Seqwater - Banksia Beach WTP & Borefield

Annual Compliance Report 2022/23

Revision 1 | December 2023

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Executive Summary

This Annual Compliance Report covers the ninth monitoring period for the Banksia Beach Water Treatment Plant (WTP) and Borefield under the approved Borefield Environmental Management Plan (BEMP), spanning from 1/09/2022 to 31/08/2023. This report addresses the condition requirements set by the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval 2007/3396. The overarching BEMP contains several sub-monitoring programs, including the Aquifer Management Monitoring, the Ecological Monitoring Program, and the Meteorological Monitoring Program. Seqwater's internal procedures and protocols, including the Borefield Operating Management Plan (BOMP) and BEMP have been developed to ensure both protection of sensitive ecological communities and careful management and monitoring of groundwater levels and quality to ensure long term sustainability of the resource.

Given Seqwater have not extracted groundwater from the Banksia Beach Borefield since the Banksia Beach WTP ceased operations in April 2014, the BEMP was updated to reflect a reduced monitoring program for cold standby periods (shutdown > 12 months). During cold standby, the Aquifer Management Monitoring Program is not required as there is no risk of seawater intrusion or groundwater depletion because of extraction. In addition, the Ecological Monitoring Program was refined in 2013 with a specific aim to establish baseline vegetation conditions and determine the natural range of variation that occurs in terms of vegetation structure, composition, and condition.

Ecological consultants, 3d Environmental, were engaged to deliver the 2023 bi-annual Ecological Monitoring Program report, '*Bribie Island Borefield Groundwater Dependent Ecosystems: Annual Vegetation Monitoring Report 2023*' (Appendix A). This report presents a comprehensive dataset inclusive of 16 bi-annual monitoring events captured between April 2016 and September 2023. The breadth of data, covering both drying and wetting climatic cycles, greatly enhances the ability to predict the potential impacts of groundwater drawdown on groundwater dependent ecosystem (GDE) structure and function, as well as their capacity to recover from drier climatic perturbations. This is the first annual report that indicates a correlation has now been established linking increased rainfall and soil moisture with greater woody stem counts and higher species richness, which suggests that a predictive ecological baseline has been established. As per the BEMP, the Ecological Monitoring Program must only continue until a baseline is established and presented to the Commonwealth Department of Climate Change, Energy, the Environment, and Water (DCCEEW). Following the submission and review of this annual report, Seqwater intends to discuss potential optimisations or discontinuations of monitoring program(s), considering long-term planning, the WTP's future status, and the establishment of a predictive ecological baseline for Bribie Island's wet heath community.

Overall, Seqwater remains compliant with the EPBC approval conditions and associated BEMP, with the exception of minor monitoring data gaps, which have been detailed in this report.

1. Introduction

The Queensland Government initiated a series of water infrastructure projects in response to the millennium drought and water supply challenges in South East Queensland (SEQ). In 2006, the *Water Regulation 2002* was amended to include bulk water services supply objectives and provisions around Seqwater's water security program, with the aim to secure essential drinking water supplies for SEQ in anticipation of growing urban demand. The revised Schedule 10B set a target to substitute 10 megaliters per day from the existing water supply system, with water sourced from Bribie Island's deep sand aquifer.

Subsequent aquifer and groundwater modelling studies revealed that sustainable production at the proposed Banksia Beach WTP and the existing Woorim WTP was limited to 8 ML/d. Therefore, the proposed extraction rate was formally reduced to 5 ML/day in November 2007. The Banksia Beach WTP was designed for a maximum daily production of 5 ML/day and an annual daily average of 4.32 ML/day, not exceeding 1580 ML/year.

Given its proximity to National Matters of Environmental Significance (NMES), the proposed Banksia Beach WTP and borefield project was referred to the Department of the Environment and Water Resources (DEWR) (now the Department of Climate Change, Energy, the Environment and Water– DCCEEW). The project was formally declared a *controlled action* (Section 95a, Controlling provision – Wetlands of international importance (Sections 16 and 17B)) in May 2007.

The Banksia Beach WTP and borefield were constructed and commissioned in 2007/2008 by the Brisbane Caboolture Aquifuture Alliance (BCAA). Commonwealth approval was granted in April 2008 (EPBC 2007/3396). At the same time, the Woorim WTP was decommissioned in 2008 due to infrastructure and water quality issues.

In accordance with the approval conditions, the BOMP and the BEMP were implemented to protect ecological communities (e.g., Ramsar Wetland) and manage groundwater. The BEMP aims to ensure the long-term sustainability of the Groundwater Development Unit (GDU) and associated Groundwater Dependent Ecosystems (GDEs). The BEMP contains several monitoring programs, including the Aquifer Management Monitoring Program, the Ecological Monitoring Program, and the Meteorological Monitoring Program.

Following a 3-year detailed review, the Ecological Monitoring Program was refined in 2013 (approved April 2015) with a specific aim to establish baseline vegetation conditions and determine the natural range of variation that occurs in terms of vegetation structure, composition, and condition. Given Seqwater have not extracted groundwater from the Banksia Beach Borefield since the Banksia Beach WTP ceased operations in April 2014, the BEMP was updated again in 2016 to reflect a reduced monitoring program for cold standby periods (shutdown > 12 months). During cold standby, the Aquifer Management Monitoring Program is not required as there is no risk of seawater intrusion or groundwater depletion because of extraction.

Since this time, minor reviews of the BEMP have occurred, most recently the amendment to discontinue Normalized Difference Vegetation Index (NDVI) data capture was approved by the Department in May 2022.

This ninth Annual Compliance Report specifically addresses EPBC 2007/3396 Condition 3, which requires Seqwater to publish on its external website a Compliance Report summarising the implementation of the BEMP.

2. Summary of Current Monitoring Requirements

In March 2016, the BEMP was amended to account for the cold standby shutdown, which included:

- Ceasing quarterly operational reports
- Reducing Community Reference Group meetings to specific issues
- Ceasing Aquifer Monitoring Program, including Standing Water Level and Electrical Conductivity monitoring
- Ceasing quarterly assessment of meteorological data.

During the 2021-2022 reporting period, the DCCEEW approved the discontinuation of NDVI data capture and analysis. This change was made because NDVI data was found to have no ongoing utility in assessing floristic composition or structural diversity in the wet heath habitats under consideration. Table 1 details the current Ecological Monitoring Program requirements for cold standby periods.

Table 1. Ecological Monitoring Program Requirements during Banksia Beach WTP cold standby

	Monitoring Type	Frequency (during cold standby)
Ecological Monitoring Program	Vegetation transects surveying at GDE Site 5 (potential drawdown) & GDE Site 6 (control)	Twice yearly – once during the wet season (~March) and once at the end of the dry season (~September). Continue until baseline is established*
	Soil Moisture data collection at GDE Site 5 (potential drawdown) & GDE Site 6 (control)	4 hourly readings taken using a submersible data logger. Continue until baseline is established*

** The baseline is set when future differential changes can be statistically evaluated. Once established, it should be included in the Annual Compliance Report, explaining how it was determined.*

3. Conditions of Compliance

Table 2 summarises compliance with the EPBC Act approval conditions by condition number, referring to the Variation to Conditions of Approval Letter dated 10/04/2015. The table presents the status of condition compliance along with a brief summary. Additional compliance details are available in the following sections.

Table 2. Summary of EPBC Act Controlled Action Conditions and Compliance for the Banksia Beach WTP and Borefield

Condition Number	Condition / Requirement	Status	Compliance Assessment
EPBC 1	The approval holder must create and obtain Ministerial approval for a BEMP designed to safeguard the ecological character of the Moreton Bay Ramsar wetlands. Once approved, the BEMP must be implemented and promptly made accessible on the approval holder's website within one month. This information should be easy to find through web searches. The Department must be informed within five business days of the BEMP being published on the website, and the BEMP should remain available for the duration of the approval.	Ongoing	☒ Compliant ☐ Non-compliant
EPBC 3	The approval holder must restrict groundwater extraction from the Northern Borefield as specified in the BEMP: an annual average of 4.32 ML/day, with a maximum daily rate of 5 ML/day, and not exceeding 1580 ML/year, subject to conditions 1, 4, and 5.	Ongoing	☒ Compliant ☐ Non-compliant
EPBC 3	The approval holder must maintain accurate records of all BEMP implementation measures and provide these to the Department when requested. Every year, within three months of the action's anniversary, a Compliance Report addressing BEMP implementation must be published on the approval holder's website. If there is non-compliance, the approval holder must inform the Department in writing within ten business days of awareness. Compliance Reports must be published annually, as agreed upon by the Minister, and may be audited or used to verify compliance with the approval conditions.	Ongoing	☐ Compliant ☒ Non-compliant (partial non-compliance)
EPBC 4	To deviate from the BEMP, the approval holder must seek the Minister's written approval for a revised plan. The altered activity cannot begin until the Minister approves the revised plan in	Noted – general obligation condition	☒ Compliant ☐ Non-compliant

	writing. Once approved, the revised plan replaces the initially approved plan. All Minister-approved revised plans must be made accessible on the approval holder's website within one month of approval.		
EPBC 5	If the Minister deems it necessary or convenient for better protection of NMES, they can ask the approval holder to revise the BEMP and submit it for written approval. Once approved, the revised plan must be followed. Until the Minister approves the changes, the approval holder must adhere to the initially approved BEMP and its conditions.	Noted – general obligation condition	☒ Compliant ☐ Non-compliant
EPBC 6	Upon the Minister's request, the approval holder must arrange an independent compliance audit, with both the auditor and audit criteria requiring Ministerial approval before commencement. The audit report must address the criteria to the satisfaction of the Minister.	Noted – general obligation condition	☒ Compliant ☐ Non-compliant

2.1. EPBC Condition 1

Compliance Assessment – Compliant

Following the Variation to Conditions approvals notice in August 2015, Seqwater promptly implemented the BEMP, which was published on Seqwater's website in September 2015.

The BEMP was later amended in March 2016 to incorporate changes related to the Banksia Beach WTP's cold standby shutdown (>12months). This revised BEMP was published on Seqwater's website in March 2016.

In July 2021, Seqwater requested the removal of annual vegetation change assessment using remote sensing methods (NDVI image capture and analysis) from the approved BEMP. This request was granted by the DCCEEW on 20/05/2022 as part of BEMP Revision 13 (13/04/2021). The amended approved BEMP is available on Seqwater's website: Corporate Publications, as required by Condition 1 of the EPBC approval.

2.2. EPBC Condition 2

Compliance Assessment – Compliant

The Banksia Beach WTP has been in cold standby (>12 months) since April 2014, following the BEMP's monitoring and sampling regime. There was no borefield extraction during this reporting period.

2.3. EPBC Condition 3

Compliance Assessment – Partial Non-compliance

This report fulfills EPBC Condition 3, which necessitates BEMP implementation within three months of the September 1st anniversary date, with the Annual Compliance report due annually by December 1st.

During the preparation of this report, Seqwater became aware of intermittent transmission issues from the Alert Weather Stations (AWS) and erroneous Soil Moisture Probe (SMP) readings. On 23/11/2023, Seqwater contacted the DCCEEW Post Approvals Section to clarify if minor data gaps constituted a non-compliance with the approval. The Environmental Compliance Division responded on 24/11/2023 and recommended that Seqwater should report the monitoring gaps under Condition 3, noting it as a partial non-compliance in the annual report to ensure clarity in reporting. On 24/11/2023, Seqwater notified DCCEEW of these minor monitoring data gaps. Further details on these data gaps have been provided below. No additional compliance issues arose during this period.

Meteorological Monitoring Requirement (BEMP Requirement: Section 7.3)

Following inclement weather in the summer of 2020-2021, the Northern Access Track was closed by Queensland Parks and Wildlife Services (QPWS) in late January 2022 due to unsafe conditions and coastal erosion. Seqwater’s Hydrometric team uses this track for critical maintenance of the Northern AWS (National Park AWS), which records local climate data for ongoing model refinement and validation for long-term assessment of groundwater level data. QPWS reopened the track in July 2023, which enabled Seqwater's Hydrometric team to service the Northern AWS on 21/09/2023. The inability to undertake critical maintenance and calibration of the telemetry infrastructure and monitoring equipment has resulted in data validity and reliability issues. In addition, the Northern AWS wind sensor was found to be faulty, and a replacement is currently on order. However, it has been noted that the Northern AWS wind sensor is located on a 2m mast in a narrow corridor surrounded by tall vegetation, the positioning of the mast is likely to impact the accuracy of the data.

As per the BEMP, if Northern or Southern AWS data is unavailable, the Redcliffe and Beerburrum Bureau of Meteorology site can meet meteorological monitoring requirements. Additionally, the Bureau of Meteorology Bribie Island Alert Station 040978 has been collecting local rainfall data since 2006. This site is not noted as a data source within the BEMP, presumably because it was only available on the BOM Climate Database in 2019, after the implementation of the BEMP. The Ecological Consultant, 3D Environmental, engaged by Seqwater to complete the *Annual Vegetation Monitoring Report 2023*, has confirmed that the BOM Bribie Alert Station provides accurate and reliable local rainfall data, which can be used for the purposes of the Ecological Monitoring Program assessment.

Ecological Monitoring Program – Soil Moisture (BEMP Requirement: Section 7.2)

The Soil Moisture Probes (SMP) measure moisture at five depths, collecting data every four hours over a 24-hour period. During the monitoring period, the Southern SMP (Control Site) recorded 53 null readings over 46 days in July and August 2023, constituting only 2.4% of the total dataset. The remaining Southern SMP data is adequate to confirm soil moisture trends at this location.

The 350mm Northern SMP (Impact Site) sensor experienced intermittent failures, rendering data unreliable for the monitoring period. However, data from the other four depths remained stable and representative. The Northern SMP failures are a reoccurring issue and generally occur at isolated depths, rather than failures across all sensors. The instrument supplier performed remote diagnostics and could not find any sensor or communication faults. After further investigation, it was determined that the likely cause of the intermitted failure was due to air pockets around the position of the probe which resulted in improper contact with the soil.

As the null readings result from air pockets caused by natural soil variations are beyond Seqwater's control, it is likely that these data gaps will occur during each monitoring period. However, the absence of this data is not expected to affect the long-term system understanding. In addition, the Ecological Consultant, 3D Environmental, engaged by Seqwater to complete the *Annual Vegetation Monitoring Report 2023*, has verified that the dataset is adequate for confirming soil moisture trends and making assumptions regarding data gaps. Nevertheless, Seqwater will explore options with the supplier to enhance instrument performance and reliability.

2.4. EPBC Condition 4

Compliance Assessment – Compliant

Following the Department's approval on 20/05/2022, the revised BEMP was implemented for the monitoring period. All monitoring activities during the reporting period followed the BEMP.

2.5. EPBC Condition 5

Compliance Assessment – Compliant

No formal requests for BEMP or approval amendments were received from the Minister by Seqwater during the reporting period.

2.6. EPBC Condition 6

Compliance Assessment – Compliant

No Ministerial requests for an independent audit were received during the reporting period.

3. Implementation of the BEMP

3.1. Annual Monitoring Report

In accordance with the BEMP requirements, Seqwater engaged a qualified consultant to conduct bi-annual vegetation transect surveys, which occur at the potential drawdown site (impact plot) and the control site. The consultant also prepared the Annual Monitoring Report, which includes a detailed review of floristic data, complemented by soil moisture and meteorological data, to assess vegetation condition at the control and impact sites and evaluate seasonal variations. This report presents a comprehensive dataset inclusive of 16 bi-annual monitoring events captured between April 2016 and September 2023. The detailed monitoring report is available in Appendix A, and the scientific peer review is available in Appendix B. The following key findings are taken from the *Bribie Island Borefield Groundwater Dependent Ecosystems: Annual Vegetation Monitoring Report 2023* prepared by 3D Environmental:

- Soil moisture probes at Northern Impact Plots (IPs) and Southern Control Plots (CPs) recorded volumetric moisture content (VMC) at various depths down to 1250mm. The data confirms rainfall as the primary factor controlling soil moisture, with climatic drying periods characterised by fluctuating soil moisture content, most notably in the upper 35cm. Occasionally, drying extended beyond 650mm and rarely to depths > 950mm, observed in April to May 2019 during the driest spell in the longer-term monitoring period.
- Woody stem counts and species richness strongly correlate with rainfall volume (expressed as cumulative rainfall departure or CRD), reflecting soil moisture and groundwater fluctuations. Both IPs and CPs show a positive and statistically significant correlation between rainfall volume and total stem counts, particularly at the IPs. The positive correlation's strength at the IPs may be attributed to the combined effects of wildfire and increased rainfall, stimulating the soil seed bank.
- Species richness shows an extremely strong positive correlation (statistically significant) with cumulative rainfall departure (CRD) at the CPs and a moderate positive correlation at the IPs (Site 6). The August 2019 wildfire event, acting as a data outlier, slightly diminishes the positive correlation's strength. Forbs and shrubs exhibit greater reliance on rainfall and soil moisture availability, while the richness and cover of sedges/grasses and grasstree remain relatively stable across different climatic regimes.

The dataset, spanning drying, wetting, and subsequent drying climatic cycles, greatly enhances its utility in predicting changes to the floristic composition and structure of wet heath communities linked to decreased rainfall and drying soil profiles. A correlation now links increased rainfall and soil moisture to higher woody stem counts and species richness, indicating the establishment of a predictive ecological baseline for Bribie Island's wet heath community.

In addition, the comprehensive dataset greatly increases the ability to accurately predict the potential impacts of groundwater drawdown on GDE and their resilience to drier climatic perturbations. Natural soil profile drying during drier climatic periods may impact vegetation, compounded by groundwater abstraction if not managed carefully. However, the report notes that minor reduction in groundwater levels is unlikely to promote any noticeable shift in the ecological state of vegetation within the drawdown area in the short term, with detectible impacts possible over decadal cycles.

3.2. Community Reference Group (CRG)

No CRG meetings occurred during this reporting period, as per the BEMP, which mandates CRG meetings only when specific cold standby shutdown issues arise. No issues were raised by the CRG during this period.

4. Conclusion

Seqwater have not extracted groundwater from the Banksia Beach Borefield since the Banksia Beach WTP ceased operations in April 2014. Seqwater has not undertaken activities on Bribie Island that could significantly impact EPBC Act listed species or NMES throughout the monitoring period. Seqwater will continue to implement the BEMP as per EPBC approval and engage with the Department to discuss potential optimisations or discontinuations of monitoring program(s), considering long-term planning, the WTP's future status, and the establishment of a predictive ecological baseline for Bribie Island's wet heath community, as indicated in the *Annual Vegetation Monitoring Report 2023*.

In 2019, Seqwater engaged an external consultant to model the performance of Banksia Beach WTP during both drought and non-drought conditions. As a result of this assessment, an internal recommendation was made by the water security planning team that the facility was not required in the short term as a water supply option or drought response supply augmentation option. The WTP was taken out of “care and maintenance” mode and reduced to “keep safe only” level of maintenance.

The Banksia Beach WTP has remained in cold standby for >8 years, and Seqwater currently has no plans to reinstate it due to the substantial resources required for operational restoration.

Appendix A – Groundwater Dependent Ecosystems (GDE) Vegetation Surveys

Refer to below *Bribie Island Borefield Groundwater Dependent Ecosystems: Annual Vegetation Monitoring Report 2023* prepared by 3D.

3D Environmental
Landscape & Vegetation Science

Bribie Island Borefield

Groundwater Dependent Ecosystems -

Annual Vegetation Monitoring Report - 2023

Prepared for Seqwater *by* 3D Environmental

Final – 28 November 2023

Document Control

Project No: 2022_193a
Project Manager: David Stanton
Client: Seqwater
Purpose: Annual vegetation monitoring report for Groundwater Dependent Ecosystems – Bribie Island Borefield – 2023 Monitoring Event

Draft	Date Issued	Issued By	Review	Purpose
Revision 1	20 November 2023	David Stanton		Initial draft
Revision 2_Final Draft	25 November 2023	David Stanton	Paul Williams / Seqwater	Final Draft
Final	28 November 2023	David Stanton		Final report following peer review

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Summary

This report represents a compilation and analysis of eight years intensive data structural and floristic data collection (2016 to 2023 excluding a single February 2015 assessment) collected from a ‘groundwater dependent’ wet heath community (RE 12.2.2) as a component of Seqwater’s Annual Compliance Report for the Banksia Beach Borefield. This monitoring has been undertaken in accordance with Seqwater’s Banksia Beach Borefield Environmental Monitoring Plan (BEMP) and the associated approval under the Commonwealth *Environmental Protection and Biodiversity Conservation Act* (EPBC Act 1999). Seqwater has not undertaken groundwater abstraction since the Banksia Beach Water Treatment Plant went into Cold Standby in April 2014.

From long-term temporal analysis of two survey localities at the southern (Control Plots) and northern (Impact Plots) locations on the borefield, it is determined that the Control Plots (CPs) and Impact Plots (IPs) have broadly similar floristic attributes, with some variation in species composition and structural attributes including a greater stem density in the IPs

. Prior to a severe wildfire which affected the IPs in August 2019, stems at the IPs were declining with a 49.6% reduction between April 2016 and May 2019 with all species excluding *Persoonia virgata* being affected. Stem counts at the IPs strongly rebounded following the August 2019 wildfire. There was also a strong shift in species composition with the previously dominant *Leptospermum liversidgei* being reduced to scattered shrubs while the population of *Persoonia virgata* was eliminated commensurate with the expansion of *Phyllota phylicoides,* a fast-growing obligate seeder which germinated large numbers of fire-promoted seedlings. Species richness also suffered a significant decline at the IPs and the post-fire peak of 39 species recorded in the EV14 (October 2022) monitoring event is significantly below the initial peak value for species richness reported in EV2 (September 2016 with 50 species). At the CPs which remained unburnt, changes in stem count and cover were more subtle with a gradual decline in woody stem mass from EV5 (April 2018) through to EV12 (October 2021) after which stem counts were subject to steady increases though to EV15 (April 2023). Species richness followed a similar trend with highest counts in EV2 (49 species), declining gradually through to EV7 (31 species) before a steady rise to EV15 (April 2023) where 45 species were reported.

Soil moisture probes installed at the IPs and CPs recorded soil moisture (volumetric moisture content or VMC) at five depths in the profile down to 1250mm. The data confirms that rainfall is the primary control on soil moisture with periods of climatic drying marked by strongly fluctuating soil moisture content in the upper soil profile, with drying typically most pronounced in the upper 350mm. Occasionally this drying extended beyond 650mm, and rarely to depths > 950mm as occurred in April to May 2019 in what was the climatically driest spell of the longer-term monitoring period. Both woody stem counts, and species richness have demonstrated strong correlation to rainfall volume (expressed as cumulative rainfall departure or CRD), and hence with soil moisture and groundwater fluctuations. For both the IPs and CPs, a positive correlation is identified between rainfall volume and total stem counts with the correlation being strongly positive and statistically significant at the IPs. While the influence of the wildfire is noted at the IPs, the strength of the positive correlation is likely related to the double trigger of fire and increased rainfall acting in unison to stimulate the soil seed bank. Species which appear strongly promoted by increased

moisture availability include the resprouter species *Leptospermum semibaccatum* and *Leptospermum polygalifolium,* as well as the obligate seeder species *Phyllota phylicoides.*

For species richness, there is also an extremely strong positive correlation (statistically significant) between species richness and CRD at the CPs and a moderate positive correlation for the IPs (Site 6). The August 2019 wildfire event has again had an influence on these results, producing a data outlier which acted to reduce the strength of the positive correlation. Species richness of the forb and secondly the shrub lifeforms have the greatest reliance on rainfall and soil moisture availability, while the richness and cover of sedges / grasses and grasstree are relatively stable regardless of the climatic regime. Combined, the IPs and the CPs indicate soil moisture, governed by rainfall, strongly influences species richness and plant abundance, with additional effects from fire, which promotes some species while limiting others.

That the dataset spans drying, wetting, and subsequent drying climatic cycles greatly increases its utility as a tool to predict changes to the floristic composition and structure of wet heath communities that may be attributed to decreased rainfall and an associated drying soil profile. The drying of the soil profile occurs naturally during drier climatic periods, though the impacts of this on vegetation structure and composition may be compounded by groundwater abstraction if not carefully managed. A correlation has now been established linking increased rainfall and soil moisture with greater woody stem counts and higher species richness, which suggests that a predictive ecological baseline has been established for the wet heath community on Bribie Island.

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1.0 Introduction

3d Environmental was engaged by Seqwater to complete the 2023 bi-annual monitoring event for groundwater dependent vegetation (otherwise referred to as groundwater dependent ecosystems or GDEs) at Seqwater's Banksia Beach Borefield and Water Treatment Plant (WTP), located on Bribie Island.

The Banksia Beach WTP has not been operational since April 2014 and no water extraction has occurred since this time. This shutdown in operations has subsequently triggered the cold standby (shutdown >12months) reduced monitoring program and sampling regime as outlined within the BEMP, with this assessment forming a component of the Annual Compliance Report, the first of which was issued in December 2015. The intent of the BEMP is to address conditions of approval under the Commonwealth *Environmental Protection and Biodiversity Conservation Act* (EPBC Act 1999). This report follows the initial GDE monitoring survey report prepared by Jacobs (2015) for the 2014 – 2015 reporting period and eight subsequent reports prepared by 3d Environmental for the 2016, 2017, 2018, 2019, 2020, 2021, 2022 and 2023 reporting periods.

1.1 Previous Work and Assessment Approach

As an outcome of the *Groundwater Model Refinement, GDE Assessment and Monitoring Review* (SKM, 2013) two terrestrial monitoring locations were selected with the following objectives:

- to determine water level patterns of terrestrial vegetation and partition the dominant water source of shallow and deep-rooted vegetation, and
- to establish the relationship between seasonal high water tables and water availability for shallow rooted vegetation.

The northern monitoring location is in the north of the assessment area where drawdown in the shallow aquifer has been modelled as likely to occur and this area is referred to as Site 6 or the 'Impact Plots' (IPs 6a - c). The southern monitoring location is approximately 1km south of the northern monitoring location, though outside of the predicted drawdown zone, referred to as Site 5 or the 'Control Plots' (CPs 5a - c). Jacobs (2015) established two transects at each monitoring location (impact and control localities). These were subsequently assessed for floristic composition and structure during two monitoring events completed in September 2014 and February 2015. These events were timed to coincide with the latter part of the dry season and the wet season respectively to account for seasonal responses in vegetation. An additional transect was added to each site by 3d Environmental in 2016 to increase the quality of the floristic data. Ongoing vegetation monitoring events have occurred after the initial vegetation survey with a specific aim to establish baseline vegetation condition and determine the natural range of variation that occurs in terms of vegetation structure, composition, and condition. The location of the monitoring sites is shown in **Figure 1**.

1.2 Purpose of Assessment and Scope

The overarching purpose of the Ecological Monitoring Program component of the BEMP is to provide a temporal analysis of natural variations in the structural and floristic composition of coastal heathland. The intent of this data collection is to provide a baseline data set of the variability of activity across the terrestrial vegetation, which can be used to statistically assess differential changes relating to the impacts of groundwater abstraction on groundwater dependent vegetation. The scope of the current cold standby Ecological Monitoring Program is to:

1. Undertake field assessment and associated quantitative floristic analysis of the existing vegetation monitoring sites established by Jacobs (2015) and 3d Environmental (2016) utilising methods compatible with previous assessments.
2. Analyse floristic data collected during the current survey in conjunction with complementary datasets, including Normalised Difference Vegetation Index (NDVI) and Soil Moisture, to determine condition of vegetation at the control and impact sites as well as assesses seasonal variability. Comparison is to be made with previous monitoring survey results, primarily Jacobs (2015), 3d Environmental (2016, 2017, 2018, 2019, 2020, 2021 and 2022) to assist in the characterisation of the baseline condition of vegetation.

Capture and analysis of NDVI imager has not been included in the suite of monitoring parameters since 2021 due to lack of any measurable correlation to field based indices. The amended BEMP and removal of NDVI as a monitoring parameter was approved by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) on the 20/05/2022.

1.3 Background and Ecological Context

The monitoring sites assessed in this survey are located within 'wet heath' communities. All transects are mapped as occurring within Regional Ecosystem 12.2.12 (closed heath on seasonally waterlogged sand plains), which has "Of Concern" status under Queensland's *Vegetation Management Act 1999* and a Biodiversity Status of 'Endangered'. Regional Ecosystem 12.2.12 spans most of the coastal edge of the South East Queensland Bioregion, from Gladstone to the Gold Coast. Bribie Island contains a significant area of RE 12.2.12 and due to extensive clearing for urbanisation south of Noosa, it is considered an Endangered RE (REDD).

Heaths are essentially treeless plant communities dominated by low shrubs and various other ground flora. Australian heaths are invariably associated with oligotrophic (low nutrient) soils deficient in phosphorus and nitrogen (DERM 2010). Wet heaths rely on shallow groundwater for maintenance of their unique structure and composition and the shallow soil profile is likely to be saturated over a considerable proportion of the year.

Knowledge of vegetation dependence on groundwater is relatively undeveloped in the Australian context. Recent studies in coastal heathlands in eastern Australia indicate a need for longer term monitoring before definitive statements on the response of vegetation to groundwater drawdown can be made (Griffith et al 2015). Although some inferences can be drawn from Western Australian examples where monitoring of coastal heath vegetation in the groundwater abstraction area of the Swan Coastal Plain has been continuous for several decades (Froend and Summer 2010; Froend et al 2004, Groom 2004, Groom 2003; Groom et al 2001; Groom 2000), the situation on Bribie Island is considerably more dynamic with higher rainfall and a much shallower groundwater table, and therefore direct comparison may not be possible.

In the context of Bribie Island, the shallow-rooted heath vegetation is formed by a mix of phreatophytes and facultative phreatophyes (i.e. utilise groundwater but can survive without it). Wet heath vegetation typically has rooting material, mostly from sedges herbs and small shrubs, concentrated in the upper 15cm of soil, the portion of the profile most exposed to periodic cycles of wetting and drying in response to rainfall. There are also several deeper-rooted species such as *Banksia aemula* and broad-leaf paperbark (*Melaleuca quinquenervia)* with the ability to adapt rapidly to changing groundwater levels through accelerated root growth (Griffith et al 2015). The predicted shallow groundwater level reductions created because of borefield abstraction for both the average and dry weather conditions are limited with maximum predicted drawdowns of 0.2 m and 0.3 m respectively and drawdown impacts of 0.1 m extending into the eastern Ramsar area towards Welsby and South Welsby lagoons (Seqwater 2015). Based on Western Australian case studies where groundwater drawdown of several metres over a protracted period was required to illicit a measurable response in vegetation (Groom et al 2000a, 2000b, Groom 2003, 2004, Froend et al 2010), such minor reduction in groundwater levels is unlikely to promote any noticeable shift in the ecological state of vegetation within the drawdown area in the short term, with detectible impacts possible over decadal cycles.

