kerrigan, R. and I. Cowie. (2007a). *Typhonium taylori*. In *Lost from our landscape: threatened species of the Northern Territory*. J. Woinarski, C. Pavey, R. Kerrigan, I. Cowie and S. Ward (eds.). Darwin, Northern Territory Government.
- Kerrigan, R. and I. Cowie. (2007b). *Utricularia dunstaniae*. In *Lost from our landscape: threatened species of the Northern Territory*. J. Woinarski, C. Pavey, R. Kerrigan, I. Cowie and S. Ward (eds.). Darwin, Northern Territory Government.
- Kerrigan, R., I. Cowie and D. Liddle. (2007). Darwin palm, *Ptychosperma macarthurii*. In *Lost from our landscape: threatened species of the Northern Territory*. J. Woinarski, C. Pavey, R. Kerrigan, I. Cowie and S. Ward (eds.). Darwin, Northern Territory Government.
- Liddle, D.T., B. Brook, J. Matthews, S.M. Taylor and P. Caley (2006). Threat and response: A decade of decline in a regionally endangered rainforest palm affected by fire and introduced animals. *Biological Conservation* 132: 362-375.
- Liddle, D.T. and Trikojus, N.A. (2010). Distribution, life history, population monitoring and management recommendations for the endangered herb *Typhonium taylori* in the Northern Territory of Australia. Palmerston, Department of Natural Resources, Environment, the Arts and Sport.

- National Committee on Soil and Terrain (2009). Australian soil and land survey field handbook. CSIRO Publishing.
- NRETAS (2010). Land clearing guidelines. Technical Report No. 20/2009D. Department of Natural Resources, Environment, The Arts and Sport. Darwin, Northern Territory.
- NT Herbarium (2013). The genus *Utricularia* in the Northern Territory
http://www.lrm.nt.gov.au/data/assets/pdf_file/0004/146560/DLRM-Utricularia-Factsheet.pdf Accessed 10 October 2013.
- NTLIS (2000). Metadata : Land Resources of the Elizabeth, Darwin and Blackmore Rivers - Greater Darwin Area, Northern Territory. ANZLIC Identifier: 2DBC771203606B6E040CD9B0F274EFE
http://www.ntlis.nt.gov.au/metadata/export_data?metadata_id=2DBC771203606B6E040CD9B0F274EFE&type=html#metadata
- NTLIS (2010). Imagery Catalogue Index. ANZLIC Identifier: 9679538FB851DC96E040CD9B21441B42
<http://ilis.nt.gov.au/imf/imf.jsp?site=ilismap>
- Russell-Smith, J. (1991). Classification, species richness and environmental relations of monsoon rainforest in northern Australia. *Journal of Vegetation Science* 2, 259-278.
- Taylor, P. (1989). The genus *Utricularia* – a taxonomic monograph. *Kew Bulletin additional series XIV*.
- Ward, S. (2007). Howard River Toadlet, *Uperoleia daviesae*. In *Lost from our landscape: threatened species of the Northern Territory*. J. Woinarski, C. Pavey, R. Kerrigan, I. Cowie and S. Ward (eds.). Darwin, Northern Territory Government.
- Williams, M. A. J. (1969). Geomorphology of the Adelaide-Alligator area. In *Lands of the Adelaide-Alligator Area, Northern Territory*. R. Story, M. A. J. Williams, R. E. O'Ferrall and J. R. McAlpine (eds.). Melbourne, CSIRO: 71-94.
- Woinarski, J. C. Z., C. Hempel, I. Cowie, K. Brennan, R. Kerrigan, G. Leach and J. Russell-Smith (2006). Distributional pattern of plant species endemic to the Northern Territory, Australia. *Australian Journal of Botany* 54: 627-640.