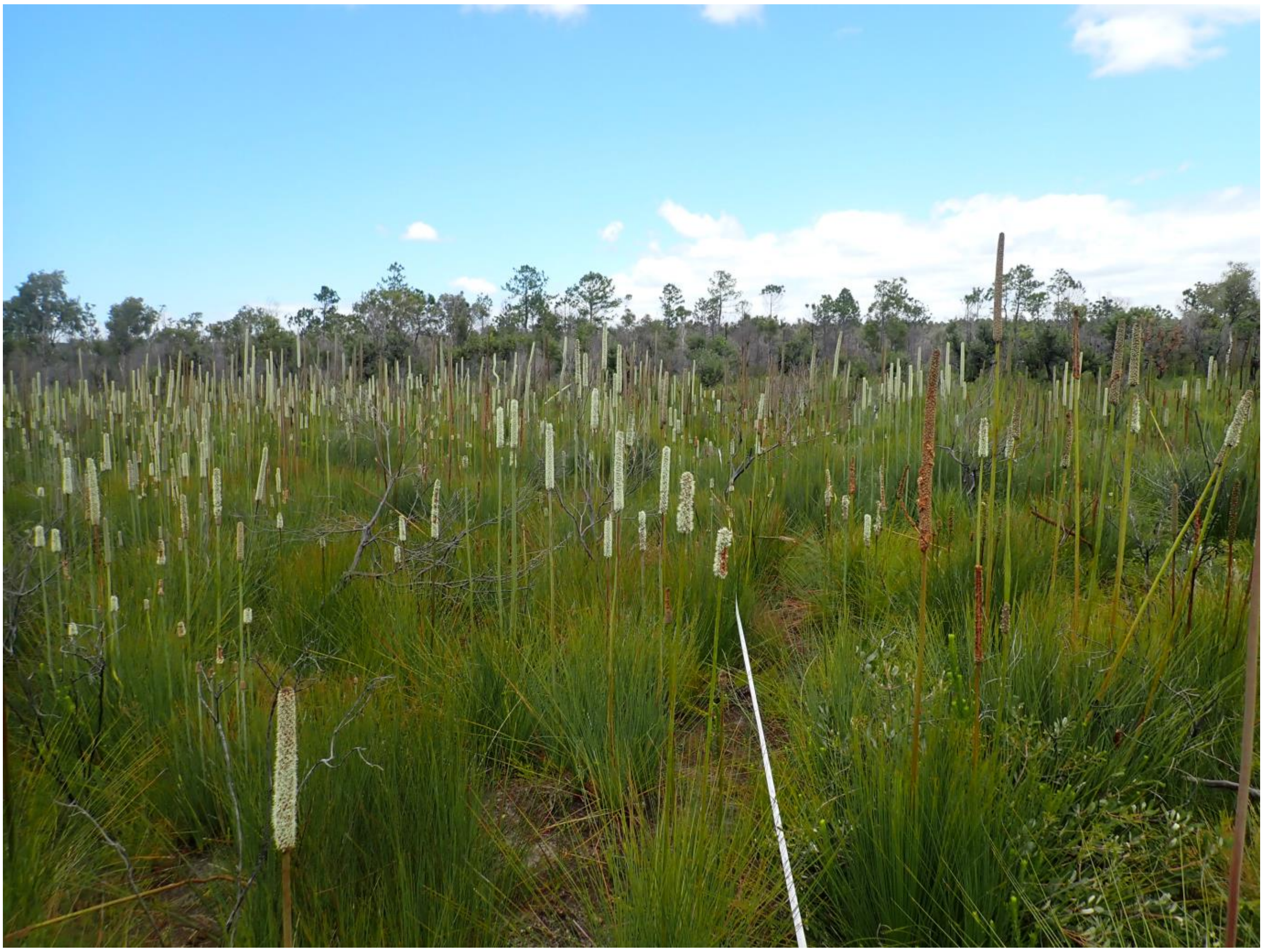
Banksia Beach Borefield
Annual Monitoring Report 2021 - 2022