On North Stradbroke Island, a monitoring program between 1988 and 2006 in 18 Mile Swamp demonstrated some vegetation composition and structural changes associated with water extraction (Specht & Stubbs 2011). They found broad-leaf paperbark trees expanded into heath and sedgeland areas when water table levels fluctuated in response to drought and water extraction. The paperbarks rapidly grew in height and out competed sedges and smaller shrubs, such as *Leptospermum juniperinum*, thought to have shallower roots (Specht & Stubbs 2011). This vegetation change has increased the intensity of fires in 18 Mile Swamp, with smouldering bark from paperbarks capable of blowing across fire breaks (Kington et al 2016).

1.4 August 2019 Fire

An extremely hot fire engulfed an extensive area within the northern portion of Bribie Island National Park including the Banksia Beach borefield on 21st August 2019 with approximately 2400 ha of native vegetation combusted. Due to containment lines, habitats at Site 5 (Control Site or CPs) were not burnt, though a vast tract of wallum heathland north of Site 5, including Site 6 (impact Site or IPs) was scorched. Visual inspection of the area burnt one month after passing of the fire indicates that the fire was particularly hot and resulted in combustion of all living vegetation and nearly all ground fuel including leaf litter and humous, leaving a scorched ground surface of white sand and fine ash.

Data from the Bribie Island National Park Alert Weather Station (AWS) indicates relative humidity at the time of the wildfire was very low at 16% (Max T°C) with a maximum temperature of 25.9°C and maximum wind velocity of 55.2km/hr blowing from the south-east (129°). The August 2019 wildfire occurred after several dry years, though was not as dry as 2007. Site 6 had last burnt in 2004, so that the fire occurred in fairly long unburnt heath during dry conditions. The burn characteristics of this wildfire would be consistent with the 'extreme' fire category from Brewer (2005) with full canopy, subcanopy and understorey consumption. The location of the fire relative to monitoring points is shown in **Figure 2**.

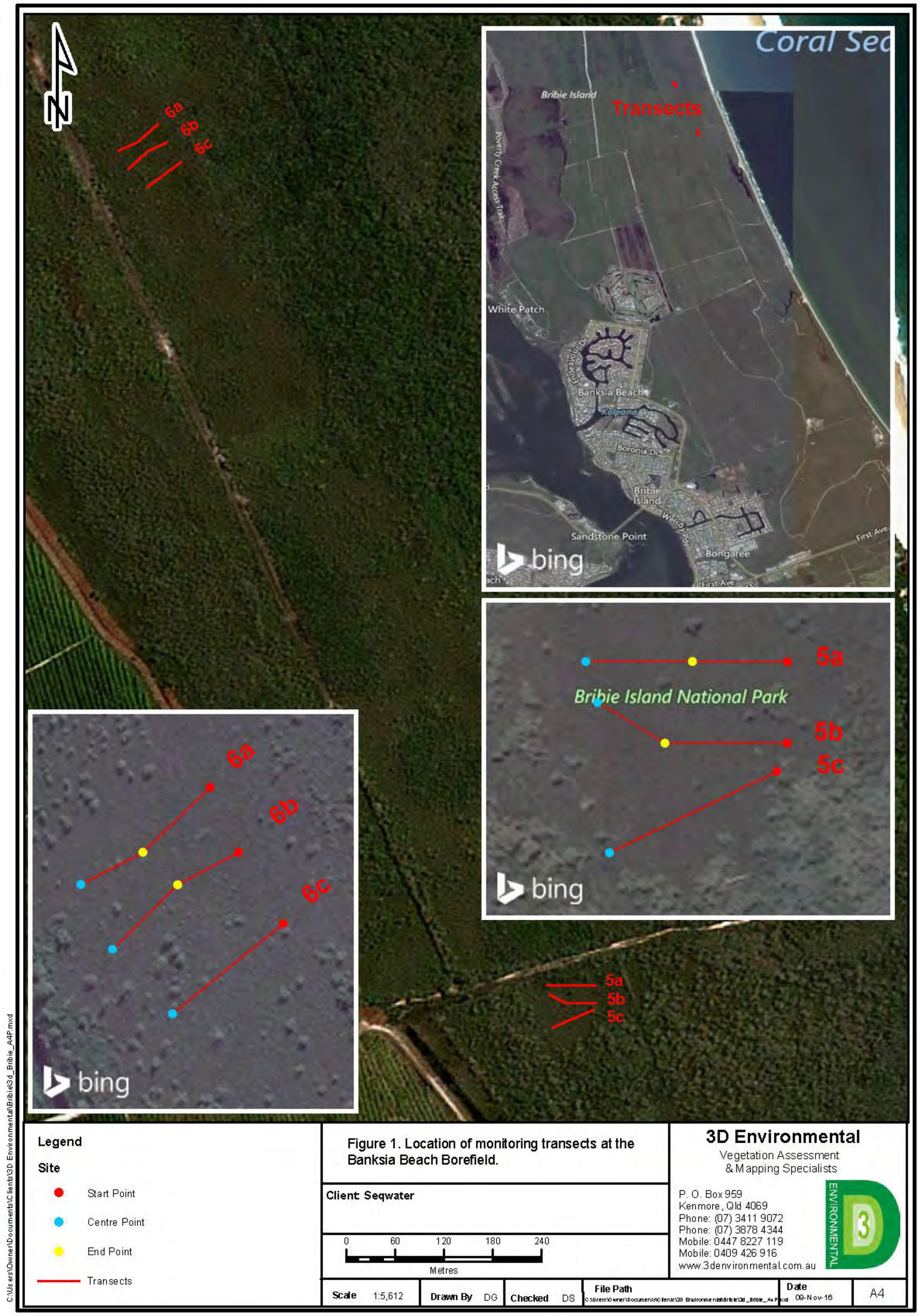

Figure 1. Location of monitoring transects at the Banksia Beach Borefield.

Figure 2. NDVI imagery showing the extent of fire scarring from September 7 Spot Imagery with delineation between burnt and unburnt vegetation indicated by blue dashed line. The area of red wash indicates living vegetation, noting that monitoring Site 5 has not been burnt.

2.0 Methods

2.1 Field Survey

Timing: The post wet season monitoring event was completed on 30th April, with the dry season monitoring event completed on the 21st September 2023. The post wet season assessment immediately followed an extended period of climatic wetting that continued from November 2021 through to January 2023. Additional information on climatic conditions prior to the assessment is provided in **Section 2.3**. Floristic assessment followed a modified version of those documented in Jacobs (2015) which was adapted from the Biocondition Methodology (Eyre et al 2015) to provide an assessment of vegetation composition and structure.

Each survey transect (plot) was formed by a central 50m transect marked with star pickets and a 50m tape measure stretched tightly between end points. The transect was extended 5m either side of the centreline to provide a 50 m x 10 m plot (0.05ha). Four transects (Plots 5a, 5b, 6a 6b) were established in September 2014 (each had a third star picket placed at the transect mid-point). An additional two transects (5c and 6c) were established in April 2016 although a central picket was not used for these. Specific details of data collected at each plot is provided below with deviations from the methods of Jacobs (2015) identified and discussed in the following sections:

- Canopy intercept of woody species over a measured centre line, from 0 to 50m separated into:
    - Tree (T1) structural layer being trees > 6m height.
    - Upper shrub (S1) structural layers, being shrubs > 1m height.
    - Lower shrub (S2) structural layers being shrubs in the height range of 0.5 to 1m[1].
    - Ground (G) being all floristic life forms <0.5m height.
- Species richness for all floristic lifeforms within each 0.05 ha plot totalled for the two survey events. Lifeforms allocated in the assessment are:
    - Trees (single stemmed woody plants > 6m).
    - Shrubs (woody multi-stemmed vegetation)
    - Forbs (herbaceous vegetation that is not a grass or other life form)
    - Native perennial grass / sedge / rush (includes graminoids such as sedges, tussock grasses and restionaceae species. Lomandra spp[2] have also included in this category).
    - Grasstree[3] (Xanthorrhoea spp.)
- Counts of woody species within the survey plots within height classes (Trees T1; Shrubs S1 and S2) were an additional parameter added to the survey method in the 2016 monitoring event. Stem counts were completed in a 2m wide belt transect positioned either side of the centreline tape. This narrow width allows for the accuracy in stem counts required in repeat measure monitoring surveys.
- Groundcover of floristic lifeforms within 10 x 1m^2 quadrats placed at 10m intervals along the tape measure with the initial quadrat position (Q1) at the 4 – 5m interval on the left side of

[1] Shrubs in the 0.5 to 1m height range were included in the Ground (G) structural layer in Jacobs 2015.
[2] Included in the shrub category in Jacobs (2015) although overall cover very low.
[3] Not included in the biocondition methodology

the tape measure and flipped to measure Q2 on the right. The final quadrats Q9 and Q10 were positioned at 44 – 45m on the left and right side of the transect respectively. Cover measurements utilised the Braun-Blanquet method including % proportions of:

  - Native Shrubs < 0.5m. (Specht & Stubbs 2011).
  - Native perennial grass/ sedge/ rush
  - Native forbs
  - Grasstrees
  - Exotic shrubs
  - Leaf litter (% of dead leaf matter)
  - Bare ground (exposed sand).
- Canopy heights were recorded for all canopy intercepts in the T1, S1 and S2 structural layers.

GPS localities of start and end points were recorded in the field and photographs were taken at the transect centre point from centre to start, centre to end, centre to north (right), centre to left. A generalised plot layout is shown in **Figure 3.**

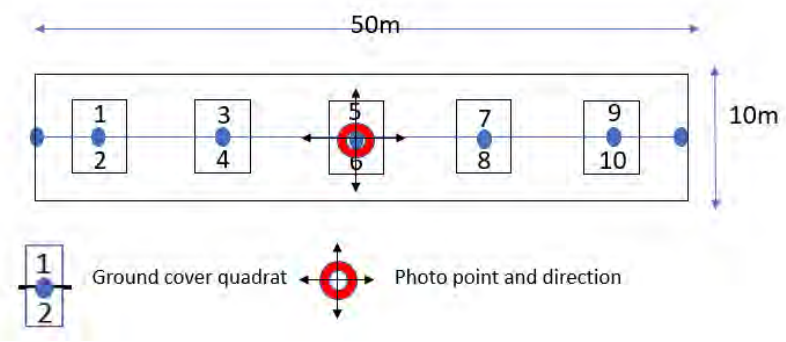

Figure 3. Survey plot layout.

Regarding the assessment of shrub cover, all shrubs >0.5 m height were attributed to the shrub layer and <0.5m to the ground layer, consistent with methods described in Neldner et al (2012). Previous surveys by Jacobs (2015) included shrubs <1m height to the ground layer, although this was considered impractical in this assessment due to the strong stratification of other groundcover components into the dense clumping cover typically < 0.5m height.

A total of six plots have been established throughout the course of the survey with plots 5a, 5b, 6a and 6b established by Jacobs (2015) in the previous survey event and an additional two sites (5c and 6c) established by 3d Environmental during the 2016 survey event. A summary of all sites is provided in **Table 1** with floristic and structural data from all transects provided in **Appendix A**.

Table 1. Monitoring sites established in the study area.

Transect No.	Purpose of Site	Lat. / Long. Start	Lat. / Long. Centre	Lat. / Long. Finish	Date Established
5a	Control	-26.9942 / 153.1587	-26.9942 / 153.1591	-26.9942 / 153.15932	26 September 2014
5b	Control	-26.9943 / 153.1588	-26.9944 / 153.1590	-26.9944 / 153.15932	26 September 2014
5c	Control	-26.9946 / 153.1588	NA	-26.9944 / 153.15930	4 April 2016
6a	Impact	-26.9856 / 153.1540	-26.9849 / 153.1543	-26.9847 / 153.15449	26 September 2014
6b	Impact	-26.9852 / 153.1542	-26.9852 / 153.15438	-26.9849 / 153.15458	26 September 2014
6c	Impact	-26.9852 / 153.1542	NA	-26.9849 / 153.15458	4 April 2016

2.2 Data Analysis

Field data was entered into biocondition datasheets for each individual transect. Data was then summarised to allow calculation of total per cent (%) cover of shrub layers, shrub density as well as components of the ground cover attributed to growth form, leaf litter and bare ground. Data from the two 2023 survey events is provided in **Appendix A**. The accumulation of large volumes of data with completion of each annual monitoring event has created considerable clutter and complexity associated with data presentation and analysis. To simplify analysis and de-clutter graphs, data collected from monitoring transects at both the control (CPs) and impact sites (IPs) was combined in monitoring periods commencing in the 2021 assessment and continued in the current (2023) assessment, resulting in an overall value score for each of the floristic and structural parameters being monitored. The overall values were carried through into the data analysis components of the assessment.

ANOVA was used to determine the significance of any differences identified between mean values for structural and floristic features recorded during the data collection process including the statistical significance of any changes over time in plant cover and species richness. It also allowed an assessment of whether there are consistent differences in any structural group abundance between CPs (5a - c) and IPs (6a - c). Statistical analysis was completed using GraphPad Prism (Version 8.3.1). Tests for normality and lognormailty were applied prior to ANOVA and a p-value < 0.05 was considered indicative of a significant difference in mean values or variance.

For some parameters Pearson Correlation (*r*) was calculated between dataset to identify correlations and co-dependencies. For correlation assessments, Cumulative Rainfall Departure (CRD) was utilised as a standard variable as this accounted for the cumulative influences of previous climatic regimes, both short term and long term. Further information on CRD is provided in **Section 3.1.1**.

2.3 Climate Data

Automated weather stations (AWS) have been used throughout the extended period of the monitoring program to gather information on local rainfall patterns. Seqwater operate and maintain two AWS sites, including the Northern AWS which is located in the Bribie Island National Park, and the Southern AWS (or AWS BBWTP) which is located near the Banksia Beach Water Treatment Plant. Following inclement weather, the Northern Access Track was closed by Queensland Parks and Wildlife Services (QPWS) in late January 2022 due to unsafe conditions and coastal erosion. The inability to undertake critical maintenance and calibration of the telemetry infrastructure and monitoring equipment has resulted in data validity and reliability issues. Weather recordings from the Southern AWS at the Banksia Beach Water Treatment Plant (AWS BBWTP) are complete between 4th November 2019 and 12th October 2023 and are the primary source of rainfall data utilised in the assessment. Where data gaps were present in earlier surveys, values from the Bribie Island Alert Station (Bureau of Meteorology or 'BOM' Recording Station 040978 located at -27.14, 153.3 in the township of Woorim) were utilised as a supplement. Local rainfall data was compared to the long-term monthly rainfall recorded at Beerburrum State Forest (-26.96, 152.967), a BOM recording station located approximately 10 km west of Bribie Island. Annual rainfall averages for this weather station date back to 1898 and were utilised during analysis of the climate data to compare local data with long term regional rainfall trends.

2.4 Soil Moisture Data

Automated soil moisture probes (SMP) were installed at the location of the CPs (5a – 5c) (Southern SMP) and IPs (6a – 6c) (Northern SMP). The SMPs capture moisture levels at five different depths, collecting data at four-hour intervals over a 24-hour period. Soil moisture data provides additional context to interpret changes in vegetation condition that could be attributed to seasonal cycles of wetting and drying. Sensors were installed to depths of 15cm, 35cm, 65cm, 95cm and 125cm. The soil moisture logger installed at the northern control site (Northern SMP) was destroyed during August 2019 wildfire and due to covid border restrictions (consultant is NSW-based) the SMP was not able to be replaced until April 2021. Data outputs from 35 cm and 65 cm sensors at the Northern SMP have were erroneous from the date of instalment in April 2021 to November 2022 when operation of the 65cm sensor was restored. While Data gaps also occurred in the Southern SMP between the 22nd of April and 17th of August 2021, data recording at this SMP has been otherwise relatively continuous up the latest monitoring event in September 2023. A total of 53 random null-readings occurred between July and August 2023, mostly from the 350mm sensor. However, given the 4-hourly recording interval and that data was reported for every day within this period, the null readings did not negatively affect the outcomes of the soil moisture monitoring at the southern SMP, nor the intent of the data collection.

3.0 Results

Results of the assessment are detailed below and provide analysis of those factors considered critical to the assessment of vegetation condition, structure, and floristic change. The analysis includes assessment of:

- Climate data;
- Soil moisture data;
- Shrub cover and stem density;
- Groundcover composition;
- Species richness; and

Comparisons between control and impact sites are made and where possible, comparisons between the current and previous survey events back to the 2015 survey period are made.

3.1 Climate and Soil Moisture

Rainfall and soil moisture data are intimately linked and are dealt with consecutively in this section. As previously discussed in **Sections 2.4** and **Sections 2.5**, some datasets were incomplete and hence have not been used in the analysis.

3.1.1 Climate data

Rainfall recorded at AWS BWTP for the period between 1st October 2022 to 30th September 2023 was 993.4mm, significantly below the long term annual average rainfall of 1414.3mm reported from the Beerburrum State Forest (SF). While November and December 2022 reported close to average rainfall volume, precipitation declined significantly through January to October 2023. August and September 2023 were particularly dry, reporting only 30.7mm, compared to a long-term average of 99.5mm for those months from the Beerburrum SF. The long-term annual rainfall average from the Beerburrum SF is slightly higher than the 30-year average rainfall reported from the Bongaree Bowls Club (near the Bribie Island bridge) of 1211.7mm, extracted from the SILO dataset (SILO 2023). This suggests that the climate of Bribie Island is slightly dryer than the mainland to the west. A comparison of rainfall trends from the various recording stations for the period from January 2022 to September 2023 is provided in **Figure 4.**

To place the vegetation surveys in the context of longer-term climatic cycles, a calculation of rainfall mass (Cumulative Rainfall Departure or 'CRD') was completed for the period from January 1990 to October 2023 on the SILO climate dataset for Bribie Island (Bongaree Bowls Club) as shown in **Figure 5**. The calculation of CRD subtracts the long-term average monthly rainfall from the actual monthly rainfall and provides a monthly departure from average rainfall conditions (Weber and Stewart 2004). Shallow aquifers, such as those hosted in the Bribie Island sand mass tend to follow the same relative patterns in terms of depletion and recharge. The period between 2000 and 2009 was one of the driest on record, termed the millennium drought. A strongly increasing rainfall trend is evident between 2010 and 2014, with monitoring surveys commencing in 2015, the point at which another strong drying trend is initiated. In the context of broader climatic trends, the GDE surveys have been completed within a drying climatic cycle up to 2019, after which rainfall returned to above average levels with an associated rise in the rainfall mass curve though to December 2022. **Figure 5** indicates that surveys completed at the Banksia Beach Borefield cover both extended wetting and drying climatic cycles, with the strong wetting cycle spanning November 2021 through to December 2022 being interrupted by a steep plunge in the CRD curve in 2023 and a strong drying trend continuing through to the September 2023 assessment event. That the survey period spans both strong wetting and drying cycles greatly increases the capacity of the surveys to predict the potential impacts of groundwater drawdown on GDE structure and function, as well as their capacity to recover from dryer climatic perturbations. CRD values for individual survey events (from 2016) based on climate data dating back to January 1990 are provided in **Table 2.** The calculation of CRD requires a time point be established for the start of the period, at which CRD will be set at zero, meaning that absolute CRD values are only relevant to the selected period. While this is considered a major limitation of the method (Weber and Stewart 2004), the slope of the curve is considered the critical indicator of rainfall trends (McCallum et al 2009).

Table 2. Monthly CRD values calculated for each individual survey event.

Survey Event	Month / Year	CRD Value (mm)
Event 1	Apr-16	487.6
Event 2	Sep-16	557.4
Event 3	Apr-17	201.4
Event 4	Oct-17	353.4
Event 5	Apr-18	273.7
Event 6	Sep-18	197.2
Event 7	Apr-19	30.3
Event 8	Oct-19	-102.2
Event 9	Apr-20	63.4
Event 10	Nov-20	-108.7
Event 11	May-21	100.6
Event 12	Sep-21	5.9
Event 13	Apr-22	989.4
Event 14	Oct-22	1248.1
Event 15	Mar-23	852.7
Event 16	Sept-23	696.6

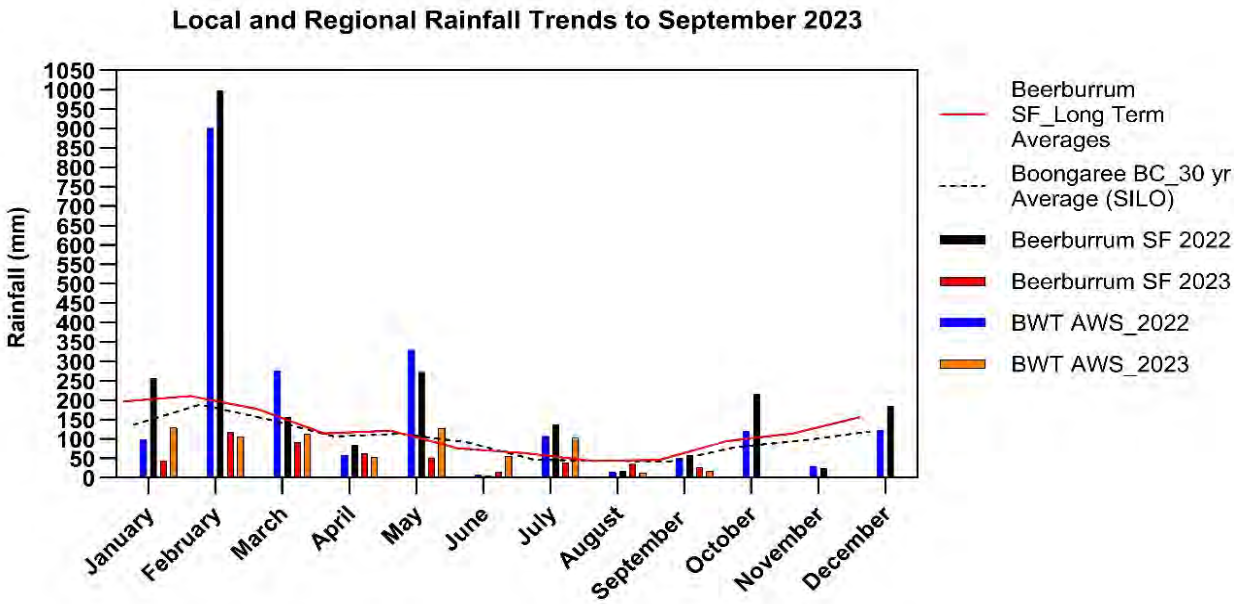

Figure 4. Regional rainfall recorded at Beerburum SF, AWS BWTP and supplementary data from the Bribie Alert recording stations for January 2022 – September 2023.

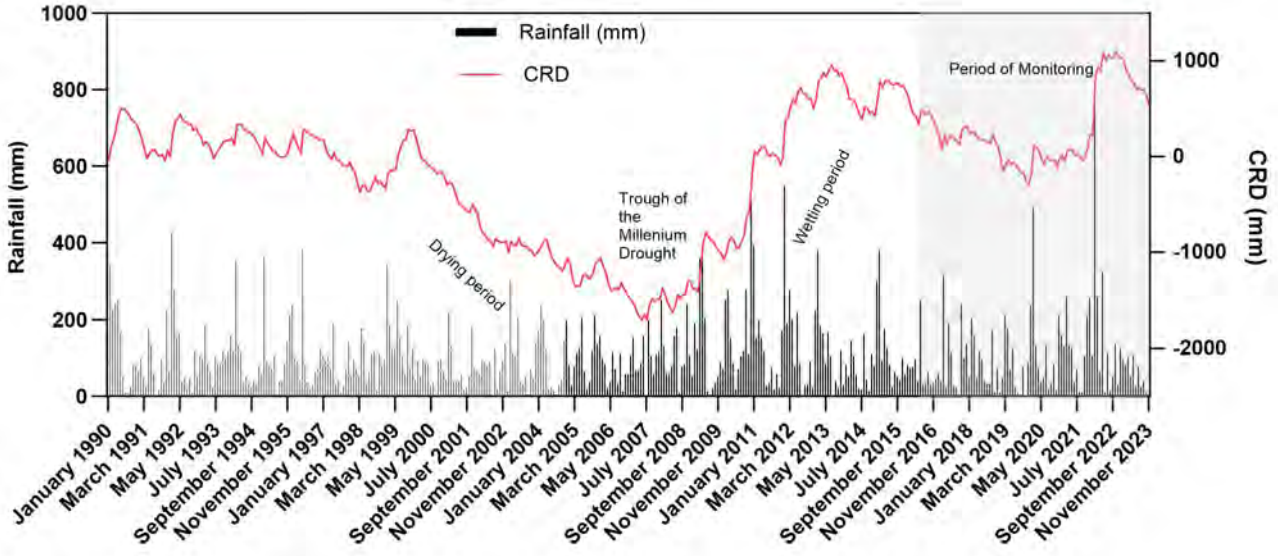

Figure 5. Cumulative rainfall departure calculated for the Boongaree Bowls Club (SILO 2023) with a strong up kick in the rainfall trend indicated in February 2022 associated with an extremely strong rainfall event, a transition into a wetter climatic regime post 2021, and a strong decline in rainfall volumes post December 2022 through to the September 2023 assessment (EV16).

3.1.2 Soil moisture data

As described in **Section 2.4**, The soil moisture logger installed at the northern control site (Northern SMP) was destroyed during August 2019 wildfire and due to covid border restrictions (consultant is NSW-based) the SMP was not able to be replaced until April 2021. Data outputs from 35 cm and 65 cm sensors at the Northern SMP have were erroneous from the date of instalment in April 2021 to November 2022 when operation of the 65cm sensor was restored. Post 17th August 2021, continuous data has been recorded for all depths at the Southern SMP (except for scattered null readings described in **Section 2.4**, which is sufficient to confirm soil moisture trends at this locality and make assumptions regarding soil moisture at the Northern SMP wherever data gaps are present.

In the period from November 2021 to September 2022, the entire soil profile at the Southern SMP remained saturated with volumetric moisture content >32% apart from minor, short period moisture deflections in the 150mm probe. Post October 2022, soil moisture content fluctuated considerably with periods of extended drying at the 150mm and 350mm probes where VMC consistently fell below 10% for extended periods. While the 650mm probe at the Southern SMP remained consistently saturated, periods of drying occurred between April and May 2023 and post August 2023 when VMC began a consistent decline from saturation to 16.2% VMC coinciding with the 2023 dry season monitoring event (EV16).

The Northern SMP was consistently wetter than the Southern SMP. VMC at the 150mm probe however followed similar drying trends to the Southern SMP post October 2022 with VMC falling as low as 16%. Slightly less intense drying events were also reported at the 650mm probe between April and May 2023, with a more pronounced dip in VMC from mid-September with values falling as low as 22% VMC coinciding with EV16.

Soil moisture trends from August 2021 through to the end of September 2023 in relation to the individual monitoring survey events is shown in **Figure 6**.

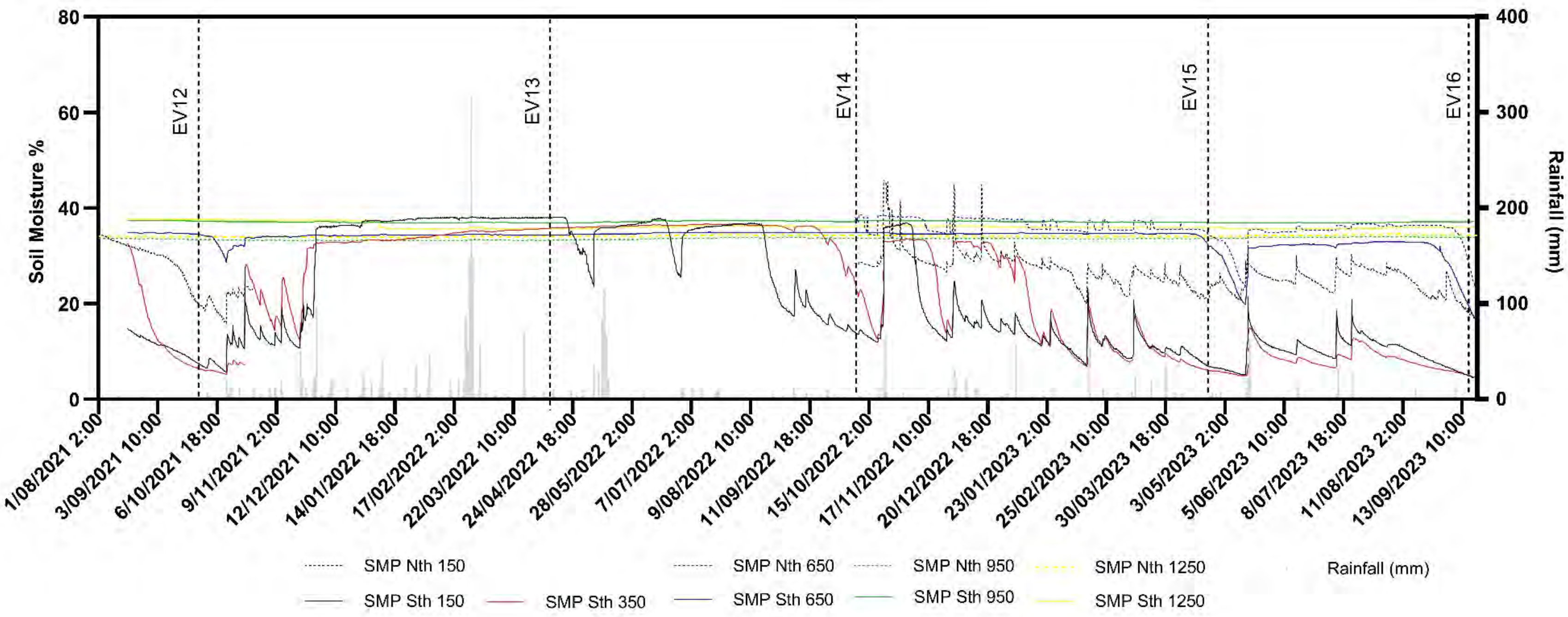

Figure 6. Soil moisture content (%) for the period covering four monitoring events from August 2021 to late September 2023 for both the Southern and Northern SMP's relative to floristic monitoring events. Significant data gaps are evident at the Northern SMP. The 350mm sensor at the Northern SMP has been omitted from this graph due to sensor malfunction.

3.2 Shrub Cover (%) and Stem Density

Shrub cover data has been averaged across all three transects for all assessment events for the purpose of ongoing monitoring of shrub cover values. The average cover values (%) for shrubs >1m in both CPs and IPs is shown in **Figure 7**. This data indicates that for the CPs, cover of shrub crowns reached a peak in April 2017 (21.27%) and progressively declined through to September 2019 (EV8). Post EV8, shrub cover values have been relatively stable ranging from 6.8% in them most recent September 2023 (EV16) assessment to 4.7% in October 2021 (EV12). For the IPs, shrub cover demonstrates an erratic decline through April 2016 (EV1) through to May 2019 (EV7), followed by almost complete destruction of this tallest shrub layer because of the August 2019 wildfire. Following the 2019 wildfire event, cover in the >1m category has gradually increased to 17.2% in April 2023 (EV15), declining slightly (16.45%) in the latest October 2023 assessment (EV16). This is compared to the previous high value of 26.67% cover reported in April 2018. Repeat Measures ANOVA indicates that the differences in cover values between survey events is statistically significant for both the CPs ($F_{1.847, 3.695}$ = 9.46, P = 0.033) and the IPs ($F_{1.707, 3.415}$ = 13.80. P = 0.024). As noted in previous surveys, there has been no recruitment of the previously dominant geebung (*Persoonia virgata)* at either the CPs or IPs, and cover of the previously dominant resprouter *Leptospermum liversidgei* at the IPs has been replaced by *Phyllota phylicoides,* an obligate seeder which recruited prolifically following the wildfire. Further information on this shift in shrub species dominance is addressed in the stem count data in following sections.

For shrubs in the 0.5m to 1m size classes, shrub cover values have been more erratic and variable (see **Figure 8**). For the CPs, there has been some re-stimulation of the lower shrub layer post April 2022 (EV13) when cover values began an incremental increase peaking at 5.7% in April 2023 (EV15). While cover values of the lower shrub layer at the IPs have increased dramatically following complete absence in the September 2019 assessment, this recovery has been more erratic than the taller (>1m) shrub layer, which is likely due to continued migration of shrubs between the lower and upper size classes. Lower shrub cover is significantly higher for the IPs than the CPs, peaking at 14.9% in April 2023 (EV15) followed by a significant decrease in October 2023 (8.8% in EV16). Differences in cover values for the lower shrub layer between monitoring events are not statistically significant for either the CPs ($F_{1.297, 2.594}$ = 2.970; P = 0.204) or the IPs ($F_{1.991, 3.981}$ = 1.757, P= 0.284). This suggests that cover values of the lower shrub layer do not provide a suitable parameter for the description of structural changes that have occurred in the wet heath communities over the period of the monitoring program.

As noted in previous assessments, **Figure 9** demonstrates that IPs have on average a much greater density of shrubs >0.5m than CPs. The highest shrub stem counts for the CPs were reported in April 2016 (EV1 at 210 stems) and this initial value declined significantly through to October 2021 (EV12) where 46 stems were reported. Coincident with increasing rainfall volumes, stem counts increased from this event with 146 stems reported for both EV14 and EV15, followed by a substantial decline in the September 2023 assessment (105 stems for EV16). *Persoonia virgata* suffered by far the most significant stem count declines in the CPs over the longer period of monitoring and this originally dominant species is now largely absent from the species mix at the CPs except for scattered senescing individuals.

Prior to the August 2019 wildfire, stems at the IPs were declining with a 49.6% reduction between April 2016 (567 stems in EV1) and May 2019 (286 stems (EV7). The declining stem count affected most species except for *Persoonia virgata* where the stem counts were relatively stable (see **Appendix B**). Following almost complete destruction of woody vegetation by the wildfire in August 2019, a strong rebound in stem densities at the IPs has occurred with a consistent increase in counts between monitoring events, peaking with 910 stems reported in the September 2023 assessment (EV16). As noted in more recent monitoring reports, there has however been a dramatic shift in species composition with the previously dominant *Leptospermum liversidgei* being largely absent from the stem counts which are now dominated by *Phyllota phylicoides.* While phyllota is an obligate seeder for which the soil seed bank has likely been stimulated by the fire disturbance, other obligate seeder species including *Persoonia virgata* and *Dillwynnia floribunda* have not had similar rebounds and remain largely absent from the species mix up to the most recent monitoring assessment (see **Appendix B**). The increase in stem count values at the CPs (which were unburnt) indicate that changes in stem density cannot be attributed to wildfire alone and that moisture availability is likely to be a contributing factor. However, long absence of fire may be a factor that has also contributed to senescence of the shrub layer.

Pearson Correlation (*r*) indicates that there is a weak positive correlation between rainfall volumes (expressed as CRD) and total stem counts at the CPs, although this correlation is not statistically significant ($r = 0.38, p=0.14$) (see **Figure 10**). For the IPs, the correlation between stem counts and rainfall volumes is extremely strong and positive ($r = 0.8518, p<0.0001$). While the influence of the wildfire is noted for at the IPs, the positive correlation is best attributed to the double trigger of fire and increased rainfall acting simultaneously to stimulate the seed bank.

While not all species are reactive to rainfall volumes, some shrub species show a consistently positive strong correlation between rainfall volumes and stem counts at both IPs and CPs including:

1. *Leptospermum semibaccatum* ($r = 0.7295, p<0.0013$ for the CPs and $r = 0.7579, p<0.0007$ *for the IPs).*
2. *Leptospermum polygalifolium* ($r = 0.5921, p=0.0157$ for the CPs and $r = 0.5401, p<0.031$ *for the IPs).*

The following shrub species also show a strong positive correlation between stem counts and rainfall volume at either the CPs or the IPs:

1. *Pultenaea palacea* ($r = 0.6246, p<0.0097$ for the IPs)
2. *Phyllota phylicoidies* ($r = 0.5921, p=0.0011$ for the IPs).
3. *Leucopogon leptospermoides* ($r = 0.7520, p=0.0008$ for the IPs).
4. *Banksia aemula* ($r = 0.6858, p=0.0034$ for the IPs)
5. *Banksia oblongifolia* ($r = 0.7110, p=0.002$ for the IPs).
6. *Baeckea frutescens* ($r = 0.6677, p=0.005$ for the CPs).
7. *Homoranthus virgatus* ($r = 0.7261; p=0.0014$ for the CPs).
8. *Melaleuca quinquenervia* ($r = 0.5797; p=0.0186$ for the CPs).
9. *Melaleuca pachyphyllus* ($r = 0.5036; p = 0.0467$ for the CPs).

Simple correlation plots between stem counts and rainfall are shown in **Figure 10** (CPs) which demonstrates that *Leptospermum semibaccatum* contributes the dominant proportion of recruiting shrubs as the population of *Persoonia virgata* senesced, and that other shrubs demonstrating a positive correlation have relatively low abundance in the total stem counts. For the IPs shown in **Figure 11**, the strong statistically significant correlation between rainfall volumes and total stem counts is clear, carrying through to a strong positive correlation between rainfall volume and *Phyllota phylicoides* which dominates the stem counts and was observed to be seeding for the first time since fire in EV16. Stem count data is provided in **Appendix B** with summary statistics from the correlation assessment provided in **Appendix C**.

This data may indicate that with increasing rainfall and associated surface expression of the shallow groundwater table, increased dominance of *Leptospermum semibaccatum* and *Leptospermum polygalifolium* might be expected. For the other species identified as presenting a correlation to rainfall volume, species trends might also be partly dependent on the presence or absence of fire in the landscape.

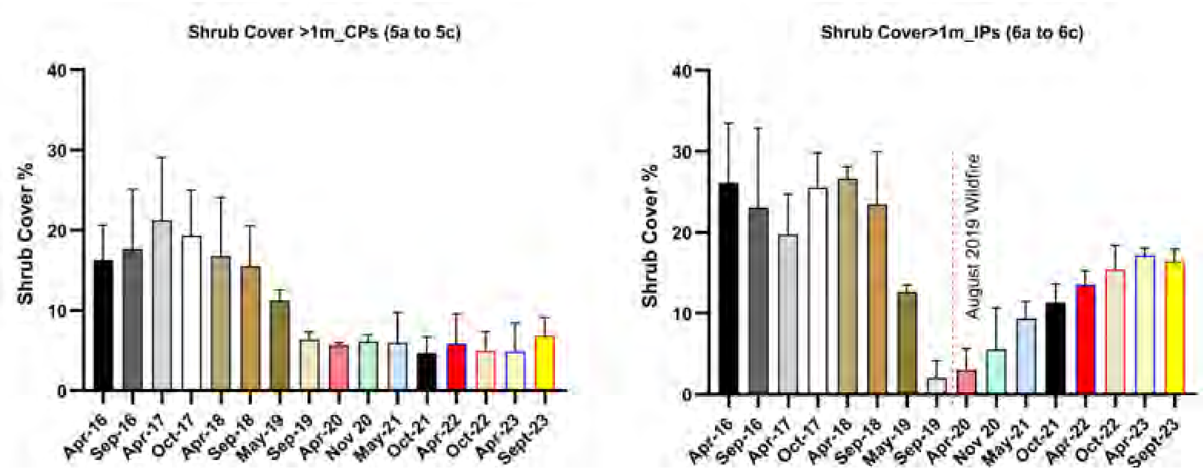

Figure 7. Average shrub cover values in the > 1m size class for the CPs (left) and IPs (right) showing strong declines in cover for both site localities up to May 2019.

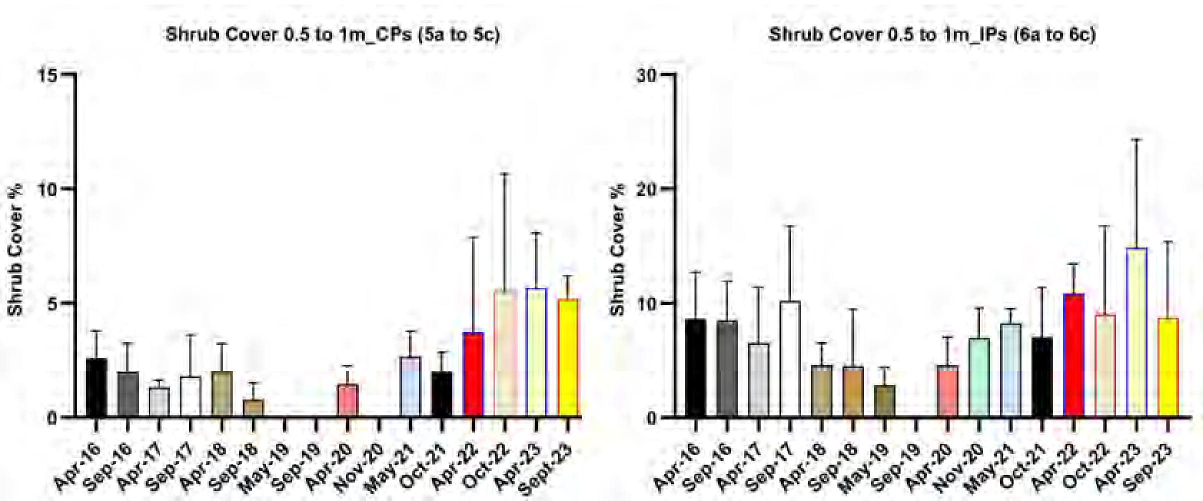

Figure 8. Average shrub cover values in the 0.5 to 1m size class for the CPs (left) and IPs (right) showing variable shrub cover values.

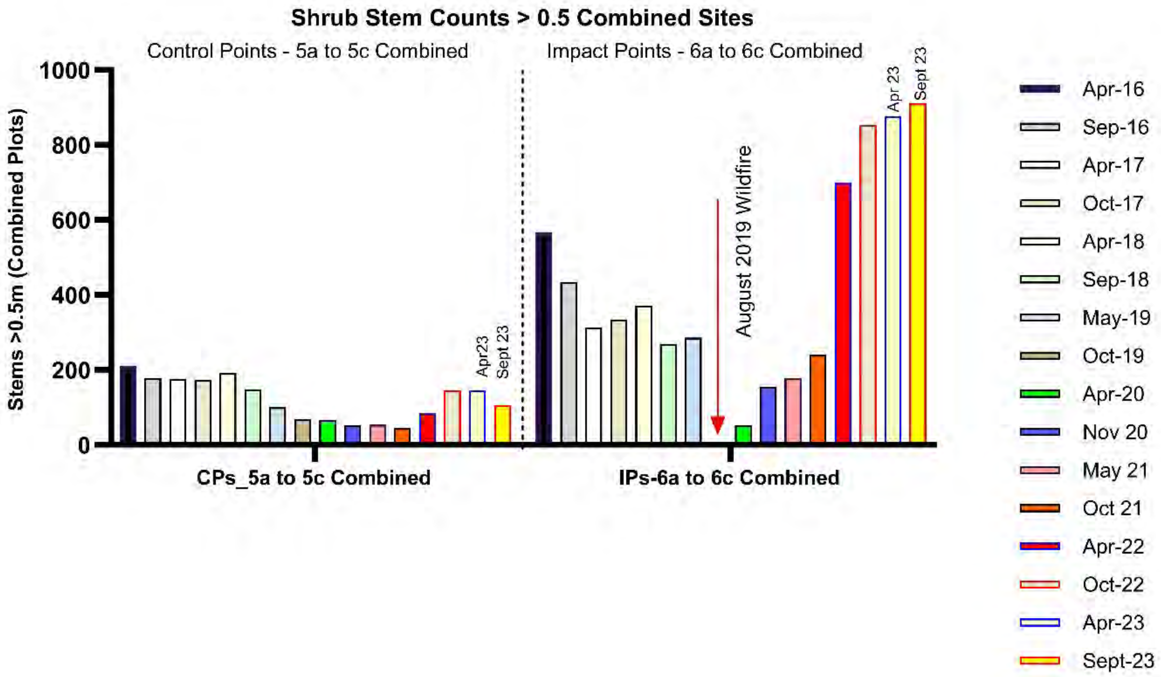

Figure 9. Stem counts for shrubs (> 0.5 m) combining data from individual transects to provide an overall stem count for both the CPs and the IPs (2016 – 2023). The strong rebound in stem counts following the August 2019 wildfire is evident for the IPs with a trend toward increasing stem counts for the CPs evident after the October 2021 assessment.

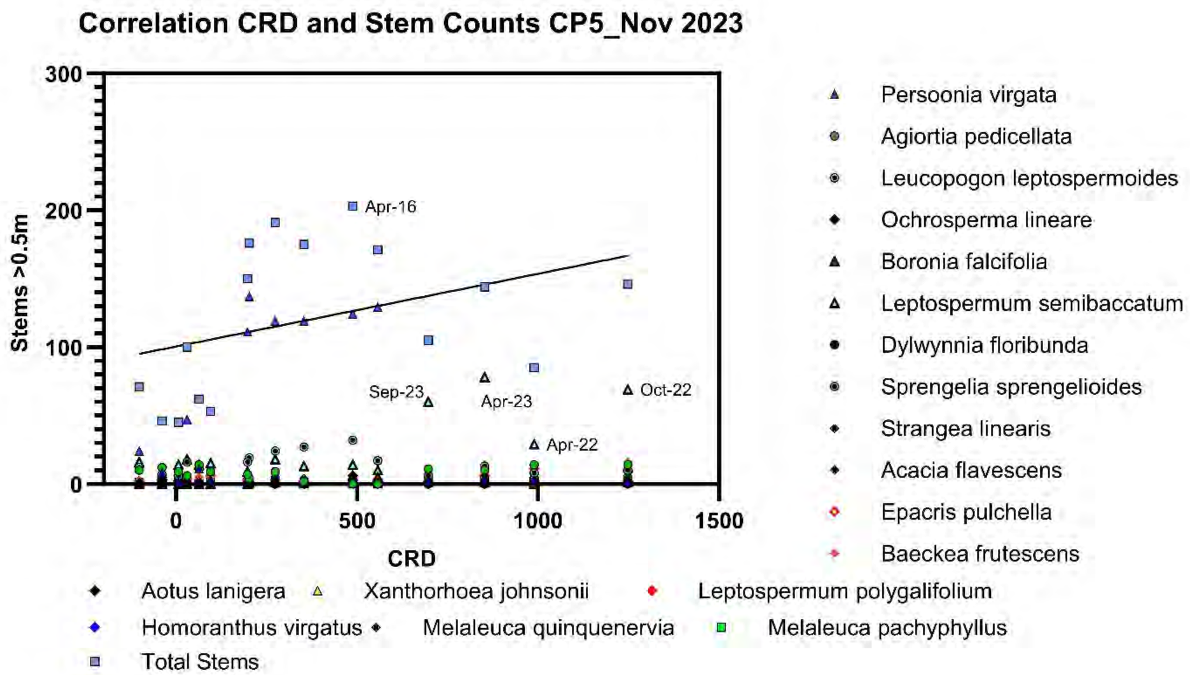

Figure 10. Simple XY correlation between CRD and shrub stem counts (>0.5m) at the CPs showing spike in *Leptospermum semibaccatum* in the 2023 assessment period consistent with CRD trends.

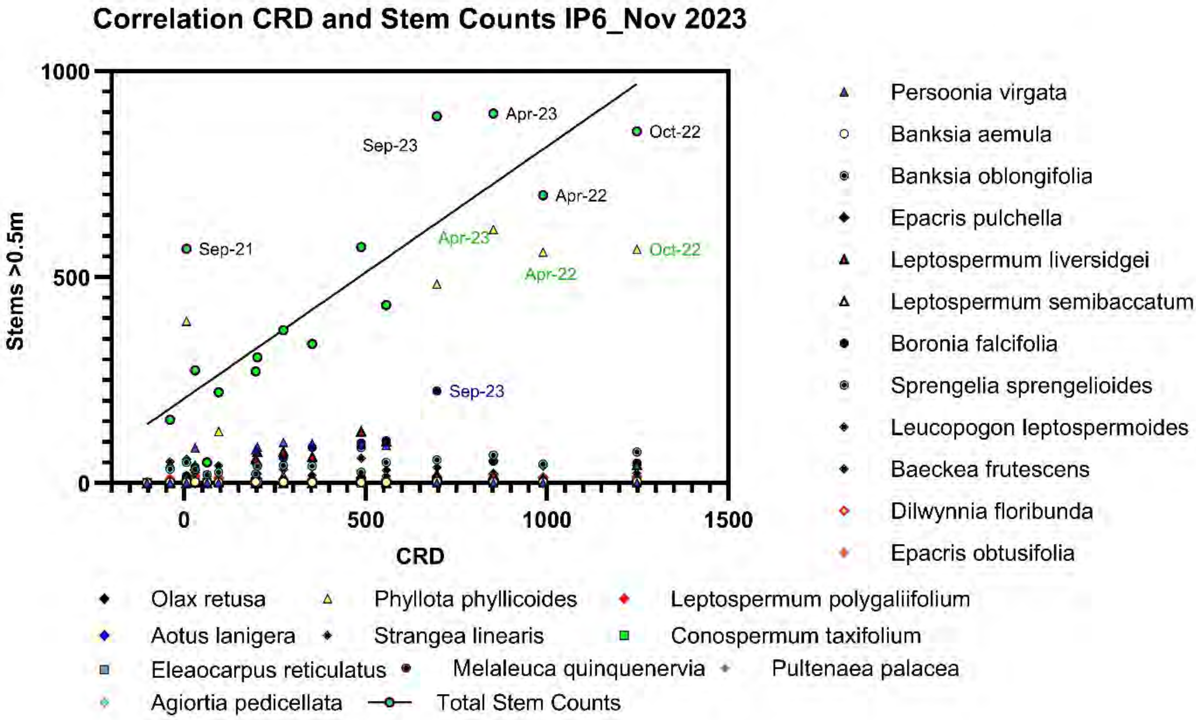

Figure 11. Simple XY correlation between CRD and shrub stem counts (>0.5m) at the IPs showing spike in stem counts dominated by *Phyllota phylicoides* in the post 2023 assessment period consistent with CRD trends.

3.3 Composition and Nature of Groundcovers

Previous monitoring events note sharp and sustained changes in soil moisture for both CPS and IPs in the upper 65cm of the soil profile. This includes extended periods when the upper 35cm of the soil profile has dried to < 5% VMC, notably between December 2018 and March 2019, September 2020, and January 2021. The period leading up to the 2023 monitoring event was particularly wet with dune sands continuously saturated at the surface between December 2021 and October 2022. With an ensuing drier climate, soil moisture content fluctuated continuously in the upper 35cm of the soil profile post October 2022 through to completion of EV16, with the Northern SMP (IPs) holding surface moisture for longer than the Southern SMP (CPs) with less pronounced fluctuation. The continuous VMC fluctuation in the shallow soil profile would have a significant influence on moisture availability to shallow rooted sedges, forbs and shrubs that form components of the groundcover, with rooting matter observed to be largely confined to the upper 30cm of the soil profile.

Section 3.4.1 to **Section 3.4.6** provides an analysis of the composition, structure, and floristic trends of groundcover components at each monitoring site, hosting lifeforms that have greatest exposure to soil moisture fluctuations. A statistical summary is provided in **Table 2** for all survey localities with contribution to total cover of various lifeforms over all monitoring events to EV16 (September 2023). Note that average groundcover values for the CPs and IPs are provided in this assessment rather than values for individual transects, to reduce data volume and simplify statistical analysis.

3.3.1 Native perennial grass / sedge / rush cover

The cover of living grass, sedge and rushes has changed subtly at both northern (IP) and southern (CP) sites over the extended period of monitoring (see **Figure 12**). This indicates that these lifeforms remain relatively resilient to extended periods of drying in the upper soil profile, yet also have capacity to adapt to periods when the upper soil profile is saturated for extended periods.

Grasses and sedges were completely combusted at the IPs when the September 2019 monitoring event (EV8) was completed due to the August 2019 fire, although these values had recovered to pre-fire levels by the May 2021 monitoring event. Cover values for the CPs which were not impacted by wildfire have maintained relatively consistent grass and sedge cover throughout the entire assessment period, although groundcover values demonstrate subtle incremental increases from EV1 to EV16.

Repeat Measures ANOVA applied to seasonal monitoring data for the southern CPs indicates that changes in native grass, sedge and rush cover are not statistically significant ($F_{1.612, 3.224} = 3.644$, P=0.1485). For the IPs, Repeat Measures ANOVA demonstrates statistically significant differences between monitoring events ($F_{1.873, 3.746} = 7.564$, P=0.049), which can be largely attributed to cover changes initiated by the August 2019 wildfire. At completion of EV16, there is no correlation identified between groundcover sedge / grass / rush values and rainfall volume (CRD) when the CPs and IPs are assessed in combination ($r = -0.2762$, $p=0.126$).

3.3.2 Groundcover shrubs

Although variable between years, native shrubs in the groundcover (< 0.5 m) have generally fluctuated within a consistent cover range between 12.3% and 18.3% for CPs, and 15.7% and 26.8% for the IPs. The exception is the post fire (September 2019) monitoring event where groundcover shrubs were completely combusted at the IPs (see **Figure 13**). The low groundcover shrub values reported in October 2022 at the CPs (10.37%) may be due in part to a migration of groundcover stems into a taller size class (>0.5m) where they contribute to woody shrub stem cover and stem counts rather than a groundcover component.

Groundcover shrubs were the component that recovered most rapidly from fire disturbance at the IPs, with observations suggesting that this was due to initial rapid nodal re-sprouting of *Baeckea frutescens* and *Banksia oblongifolia,* followed by dense germination of *Phyllota phylicoides*. Repeat Measures ANOVA indicates that the changes to shrub cover values between survey events at the IPs are not statistically significant ($F_{1.366, 2.732} = 7.950$, P = 0.0737) despite complete destruction of shrub cover in the August 2019 wildfire (prior to EV8). For the CPs, shrub cover differences between monitoring events are similarly not statistically significant ($F_{1.751, 3.502} = 0.9352$, P = 0.459). At completion of EV16, there is no correlation between groundcover shrub values and rainfall volume (CRD) when CPs and IPs are assessed in combination ($r = -0.028$, $p=0.8759$).

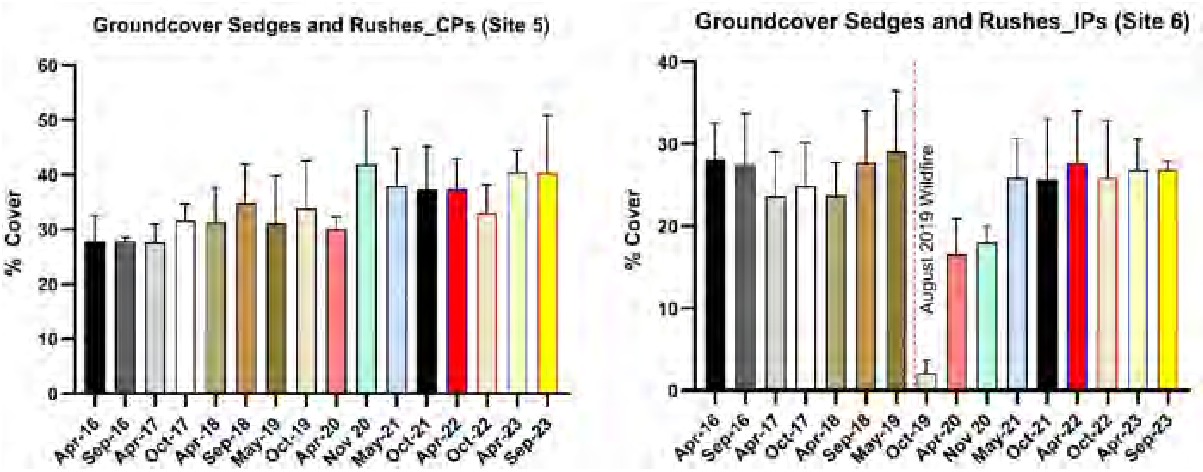

Figure 12. Cover (%) of native grasses, sedges and rushes in the CPs (left) and IPs (right) for all monitoring events.

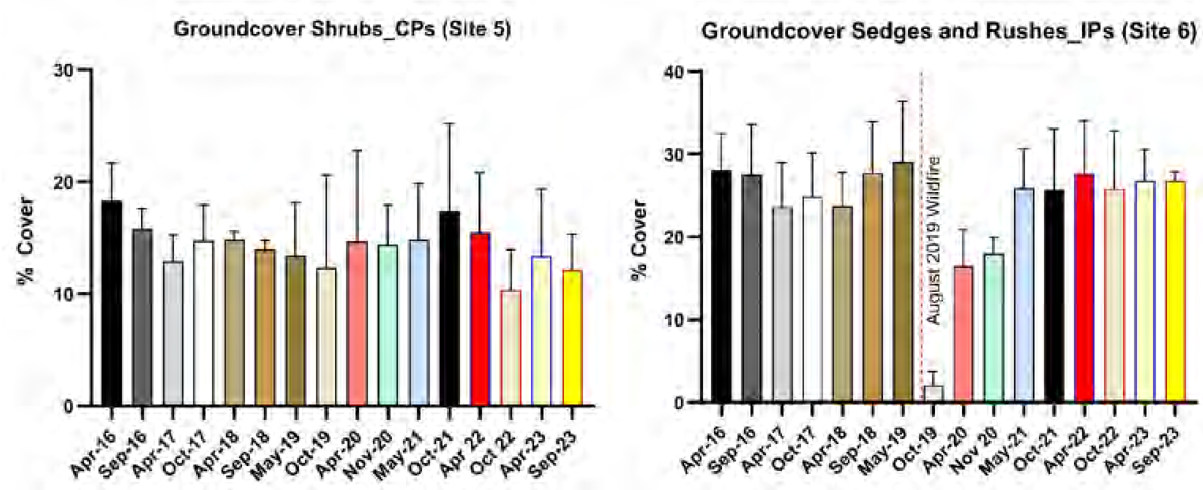

Figure 13. Cover (%) of groundcover shrubs (< 0.5 m) across all sites (2016 – 2023) demonstrating the impact of the 2019 wildfire at the IPs, after which ground cover shrubs recovered to pre-disturbance cover values.

.3.3 Groundcover forbs

Forbs provide a relatively small contribution to total groundcover values. Due to a general preference for mesic conditions, forb diversity and % cover is sensitive to droughting and vary according to seasonal conditions. The highest cover of forbs at the CPs was recorded in the April 2022 monitoring assessment (3.02%) when the soil profile had been saturated at surface for a period of 5 months. At the IPs, the highest contribution of forbs to total groundcover values was recorded in the October 2021 (EV12) assessment (4.2%) although consistent values were reported for the April 22 (EV13) assessment (4.1%), with a minor decrease from EV14 to EV16 where cover values ranged from 2.38 to 3.48%. In general, for both CPs and IPs, forb cover values are higher in the post wet assessment on annual basis than for dry season assessments (**Figure 14**). Repeat Measures ANOVA indicates that despite significant variation in measured forb cover, seasonal variation is not statistically significant for either CPs or IPs ($F_{1.904, 3.809}$ = 5.611, P=0.073 and $F_{1.403, 2.806}$ = 5.972, P=0.09 respectively). At the completion of EV16, the groundcover value for forbs retains a strong positive correlation to rainfall volumes (CRD) across both the IPs and CPs (*r* = 0.6002*, p*=0.0003).

Further discussion regarding the variation in the diversity and composition of forbs between survey events is provided in **Section 3.3.6**.

3.3.4 Grasstree cover

Consistent with previous assessments, there are no readily apparent trends with the variability of grasstree cover values seemingly independent of site locality and seasonal survey effort (**Figure 15**). The largest decrease in grasstree cover occurred at the IPs in response to the August 2019 wildfire although these values rebounded rapidly to post fire levels by May 2021 indicating the resilience of grasstree to burning through abundant post fire resprouting from subterranean rhizomes. Repeat Measures ANOVA indicates that the variation in grasstree cover between seasonal monitoring efforts at the CPs is not statistically significant ($F_{1.721, 3.441}$ = 1.939, P= 0.268). Although a greater level of significance applies to grasstree cover values between survey events at the IPs (F1.765, 3.530 = 6.944, P = 0.61), these differences are also not statistically significant. There is no correlation identified between grasstree cover values (%) and rainfall volumes when values for the CPs and IPs are assessed in combination (*r* = -0.2513, *p*=0.1653).