Revision 1 | December 2022

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Name/Department	Title/group
The Commonwealth Department of Climate Change, Energy, the Environment and Water	EPBC Monitoring

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Reviewer		
Date	**Name**	**Position**
30/11/2022	Ashleigh Muir	Senior Environmental Advisor

Approved for issue			
Date	**Name**	**Position**	**Signature**
30/11/2022	Jamie Richters	Principal Environment Heritage and Land Use Planning	

Contents

Executive Summary

This annual compliance report encompasses the reporting period between 1/09/2021 – 31/08/2022, which is the eighth monitoring period of operation and management of the Banksia Beach Water Treatment Plant (WTP) and Borefield under the Borefield Environmental Management Plan (BEMP). This report addresses the requirements of conditions applied to the Project under the *Environmental Protection and Biodiversity Conservation Act 1999 (*EPBC Act).

During this reporting period all 6 conditions for the controlled action were active. The Banksia Beach WTP has not been operational since April 2014 and has subsequently triggered the cold standby shutdown (shutdown >12months) monitoring and sampling regime as outlined within the BEMP. As such, no extraction from the Borefield has occurred. The conditions active during this reporting period have been assessed for compliance. A summary of the results is presented in Table 1 and more detailed descriptions of the compliance assessment are presented in Sections 3.1 - 3.6.

The outcomes of the compliance assessment indicate no instances during this reporting period of any significant impact on EPBC Act listed species. All ongoing active EPBC conditions of approval will continue to be implemented during the operational phase of Banksia Beach Water Treatment Plant and Borefield.

1. Introduction

The Queensland Government mandated the implementation of a series of water infrastructure projects as part of a regional drought management strategy in response to the millennium drought (2001-2009) and the lack of security of potable water supplies in South East Queensland (SEQ). In 2006 the Queensland *Water Regulation 2002* was amended to include bulk water supply service objectives and provisions around Seqwater's water security program. The objective of the amendment was to ensure the security of essential drinking water supplies for the SEQ community in response to the projected regional urban demand. The *Water Regulation 2002* listed specific measures and outcomes to be achieved including the development of underground water resources at Bribie Island and in the area around Brisbane. Schedule 10B prescribed that necessary steps must be taken to make a substitution of 10 megalitres (ML) of water per day from the existing water supply system with underground water sourced from Bribie Island, with the action to be completed by 31 December 2007.

Subsequent investigations of the aquifer and groundwater modelling for Bribie Island demonstrated that the sustainable combined production level at the proposed Banksia Beach WTP and the then existing Woorim WTP was limited to approximately 8 ML/d. The Queensland Government acknowledged this and the proposed extraction rate for the northern and southern borefields was formally revised in November 2007 to 5 ML/day. The Banksia Beach WTP was designed for the production of water not exceeding 4.32 ML/day (annual daily average) at a maximum daily rate of 5ML/day and totaling no more than 1580ML/year. The Woorim WTP was decommissioned in 2008 by Seqwater due to poor infrastructure condition and poor source water quality.

As the proposed Banksia Beach WTP and associated borefield was located in close proximity to known National Matters of Environmental Significance (NMES), the Project was referred to the Commonwealth Department of the Environment and Water Resources (DEWR) under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). The Department has been subsequently renamed and is herein referred to as the Department of Climate Change, Energy, the Environment and Water (DCCEEW). The Department subsequently declared the Project a *controlled action* under the EPBC Act section 95a under the controlling provision – Wetlands of international importance (sections 16 and 17B).

Conditional approval was granted in June 2007 for the construction and operation of the WTP and borefield under Development Approval 2007/3396. As per the approval conditions, Seqwater implemented a Borefield Environmental Management Plan (BEMP). The BEMP ensures the protection of sensitive ecological communities, including the Ramsar Wetland, and careful management and monitoring of groundwater levels and quality. Seqwater's BEMP aims to ensure long-term sustainability of the Groundwater Development Unit (GDU) and associated Groundwater Dependent Ecosystems (GDEs). The Banksia Beach WTP has not been operational since April 2014 and has subsequently triggered the cold standby (shutdown >12months) reduced monitoring program as outlined within the BEMP.