3.3.5 Total living groundcover

Total living groundcover represents the portion of the groundcover that is living with capacity for photosynthesis and is a possible measure of the health or vigour of a vegetation community at a given point in time. Living groundcover values are balanced by leaf litter and small patches of bare ground (humic sand) which form a component of the ground surface at most sites. The proportion (%) of living groundcover is provided in **Figure 16** with CPs on left and IPs on right. Continuing ongoing trends observed during previous assessment periods, subtle variations occur between survey events and standard deviation of values between monitoring transects remains relatively small without any strong indicators of seasonality in cover values. At completion of the September 2023 assessment, the average living cover value at the CPs was 67.91 % indicating recovery from the lowest value of 57.75% reported in October 2022 (EV14) at the peak of the climatic wetting trend. At the IPs, total living groundcover was at 62%, showing similar recovery to the CPs from the lowest living groundcover values recorded during EV14 (52.4%), excluding the September 2019 post wildfire assessment when living groundcover was totally combusted. This indicates that the extremely wet period that coincided with (and prior to) the 2022 assessment period did not provide any stimulus to living groundcovers, and possibly may have had a negative influence, with reductions offset by increase in woody stems. Repeat Measures ANOVA indicates that the variation in living groundcover between seasonal survey efforts is statistically significant for the IPs ($F_{1.654, 3.309}$ = 20.91, P = 0.139) although not for the CPs (F1.895, 3.789 = 2.384). This result would be strongly influenced by the 2019 wildfire event which completely combusted groundcover at the IPs creating an anomaly in living groundcover values. At both the CPs and IPs, there is no correlation identified between living groundcover values (%) and rainfall volumes (*r* = 0.138, *p*=0.4513). As concluded in prior assessments, this suggests that increasing rainfall and moisture availability does not stimulate increased living biomass in the groundcover layers, rather promotes increased vegetation productivity and biomass in the taller woody shrub layers.

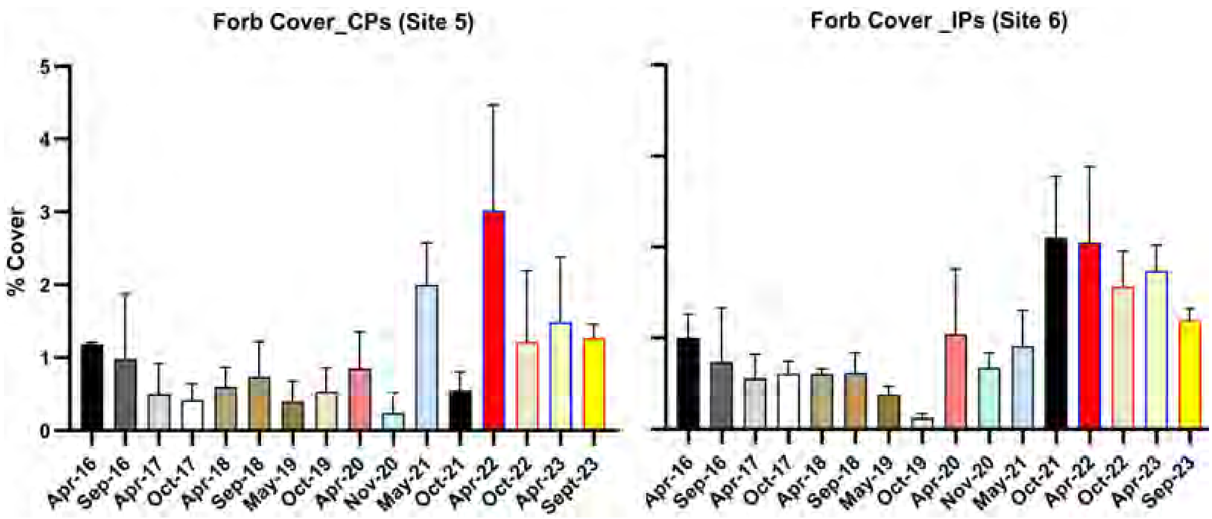

Figure 14. Forb cover (%) across all sites (2016 – 2023) with CPs shown on left, and IPs on right, noting highest forb cover values concentrated in the later monitoring events at both sites.

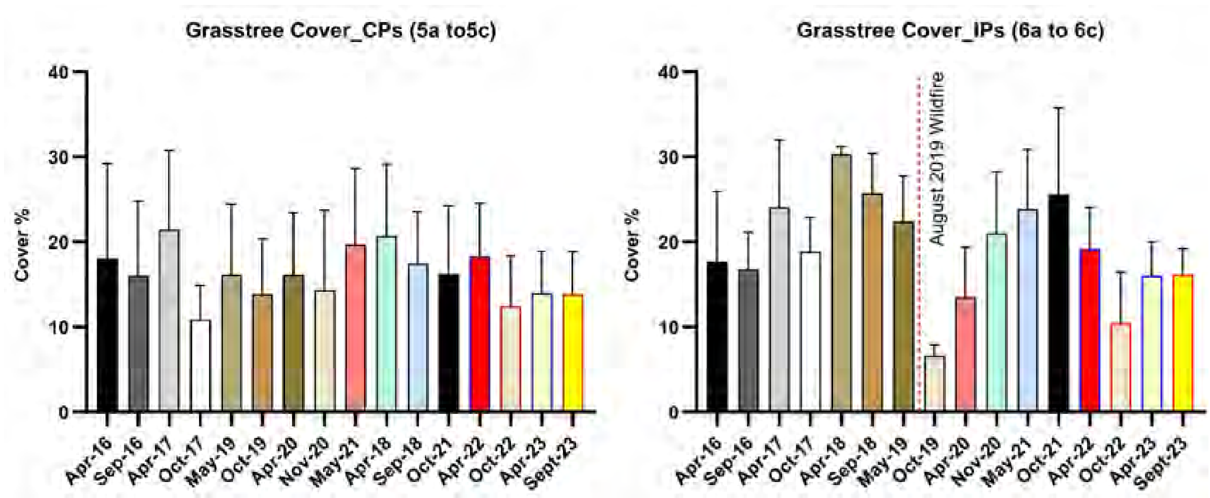

Figure 15. Grasstree groundcover (%) across CPs (left) and IPs (right) for the period from 2016 to 2023**.**

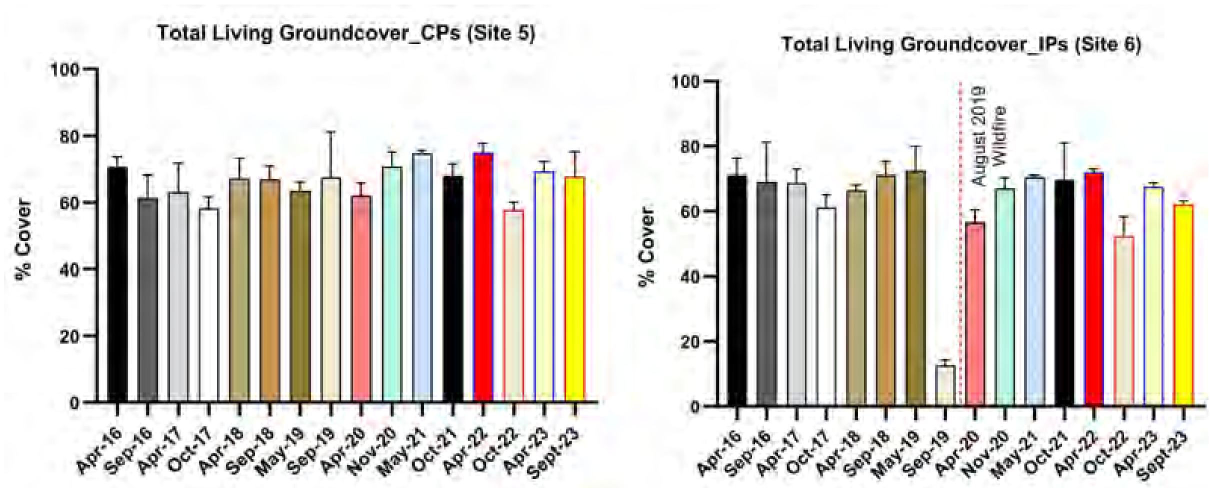

Figure 16. Living groundcover values (%) for CPs (left) and IPs (right) for the period from 2016 to 2023 demonstrating subtle variations in cover values between surveys.

Table 3. Summary of groundcover contribution by various lifeforms over the assessment periods from 2016 to 2023.

Monitoring Site / Event	Forb % Cover	Sedge / Rush/ Grass % Cover	Shrub % Cover	Grasstree % Cover	Bare % Cover	Leaf % Cover	Exotics % Cover	Cryptogams	Total % Cover	Total Living Groundwater
Site 5_April 2016	2	28.5	15.5	21.25	0.5	32.25	0	0	100	70.50
Site 6_April 2016	0.85	33.15	37.15	9.5	0.25	19.1	0	0	100	73.25
Site 5_September 2016	1.2	28.45	15.05	24	1.2	30.05	0.05	0	100	61.12
Site 6_September 2016	1.8	33.1	21.2	13	0.2	30.6	0.1	0	100	66.23
Site 5_April 2017	1.05	31.1	12.5	28	0	27.35	0	0	100	63.17
Site 6_April 2017	0.85	29.8	22.05	16.5	0	30.8	0	0	100	67.77
Site 5_October 2017	0.7	28	18.3	10.7	1.5	40.7	0.1	0	100	58.02
Site 6_October 2017	1.2	30	19.8	14.5	0.75	33.75	0	0	100	62.88
Site 5_April 2018	0.8	24.65	14.85	24	0	35.7	0	0	100	67.35
Site 6_April 2018	1.3	28.35	20.5	31.35	0.5	18	0	0	100	71.02
Site 5_September 2018	0.2	27	14.4	23.5	2.5	32.3	0.1	0	100	67.07
Site 6_September 2018	0.95	31.95	22	24.1	3.5	17.5	0	0	100	72.17
Site 5_April 2019	0.45	21.6	10.8	31.5	1.55	34.1	0	0	100	63.87
Site 6_April 2019	0.6	37	23	16.25	0.75	22.4	0	0	100	68.75
Site 5_October 2019	0.4	25.65	9.8	20.5	1.5	42.05	0.1	0	100	60.62
Site 6_October 2019	0.3	5.1	4.85	7.9	10	71.85	0	0	100	13.97
Site 5_April 2020	0.85	28	9.2	22	15.4	24.55	0	0	100	61.98
Site 6_April 2020	1.35	14.7	34.75	7	19.05	23.15	0	0	100	56.73
Site 5_November 2020	0.55	30.6	13.1	25	5.25	25.5	0	0	100	68.20
Site 6_November 2020	1.3	16.5	32.05	14	33.65	2.5	0	0	100	67.10
Site 5_May 2021	2.05	30.25	15.45	26.5	4.8	20.95	0	0	100	75.05
Site 6_May 2021	1.6	24.85	28.2	16.5	24.25	4.6	0	0	100	66.92
Site 5_October 2021	0.8	28.55	10.3	15	6.25	39.1	0	0	100	63.10
Site 6_October 2021	5.1	28.1	30.95	14.25	14.65	6.95	0	0	100	70.42
Site 5_April 2022	3.7	32	12.4	23.5	6.35	21.85	0	0.2	100	75.00
Site 6_April 2022	3.4	30.75	24.35	14.5	17.35	9.65	0	0	100	71.98
Site 5_October 2022	2.15	27.6	7.4	18.5	16.65	27.6	0.1	0	100	57.38
Site 6_October 2022	3.7	24.05	14.1	4	17.3	36.85	0	0	100	52.43
Site 5_April 2023	1.48	40.48	13.37	14.00	8.60	20.33	0.08	1.65	100	70.98
Site 6_April 2023	3.48	26.80	21.22	16.03	7.15	25.32	0.00	0.00	100	67.53
Site 5_September 2023	1.27	40.33	12.15	13.83	7.12	23.98	0.23	1.08	100	68.67
Site 6_September 2023	2.38	26.77	17.58	16.17	1.77	35.33	0.00	0.00	100	62.90

3.3.6 Species richness

Calculation of species richness is based on combined data for the three monitoring transects at both the CPs and IPs. That is, the number of species within 0.15ha. For both the CPs and IPs, the highest species richness was recorded in the September 2016 survey (**Figure 17**) with 49 and 50 species recorded respectively. Species richness at the CPs declined from this monitoring event through to April 2019 when 30 species was reported, followed by incremental increase through to October 2022 with 45 species reported. Similar trends are reported for the IPs, although species richness was slightly higher in the earlier monitoring events than for the CPs, and the August 2019 wildfire reduced species richness to extremely low values (12) in the post fire October 2019 (EV8) monitoring event. Species richness at the IPs has recovered significantly following the wildfire, being primarily driven by increases in shrub species with time since fire. Although the 39 species reported in the October 2022 (EV14) monitoring assessment remains below peak species richness (50 species) reported in October 2016 (EV2) and remains lower than species richness at the CPs reported at the same monitoring event (45 species reported in EV14). Data from the 2023 assessment period indicates species richness has declined from EV14 values at both the CPs and IPs, commensurate with decreasing rainfall volumes. At the completion of EV16, 40 species were reported from the CPs compared to 36 species reported from the IPs despite baseline species richness values being significantly higher at the IPs during EV1 and EV2. From this data, it is apparent that the wildfire has likely had an overall negative impact on species richness at the IPs, despite being strongly beneficial to regeneration of some obligate seeder species including *Phyllota phylicoides*. A list of species recorded during the current 2023 survey period attributed to individual monitoring sites is provided in **Appendix D**.

As calculated in prior assessments, there is also an extremely strong positive correlation between species richness and CRD at the CPs (Site 5) (r = 0.7439, p=0.001), and a moderate (non-significant) positive correlation (r = 0.404, p=0.124) for the IPs (Site 6). This correlation is shown in **Figure 18** which also demonstrates the data outlier created by the wildfire at the IPs in the October 2019 (EV8) assessment. Species richness values from the CPs and IPs form similar trendlines when plotted against CRD suggesting that species richness has a relatively predictable response to changing rainfall volumes and hence fluctuations in shallow soil moisture content, increasing during wetter periods and declining as the climate dries.

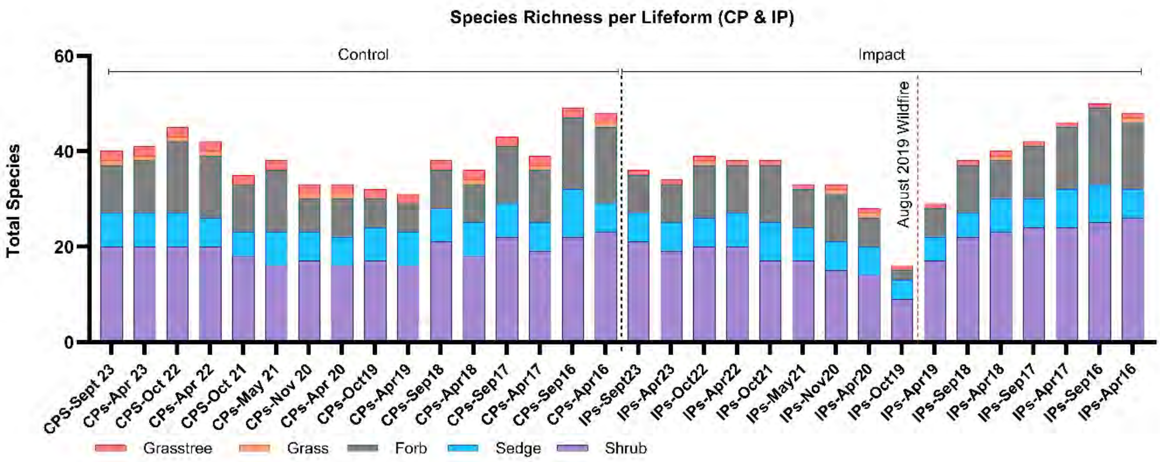

Figure 17. Number of species per lifeform for combined transects from the CPs (Site 5) and IPs (Site 6).

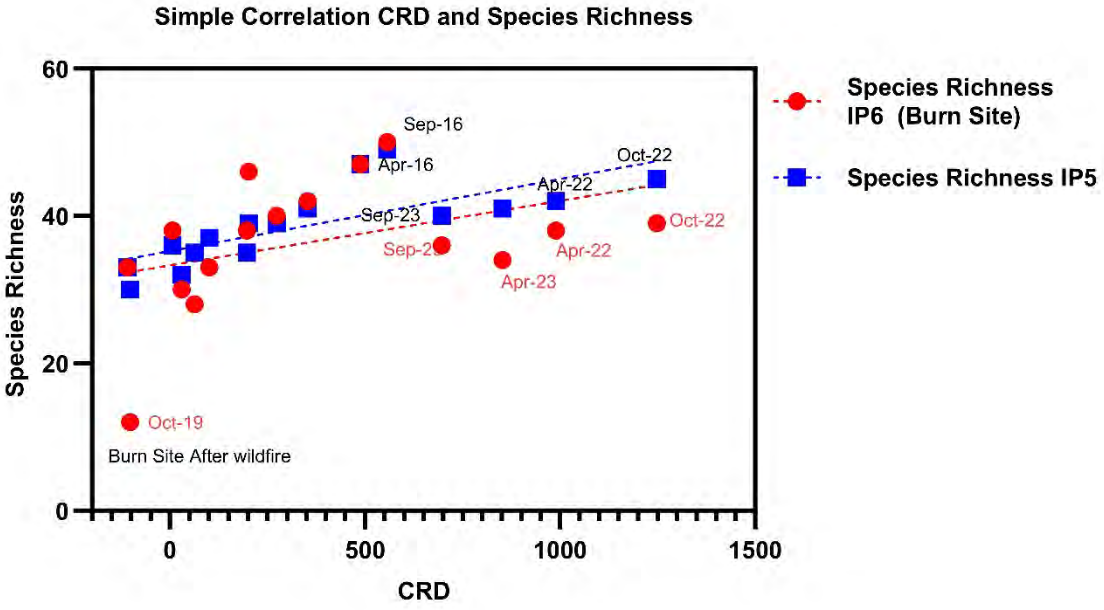

Figure 18. XY correlation plot comparing CRD to species richness for both the CPs (Site 5) and IPs (Site 6) showing the data outlier created by the wildfire (Oct 19 Burn Site after Wildfire).

4.0 Discussion and Summary

The 9th year of biannual GDE monitoring at the Banksia Beach Borefield has been completed with a comprehensive dataset formed by 16 bi-annual monitoring events captured between April 2016 and September 2023. The dataset has been captured over periods of climatic wetting and drying and shows the following major structural and floristic trends:

1. Species richness for both the CPs (Site 5) and IPs (Site 6) remains highest in September 2016 monitoring assessment which occurred after multiple wet years. The lowest species richness values are reported for the dry period in April 2019 (EV7) with 31 species recorded. For the IPS, the lowest values were reported for the October 2019 (EV8) assessment recording 12 species, immediately following an extreme wildfire event which combusted nearly all living vegetation and leaf litter. The second lowest species richness for IPs was during the dry spell of April 2019. Following the trough in species richness in April and October 2019 for the CPs and IPs respectively, species richness at both sites increased incrementally through to the October 2022 (EV14) where 45 species were reported at the CPs and 39 species reported at the IPs. Subsequent declines in species richness were reported through the 2023 monitoring period commensurate with declining rainfall values. At the completion of the 2023 monitoring period, Pearson correlation continues to indicate that species richness is strongly correlated to rainfall volume (using CRD value as a surrogate) for month and year in which monitoring is undertaken. This is particularly valid for the CPs where the correlation is extremely strong and statistically significant, though less for the IPs where severe wildfire interrupted the trajectory of undisturbed vegetation response.

2. The CRD curve generally reflects the soil moisture status in the upper soil profile, with strong rainfall replenishing perched groundwater tables. In highly permeable sands that characterise Bribie Island, this results in saturation of the soil column and expression of groundwater at the surface. Prior to the 2022 monitoring event, a series of significant rainfall events (80.26mm on 23rd November, 96.52mm on 2nd December 2021) recharged the shallow soil profile at the Southern SMP with saturation (35.9% VMC) reached at the at the 150mm sensor. This saturation in the upper soil profile was maintained through to late September 2022, sustained by some massive rainfall totals between 26th and 28th February 2022 when 610mm was recorded over the two-day period. Hence for most of the 2022 monitoring period groundwater was held at very shallow levels in the soil profile where it would have readily interacted with the rooting zone of shallow rooted shrubs, sedges, and forbs. Post October 2022, soil moisture content fluctuated considerably at the Southern SMP with periods of extended drying at the 150mm and 350mm probes where VMC consistently fell below 10% for extended periods. Drying of the soil profile also occurred below 650mm depth between April and May 2023 and post August 2023 when VMC began a consistent decline from saturation to 16.2% VMC coinciding with the 2023 dry season monitoring event (EV16). The Northern SMP was in comparison significantly dryer than the Southern SMP with more sustained periods of saturation in the shallow soil profile. General patterns of wetting and drying were however consistent with the Southern SMP, with a dip in VMC at the 650mm probe between April and May 2023, and a more significant drying trend in the 650mm probe in late August 2023. The general trend toward drying of the soil profile post October 2022 corresponds with a plateauing of the CRD curve, with a strongly declining trend in the CRD curve throughout 2023 reflected in significant drying of the shallow soil profile.

3. Groundcover forbs are mesic lifeforms which demonstrate statistically significant and strong positive correlation to rainfall volumes (CRD), while other groundcover lifeforms including sedges, shrubs and grasstree fail to demonstrate any correlation. In contrast, woody stem counts (shrubs >0.5m) demonstrate a weak positive correlation between rainfall volumes and total stem counts at the CPs, and an extremely strong and statistically significant positive correlation between woody stem counts and rainfall volumes at the IPs. This extremely strong positive correlation is likely to be related to the double trigger effect of fire and increased rainfall acting in unison to stimulate the seed bank. The data also suggests that increased rainfall and moisture availability favours the development of woody biomass in the taller shrub layers, while groundcover values remain relatively unaffected for all lifeforms except for increased cover and richness of forbs.

4. Shrub species that show a consistently positive strong correlation between rainfall volume and stem counts at both IPs and CPs are *Leptospermum semibaccatum* and *Leptospermum polygalifolium*. It is expected that with increasing rainfall volumes, these species will continue to increase in stem density and cover. A range of additional species including, but not limited *to Pultenaea palacea, Phyllota phylicoidies, Leucopogon leptospermoides*, *Banksia aemula* and Banksia *oblongifolia* also show strong positive

correlation to rainfall volume at either the IPs or CPs. For some of these species, particularly *Phyllota phylicoidies*, response to rainfall volume is also likely to be influenced by a fire regime that provides a stimulus for germination. Other species including *Persoonia virgata* and *Leptospermum liversidgei* have continued to demonstrate declining stem counts irrespective of rainfall volumes and trends at the IPs. For these species, limited recruitment, and senescence of stems prior to the wildfire was further impeded by respective damage to subterranean lignotubers and destruction, rather than stimulation of the soil seed bank.

5. Despite higher species richness at the IPs compared to CPs in the earlier monitoring events (EV1 to EV4), species richness at the IPs remains only 90% of the value reported for the CPs at the completion of EV16 (36 compared to 40 species). Shrub species are the most significantly affected, with some species including *Agiortia pedicellata, Aotus lanigera, Austromyrtus dulcis, Eleaocarpus reticulatus, Conospermum taxifolium* and *Persoonia virgata* being almost eliminated from post fire stem counts. This can only be attributed to destruction of the soil seed bank and lignotubers by the August 2019 wildfire.

Summary: Ecological data collected over eight survey periods spanning 2016 to 2023 (excluding a February 2015 assessment) indicates that the CPs and IPs have broadly similar floristic attributes, with some variation in species composition and structural features including stem density. Prior to the August 2019 wildfire, stems at the IPs were declining with a 49.6% reduction between April 2016 (567 stems in EV1) and May 2019 (286 stems in EV7) with all species excluding *Persoonia virgata* being affected. Stem counts at the IPs strongly rebounded following the August 2019 wildfire. There was also a strong shift in species composition with the previously dominant *Leptospermum liversidgei* being reduced to scattered shrubs and the population of *Persoonia virgata* was eliminated at the expense of *Phyllota phylicoides,* a fast-growing obligate seeder. Species richness also suffered a significant decline and the post-fire peak of 39 species recorded in the EV14 monitoring event is significantly below the initial peak value for species richness reported in EV2 (September 2016). At the CPs which remained unburnt, changes in stem count and cover were more subtle with a gradual decline in woody stem mass from EV5 (April 2018) through to EV12 (October 2023) after which stem counts were subject to steady increases though to EV15 (April 2023). Species richness followed a similar trend with highest counts in EV2 (49 species), declining gradually through to EV7 (31 species) before a steady rise to EV15 (April 2023) with 45 species reported.

Soil moisture probes installed at the IPs and SPs recorded soil moisture (volumetric moisture content or VMC%) at several depths in the profile down to 1250mm. Rainfall is the primary control on soil moisture with periods of climatic drying marked by strongly fluctuating soil moisture content in the upper soil profile, with drying typically most pronounced in the upper 35cm from the surface. Occasionally this drying extended beyond 650mm, and rarely to depths > 950mm as occurred in April to May 2019 in what was the climatically driest spell of the longer-term monitoring period. Both woody stem counts, and species richness have demonstrated strong correlation to rainfall volume (CRD), and hence with soil moisture and groundwater fluctuations. For both the IPs and CPs, a positive correlation is identified between rainfall volume and total stem counts with the correlation being strongly positive and statistically significant at the IPs. While the influence of the wildfire is noted at the IPs, the strength of the positive correlation is likely related to the double trigger of fire and increased rainfall acting in unison to stimulate the seed bank. Species which appear strongly promoted by increased moisture availability include the resprouter species *Leptospermum semibaccatum* and *Leptospermum polygalifolium,* as well as the obligate seeder species *Phyllota phylicoides.*

For species richness, there is also an extremely strong positive correlation (statistically significant) between species richness and CRD at the CPs and a moderate (non-significant) positive correlation for the IPs (Site 6). The August 2019 wildfire event has again had an influence on these results, producing a data outlier which reduced the strength of the positive correlation. Species richness of the forb and secondly the shrub lifeforms have the greatest reliance on rainfall and soil moisture availability, while the richness and cover of sedges / grasses and grasstree are relatively stable regardless of the climatic regime.

1. That the dataset spans drying, wetting, and subsequent drying climatic cycles greatly increases its utility as a tool to predict changes to the floristic composition and structure of wet heath communities that may be attributed to decreased rainfall and an associated drying soil profile. The drying of the soil profile occurs naturally during drought conditions, though the impacts of this on vegetation structure and composition may be compounded by groundwater abstraction if not carefully managed. A correlation has now been established linking increased rainfall and soil moisture with greater woody stem counts and higher species richness, which suggests that a predictive ecological baseline has been established. This provides evidence that floristic diversity (species number and abundance of key species) is strongly linked to, and increased by, soil moisture, suggesting water extraction could have a negative influence on species diversity in heaths on Bribie Island.