The BEMP has undergone a number of reviews and amendments which were approved by the relevant Commonwealth Department at the time of submission. Following the three-year detailed monitoring program review, the EPBC approval conditions were amended, and the new conditions were activated on 17/04/2015. During the current reporting period an amendment to the BEMP was approved by the Department for the removal of the NDVI image capture and analysis data for future monitoring events. This requirement was removed as it did not have any significant ongoing utility in the assessment of floristic composition, nor structural diversity in the wet heath habitats that are the subject of this assessment. The Department approved the amended BEMP on 20/05/2022. This report is the eighth annual compliance report and demonstrates the compliance with relevant approval conditions between 1/09/2021 – 31/08/2022.

2. Summary of Current Monitoring Requirements

The Banksia Beach WTP has not been operational since April 2014. The BEMP was amended in March 2016 to include changes when the Banksia Beach WTP is in cold standby shutdown (shutdown >12months). These changes include:

- No quarterly operational reports
- No Community Reference Group meetings unless specific issues arise
- No Standing Water Level and Electrical Conductivity monitoring
- No quarterly assessment of meteorological data.

During this reporting period, the DCCEEW approved an amendment to the BEMP to discontinue the Normalised Difference Vegetation Index (NDVI) data capture. This change was recommended as the NDVI data has not demonstrated to have any significant ongoing utility in the assessment of floristic composition, nor structural diversity in the wet heath habitats that are the subject of this assessment.

Table 1 outlines the current Ecological monitoring required during cold standby periods.

Table 1 Monitoring Program during cold standby

	Monitoring Type	Frequency (during cold standby)
Ecological Monitoring Program	Vegetation transect 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 submersible data logger. Continue until baseline is established*

** Baseline is established once information from any future differential changes can be statistically assessed. Once baseline has been established then this should be presented in the Annual Compliance Report outlining the details on how baseline has been determined.*

3. Conditions of Compliance

To demonstrate compliance with the individual EPBC Act conditions of approval, Table 1 summarises each condition number as per the Variation to Conditions of Approval Letter (dated 10/04/2015). The status of the condition compliance has been provided as well as a summary of condition compliance status. Further details of compliance status have been provided below this table. Refer to Appendix 6 for a copy of the Variation to Conditions of Approval Letter.

Table 1: Reference Table for EPBC Act Controlled Action Conditions

Condition Number	Condition/Requirement	Status	Compliance assessment
EPBC 1	The approval holder must submit for approval by the Minister a BEMP designed to protect the ecological character of the Moreton Bay Ramsar wetlands. Once approved, the BEMP must be implemented. The approved BEMP must be published on the approval holder's website, with a location and/or metadata that enables easy discovery by relevant web searches, within one month of approval by the Minister. The approval holder must notify the Department within 5 business days of publishing the BEMP on its website. The BEMP must remain on the website for the period the approval has effect.	Ongoing	Compliant* *See section 3.1 for details
EPBC 2	In accordance with the yield identified in the BEMP, the approval holder must limit groundwater extraction from the Northern Borefield to no greater than an annual average of 4.32ML/day, at a maximum daily rate of 5ML/day and totalling no more than 1580ML/year, subject to the requirements of conditions 1,4 & 5.	Ongoing	Compliant.
EPBC 3	The approval holder must maintain accurate records of all measures taken to implement the BEMP according to conditions of this approval, and must make these records available to the Department on request. Within 3 months of every anniversary of the commencement of the action, the approval holder must publish a Compliance Report on its website addressing the implementation of the BEMP. The approval holder must also notify of any non-compliance with this approval to the Department in writing within 10 business days of becoming aware of the non-compliance. The approval holder must continue to annually publish the Compliance Report until such time as agreed in writing by the Minister. Such records may be subject to audit by the Department or be used to verify compliance with the conditions of the approval.	Ongoing	Non-compliant (partial data gaps)
EPBC 4	If the approval holder wishes to carry out any activity otherwise than in accordance with the BEMP, the person taking the action must submit to the Department for the Minister's written approval a revised version of the BEMP. The varied activity shall not commence until the Minister has approved the revised plan in writing. If the Minister approves the revised plan, that plan must be implemented in place of the plan originally approved. All revised plans approved by the Minister must be published on the approval holder's website within one month of their approval by the Minister.	Noted – general obligation condition	Compliant.
EPBC 5	If the Minister believes that it is necessary or convenient for the better protection of the relevant matters of environmental significance to do so, the Minister may request the approval holder to make specific revisions to the BEMP and submit the revised plan for the Minister's written approval. Once approved, the revised plan must be implemented. Unless the Minister has approved the revised plan, the approval holder must continue to implement the originally approved BEMP, as specified in the conditions.	Noted – general obligation condition	Compliant.
EPBC 6	Upon the direction of the Minister, the approval holder must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the Minister. The independent auditor and audit criteria must be approved by the Minister prior to the commencement of the audit. The audit report must address the criteria to the satisfaction of the Minister.	Noted – general obligation condition	Compliant.