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6.0 Appendix

Appendix A - Monitoring Transects

Survey Locality 5a

Date of Assessment: 30.04.23 / 21.09.23
Plot Size: 50 m linear transect (Canopy Cover); 50 x 4m transect for S2 shrubs >0.5m; 10 x 1m x 1m quadrats for Ground Cover.
Location (Plot Centreline): *Start* -26.9942/ 153.158764; *Centre* --26.9942/ 153.1590571; *Finish* -26.9942/ 153.15932
Structure: Heath

<u>Shrub Cover** – Canopy Intercept (>50cm) (summarised 50 m transect)</u>

<u>March 2023</u>

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
12.9 – 14.2	*Agiortia pedicellata*	1.3	2.0		
17.6 – 19.4	*Agiortia pedicellata*	1.6	2.3		
23.0 – 24.2	*Agiortia pedicellata*	1.6	1.5		
26.3 – 26.8	*Leptospermum semibaccatum*			0.5	0.6
27.7 – 27.9	*Leptospermum semibaccatum*			0.2	0.6
36.3 – 37.2	*Leptospermum semibaccatum*			0.9	0.6
Total Cover		4.5		1.6	
Median Height			2.0		0.6

* Projected over 100 m; ** Shrubs > 1m

<u>September 2023</u>

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
12.8 – 14.2	*Agiortia pedicellata*	1.4	2.2		
17.6 – 19.4	*Agiortia pedicellata*	1.6	2.7		
23.0 – 24.7	*Agiortia pedicellata*	1.7	1.9		
26.3 – 26.8	*Leptospermum semibaccatum*			0.5	0.6
26.9 – 27.8	*Leptospermum semibaccatum*			0.9	0.6
36.2 – 37.1	*Leptospermum semibaccatum*			0.7	0.9
Total Cover		4.7		2.1	0.7
Median Height				0	NA

* Projected over 100 m; ** Shrubs > 1m

<u>Stem Counts (50 x 4) – Shrubs > 0.5m</u>

Species	50 m x 4 m Stems (50x4m) March 2023	50 m x 4 m Stems (50x4m) September 2023
	S2	
Leptospermum semibaccatum	11	6
Agiortia pedicellata	5	6
Baeckea frutescens	4	
Leucopogon leptospermoides	1	1
*Pinus elliottii***		

Melaleuca quinquenervia	1	1
Strangea linearis	1	
Leptospermum polygaliifolium	1	1
Totals	24	15

**projected count over 50 x 10m

Ground Cover %- 1 x 1m Sub-plots

March 2023

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean March 2023
Native perennial grass / sedges	*Caustis recurvata*	30	10	10	20	25	10	20	20	20	30	**43.9**
	Sporodanthus interuptus	5		20		15	30		30	30	20	
	Lomandra elongata		5		2.5				1	5	0.5	
	Baloskion tenuiculme		25	5	50							
Native forbs and other spp.	*Pimelea liniifolia*	1		0.5		1		0.5			0.5	**0.8**
	Pseudanthus orientalis				0.5			0.5			0.5	
	Cassytha glabella	1						0.5		1		
	Hibbertia salicifolia									0.5		
Native shrubs ,<1m	*Leucopogon leptospermoides*	1		2		1		2.5	10		0.5	**8.2**
	Baeckea imbricata											
	Baeckea frutescens				5					5	0.5	
	Strangea linearis		5	0.5	0.5	5		5			2.5	
	Leptospermum semibaccatum					5	2.5	15				
	Dilwynnia floribunda						1				0.5	
	Boronia		1									
	Ochrosperma lineare	2.5	1		0.5	0.5	2.5		2.5	1		
	Acacia bauerii								0.5			
Grass Tree	*Xanthorrhoea fulva*	35	25	40		25	20	10		15	10	**18**
Cryptogams				1	2.5		2.5		1			**0.7**
Bare Ground		5	10	5	10	2.5	10	41	10	10	10	**11.35**
Exotic Shrubs												
Leaf litter		19.5	18	16	8.5	20	21.5	5	25	11.5	24.5	**16.95**

Ground Cover Type	**Species**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Mean March 2023**
Timber (>/= 10cm)												
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100%**

September 2023

Ground Cover Type	**Species**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Mean September 2023**
Native perennial grass / sedges	*Caustis recurvata*	30	10	52	10	10	10	40	10	10	15	**45.85**
	Sporodanthus interuptus	1				2.5	5	2.5		5	5	
	Lomandra elongata		5	7.5					2.5	2.5	2.5	
	Lomandra longifolia										1	
	Eriachne pallescens var. gracilis		1									
	Baloskion tenuiculme	10	20	15	53.5	25	20	15	15	25	20	
Native forbs and other spp.	*Pimelea liniifolia*	1	1		1	1		1			1	**1.05**
	Pseudanthus orientalis							1	1			
	Laxmannia gracilis				1		1					
	Cassytha glabella	0.5										
Native shrubs ,<1m	*Leucopogon leptospermoides*	1					2		1			**9.55**
	Baeckea imbricata				5							
	Homoranthus virgatus	1	2.5	1				2.5	10	1		
	Strangea linearis		2.5	5				5	1		2.5	
	Leptospermum semibaccatum					2	2.5	2.5	20			
	Dilwynnia floribunda		1	2.5	2.5		1	1				
	Ochrosperma lineare	2.5		2		2.5	2.5	1	5		1	
	Boronia	1										
Grass Tree	*Xanthorrhoea fulva*	50	15	5	15	15	5	5		15	10	**13.5**
Cryptogams												
Bare Ground		1	5	5	5	10	5	17.5	10	5	5	6.85
Exotic Shrubs					2			1				0.3
Leaf litter		1	37	5	5	32	46	5	24.5	36.5	37	22.9

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean September 2023
Timber (>/= 10cm)												
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100%**

Additional Species (50 x 50m plot) recorded in May and September surveys:

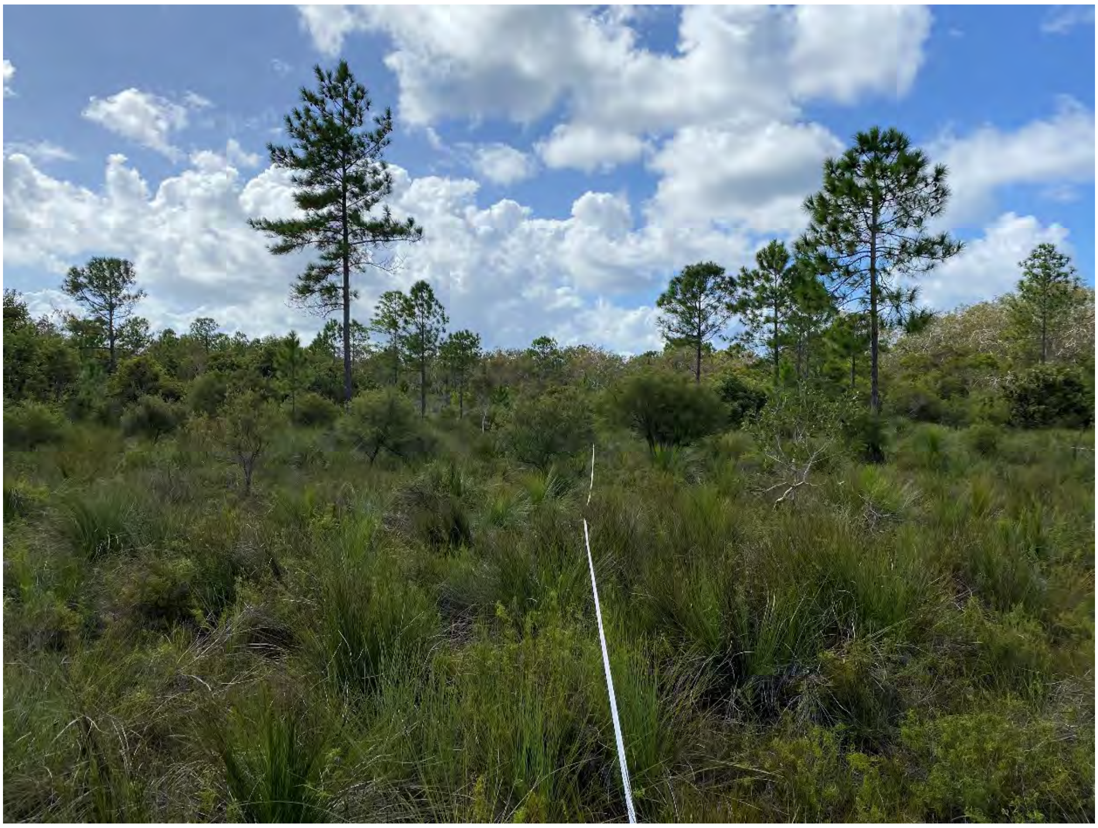
Boronia , Patersonia sericea, Epacris oblongifolia

Structural / Floristic Summary

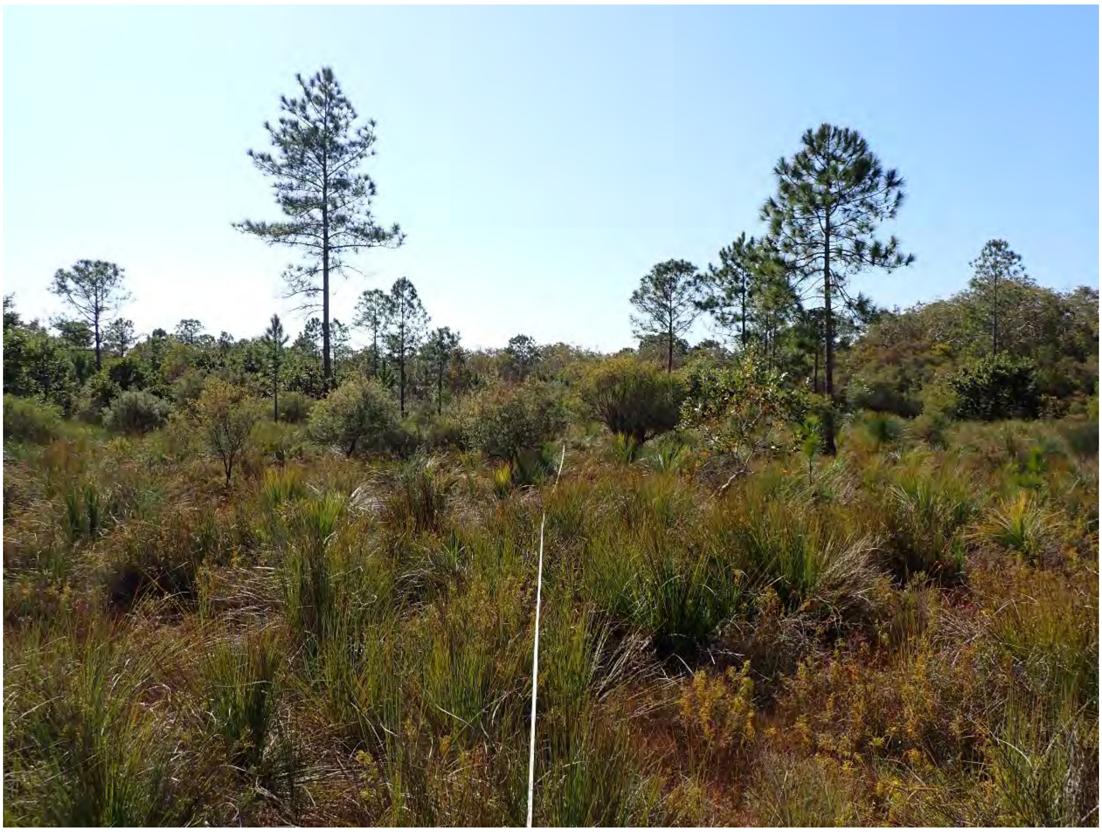
BioCondition Attribute		March 2023	Sept 2023
Native Plant Species Richness	Tree:		
	Shrub:	11	
	Grass Tree	2	
	Grass / Sedge / Rush	6	
	Forbs and other:	6	
Total Species No.**		25	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	9.0	9.4
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	3.2	4.2
	Median Height >1m	2.0	2.1
Native Ground cover (%):	Native perennial grass / sedge cover (%):	43.9	45.85
	Native shrubs (%)	8.2	9.55
	Grass tree	18	13.5
	Organic litter cover (%):	16.95	22.9
	Native forb cover	0.8	1.05
Coarse woody debris:	Total length (m) of debris ≥ 10cm diameter and ≥0.5m in length per hectare	0	0
Non-native plant cover	Non-native Grasses	0	0
	Non-native shrubs	0	0.3

**Excludes Exotic Species

Plot 5a – Centre to Start; March 2023 (Above) and September 2023 (below).



Plot 5a – Centre to End; March 2023 (Above) and September 2023 (below).



Plot 5a – Centre to North; March 2023 (Above) and September 2023 (below).

Plot 5a – Centre to South: March 2023 (Above) and September 2023 (below).

Survey Locality 5b

Date of Assessment: 30.04.23 / 21.09.23
Plot Size:50 m linear transect (Canopy Cover); 50 x 4m transect for S2 shrubs >0.5m; 10 x 1m x 1m quadrats for Ground Cover.
Location (Plot Centreline): *Start* -26.9943/ 153.1587965; *Centre -26.9944*/ 153.1589816; *Finish* -26.9944/ 153.1593191
Structure: Heath

Shrub Cover** – Canopy Intercept (>50cm) (summarised 50 m transect)

March 2023

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
17.7 – 18.4	*Xanthorrhoea johnsonii*			0.7	0.8
18.7 – 19.3	*Leptospermum semibaccatum*			0.6	0.6
20.4 – 20.9	*Leptospermum semibaccatum*			0.5	0.9
22.9 – 23.3	*Leucopogon leptospermoides*			0.4	0.7
24.7 – 25.4	*Leptospermum semibaccatum*			0.7	0.5
31.3 – 32.1	*Leptospermum semibaccatum*			0.8	0.6
38.7 – 39.0	*Strangea linearis*			0.3	0.6
Total Cover				4.0	
Median Height					0.7

** Shrubs > 1m

September 2023

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
14.6 – 15.5	*Leptospermum semibaccatum*			0.6	0.6
17.5 – 18.5	*Xanthorrhoea johnsonni*	1.0	1.0		
18.8 – 19.4	*Leptospermum semibaccatum*			0.6	0.6
20.2 – 20.4	*Leptospermum semibaccatum*			0.2	0.6
20.6 – 20.9	*Leptospermum semibaccatum*	0.3	1.0		
24.6 – 25.5	*Leptospermum semibaccatum*			0.9	0.6
28.2 – 28.5	*Leptospermum semibaccatum*			0.3	0.6
31.6 – 32.1	*Leptospermum semibaccatum*			0.5	0.6
Total Cover		1.3		3.1	
Median Height			1.0		0.6

** Shrubs > 1m

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) March 2023	50 m x 4 m Stems (50x4m) September 2023
	S2	S2
Persoonia virgata	1	1
Leucopogon leptospermoides	3	2
Ochrosperma lineare		
Boronia		3
Leptospermum semibaccatum	43	34
Sprengelia sprengelioides		
Strangea linearis	2	
Acacia flavescens		
Epacris pulchella		
Agiortia pedicellata	3	3

Species	50 m x 4 m Stems (50x4m) March 2023	50 m x 4 m Stems (50x4m) September 2023
	S2	S2
Baeckea frutescens	1	
Xanthorrhoea johnsoni (from top of trunk	1	1
Boronia	1	2
Acacia flavescens	1	1
Leptospermum polygaliifolium		1
Totals	56	48

**projected count over 50 x 10m *Exotic species not counted in stem counts

Ground Cover %- 1 x 1m Sub-plots

March 2023

Ground Cover Type	**Species**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Mean March 2023**
Native perennial grass / sedges	*Caustis recurvata*	15	10	15	20	25	5	5	20	20	20	**41.55**
	Sporodanthus interuptus	25	30	10	25	20	30	15	15	25	25	
	Baloskion tenuiculme		20	5								
	Lomandra elongata		2.5	2.5	1					2.5		
	Eriachne pallescens var. gracilis											
	Hypolaena fastigiata				1			1	2.5		2.5	
Native forbs and other spp.	*Pimelea liniifolia*	2.5	1	0.5			1			0.5		**1.15**
	Cassytha glabella				1					0.5		
	Pattersonia sericea		2.5									
	Laxmannia compacta								0.5			
	Drosera binnata									0.5		
	Pseudanthus orientalis				1							
Native shrubs ,<1m	*Leucopogon leptospermoides*	5			10	2.5	5	2.5	2.5	2.5	5	**19.95**
	Strangea linearis			0.5				5				
	Epacris pulchella				2.5	1						
	Leptospermum semibaccatum			20	10	10	20	40	20	1		
	Dilwynnia floribunda	1	2.5			2.5	1			2.5	1	
	Homoranthus virgatus											
	Baeckea frutescens					2.5						
	Olax retusa	1										
	Ochrosperma lineare			1	1				5	10		

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean March 2023
	Acacia baueri			1	2.5							
	Epacris obtusifolia											
	Leptospermum polygalifolium											
Grass Tree	*Xanthorrhoea fulva*	20		25		10	15			10	10	**8.5**
Cryptogams				10	10	2.5	2.5	5	2.5			**3.25**
Bare Ground		5	10	10	15	10	10	10	5	2.5	5	**8.25**
Exotic Shrubs	*Pinus elliottii***									1		**0.1**
Leaf litter		25.5	21.5	4.5	0	14	10.5	16.5	27	21.5	31.5	**17.25**
Timber (>/= 10cm)												
Total		**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100%**

<u>Additional Species:</u> *Dillwynia floribunda. Boronia*

<u>September 2023</u>

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Sept 2023
Native perennial grass / sedges	*Caustis recurvata*	20	5	10	25	10	15	10	15	15	20	**46.95**
	Sporodanthus interuptus	15		2.5	10	5	10	5	10	5	5	
	Baloskion tenuiculme	30	60	5	25	10	10	20	15	20	25	
	Lomandra elongata		5	5			2.5	2.5		5		
	Schoenus calostachys											
	Hypolaena fastigiata			2.5	2		4	2.5	1	2.5	2.5	
Native forbs and other spp.	*Pimelea liniifolia*	1	1	1	1			1				**1.4**
	Cassytha glabella								1			
	Pattersonia sericea		5									
	Laxmannia compacta					1	1					
	Fern			1								
Native shrubs ,<1m	*Leucopogon leptospermoides*	5			10		20	1		10	2.5	**15.75**
	Strangea linearis	1	2.5	2.5	1	10		5	1		2.5	
	Leptospermum semibaccatum		5			5		30	10		2.5	

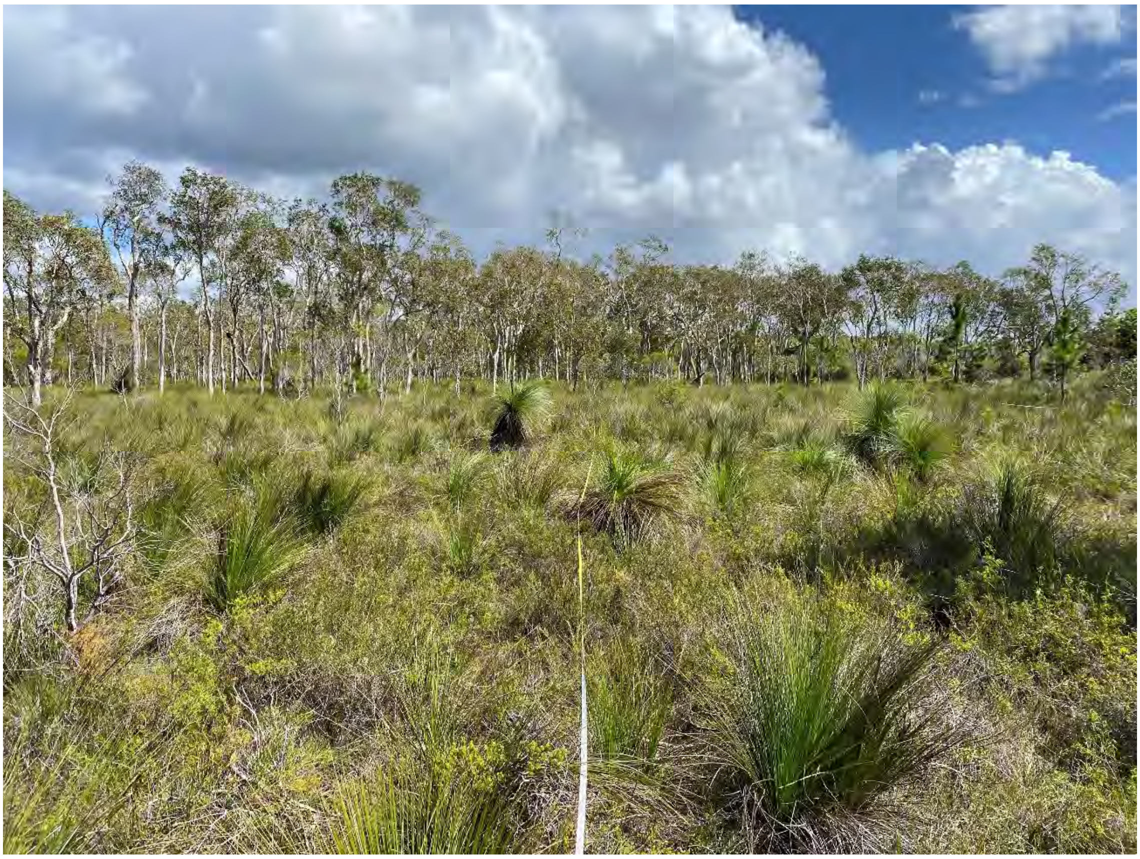
Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Sept 2023
	Dylwynnia floribunda	1	1			2.5				1	1	
	Homoranthus virgatus	1		1	2				5			
	Olax retusa	1										
	Ochrosperma lineare				1	2.5	1	1		2.5	2.5	
	Sprengellia sprengelioides					1	1					
	Acacia baueri				2							
Grass Tree	*Xanthorrhoea fulva*	20	5	25		5			10	15	10	**9.0**
Cryptogams				10	5	5	5	2.5	2.5			**3.0**
Bare Ground			5	10	10	10	5	5	5	5		**5.5**
Exotic Shrubs	*Pinus elliottii***	1	1						1	1		**0.4**
Leaf litter		4	4.5	24.5	6	33	25.5	14.5	23.5	18	26.5	**18.0**
Timber (>/= 10cm)												
Total		**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100%**

<u>Additional Species:</u> *Cassytha glabella, Burchardtia umbellata, Pattersonia sericea, Epacris obtusifolia*

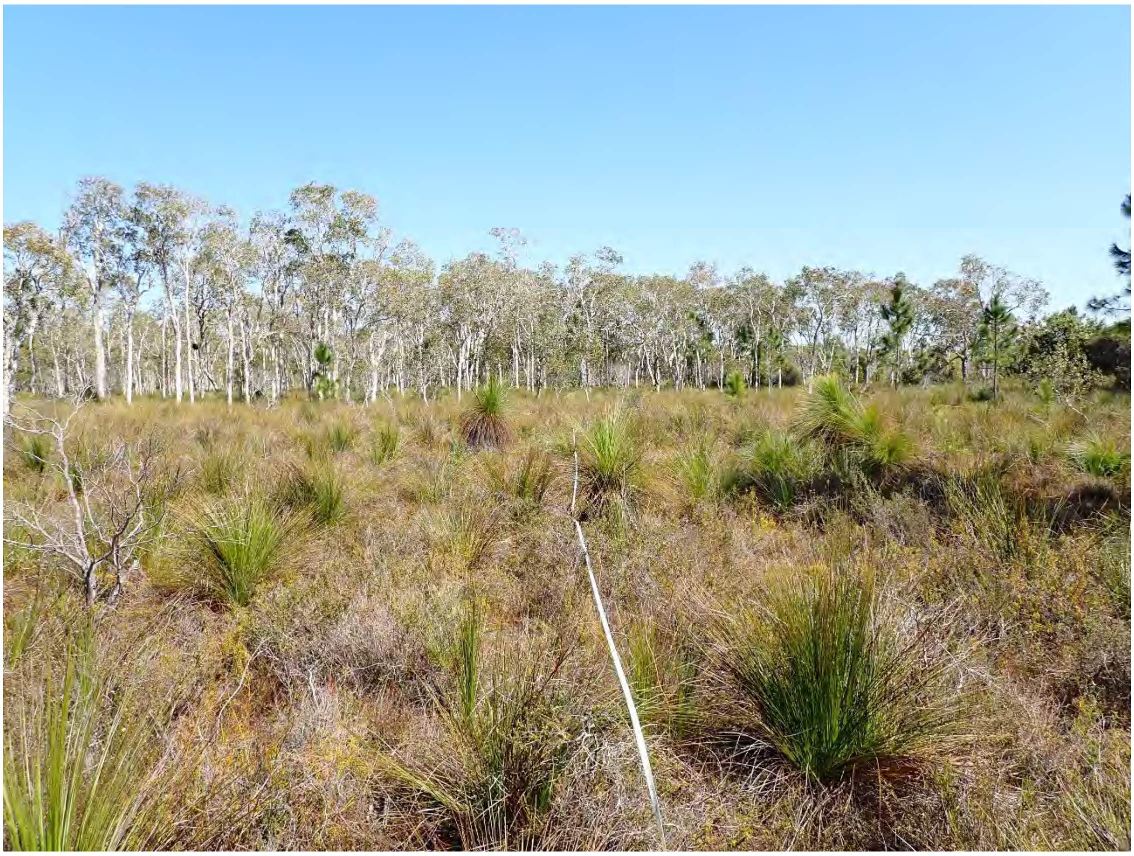
<u>Structural / Floristic Summary</u>

BioCondition Attribute		March 2023	September 2023
Native Plant Species Richness	Tree:		
	Shrub:	16	
	Grass Tree	2	
	Grass / Sedge	5	
	Forbs and other:	10	
Total Species No.**		33	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	2.6	6.2
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	8.0	6.2
Native Ground cover (%):	Native perennial grass / sedge cover (%):	41.55	46.95
	Native shrubs (%)	19.95	16.75
	Grass tree	8.5	9.0
	Organic litter cover (%):	17.25	18.0
	Native forb cover (%)	1.15	1.4
Coarse woody debris:	Total length (m) of debris ≥ 10cm diameter and ≥0.5m in length per hectare	0	0
Non-native plant cover	Non-native Grasses	0	0
	Non-native shrubs	0.1	05

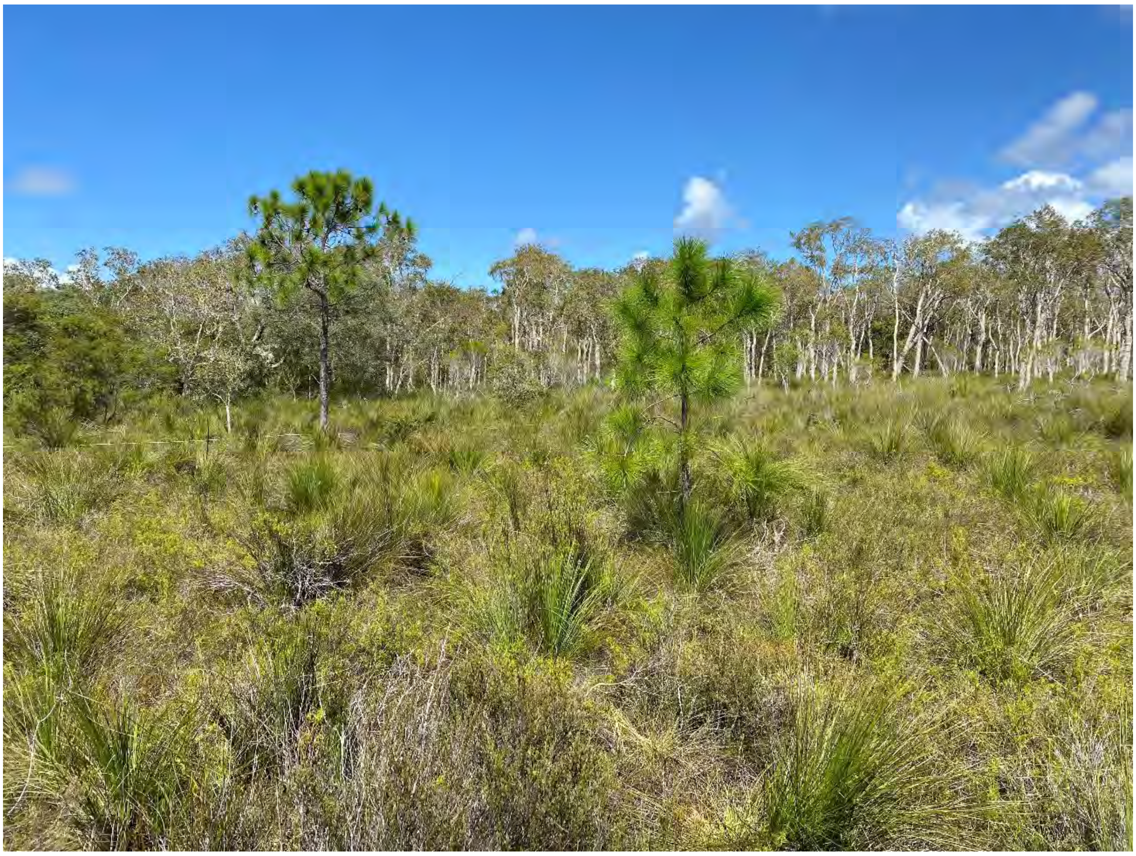
** Excludes Exotic Species



Plot 5b Centre to Start: March 2023 (above) and September 2023 (below).



Plot 5b – Centre to End: March 2023 (above) and September 2023 (below).



Plot 5b – Centre to South; March 2023 (above) and September 2023 (below).

Plot 5b – Centre to North: March 2023 (above) and September 2023 (below).

Survey Locality 5c

Date of Assessment: 30.04.23 / 21.09.23
Plot Size:50 m linear transect (Canopy Cover); 50 x 4m transect for S2 shrubs >0.5m; 10 x 1m x 1m quadrats for Ground Cover.
Location (Plot Centreline): *Start* -26.99467/ 153.15883; *Finish* -26.99447/ 153.15929
Structure: Heath

<u>Shrub Cover** – Canopy Intercept (>50cm) (summarised 50 m transect)</u>

March 2023

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
32.8 – 33.6	*Leptospermum semibaccatum*			0.8	0.6
39.8 – 40.4	*Baeckea frutescens*			0.6	0.7
40.2 – 42.9	*Leptospermum semibaccatum*			0.7	0.7
45.0 – 45.6	*Agiortia pedicellata*			0.8	0.6
48.5 - 50	*Banksia aemula*	1.5	3.5		
Total Cover		1.5		2.9	
Median Height			2.4		0.65

*** Tree not included in cover calculation

September 2023

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
32.8 – 33.6	*Leptospermum semibaccatum*			0.8	0.7
35.7 – 36.1	*Agiortia pedicellata*			0.3	0..0
37.1 - 38	*Agiortia pedicellata*	0.9	1.3		
39.7 – 40.1	*Homoranthus virgatus*			0.4	0.6
45.1 – 45.4	*Leptospermum semibaccatum*			0.3	0.6
45.0 – 46.1	*Banksia aemula*	1.1	4.5		
47.0 – 47.8	*Leptospermum semibaccatum*			0.8	0.7
48.5 - 50	*Agiortia pedicellata*	0.5	3.0		
Total Cover		2..5		2.6	
Median Height			3.5		0.6

*** Tree not included in cover calculation

<u>Stem Counts (50 x 4) – Shrubs > 0.5m</u>

Species	50 m x 4 m Stems (50x4m) March 2023	50 m x 4 m Stems (50x4m) September 2023
Persoonia virgata	1	1
Leucopogon leptospermoides	9	3
Leptospermum semibaccatum	24	20
Dillwynia floribunda	1	
Strangea linearis		
Agiortia pedicellata	2	2

Leptospermum polygalifolium	5	5
Homoranthus virgatus	6	2
Baeckea frutescens	10	3
Melaleuca pachyphyllus	1	1
Melaleuca quinquenervia	2	2
Boronia	1	2
Xanthorrhoea johnsonii	2	2
Totals	63	41

Ground Cover %- 1 x 1m Sub-plots

March 2023

Ground Cover Type	**Species**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Mean March 2023**
Native perennial grass / sedges	*Caustis recurvata*			5	30		25	20	20	10	10	
	Hypolaena fastigiata					5			2.5	2.5	5	
	Gahnia seiberiana		30	30								
	Sporodanthus interruptus		5	10	15	15	15	15	10			
	Baloskion tenuiculme	10			10		5		25		20	
	Lomandra elongata			2.5					2.5			
	Eriachne pallescens var. gracilis			5								**36**
Native forbs and other spp.	*Pimelea liniifolia*	0.5	2.5		1			0.5	1	2.5	1	
	Cassytha glabella		1	1	1		0.5	1				
	Hibbertia salicifolia		2.5									
	Laxmannia compacta					0.5		0.5	1			
	Mitrasacme paludosa					0.5	0.5					
	Mirbellia rubiifolia							0.5				
	Cryptostylis erecta											
	Drosera bipinnata											**2.5**

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean March 2023
	Gonocarpus micranthus											
	Pseudanthus orientalis			5		0.5						
	Patersonia sericea											
Native shrubs ,<1m	*Leucopogon leptospermoides*			5			10	5			5	
	Strangea linearis				2.5	5			5	2.5	2.5	
	Leptospermum semibaccatum					5	10	10		10	10	
	Baeckea frutescens	20								1		
	Baeckea imbricata											
	Dyllwynia floribunda				2.5							
	Ochrosperma lineare										2.5	
	Homoranthus virgatus		5									
	Sprengelia sprengelioides									0.5		
	Acacia bauerii							0.5				**11.95**
Grass Tree	*Xanthorhoea fulva*	30	20		25	30				40	10	**15.5**
Cryptogams	Cryptogams								5	2.5	2.5	**1**
Bare Ground	Bare	5	2	20	2.5	5	5	10	5	2.5	5	**6.2**
Exotic Shrubs	*Pinus elliottii***									0.5		**0.05**
Leaf litter	Leaf	34.5	32	16.5	10.5	33.5	29	37	23	25.5	26.5	**26.8**
Timber (>/= 10cm)												
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100%**

Additional Species: *Burchardtia umbellata, Hibbertia salicifolia, Blechnum cartiligineum, Melaleuca pachyphyllus,*

September 2023

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Sept 2023
Native perennial grass / sedges	*Caustis recurvata*			10	10	25	2.5	10	15	20	10	**28.2**
	Hypolaena fastigiata						1	1	1	1	1	

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Sept 2023
	Gahnia seiberiana		30									
	Sporodanthus interruptus	20	10		10	5	5	5	5		2.5	
	Baloskion tenuiculme				10	15	15	15	10		5	
	Lomandra elongata			2.5	2.5	1				1		
	Eriachne pallescens var. gracilis			5								
Native forbs and other spp.	*Pimelea liniifolia*		1	1							1	**1.35**
	Cassytha glabella			2.5	2.5	1						
	Cryptostylis erecta		1									
	Pseudanthus orientalis											
	Gonocarpus micranthus					1						
	Mirbelia rubiflora					1						
	Hibbertia salicifolia											
Native shrubs ,<1m	*Leucopogon leptospermoides*			5	2.5		1	10	5			**11.15**
	Strangea linearis			2.5	1	2	1		5	2.5	1	
	Leptospermum semibaccatum						2.5	10	5	2.5	5	
	Baeckea frutescens	10	2.5		2.5							
	Boronia						1					
	Ochrosperma lineare			5	5	1			1		2.5	
	Homoranthus virgatus						2.5	2.5	2.5		2.5	
	Leptospermum polygaliifolium						2.5					
	Epacris pulchella					5						
	Dillwynia floribunda											
Grass Tree	*Xanthorhoea fulva*	30	30	15	10	5	30	10	10	30	20	**19.0**
Cryptogams											2.5	**0.25**
Bare Ground		5	0	10	30	10	5	0	20	0	10	**9**

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Sept 2023
Exotic Shrubs	*Pinus elliottii***											
Leaf litter		35	25.5	41.5	14	29	31	34	20.5	43	37	**31.05**
Timber (>/= 10cm)												
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100%**

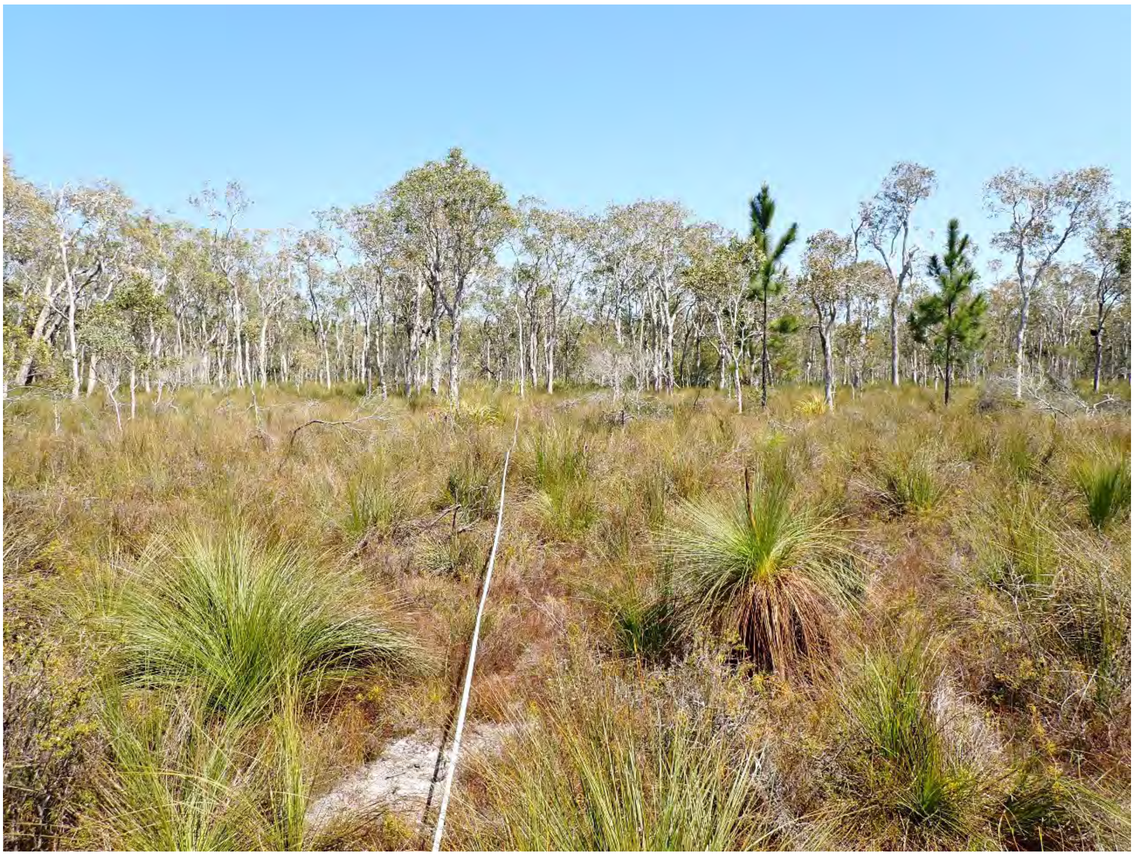
<u>Additional Species:</u> *Baeckea imbricata, Burchardtia umbellata, Boronia , Pattersonia sericea, Blechnum cartiligineum, Banksia aemula, Melaleuca pachyphyllus, Melaleuca quinquenervia, Hibbertia salicifolia*

Structural / Floristic Summary

BioCondition Attribute		March 2023	September 2023
Native Plant Species Richness	Tree:	.	
	Shrub:	15	
	Grass Tree	2	
	Grass / Sedge	7	
	Forbs and other:	13	
Total Species No.**		37	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	3	5
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	5.8	5.2
Native Ground cover (%):	Native perennial grass / sedge cover (%):	36	28.2
	Native shrubs (%)	11.95	11.15
	Grass tree	15.5	19
	Organic litter cover (%):	26.8	31.05
	Native forb cover (%)	2.5	1.35
Coarse woody debris:	Total length (m) of debris ≥ 10cm diameter and ≥0.5m in length per hectare	0	0
Non-native plant cover	Non-native Grasses%	0	0
	Non-native shrubs %	0.05	0

** Excludes Exotic Species

Plot 5c – Centre to Start: March 2023 (Above) and September 2023 (Below).



Plot 5c – Centre to End: March 2023 (Above) and September 2023 (Below).

Plot 5c – Centre to Right: March 2023 (Above) and September 2023 (Below).

Plot 5c – Centre to Left: March 2023 (Above) and September 2023 (Below).

Survey Locality 6a

Date of Assessment: 30.04.23 / 21.09.23

Plot Size:50 m linear transect (Canopy Cover); 50 x 4m transect for S2 shrubs >0.5m; 10 x 1m x 1m quadrats for Ground Cover.

Location (Plot Centreline): *Start* -26.985 / 153.1540431; Centre -26.9849 / 153.1542562 *Finish* -26.9847/ 153.1544874

Structure: Heath

Shrub Cover** – Canopy Intercept (>50cm) (summarised 50 m transect)

March 2023

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
1.6 – 1.8	*Leptospermum semibaccatum*	0.2	1		
3.3 – 5.5	*Banksia aemula*	2.2	3.5		
8.1 – 8.4	*Baeckea frutescens*			0.3	0.6
9.9 – 11.1	*Baeckea frutescens*	1.2	1.5		
12.1 - 13	*Baeckea frutescens*	0.9	1.0		
15.2 – 16.4	*Baeckea frutescens*			1.2	0.7
17.5 - 18	*Banksia oblongifolia*			0.5	0.6
22.4 – 23.3	*Banksia oblongifolia*			0.0	0.6
26.0 – 26.4	*Pultenaea palaceae*			0.4	0.9
28.4 – 29.3	*Phyllota phyllocioides*	0.9	1.2		
28.9 – 29.4	*Banksia oblongifolia*			0.5	0.6
31.8 – 32.5	*Banksia oblongifolia*			0.7	0.5
34.2 – 34.4	*Phyllota phyllocioides*	2.2	1.2		
34.7 - 35	*Phyllota phyllocioides*			0.3	0.6
35.6 – 35.8	*Phyllota phyllocioides*			0.2	0.6
36.1 – 36.8	*Phyllota phyllocioides*			0.7	0.9
37.2 – 37.5	*Phyllota phyllocioides*			0.3	0.9
38.1 – 39.2	*Phyllota phyllocioides*			1.1	0.9
39.3 – 39.5	*Phyllota phyllocioides*			0.2	0.9
40.5 – 41.1	*Banksia oblongifolia*			0.6	0.5
42.7 – 42.8	*Phyllota phyllocioides*			1.1	0.6
46.1 – 46.7	*Phyllota phyllocioides*	0.6	1.0		
47.4 – 47.6	*Phyllota phyllocioides*	0.2	1.0		
48.4 – 48.9	*Leptospermum liversidgei*			0.5	0.6
49.5 – 49.8	*Leptospermum liversidgei*			0.3	0.7
49.8 – 50.0	*Phyllota phyllocioides*			0.2	0.5
Total Cover		8.4		9.1	
Median Height			1.8		0.7

*** Tree not included in cover calculation

September 2023

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
1.5 – 1.7	*Leptospermum semibaccatum*	0.2	1		
3.3 – 5.4	*Banksia aemula*	2.1	3.5		
10.4 – 11.1	*Baeckea frutescens*	0.7	1.7		
12.2 – 12.9	*Baeckea frutescens*	1.2	1.0		
15.2 – 15.4	*Baeckea frutescens*	0.2	1.0		

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
17.3 – 17.9	*Banksia oblongifolia*			0.6	0.75
21.5 – 23.5	*Banksia oblongifolia*			2.0	0.8
28.3 – 29.1	*Phyllota phylicoides*	0.8	1.4		
29.5 – 29.8	*Banksia oblongifolia*			0.3	0.6
29.9 – 30.4	*Phyllota phyllocioides*	0.5	1.0		
31.7 – 32.3	*Banksia oblongifolia*			0.5	0.8
35.5 – 35.7	*Phyllota phyllocioides*			0.2	0.8
36.1 – 36.3	*Phyllota phyllocioides*			0.2	0.8
37.0 – 37.2	*Phyllota phyllocioides*	0.2	1.0		
37.8 – 38.1	*Phyllota phyllocioides*			0.3	0.8
38.2 – 38.8	*Banksia oblongifolia*			0.6	0.6
38.1 – 38.5	*Phyllota phyllocioides*	0.4	1.0		
40.1 – 41.0	*Banksia oblongifolia*			0.9	0.7
45.8 – 46.2	*Phyllota phyllocioides*	0.4	1.0		
48.3 – 48.7	*Leptospermum liversidgei*			0.4	0.6
49.4 – 49.6	*Leptospermum liversidgei*			0.2	0.7
49.8 - 50	*Phyllota phyllocioides*			0.2	0.5
Total Cover		7.4		6.4	
Median Height			1.8		0.7

*** Tree not included in cover calculation

<u>Stem Counts (50 x 4) – Shrubs > 0.5m</u>

Species	50 m x 4 m Stems (50x4m) March 2023	50 m x 4 m Stems (50x4m) Sept 2023
	S2	
Persoonia virgata		
Banksia aemula	1	1
Banksia oblongifolia	31	28
Epacris pulchella		
Leptospermum liversidgei	13	7
Leptospermum semibaccatum	13	14
Boronia	29	45
Sprengelia sprengeliodes		
Leucopogon leptospermoides	3	2
Baeckea frutescens	16	8
Dilwynnia floribunda	9	1
Epacris obtusifolia		
Strangea linearis	1	
Phyllota phylicoides	177	102
Sprengelia sprengelioides	1	
Pultenaea paleacea	3	

Leptospermum polygalifolium	4	4
Totals	301	212

Ground Cover %- 1 x 1m Sub-plots
March 2023

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean March 2023
Native perennial grass / sedges	*Caustis recurvata*	5		5	10	2.5						
	Sporodanthus interruptus	20	10	30	25	20	25	5	20	20	10	
	Lomandra longifolia											
	Lomandra elongata			10								
	Hypolaena fatigiata	2.5	2.5									
	Lomandra longifolia					2						22.45
Native forbs and other spp.	*Pimelea liniifolia*				2.5	1	1	1	1	1		
	Cassytha glabella	1			1	2.5	1		1		1	
	Selaginella uliginosa											
	Burchardia umbellata					2	1			2.5	1	
	Drosera binata											
	Gonocarpus micranthus										2.5	
	Hibbertia salicifolia							1		1	2.5	2.85
Native shrubs ,<1m	*Boronia*	5	10	10	10	10	20	1	5	10	5	
	Baeckea imbricata			2.5	2.5		2.5	1	5	15	2.5	
	Leucopogon leptospermoides				1							
	Banksia oblongifolia								20			
	Leptospermum semibaccatum	5	20	5	15							
	Strangea linearis				2.5	2.5	2.5				1	
	Leptospermum liversidgei											
	Sprengelia sprengelioides		2			2.5		1	5	1		
	Dillwynnia floribunda	2.5	10						2.5			
	Ochrosperma lineare	10	5									
	Pultenaea paleaceae					2.5	1	10				24.9

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean March 2023
	Baeckea frutescens											
	Phyllota phylicoides										2.5	
Grass Tree	*Xanthorrhoea fulva*					25	20	50	20	15	50	18
Cryptogam												
Bare Ground	Bare	0	5	5	30.5	27.5	26	20	10.5	5	5	13.45
Exotic Shrubs												0
Leaf litter	Leaf	49	35.5	32.5	0	0	0	10	10	29.5	17	18.35
Timber (>/= 10cm)												
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100%**

September 2023

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Sept 2023
Native perennial grass / sedges	*Caustis recurvata*	1	2.5		2.5							26.2
	Sporodanthus interruptus	20	25	10	25	25	30	10	25	15	10	
	Baloskion tenuiculme			30	10	5	5					
	Hypolaena fastigiata											
	Lomandra elongata	1		10								
Native forbs and other spp.	*Pimelea liniifolia*			1		1		2.5	1		1	2.1
	Cassytha glabella				1							
	Hibbertia salicifolia											
	Pseudanthus orientalis											
	Burchardia umbellata											
	Selaginella uliginosa								1			
	Patersonia sericea			2.5		2.5	5			2.5		
	Gonocarpus micranthus											
Native shrubs ,<1m	*Boronia*	2.5	5	5	5	20	10		2.5	10	2.5	20.2
	Baeckea imbricata			1	1	2.5	2			1	10	
	Leucopogon leptospermoides		1									

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Sept 2023
	Banksia oblongifolia								10			
	Leptospermum liversidgei									2.5		
	Dylwynnia floribuna						1		2.5			
	Homoranthus virgatus	2.5	5			1						
	Leptospermum semibaccatum	20		2.5	5							
	Strangea linearis				2.5				2.5			
	Homoranthus virgatus	2.5	5			1						
	Sprengelia sprengelioides		1			2.5			1		1	
	Olax retusa						1					
	Epacris pulchella					2.5	2.5	2.5				
	Pultenaea paleaceae					1	2.5	5	1		1	
	Baeckea frutescens											
	Phyllota phylliocoides									2.5	2.5	
	Ochrosperma lineare	10	10	1	2.5	2.5						
Grass Tree	*Xanthorrhoea fulva*			5	5	15	5	60	20	15	30	15.5
Cryptogam												
Bare Ground	Bare	0	0	5	10	0	5	0	0	5	0	2.5
Exotic Shrubs												
Leaf litter	Leaf	40.5	45.5	27	30.5	18.5	31	20	33.5	46.5	42	33.5
Timber (>/= 10cm)												
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100%**

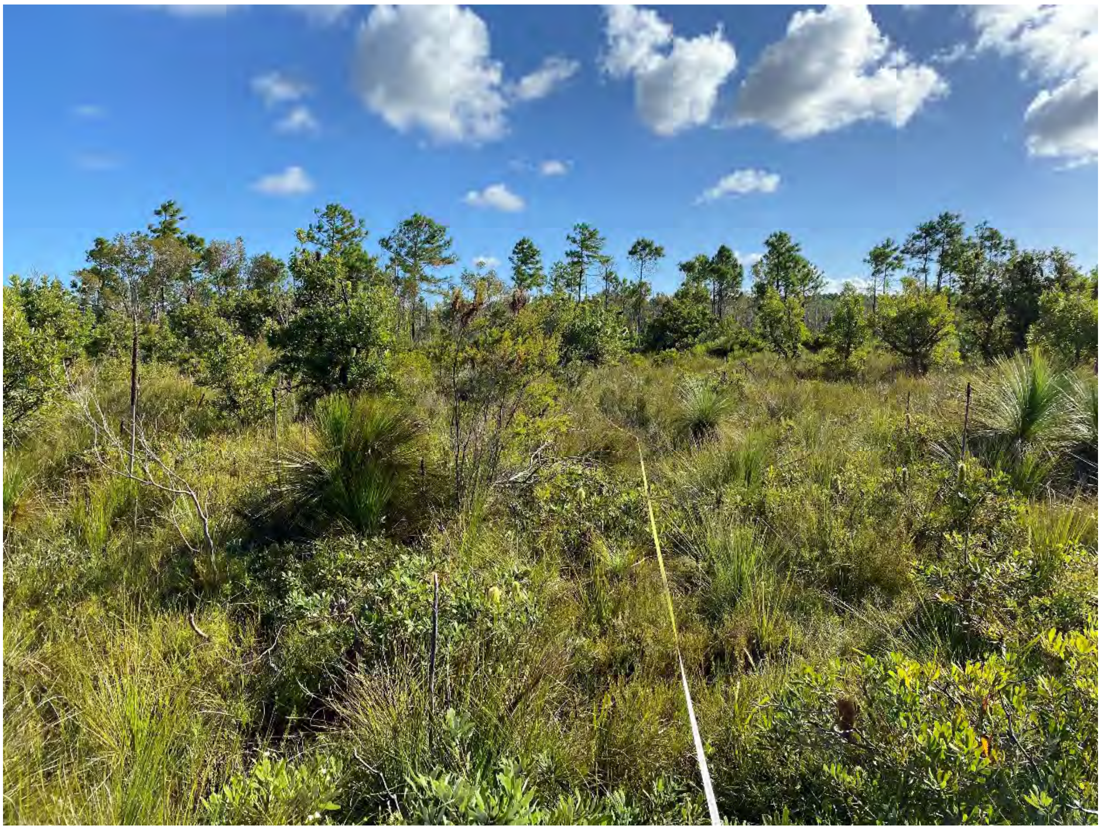
<u>Additional Species:</u> *Selaginella uliginosa, Commosperma sphaericum*

<u>Structural / Floristic Summary</u>

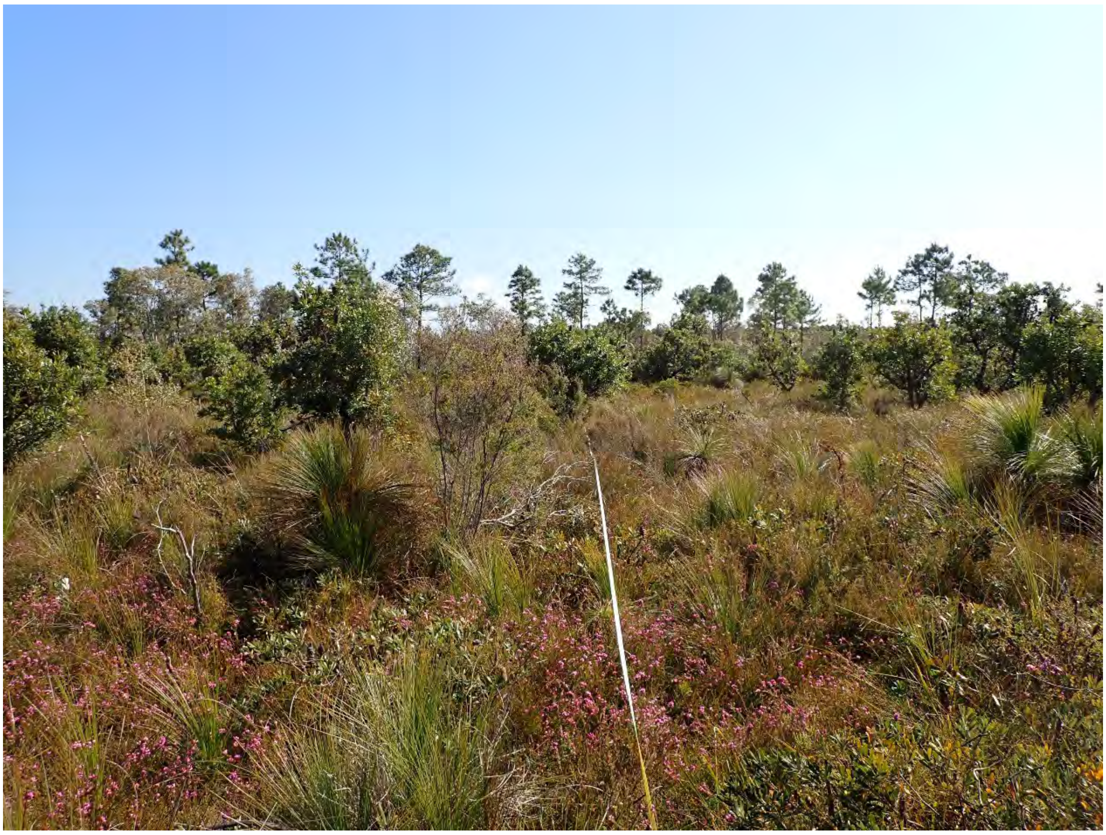
BioCondition Attribute		March 2023	September 2023
Native Plant Species Richness	Tree:		
	Shrub:	19	
	Grass Tree	1	
	Grass / Sedge	6	
	Forbs and other:	6	
Total Species**		32	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	16.8	14.8
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	18.2	12.8

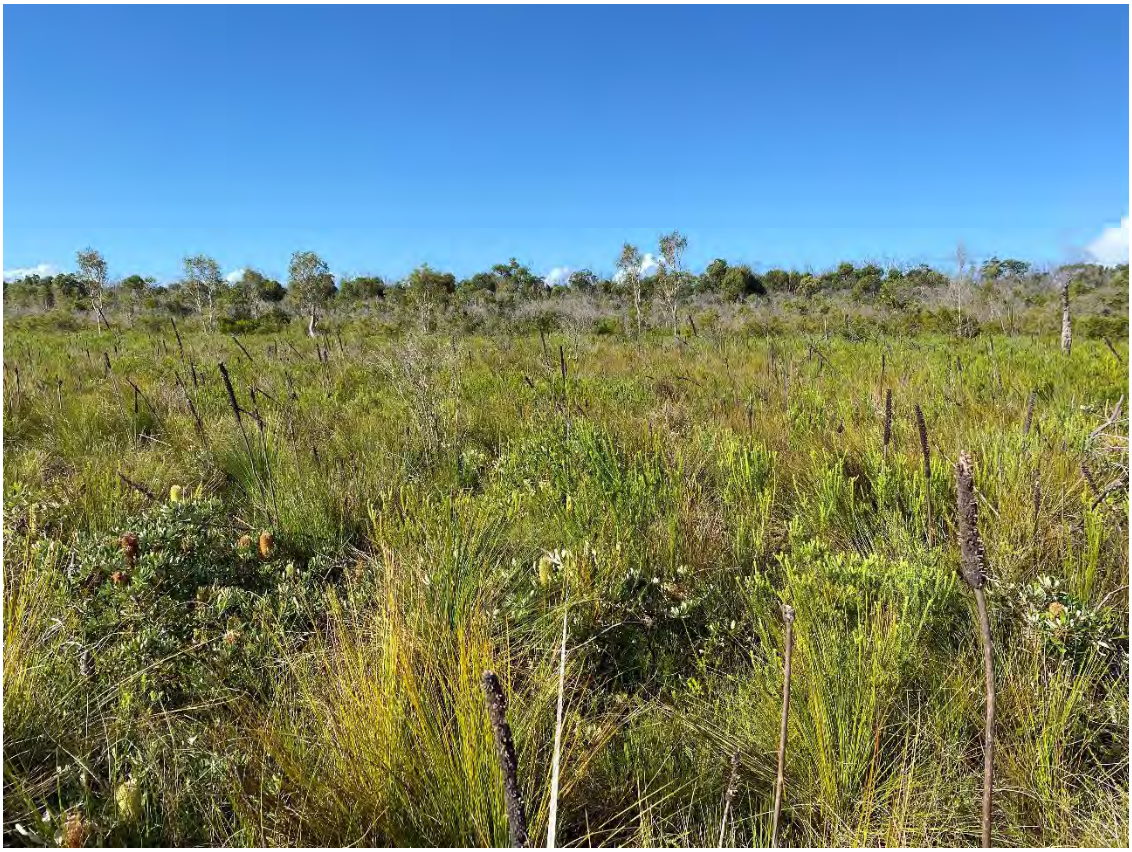
BioCondition Attribute		March 2023	September 2023
Native Ground cover (%):	Native perennial grass / sedge cover (%):	22.45	26.2
	Native shrubs (%)	24.9	20.2
	Grass tree	18	15.5
	Organic litter cover (%):	18.35	33.5
	Native forb cover (%)	2.85	2.1
Coarse woody debris:	Total length (m) of debris ≥ 10cm diameter and ≥0.5m in length per hectare		
Non-native plant cover	Non-native Grasses%	0	0
	Non-native shrubs %	0	0

**Excludes Exotic Species

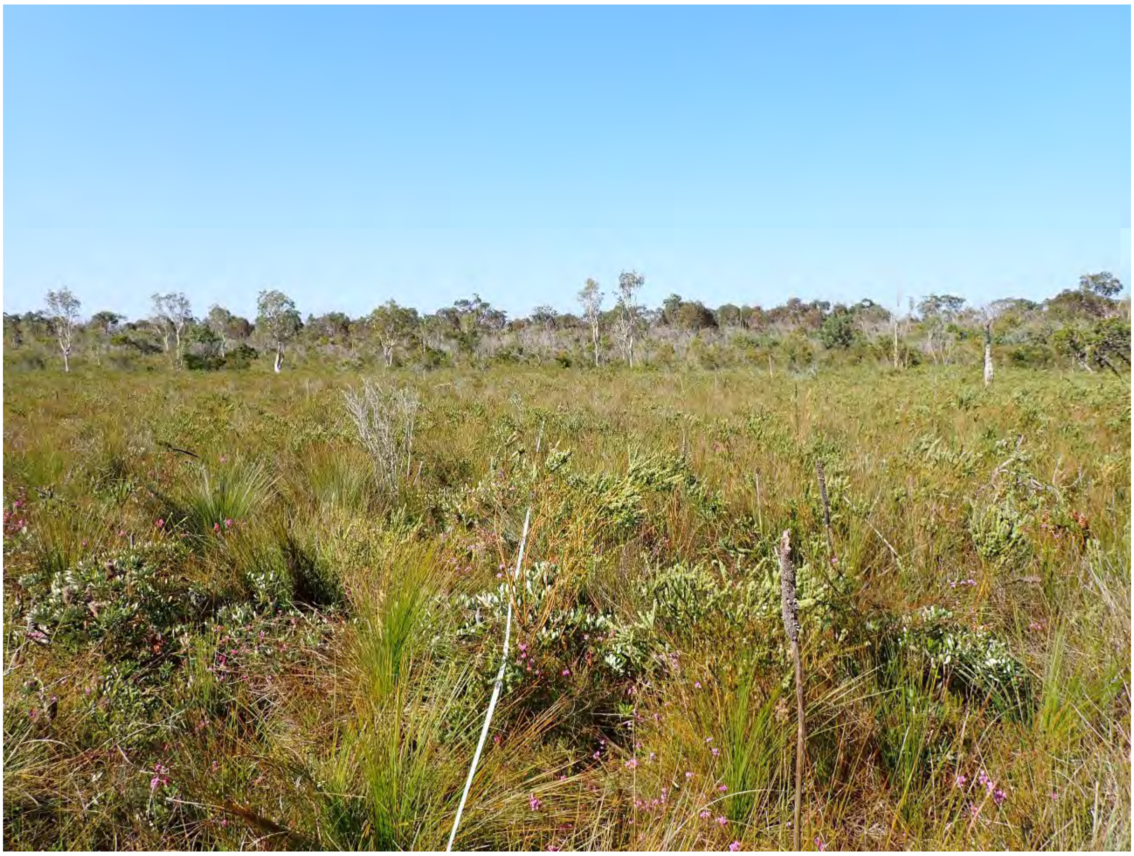


Plot 6a – Centre to Start; March 2023 and September 2023 (Below).