3.1 EPBC Condition 1

Following the receipt of the Variation to Conditions approvals notice in August 2015 Seqwater implemented the BEMP, which was published on Seqwater's website on in September 2015 within one month of receiving the approval from the Department. Notification to the Department occurred within 5 days of publishing the BEMP on Seqwater's website.

The BEMP was subsequently amended in March 2016 to include changes when the Banksia Beach WTP is in cold standby shutdown (shutdown >12months). The BEMP was published on Seqwater's website in March 2016 within one month of receiving approval from the Department. Notification to the Department occurred within 5 days of publishing the BEMP on Seqwater's website.

In July 2021 Seqwater submitted a request to the Department to remove the requirement for annual assessment of changes in vegetation across Bribie Island, utilising remote sensing methods (NDVI image capture and analysis), from the approved BEMP. This change was recommended as the NDVI data has not demonstrated to have any significant ongoing utility in the assessment of floristic composition, nor structural diversity in the wet heath habitats that are the subject of this assessment.

On the 20/05/2022 the DCCEEW approved Revision 13 (13/04/2021) of the BEMP, including the discontinuation of the NDVI data capture.

In accordance with Condition 1 of the EPBC approval the BEMP is available on Seqwater's website at https://www.seqwater.com.au/corporate-publications.

Status – Compliant*

*With the exception of notification to the Department within 5 days of publishing the amended BEMP on Seqwater's website in 2022. Seqwater received the approval from the Department to implement the BEMP and Seqwater acknowledged receipt of the email and approval letter. Hereafter, Seqwater will ensure notification is made to the Department when there are changes to the BEMP and a new upload occurs on Seqwater's website.

3.2 EPBC Condition 2

The Banksia Beach WTP has not been operational since April 2014 and has subsequently triggered the cold standby shutdown (shutdown >12months) monitoring and sampling regime as outlined within the BEMP. No extraction from the borefield has occurred during the reporting period.

Status – Compliant.

3.3 EPBC Condition 3

This Annual Compliance report fulfills the requirement of EPBC Condition 3 addressing implementation of the BEMP within 3 months of the anniversary date. For the purposes of this report the anniversary date is September 1st with the Annual Compliance report due December 1st annually.

Following a period of inclement weather during the summer of 2020-2021, Queensland Parks and Wildlife Services (QPWS) closed the Northern Access Track on the 27/01/2022 due to unsafe vehicle access conditions and coastal erosion. This access track has remained closed for the remainder of the reporting period and the current status is that the track is closed until further notice. Seqwater's Hydrometric team utilise this track for access to the Northern Alert Weather Station (AWS) for critical maintenance of the telemetry infrastructure and monitoring equipment. The Northern AWS ceased to transmit data from the 21/08/2022. Seqwater became aware of the loss of transmission and the data gap during the preparation of this current Annual Compliance Report. Maintenance and restoration of the Northern AWS cannot be undertaken until the QPWS Northern Access Track is reinstated.