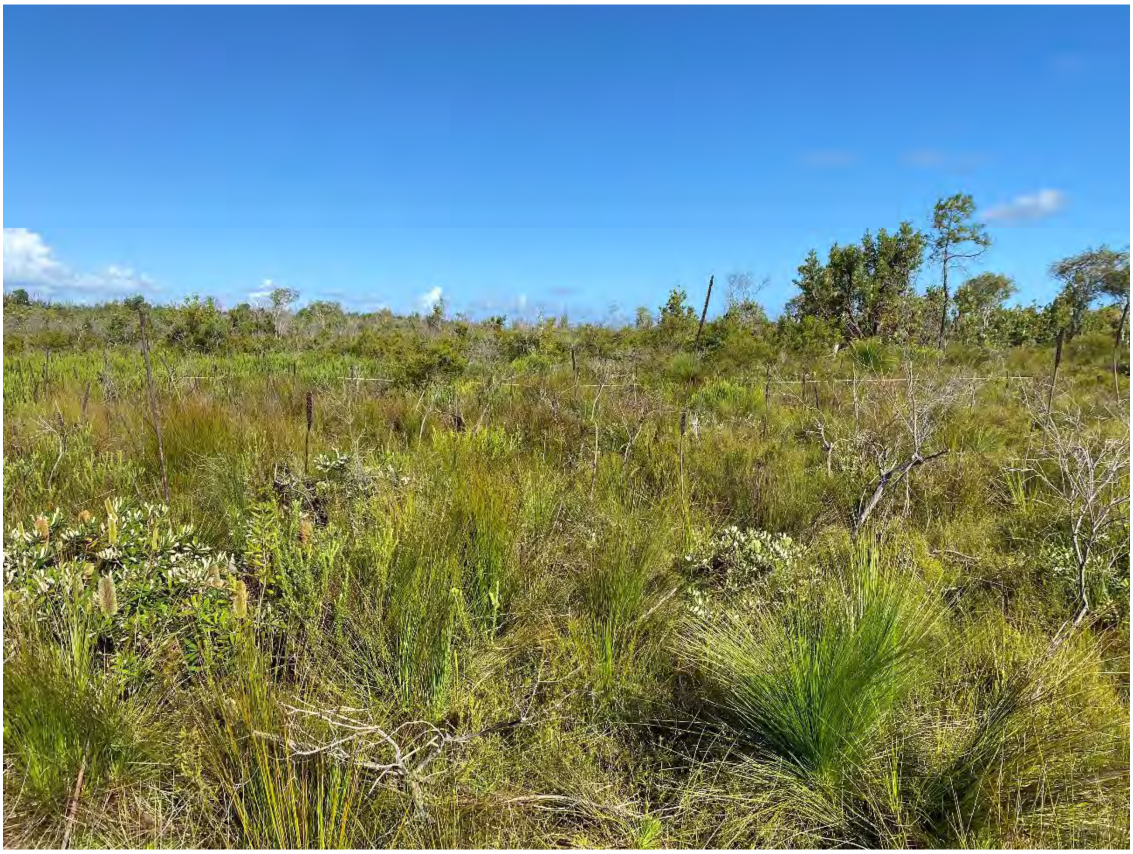




Plot 6a – Centre to End: March 2023 and September 2023 (Below).



Plot 6a – Centre North: March 2023 (Above) and September 2023 (Below)



Plot 6a – Centre to South: March 2023 (Above) and September 2023 (Below).

Survey Locality 6b

Date of Assessment: 30.04.23 / 21.09.23
Plot Size:50 m linear transect (Canopy Cover); 50 x 4m transect for S2 shrubs >0.5m; 10 x 1m x 1m quadrats for Ground Cover.
Location (Plot Centreline): *Start* -26.9852/ 153.1541529; Centre -26.985 / 153.1543768 *Finish* -26.9849 / 153.1545859
Structure: Heath

Shrub Cover** – Canopy Intercept (>50cm) (summarised 50 m transect)

March 2023

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
0.6 – 1.3	*Baeckea frutescens*			0.7	0.5
2,2 – 2.4	*Banksia oblongifolia*			0.2	0.6
3.7 – 4.0	*Banksia aemula*			0.3	0.5
12.8 – 13.8	*Banksia oblongifolia*			1.0	0.5
13.4 – 13.8	*Leucopogon leptospermoides*			0.4	0.6
14.6 – 15.2	*Leptospermum semibaccatum*			0.6	0.6
16.3 – 18.3	*Banksia oblongifolia*			2.0	0.6
18.7 – 19.4	*Leptospermum liversidgei*	0.7	1.0		
20.8 – 21.0	*Leptospermum semibaccatum*	0.2	1.0		
21 – 22.0	*Baeckea frutescens*			1.0	0.7
22.3 – 23.0	*Baeckea frutescens*			0.7	0.6
26.1 – 26.8	*Banksia oblongifolia*			0.7	0.55
28.4 – 29.3	*Phyllota phylicoides*			0.9	0.8
29.6 – 31.1	*Phyllota phylicoides*	0.5	1.0		
32.1 – 32.7	*Phyllota phylicoides*	0.6	1.0		
33.0 – 34.3	*Pultenaea palaceae*			1.3	0.7
33.5 – 34.6	*Phyllota phylicoides*			1.1	0.6
35.6 – 35.9	*Phyllota phylicoides*	0.3	1.0		
35.0 – 35.3	*Leptospermum liversidgei*	0.3	1.0		
36.9 – 37.5	*Phyllota phylicoides*	0.6	1.0		
39.2 – 40.3	*Phyllota phylicoides*	1.1	1.0		
40.7 – 42.2	*Phyllota phylicoides*	1.5	1.0		
42.8 – 43.8	*Phyllota phylicoides*	1.0	1.0		
47.5 – 49.0	*Phyllota phylicoides*	1.5	1.2		
49.5 – 50.0	*Phyllota phylicoides*			0.5	0.6
Total Cover		8.3		11.1	
Median Height			1.0		0.7

*** Tree not included in cover calculation

September 2023

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
8.3 – 8.7	*Banksia oblongifolia*				0.5
9.6 – 9.9	*Leptospermum semibaccatum*				0.5
13.2 – 14.2	*Banksia oblongifolia*				0.6
13.2 – 13.5	*Leptospermum semibaccatum*				0.8
16.7 – 18.5	*Banksia oblongifolia*				1.0
19.0 – 19.5	*Leptospermum polygaliifolium*				1.0

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
21.2 – 21.4	*Leptospermum semibaccatum*			0.2	0.7
22.9 – 23.2	*Boronia*			0.3	0.6
26.6 – 26.9	*Banksia oblongifolia*			0.3	0.6
27.9 – 28.4	*Phyllota phylicoides*	0.5	1.0		
29.9 – 31.3	*Phyllota phylicoides*	0.4	1.1		
32.6 – 32.8	*Phyllota phylicoides*	0.2	1.0		
33.2 – 33.5	*Phyllota phylicoides*	0.3	1.0		
34.0 – 35.4	*Phyllota phylicoides*	1.4	1.1		
35.4 – 36.0	*Leptospermum liversidgei*	0.6	1.0		
36.0 – 36.8	*Phyllota phylicoides*	0.8	1.1		
32.8 – 33.3	*Banksia oblongifolia*	0.5	1.0		
35.8 – 36.3	*Phyllota phylicoides*	0.5	1.0		
39.8 – 40.2	*Phyllota phylicoides*	0.4	1.1		
41.3 – 42.1	*Phyllota phylicoides*	0.9	1.0		
43.0 – 43.9	*Phyllota phylicoides*	0.9	1.0		
45.7 – 45.9	*Phyllota phylicoides*	0.2	1.0		
46.6 – 46.8	*Boronia*			0.2	0.6
48.0 – 49.1	*Phyllota phylicoides*	1.1	1.0		
49.6 – 49.8	*Phyllota phylicoides*			0.2	0.8
Total Cover		8.5		1.2	
Median Height			1.0		0.7

*** Tree not included in cover calculation

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) March 2023	50 m x 4 m Stems (50x4m) September 2023
	S2	
Persoonia virgata		
Banksia aemula	2	2
Banksia oblongifolia	26	17
Leptospermum liversidgei	2	3
Boronia falcifolia	8	32
Leucopogon leptospermoides	17	5
Baeckea frutescens	21	16
Dillwynnia floribunda	7	1
Olax retusa		
Epacris obtusifolia		
Phyllota phylicoides	278	192
Pultenaea paleacea		1
Strangea linearis	1	

Leptospermum polgalifolium		3
Leptospermum semibaccatum	6	4
Totals	368	276

<u>Ground Cover %- 1 x 1m Sub-plots</u>

<u>March 2023</u>

Ground Cover Type	**Species**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Mean March 2023**
Native perennial grass / sedges	*Caustis recurvata*	2.5		2.5			2.5					
	Sporodanthus interruptus	10	30	50	30	40	30	30	20	10	15	
	Baloskion tenuiculme											
	Schoenus calostachys											
	Lomandra elongata					2.5						
	Lomandra longifolia	10	10									29.5
Native forbs and other spp.	*Drosera binata*											
	Pimelea linifolia	2.5	2.5	2.5	2.5							
	Burchardia umbellata						10	2.5				
	Cassytha glabella	1		1	2.5	1						
	Selaginella uliginosa					1						
	Hibbertia salicifolia							1	2.5	2.5	1	
	Pseudanthus orientalis											
	Gonocarpus micranthus					1						3.7
Native shrubs ,<1m	*Boronia*		2.5	5	10	15	15	5			2.5	
	Baeckea imbricata					1	10					
	Leucopogon leptospermoides	5	5			10						
	Strangea linearis			2.5				2.5				
	Leptospermum liversidgei							2.5				
	Banksia oblongifolia											16.45

Ground Cover Type	**Species**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Mean March 2023**
	Leptospermum semibaccatum	2.5		10	5	5		2.5	2.5			
	Baeckea frutescens								5	2.5	5	
	Dyllwynia floribunda	2.5	2.5	2.5	1					1		
	Olax retusa					0.5	1		2.5			
	Sprengelia sprengeliodes										2.5	
	Phyllota phylicoides							10	2.5	2.5		
Grass Tree	*Xanthorrhoea fulva*	25	10		20	1		20	20	60	30	18.6
Cryptogams												0
Bare Ground	Bare	0	0	0	0	5	10	0	5	0	5	2.5
Exotic Shrubs	*Exotic*											0
Leaf litter	Leaf	39	37.5	24	29	17	21.5	24	40	21.5	39	29.25
Timber (>/= 10cm)												
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100%**

Additional species: *Ochrosperma lineare*

September 2023

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean September 2023
Native perennial grass / sedges	*Caustis recurvata*	5			2.5		5					28.1
	Sporodanthus interruptus	10	25	40	40	35	35	15	15	10	15	
	Lomandra longifolia											
	Baloskion tenuiculme			5								
	Lomandra elongata	10	5		2.5		2.5	1		2.5		
	Lomandra sp.											
Native forbs and other spp.	*Pimelia liniifolia*	2.5	2.5	2.5						1		2.4
	Selaginella uliginosa					1						
	Hibbertia salicifolia							2.5	2.5	2.5	1	
	Cassytha glabella	1	1	1	1		1					

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean September 2023
	Patersonia sericea											
	Gonocarpus micranthus								1			
Native shrubs ,<1m	*Boronia*	1.5		1	2.5	15	10	1	10		2.5	11.3
	Baeckea imbricata					5	5			2.5	1	
	Leucopogon leptospermoides				2.5	1						
	Homoranthus virgatus			2.5								
	Banksia oblongifolia	2.5	5				5					
	Leptospermum semibaccatum											
	Baeckea frutescens				10						10	
	Patersonia sericea				1	2.5	2.5					
	Sprengelia sprengelioides											
	Homoranthus virgatus			2.5								
	Dyllwynia floribunda	1	2.5	1					1			
	Leptospermum polygaliifolium		1									
	Phyllota phylicoides							2.5				
Grass Tree	*Xanthorrhoea fulva*	25	20	20	10	5		25	25	40	25	19.5
Cryptogams												
Bare Ground	Bare	0	0	1	0	5	0	0	0	0	0	0.6
Exotic Shrubs												
Leaf litter	Leaf	41.5	38	23.5	28	30.5	34	53	45.5	41.5	45.5	38.1
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

Additional Species: *Burchardia umbellata, Epacris pulchella, Ochrosperma lineare, Olax retusa*

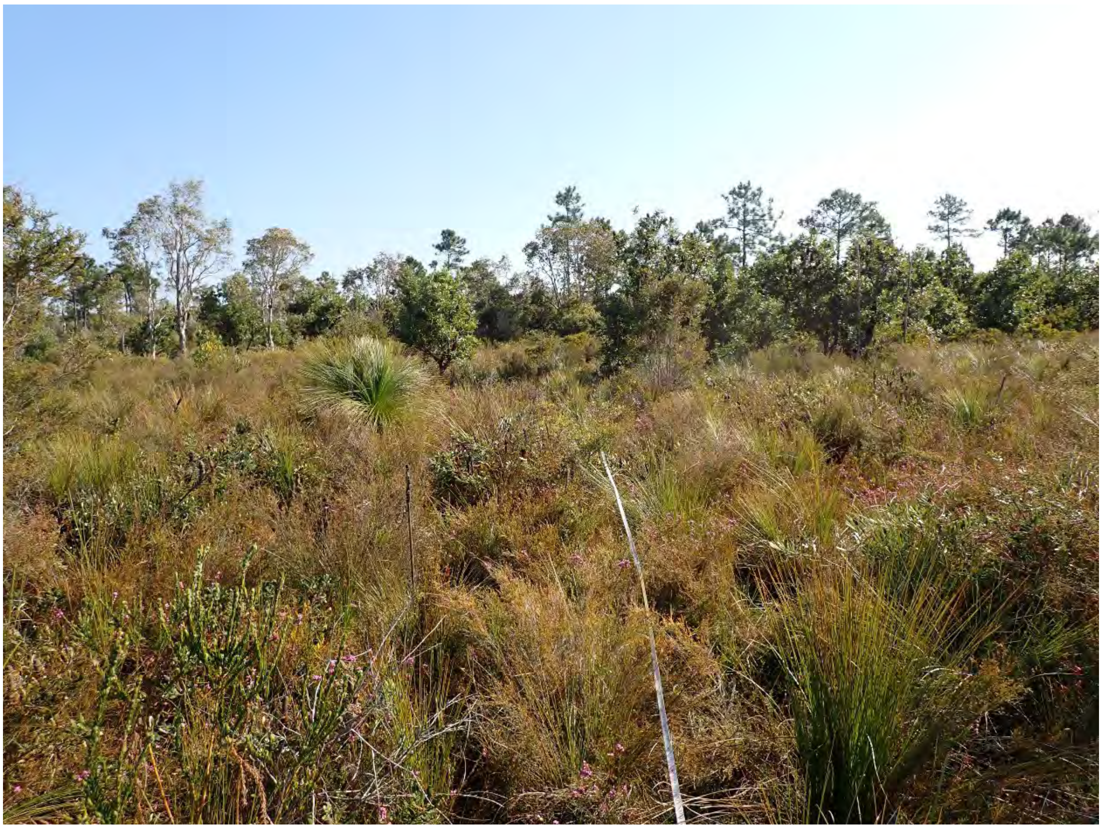
Structural / Floristic Summary.

BioCondition Attribute		March 2023	October 022
Native Plant Species Richness	Tree:		
	Shrub:	20	
	Grass Tree	1	
	Grass / Sedge	4	

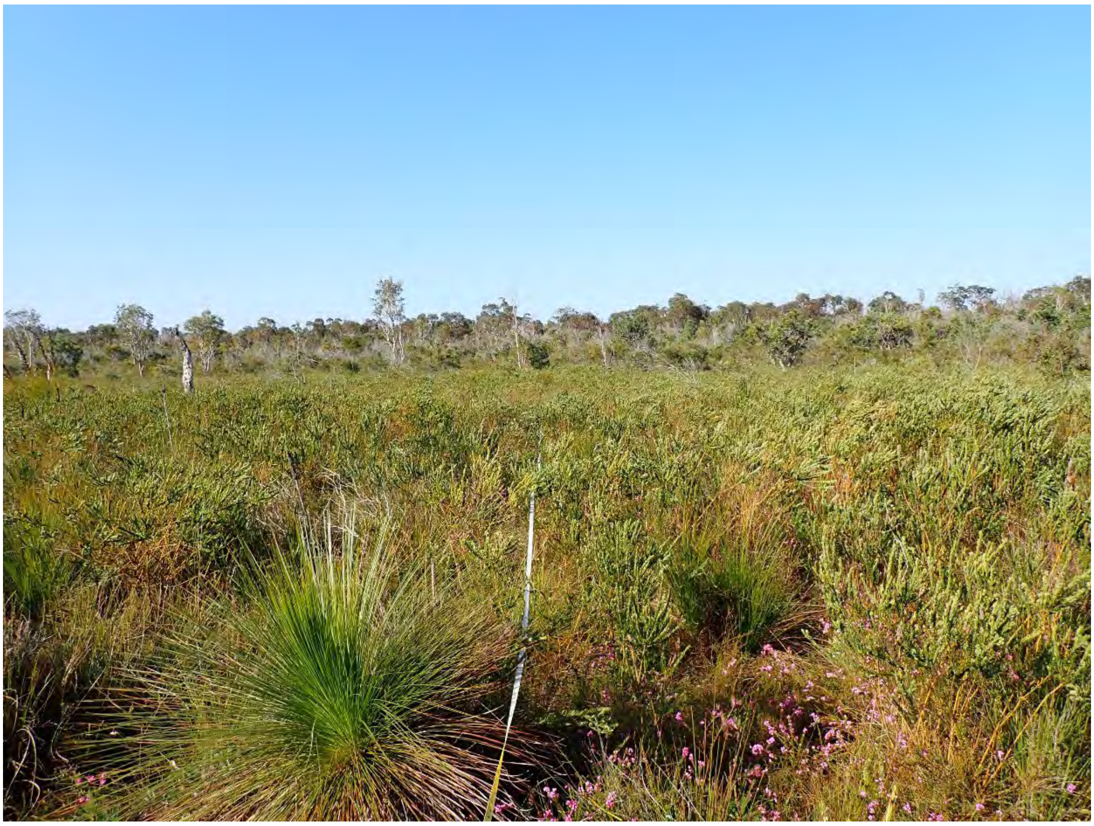
BioCondition Attribute		March 2023	October 022
	Forbs and other:	6	
Total Species No.**		31	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	16.6	17.0
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	22.0	2.0
Native Ground cover (%):	Native perennial grass / sedge cover (%):	29.5	28.1
	Native shrubs (%)	16.5	11.3
	Grass tree	18.6	19.5
	Organic litter cover (%):	29.25	38.1
	Native forb cover (%)	3.7	2.4
Coarse woody debris:	Total length (m) of debris ≥ 10cm diameter and ≥0.5m in length per hectare	0	0
Non-native plant cover	Non-native Grasses%	0	0
	Non-native shrubs %	0	0

** Excludes Exotic Species

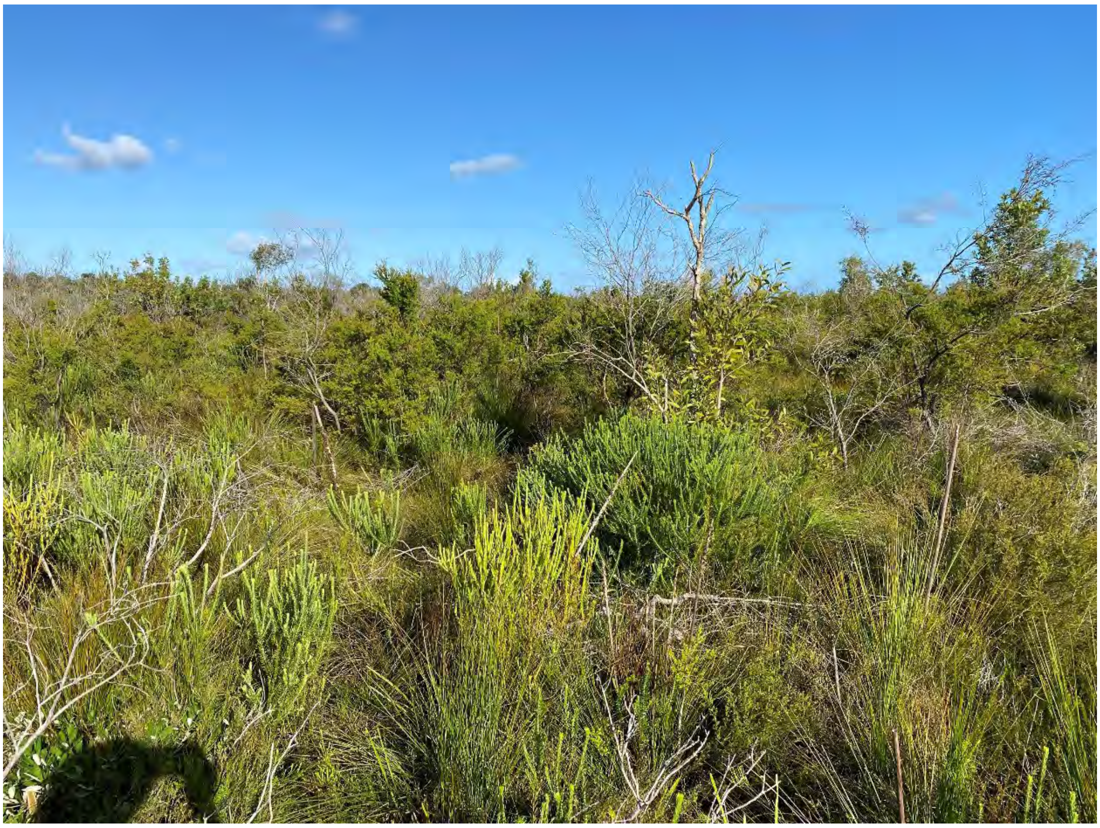
Plot 6b Centre to Start: March 2023 and September 2023 (Below)



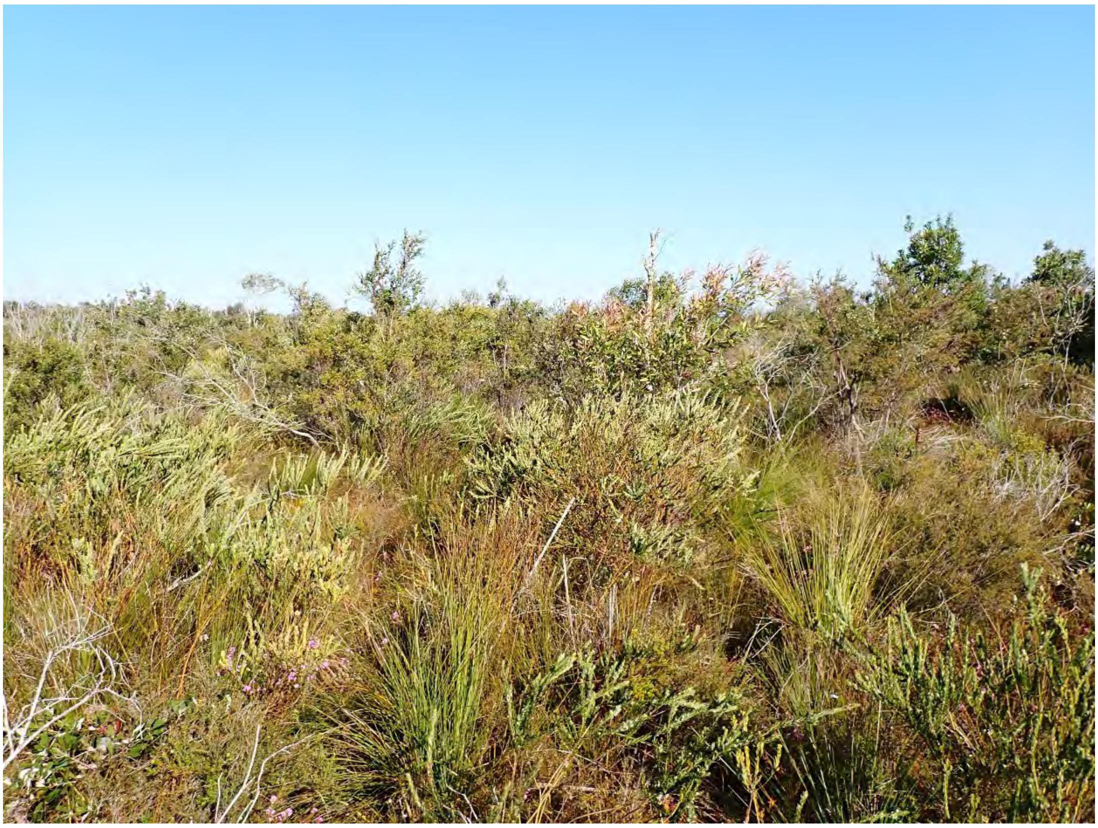
Plot 6b – Centre to End: March 2023 and September 2023 (Below)



Plot 6b – Centre to North: March 2023 and September 2023 (Below)



Plot 6b – Centre to South: March 2023 and September 2023 (Below).



Survey Locality 6c

Date of Assessment: 30.04.23 / 21.09.23
Plot Size:50 m linear transect (Canopy Cover); 50 x 4m transect for S2 shrubs >0.5m; 10 x 1m x 1m quadrats for Ground Cover.
Location (Plot Centreline): *Start* -26.9852/ 153.1541529; *Finish* -26.9849 / 153.1545859
Structure: Heath

Shrub Cover** – Canopy Intercept (>50cm) (summarised 50 m transect)

March 2023

	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
1.0 – 1.4	*Phyllota phylicoides*	0.4	1.0		
2.4 – 2.9	*Phyllota phylicoides*	0.5	1.0		
4.7 – 5.0	*Phyllota phylicoides*	0.3	1.0		
7.3 – 7.8	*Phyllota phylicoides*			0.5	0.8
8.2 – 8.7	*Phyllota phylicoides*	0.5	1.0		
10.1 – 10.8	*Phyllota phylicoides*	0.7	1.0		
12.7 – 14.1	*Baeckea frutescens*	1.4	1.0		
14.2 – 15.0	*Baeckea frutescens*	0.8	1.0		
15.0 – 16.3	*Boronia falcifolia*			1.3	0.7
16.8 – 21.1	*Phyllota phylicoides*	0.3	1.0		
22.3 – 23.8	*Phyllota phylicoides*	0.5	1.0		
22.5 – 23.8	*Melaleuca quinquenervia*	1.3	3.5		
24.5 – 25.6	*Phyllota phylicoides*	1.1	1.0		
26.5 - 27	*Phyllota phylicoides*	0.5	1.0		
30.1 – 31.6	*Leptospermum polygaliifolium*	0.5	1.5		
46.5 – 46.8	*Leucopogon leptospermoides*			0.3	0.6
48.7 – 50.0	*Banksia aemula*	0.3	4.0		
Total Cover		9.1		2.1	
Median Height			1.5		0.7

September 2023

	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
1.3 – 1.8	*Phyllota phylicoides*	0.5	1.0		
2.1 – 2.7	*Phyllota phylicoides*	0.6	1.0		
4.7 – 5.0	*Phyllota phylicoides*	0.3	1.0		
6.4 – 6.8	*Phyllota phylicoides*			0.4	0.8
7.2 – 7.7	*Phyllota phylicoides*			0.5	0
10.0 – 10.7	*Baeckea frutescens*	0.7	1.0		
13.5 – 15.0	*Baeckea frutescens*			1.5	0.8
15.9 – 16.1	*Boronia falcifolia*			0.2	0.7
18.5 – 20.3	*Phyllota phylicoides*	1.8	1.0		
21.6 – 22.0	*Phyllota phylicoides*	0.4	1.3		
22.0 – 23.1	*Phyllota phylicoides*	1.1	1.1		
22.3 – 23.8	*Melaleuca quinquenervia*	0.5	3.5		
24.0 – 25.6	*Banksia oblongifolia*			1.6	0.7
25.6 – 27.1	*Phyllota phylicoides*	0.5	1.0		

	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
30.2 – 31.6	*Leptospermum polygsliifolium*	1.4	1.5		
41.9 = 42.1	*Phyllota phylicoides*			0.2	0.6
42.1 – 43.3	*Boronia falcifolia*			1.2	0.6
46.1 – 46.7	*Leucopogon leptospermoides*			0.6	0.6
49.0 – 50.0	*Banksia aemula*	1.0	3.5		
Total Cover		8.8		6.2	
Median Height			2.5		0.7

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) March 2023	0 m x 4 m Stems (50x4m) September 2023
	S1 – S2	
Persoonia virgata		
Banksia oblongifolia	11	11
Leucopogon leptospermoides	4	11
Boronia falcifolia	16	146
Phyllota phylicoides	160	189
Baeckea frutescens	19	14
Leptospermum liversidgei	6	6
Leptospermum polygalifolium	12	8
Diiwynnia floriubunda	4	12
Melaleuca quinquenervia	1	1
Banksia aemula		1
Strangea linearis	1	2
Leptospermum semibaccatum		3
Totals	234	404

Ground Cover %- 1 x 1m Sub-plots

March 2023

Ground Cover Type	**Species**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Mean March 2023**
Native perennial grass / sedges	*Caustis recurvata*	20	5			10	2.5	10	2.5	25	25	
	Sporodanthus interruptus	10	25	25	30	15	30	15	10			28.45

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean March 2023
	Lomandra longifolia			2.5		1	2.5	1		2.5		
	Baloskion tenuiculme				5			10				
Native forbs and other spp.	*Pimelea liniifolia*		1	2.5	2.5	1	2.5		2.5		1	
	Cassytha glabella	1		1		2.5	1		2.5		1	
	Sellaginella uliginosa		1	2.5	5			2.5	2.5			
	Burchardia umbellata									2.5	1	
	Drosera binata											
	Pseudanthus orientalis											
	Gonocarpus micranthus											3.9
Native shrubs ,<1m	*Boronia*	5	5	2.5	10	5	5	5		5	10	
	Baeckea imbricata	5	1					1				
	Baeckea frutescens										10	
	Dyllwinia floribunda					2.5	5		2.5	2.5	2.5	
	Leucopogon leptospermoides				10		10					
	Persoonia virgata						2.5				1	
	Banksia oblongifolia		10						60	5		
	Strangea linearis	5			5							
	Leptospermum semibaccatum	10	5		2.5	5		1	1			
	Pyllota phylicoides										2.5	
	Agiortia pedicellata											
	Leptospermum polygaliifolium								1			
	Sprengelia sprengelioides	1		1								22.3
Grass Tree	*Xanthorrhoea fulva*	5	10			50	10	10	10	10	10	11.5
Bare Ground	Bare	5	10	10	20	2.5	5	2.5	0	0	0	5.5
Leaf litter	Leaf	33	27	53	10	5.5	24	42	5.5	47.5	36	28.35
Timber (>/= 10cm)												
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100%**

September 2023

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean March 2023
Native perennial grass / sedges	*Caustis recurvata*	10	2.5	10					5	2.5	10	
	Sporodanthus interruptus	40	45	10	10	15	25	10	10	20	20	
	Eriachne pallescens var. gracilis											
	Lomandra elongata											
	Lomandra longifolia		2.5			2.5	2.5			2.5		
	Baloskion tenuiculme							5				**26**
Native forbs and other spp.	*Pimelea liniifolia*		1				1	1	1		1	
	Cassytha glabella	1		1	1	1	1		1			
	Sellaginella uliginosa		1	1	5		1	1	2	1		
	Patersonia sericea				2.5							
	Burchardtia umbellata			1								
	Pseudanthus orientalis											**2.65**
Native shrubs ,<1m	*Boronia falcifolia*	2.5	5	10	2.5	2.5	2.5	10	1	1	5	
	Baeckea imbricata		1			2.5	1					
	Ochrosperma lineare		1			1	2.5					
	Dyllwinia floribunda			1		1	1	2.5	1	1		
	Leucopogon leptospermoides	1	1		10		2.5					
	Banksia oblongifolia		2.5	15				30	50	10		
	Strangea linearis	2.5			2.5							
	Homoranthus virgatus		1							2.5	1	
	Leptospermum semibaccatum	5		2.5	2.5	2.5		2.5	1	2.5	1	
	Persoonia virgata				1						1	
	Phyllota phylicoides										1	**21.25**
Grass Tree	*Xanthorrhoea fulva*	5	10		40	40	10			10	20	**13.5**
Bare Ground		0	0	0	15	0	5	2	0	0	0	**2.2**

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean March 2023
Leaf litter		33	26.5	48.5	8	32	45	36	28	47	40	**34.4**
Timber (>/= 10cm)												
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100%**

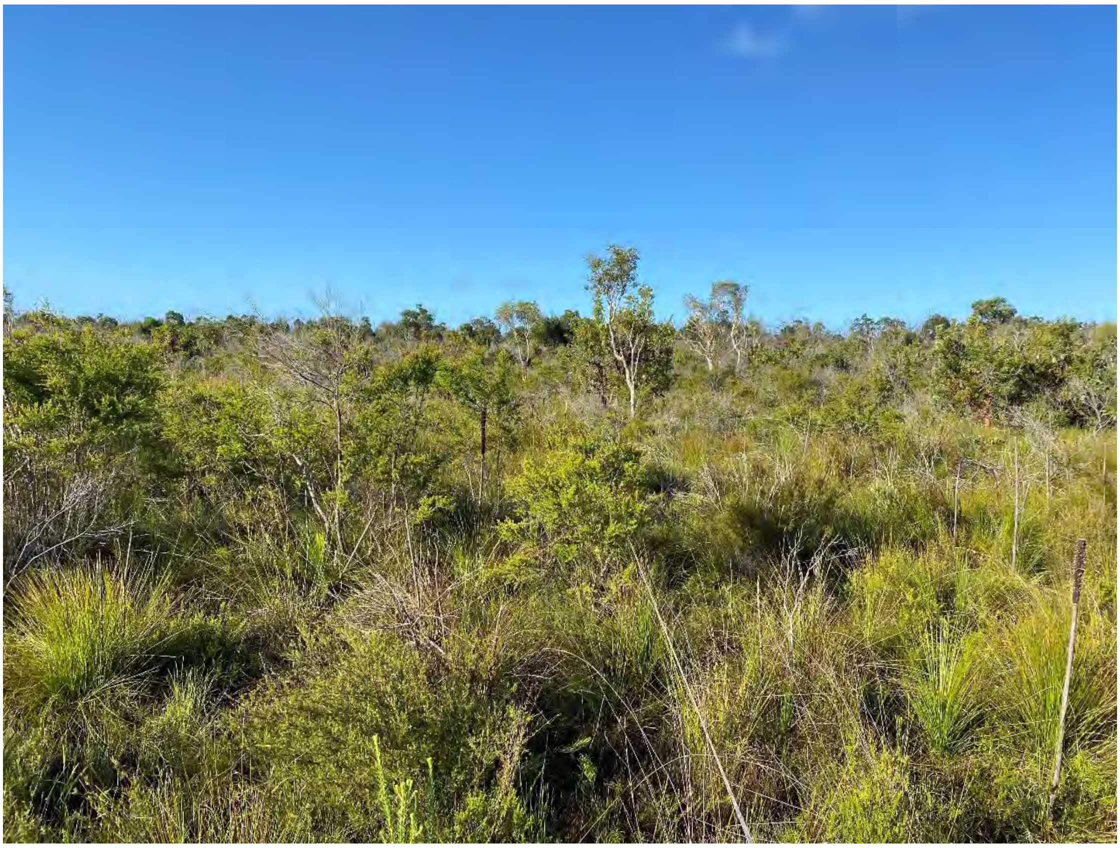
Additional Species: *Hypolaena fastigiata, Olax retusa*

Structural / Floristic Summary

BioCondition Attribute		March 2023	September 2023
Native Plant Species Richness	Tree:	.	.
	Shrub:	18	
	Grass Tree	1	
	Grass / Sedge	6	
	Forbs and other:	7	
Total Species No**		32	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	17.6	17.2
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	4.2	12.4
Native Ground cover (%):	Native perennial grass / sedge cover (%):	28.45	26.00
	Native shrubs (%)	22.3	21.25
	Grass tree	11.5	13.5
	Organic litter cover (%):	28.35	34.4
	Native forb cover (%)	3.9	2.65
Coarse woody debris:	Total length (m) of debris ≥ 10cm diameter and ≥0.5m in length per hectare	0	0
Non-native plant cover	Non-native Grasses%	0	0
	Non-native shrubs %	0	0

**Excludes Exotic Species

Plot 6c – Centre to Start: March 2023 (Above) and September 2023 (Below).



Plot 6c Centre to End – March 2023 (Above) and September 2023 (Below)..

Plot 6c – Centre to North: March 2023 (Above) and September 2023 (Below).

Plot 6c – Centre to South: March 2023 (Above) and September 2023 (Below).

Appendix B – Shrub Stem Counts per Survey Event

Month	Site	Survey Effort	Persoonia virgata	Banksia aemula	Banksia oblongifolia	Epacris pulchella	Leptospermum liversidgei	Leptospermum semibaccatum	Boronia falcifolia	Sprengelia sprengelioides	Leucopogon leptospermoides	Baeckea frutescens	Dilwynnia floribunda	Epacris obtusifolia	Olax retusa	Phyllota phylicoides	Leptospermum polygalifolium	Aotus lanigera	Strangea linearis	Conospermum taxifolium	Eleaocarpus reticulatus	Melaleuca quinquenervia	Pultenaea paleacea	Agiortia pedicellata	Total Stem Counts
Apr-16	Site 6	Event 1	93	2	86	13	125	6	97	26	15	60	8	13	3	12	9	2	0	0	1	2	0	0	**570**
Sep-16	Site 6	Event 2	91	2	50	4	101	0	103	3	17	31	3	11	0	0	8	2	1	1	1	3	0	0	**432**
Apr-17	Site 6	Event 3	87	2	41	2	75	0	43	1	9	23	3	0	0	0	6	10	0	0	1	2	0	0	**302**
Sep-17	Site 6	Event 4	95	2	41	1	64	0	87	0	8	19	0	1	0	1	9	8	0	0	1	1	0	0	**336**
Apr-18	Site 6	Event 5	99	3	43	0	76	0	62	5	10	33	5	2	0	19	9	2	0	0	1	2	0	0	**368**
Sep-18	Site 6	Event 6	81	3	22	8	58	0	50	6	8	14	0	2	0	0	3	10	0	0	1	3	0	2	**265**
Apr-19	Site 6	Event 7	85	3	34	0	42	2	39	0	6	26	2	0	0	10	17	0	0	0	3	2	0	3	**266**
Sep-19	Site 6	Event 8	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Apr-20	Site 6	Event 9	0	1	20	0	9	0	0	0	0	19	0	0	0	0	0	0	0	0	1	0	0	0	**49**
Nov-20	Site 6	Event 10	0	2	34	0	3	0	0	0	1	52	0	0	0	49	10	0	0	0	1	2	0	0	**151**
Apr-21	Site 6	Event 11	0	2	26	0	5	4	0	0	4	42	0	0	0	125	12	0	0	0	0	0	0	0	**220**
Sep-21	Site 6	Event 12	0	2	50	0	0	16	17	0	13	58	0	0	0	393	8	0	7	0	0	1	4	0	**569**
Apr-22	Site 6	Event 13	0	3	46	0	10	9	5	0	6	41	1	0	0	560	14	0	1	0	0	1	2	0	**699**
Oct-22	Site 6	Event 14	0	4	75	0	10	44	49	1	24	43	1	2	1	567	15	0	7	0	0	1	10	0	**854**
Mar-23	Site 6	Event 15	0	3	68	0	20	19	53	1	24	56	0	0	0	615	12	0	2	0	0	1	3	0	**877**
Sep-23	Site 6	Event 16	0	4	56	0	16	21	244	0	18	38	14	0	0	483	15	0	0	0	0	1	0	0	**910**

Month	Site	Survey Effort	Persoonia virgata	Agiortia pedicellata	Leucopogon leptospermoides	Ochrosperma lineare	Boronia falcifolia	Leptospermum semibaccatum	Dylwynnia floribunda	Sprengelia sprengelioides	Strangea linearis	Acacia flavescens	Epacris pulchella	Baeckea frutescens	Aotus lanigera	Xanthorhoea johnsonii	Leptospermum polygalifolium	Homoranthus virgatus	Melaleuca quinquenervia	Melaleuca pachyphyllus	Total Stems
Apr-16	Site 5	Event 1	124	0	32	6	6	14	0	1	6	1	3	4	1	3	0	0	0	0	**201**
Sep-16	Site 5	Event 2	129	0	17	0	5	10	0	0	3	1	3	1	0	1	0	0	0	0	**170**
Apr-17	Site 5	Event 3	137	4	19	0	1	4	0	0	5	1	0	1	0	1	0	0	0	0	**173**
Sep-17	Site 5	Event 4	119	2	27	1	1	13	0	0	4	1	2	1	0	1	1	2	0	0	**172**
Apr-18	Site 5	Event 5	119	9	24	0	1	18	4	0	2	1	0	7	0	1	3	0	1	1	**186**
Sep-18	Site 5	Event 6	111	7	16	0	0	9	0	0	0	1	0	1	0	1	3	0	0	1	**146**
Apr-19	Site 5	Event 7	47	6	16	0	0	18	0	0	1	1	1	3	0	2	4	0	1	1	**100**
Sep-19	Site 5	Event 8	24	10	12	0	0	16	0	0	1	1	0	2	0	2	2	0	1	1	**71**
Apr-20	Site 5	Event 9	11	14	11	0	0	14	0	0	2	1	1	5	0	1	1	0	1	0	**62**
Nov-20	Site 5	Event 10	8	12	7	0	0	6	0	0	2	1	0	5	0	1	3	0	1	0	**46**
Apr-21	Site 5	Event 11	3	9	9	0	0	15	0	0	1	1	0	6	0	1	6	0	1	1	**53**
Sep-21	Site 5	Event 12	1	9	6	2	0	14	0	0	2	1	0	1	0	1	6	0	1	1	**45**
Apr-22	Site 5	Event 13	3	14	8	2	0	29	1	0	2	1	0	7	0	1	11	0	5	1	**85**
Oct-22	Site 5	Event 14	1	14	10	2	2	69	0	0	6	1	0	16	0	1	10	9	2	3	**146**
Mar-23	Site 5	Event 15	2	10	13	0	2	78	1	0	3	1	0	15	0	3	6	6	5	1	**146**
Sep-23	Site 5	Event 16	2	11	6	0	4	60	0	0	0	1	0	3	0	3	7	2	5	1	**105**

Appendix C – Pearson Correlation Analysis for Stem Counts, CRD and Species Richness

IP5_Pearson Corellation

	CRD vs. Persoonia virgata	CRD vs. Agiortia pedicellata	CRD vs. Leucopogon leptospermoides	CRD vs. Ochrosperma lineare	CRD vs. Boronia falcifolia	CRD vs. Leptospermum semibaccatum	CRD vs. Dylwynnia floribunda	CRD vs. Sprengelia sprengelioides	CRD vs. Strangea linearis	CRD vs. Acacia flavescens	CRD vs. Epacris pulchella	CRD vs. Baeckea frutescens	CRD vs. Aotus lanigera	CRD vs. Xanthorhoea johnsonii	CRD vs. Leptospermum polygalifolium	CRD vs. Homoranthus virgatus	CRD vs. Melaleuca quinquenervia	CRD vs. Melaleuca pachyphyllus	CRD vs. Total Stems
Pearson r																			
r	-0.1345	0.1761	-0.03599	0.3073	0.4172	0.7579	0.08580	0.07844	0.4878	0.3941	0.03674	0.6677	0.07844	0.1285	0.5921	0.7261	0.5797	0.5036	0.3849
95% confidence interval	-0.5908 to 0.3871	-0.3501 to 0.6179	-0.5224 to 0.4681	-0.2223 to 0.6968	-0.09896 to 0.7565	0.4199 to 0.9112	-0.4281 to 0.5578	-0.4341 to 0.5527	-0.01049 to 0.7920	-0.1262 to 0.7444	-0.4675 to 0.5229	0.2572 to 0.8741	-0.4341 to 0.5527	-0.3922 to 0.5868	0.1365 to 0.8410	0.3600 to 0.8984	0.1178 to 0.8353	0.01055 to 0.7997	-0.1370 to 0.7395
R squared	0.01808	0.03102	0.001295	0.09441	0.1741	0.5744	0.007362	0.006154	0.2379	0.1554	0.001349	0.4459	0.006154	0.01650	0.3506	0.5272	0.3360	0.2536	0.1481
P values																			
P (two-tailed)	0.6196	0.5141	0.8947	0.2470	0.1079	0.0007	0.7520	0.7728	0.0553	0.1309	0.8926	0.0047	0.7728	0.6354	0.0157	0.0014	0.0186	0.0467	0.1410
P value summary	ns	ns	ns	ns	ns	***	ns	ns	ns	ns	ns	**	ns	ns	*	**	*	*	ns

Significant? (alpha = 0.05)	No	No	No	No	No	Yes	No	No	No	No	No	Yes	No	No	Yes	Yes	Yes	Yes	No
Number of XY Pairs	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

IP6_Pearson Corellation

	CRD vs. **Persoonia virgata**	**CRD** vs. **Banksia aemula**	**CRD** vs. **Banksia oblongifolia**	**CRD** vs. **Epacris pulchella**	**CRD** vs. **Leptospermum liversidgei**	**CRD** vs. **Leptospermum semibaccatum**	**CRD** vs. **Boronia falcifolia**	**CRD** vs. **Sprengelia sprengelioides**	**CRD** vs. **Leucopogon leptospermoides**	**CRD** vs. **Baeckea frutescens**	**CRD** vs. **Dilwynnia floribunda**	**CRD** vs. **Epacris obtusifolia**	**CRD** vs. **Olax retusa**	**CRD** vs. **Phyllota phylicoides**	**CRD**vs. **Leptospermum polygalifolium**	**CRD** vs. **Aotus lanigera**	**CRD** vs. **Strangea linearis**	**CRD** vs. **Conospermum taxifolium**	**CRD** vs. **Eleaocarpus reticulatus**	**CRD** vs. **Melaleuca quinquenervia**	**CRD** vs. **Pultenaea paleacea**	**CRD** vs. **Agiortia pedicellata**	**CRD** vs. **Total Counts**
Pearson r																							
r	-0.1445	0.6858	0.7110	0.02500	0.05464	0.7295	0.3830	0.08472	0.7520	0.3600	0.4457	0.1983	0.2643	0.7381	0.5401	-0.1402	0.3780	0.1248	-0.3931	0.03293	0.6246	-0.2590	0.8518
95% confidence interval	-0.5974 to 0.3783	0.2881 to 0.8818	0.3325 to 0.8923	-0.4766 to 0.5143	-0.4533 to 0.5358	0.3663 to 0.8998	-0.1391 to 0.7385	-0.4290 to 0.5570	0.4086 to 0.9089	-0.1652 to 0.7261	-0.06422 to 0.7710	-0.3298 to 0.6319	-0.2663 to 0.6720	0.3822 to 0.9033	0.06060 to 0.8170	-0.5946 to 0.3821	-0.1449 to 0.7358	-0.3954 to 0.5844	-0.7439 to 0.1274	-0.4705 to 0.5201	0.1867 to 0.8554	-0.6688 to 0.2716	0.6162 to 0.9474
R squared	0.02087	0.4704	0.5056	0.0006251	0.002986	0.5322	0.1467	0.007178	0.5655	0.1296	0.1986	0.03934	0.06984	0.5447	0.2917	0.01965	0.1429	0.01557	0.1545	0.001085	0.3901	0.06707	0.7255
P value																							

P (two-tailed)	0.5935	0.0034	0.0020	0.9268	0.8407	0.0013	0.1431	0.7551	0.0008	0.1708	0.0836	0.4615	0.3226	0.0011	0.0308	0.6046	0.1489	0.6451	0.1320	0.9036	0.0097	0.3328	<0.0001
P value summary	ns	**	**	ns	ns	**	ns	ns	***	ns	ns	ns	ns	**	*	ns	ns	ns	ns	ns	**	ns	****
Significant? (alpha = 0.05)	No	Yes	Yes	No	No	Yes	No	No	Yes	No	No	No	No	Yes	Yes	No	No	No	No	No	Yes	No	Yes
Num. of XY Pairs	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

Simple Linear Regression / Correlation of Stem Counts and CRD_IP6	**Total Stem Counts**
Best-fit values	
Slope	0.6117
Y-intercept	205.1
X-intercept	-335.3
1/slope	1.635
Std. Error	
Slope	0.1006
Y-intercept	53.94
95% Confidence Intervals	
Slope	0.3960 to 0.8274
Y-intercept	89.41 to 320.8
X-intercept	-754.7 to -116.0
Goodness of Fit	
R squared	0.7255
Sy.x	156.4
Is slope significantly non-zero?	
F	37.00
DFn, DFd	1, 14
P value	<0.0001
Deviation from zero?	Significant
Equation	Y = 0.6117*X + 205.1
Data	
Number of X values	16
Maximum number of Y replicates	1
Total number of values	16
Number of missing values	0

Simple Linear Regression / Correlation of Stem Counts and CRD_CP5	Total Stems
Best-fit values	
Slope	0.05311
Y-intercept	100.6
X-intercept	-1894
1/slope	18.83
Std. Error	
Slope	0.03404
Y-intercept	18.26
95% Confidence Intervals	
Slope	-0.01990 to 0.1261
Y-intercept	61.41 to 139.7
X-intercept	-infinity to -537.3
Goodness of Fit	
R squared	0.1481
Sy.x	52.93
Is slope significantly non-zero?	
F	2.434
DFn, DFd	1, 14
P value	0.1410
Deviation from zero?	Not Significant
Equation	Y = 0.05311*X + 100.6
Data	
Number of X values	16
Maximum number of Y replicates	1
Total number of values	16
Number of missing values	0

Appendix D – Site / Species Table

Habit	Fire Regeneration Strategy	Family	Species	Site 6_Presence / Absence March 2023	Site 5_Presence / Absence March 2023	Site 6_Presence / Absence Sept 2023	Site 5_Presence / Absence Sept 2023
Forb	Resprouter	Blechnaceae	*Blechnum cartiligineum*	*0*	*0*	*0*	*1*
Forb	Resprouter	Colchicaceae	*Burchardia umbellata*	*1*	*1*	*1*	*1*
Forb	Obligate Seeder	Lauraceae	*Cassytha glabella*	*1*	*1*	*1*	*1*
Forb	Resprouter	Polygalaceae	*Commosperma sphaericum*	*1*	*1*	*0*	*0*
Forb	Resprouter	Orchidaceae	*Cryptostylis erecta*	*0*	*0*	*1*	*0*
Forb	Obligate Seeder	Droseraceae	*Drosera binata*	*0*	*1*	*0*	*1*
Forb	Obligate Seeder	Haloragaceae	*Gonocarpus micranthus*	*1*	*1*	*1*	*0*
Forb	Obligate Seeder	Dilleniaceae	*Hibbertia acicularis*	*0*	*0*	*0*	*0*
Forb	Obligate Seeder	Dilleniaceae	*Hibbertia salicifolia*	*1*	*1*	*1*	*1*
Forb	Obligate Seeder	Laxmanniaceae	*Laxmannia compacta*	*0*	*0*	*1*	*1*
Forb	Resprouter	Orchidaceae	*Microtus parviflora*	*0*	*0*	*0*	*0*
Forb	Obligate Seeder	Fabaceae	*Mirbellia rubiifolia*	*0*	*0*	*1*	*1*
Forb	Resprouter	Loganiaceae	*Mitrasacme alsinoides*	*0*	*0*	*0*	*1*
Forb	Resprouter	Iridaceae	*Patersonia sericea (fragilis)*	*1*	*0*	*1*	*1*
Forb	Resprouter	Thymeleaceae	*Pimelea linifolia*	*1*	*1*	*1*	*1*
Forb	Obligate Seeder	Picrodendraceae	*Pseudanthus orientalis*	*0*	*0*	*1*	*1*
Forb	Resprouter	Selaginellaceae	*Selaginella uliginosa*	*1*	*1*	*0*	*0*
Forb	Resprouter	Laxmanniaceae	*Sowerbaea juncea*	*0*	*0*	*0*	*0*
Forb	Resprouter	Stackhousiaceae	*Stackhousia nuda*	*0*	*0*	*0*	*0*
Forb	Resprouter	Stylidiaceae	*Stylidium trichopodom*	*0*	*0*	*0*	*0*
Forb	Resprouter	Xyridaceae	*Xyris complanata*	*0*	*0*	*0*	*0*
Grass	Resprouter	Poaceae	*Eriachne pallescens var. gracillis*	*0*	*0*	*1*	*1*
Grass	Resprouter	Poaceae	*Themeda triandra*	*0*	*0*	*0*	*0*
Grass tree	Resprouter	Xanthorrhoeaceae	*Xanthorrhoea fulva*	*1*	*1*	*1*	*1*
Grass tree	Resprouter	Xanthorrhoeaceae	*Xanthorrhoea johnsonii*	*0*	*0*	*1*	*1*
Sedge / Rush	Resprouter	Restionaceae	*Baloskion heterophylla*	*0*	*0*	*0*	*0*

Habit	Fire Regeneration Strategy	Family	Species	Site 6_Presence / Absence March 2023	Site 5_Presence / Absence March 2023	Site 6_Presence / Absence Sept 2023	Site 5_Presence / Absence Sept 2023
Sedge / Rush	Resprouter	Restionaceae	*Baloskion tenuiculme*	*1*	*1*	*1*	*1*
Sedge / Rush	Resprouter	Restionaceae	*Caustis recurvata*	*1*	*1*	*1*	*1*
Sedge / Rush	Resprouter	Cyperaceae	*Cyperus sp. (gracilis?)*	*0*	*0*	*0*	*0*
Sedge / Rush	Resprouter	Cyperaceae	*Gahnia seiberiana*	*0*	*0*	*1*	*1*
Sedge / Rush	Resprouter	Cyperaceae	*Hypolaena fastigiata*	*1*	*1*	*1*	*1*
Sedge / Rush	Resprouter	Restionaceae	*Leptocarpus tenax*	*0*	*0*	*0*	*0*
Sedge / Rush	Resprouter	Laxmanniaceae	*Lomandra elongata*	*1*	*1*	*1*	*1*
Sedge / Rush	Resprouter	Laxmanniaceae	*Lomandra longifolia*	*1*	*1*	*1*	*1*
Sedge / Rush	Resprouter	Cyperaceae	*Schoenus calostachys*	*0*	*0*	*0*	*0*
Sedge / Rush	Resprouter	Cyperaceae	*Schoenus scabripes*	*0*	*0*	*0*	*0*
Sedge / Rush	Resprouter	Restionaceae	*Sporodanthus interuptus*	*1*	*1*	*1*	*1*
Shrub	Obligate Seeder	Mimosaceae	*Acacia baueri*	*0*	*0*	*1*	*1*
Shrub	Obligate Seeder	Mimosaceae	*Acacia flavesecens*	*0*	*0*	*1*	*1*
Shrub	Resprouter	Ericaceae	*Agiortia pedicellata*	*0*	*0*	*1*	*1*
Shrub	Obligate Seeder	Fabaceae	*Aotus lanigera*	*0*	*0*	*0*	*0*
Shrub	Resprouter	Myrtaceae	*Austromyrtus dulcis*	*0*	*0*	*0*	*0*
Shrub	Resprouter	Myrtaceae	*Baeckea frutescens*	*1*	*1*	*1*	*1*
Shrub	Resprouter	Myrtaceae	*Baeckea imbricata*	*1*	*1*	*1*	*0*
Shrub	Resprouter	Proteaceae	*Banksia aemula*	*1*	*1*	*1*	*1*
Shrub	Resprouter	Proteaceae	*Banksia oblongifolia*	*1*	*1*	*0*	*0*
Shrub	Resprouter	Rutaceae	*Boronia falcifolia*	*1*	*1*	*1*	*1*
Shrub	Resprouter	Proteaceae	*Conospermum taxifolium*	*0*	*0*	*0*	*0*
Shrub	Obligate Seeder	Fabaceae	*Dillwynia floribunda*	*1*	*1*	*1*	*1*
Shrub	Obligate Seeder	Ericaceae	*Epacris obtusifolia*	*1*	*0*	*1*	*1*
Shrub	Obligate Seeder	Ericaceae	*Epacris pulchella*	*1*	*1*	*1*	*1*

Habit	Fire Regeneration Strategy	Family	Species	Site 6_Presence / Absence March 2023	Site 5_Presence / Absence March 2023	Site 6_Presence / Absence Sept 2023	Site 5_Presence / Absence Sept 2023
Shrub	Obligate Seeder	Myrtaceae	*Homoranthus virgatus*	*1*	*0*	*1*	*1*
Shrub	Resprouter	Myrtaceae	*Leptospermum liversidgei*	*1*	*1*	*0*	*0*
Shrub	Resprouter	Myrtaceae	*Leptospermum polygalifolium*	*1*	*1*	*1*	*1*
Shrub	Resprouter	Myrtaceae	*Leptospermum semibaccatum*	*1*	*1*	*1*	*1*
Shrub	Resprouter	Ericaceae	*Leucopogon leptospermoides*	*1*	*1*	*1*	*1*
Shrub	Obligate Seeder	Myrtaceae	*Melaleuca pachyphyllus*	*0*	*0*	*1*	*1*
Shrub	Resprouter	Myrtaceae	*Melaleuca quinquenervia*	*1*	*1*	*1*	*1*
Shrub	Obligate Seeder	Myrtaceae	*Ochrosperma lineare*	*1*	*1*	*1*	*1*
Shrub	Resprouter	Olacaceae	*Olax retusa*	*1*	*1*	*1*	*1*
Shrub	Obligate Seeder	Proteaceae	*Persoonia virgata*	*1*	*1*	*1*	*1*
Shrub	Obligate Seeder	Fabaceae	*Phyllota phylicoides*	*1*	*1*	*0*	*0*
Shrub	Obligate Seeder	Fabaceae	*Pultenaea paleacea*	*1*	*1*	*0*	*0*
Shrub	Obligate Seeder	Fabaceae	*Pultenaea robusta*	*0*	*0*	*0*	*0*
Shrub	Obligate Seeder	Ericaceae	*Sprengelia sprengelioides*	*1*	*1*	*0*	*1*
Shrub	Obligate Seeder	Proteaceae	*Strangea linearis*	*1*	*1*	*1*	*1*
Tree	Resprouter	Elaeocarpaceae	*Elaeocarpus reticulatus*	*0*	*0*	*0*	*0*

? indicates a low level of confidence on regeneration strategies.

Appendix B – Groundwater Dependent Ecosystems (GDE) Vegetation Surveys – Peer Review

Refer to below *Peer Review of Bribie Island Borefield Groundwater Dependent Ecosystems - Annual Vegetation Monitoring Report – 2023, by 3D Environmental* by Paul Williams, Principal Hydrogeologist at Paul Williams & Associates Pty Ltd (Prepared 28/11/2023)

Peer Review of Bribie Island Borefield Groundwater Dependent Ecosystems - Annual Vegetation Monitoring Report – 2023, by 3D Environmental

Overview

The Bribie island heath monitoring discussed n this report is now a significant long term database with fire and soil moisture implications for a broad area of coastal south east Queensland.

This 2023 survey and report provide a further instalment to a significant long term heath monitoring project. The dataset is especially valuable because it combines rainfall and soil moisture profiles with species abundance fluctuations. The uniqueness of the data is further enhanced by before and after wildfire data for half of the transects.

The 2023 data further supports the evidence that species composition and richness of wet heath vegetation on Bribie Island, and presumably the Cooloola Coast and adjacent sand islands, is primarily governed by rainfall and associated topsoil moisture profiles. This will need to be taken into consideration if any water extraction is planned.

This report is well written, the data is well summarised, the statistics are valid and the conclusions are supported by the data.

I have added suggestions to a version of the report with “tracked changes”.

Specific comments

Introduction Section 1.4 August 2019 wildfire: It would be interesting to consider the effect of the dry conditions on wildfire intensity and therefore what potential effect on fire behaviour the future water extraction may have due to its influence on foliage dryness.

Results Section:

Section 3.2 shrub cover: Have you observed when Phyllota plants started flowering or seeding - e.g. 3 years after fire?

Figure 7: I assume the “2021” should be removed from the title above the IPs graph.

It is interesting that the cover in the IPs has still not yet returned to pre-fire levels at 4 years post-fire. Yet the post-fire shrub cover in IPs is much better than in the CPs, which suggests the fire has helped promote shrub cover – presumably Phyllota contributes considerably to this.

A few thoughts from the raw data in the appendices:

Leptospermum liversidgei did not germinate after the August 2019, until April 2022.This suggests its recruitment may benefit from bare areas but is stimulated by good rainfall events rather than fire (as are plenty of subtropical & tropical eucalypts).

Phyllota may have peaked in stem density at 4 years after fire recruitment.

Boronia is another that appears to have increased after fire to a density greater than any pre-fire numbers.

Shrubs that seem to have populations maintained by fire (i.e. declined over time without fire but returned to roughly earlier densities) include Leucopogon leptospermoides and Dillwynia floribunda.

All the Leptospermums species seem to respond well to wet years and do better without fire. Does this mean the ecosystem requires fire to limit the smothering dominance of Leptospermums? Without taking too much time, does the cover of taller Leptospermums become significantly high at the possible expense of other plant's persistence?

Paul Williams

28 November 2023