In addition, during this monitoring period the Southern AWS ceased to transmit data due to complete failure of the logger instrumentation. The maintenance and reinstalment of the Southern AWS instrumentation was successfully completed on the 8/11/2022. As per the BEMP, in the event that weather station data is unavailable from the Northern AWS or the Southern AWS, weather data from the Redcliffe and Beerburrum Bureau of Meteorology site can be compiled for purposes of fulfilling the meteorological monitoring program requirements under the BEMP.

As the Banksia Beach WTP has not been operational since April 2014, and therefore no extraction from the borefield has occurred since this time, it is not anticipated that the omission of this data will have an impact on the long-term understanding of the system.

In addition, during this reporting period the Northern Soil Moisture Probe (SMP) experienced intermittent failures on the 150mm, 350mm and 650mm sensors. Seqwater became aware of this issue during the preparation of the Annual Monitoring Report, when the data was extracted for inclusion into the Annual Monitoring Report (Appendix B). Seqwater have an initiated an investigation into the cause of the SMP failure and will endeavour to repair or replace the instrumentation as soon as practicable.

Seqwater advised the Department via email on the 23/11/2022 that there was a loss of transmission from the AWS's and the soil moisture probe issues during this monitoring period.

No further compliance issues have occurred during the reporting period.

Status – Non-compliant (partial data gaps).

3.4 EPBC Condition 4

During the reporting period all monitoring activities were undertaken in accordance with the BEMP.

An amendment to the BEMP was approved by the Department for the removal of the NDVI image capture and analysis data for future monitoring events. This requirement was removed as it did not have any significant ongoing utility in the assessment of floristic composition, nor structural diversity in the wet heath habitats that are the subject of this assessment. Following the approval from the Department on the 20/05/2022 the revised BEMP was implemented for the duration of the monitoring period.

Status – Compliant.

3.5 EPBC Condition 5

During the reporting period, no formal requests were received from the Minister to Seqwater in relation to amendments required to the BEMP or associated approval.

Status – Compliant.

3.6 EPBC Condition 6

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

Status – Compliant.

4. Implementation of the BEMP

4.1 Annual Monitoring Report

The Banksia Beach Water Treatment Plant has not been operational since April 2014 and has subsequently triggered the cold standby (shutdown >12months) reduced monitoring program as outlined within Seqwater's Banksia Beach (Bribie Island) Borefield Environmental Management Plan (BEMP). During this reporting period, Seqwater engaged a suitably qualified Consultant to conduct the bi-annual vegetation monitoring in accordance with BEMP. The Consultant was also engaged to prepare the Annual Monitoring Report which includes a detailed review of floristic data collected in conjunction with complementary datasets (soil moisture & AWS data) to determine condition of vegetation at the control and impact sites, as well as the assessment of seasonal variability. It is expected that the collation of ongoing vegetation monitoring data will assist with establishing baseline vegetation condition and determine the natural range of variation that occurs in terms of structure, composition, and condition.

A copy of the detailed monitoring report has been provided in Appendix B. The following key observations and comments have been extracted from the *Groundwater Dependent Ecosystems Annual Vegetation Monitoring Report* prepared by 3D Environmental:

- There is a strong correlation between species richness and cumulative rainfall data across the monitoring sites. This correlation is more prominent at the control sites as the 2019 wildfire interrupted the trajectory of undisturbed vegetation response at the impact sites. Since this time, species richness has remained lower at the impact site in comparison to the control site. This is contrary to the generally accepted paradigm that fire in heathland habitats is necessary for maintenance of species richness and diversity, and that species richness peaks shortly after a fire and then declines. Forbs and shrub appear to be the lifeform most affected by the 2019 wildfire, whilst grasses, sedges and grasstree appear to be relatively unaffected.
- Historical cumulative rainfall data generally reflects the soil moisture status in the upper soil profile, with strong rainfall replenishing perched groundwater tables. Soil moisture data indicates that the shallow soil profile at the impact site remains saturated on a more regular frequency and for longer periods compared to the control site. The variation in the shallow soil profiles of the impact and control sites have likely contributed to the subtle differences in vegetation composition between the sites. A series of significant rainfall events occurred during this reporting period, and this resulted in saturation of the upper soil profile and this water has stimulated rapid recruitment of shallow rooted shrub, sedges and forbs including those forming the groundcover. The saturation in the upper soil profile was sustained for much of the monitoring period due to continual rainfall.
- Groundcover forbs and woody stems have demonstrated a positive correlation to rainfall and increased soil moisture content within the rooting zone. Other groundcover lifeforms including shrubs, sedges and grasses, and grasstree fail to demonstrate any correlation to rainfall. It is anticipated that increased rainfall does not stimulate increased living biomass in the groundcover layers, rather promotes increased vegetation productivity and biomass in the taller woody shrub layers.
- Prior to the 2019 Bribie Island wildfire (which swept through the impact site), the impact and controlled sites followed similar trends in stem density and species richness. Following the wildfire, stem density at the impact site increased rapidly likely due to the recruitment of an obligate seeder species which was likely stimulated by the fire disturbance. During this monitoring period a strong rebound in stem densities was observed at the impact site with consistent increase in counts between monitoring events. An increase in shrub stem count was observed at the control site which indicates that changes in stem density cannot be solely attributed to the wildfire disturbance, although long absence of fire at this location may be a factor that has contributing senescence of the shrub layer. The intensity of the fire was sufficient to result in long-term alteration of the floristic composition of the wet heath at the impact site.

Overall, the vegetation monitoring surveys to date indicate that although species composition and features such as stem density differ between the impact and control sites, the floristic attributes between the sites have broad similarities. These structural and floristic changes are strongly correlated to rainfall trends which are directly linked to groundwater and soil moisture fluctuations in shallow soil profile. The Bribie Island aquifer appears to recharge directly and rapidly by rainfall due to the high permeability sands which host the unconfined groundwater table and there is minimal lag between rainfall and groundwater response. The predicted groundwater level reductions (as a result of borefield abstraction) are unlikely to promote any noticeable shift in the ecological state of vegetation within the drawdown area in the short term with detectible impacts likely over decadal cycles.

4.2 Community Reference Group (CRG)

No CRG meetings were held during the current reporting period.

In accordance with the BEMP, CRG meetings are only required in the event that specific issues arise during cold standby shutdown. No issues were raised by the CRG during this reporting period.

4. Conclusion

The Banksia Beach Water Treatment Plant has not been operational since April 2014 and has subsequently triggered the cold standby (shutdown >12months) reduced monitoring program as outlined within the BEMP. Consequently, no extraction from the borefield has occurred in this reporting period. Throughout the monitoring period, Seqwater have not undertaken any activities on Bribie Island that has the potential to significantly impact EPBC Act listed species or matters of national significance.

Seqwater will continue to implement the BEMP in accordance with the requirements of the EPBC approval. Seqwater will also continue to discuss the requirements under the BEMP with the Department, including opportunities to optimise (or cease) monitoring program/s based on long term planning and the future status of the WTP. Banksia Beach WTP has remained in cold standby for 7.5 years and at this stage, Seqwater does not plan to reinstate this asset. Banksia Beach WTP is currently not operable and significant resources would be required to return the WTP to an operational status.

6 Appendix A – EPBC Approval Conditions

Australian Government
Department of the Environment

EPBC: 2007/3396

Contact Officer: Penny Godwin
Telephone: (02) 6275 9516
Facsimile: (02) 6274 1878
Email: post.approvals@environment.gov.au

Mr Daniel Spiller
General Manager – Asset Portfolio Development and Delivery
Seqwater
PO Box 16146
City East QLD 4002

Dear Mr Spiller

Banksia Beach Water Treatment Plant and Borefield (EPBC 2007/3396)
Variation to Conditions of Approval

I write in relation to the proposed variation to the conditions of approval for *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) approval 2007/3396.

Officers of the department have considered your request, and have found that it is in accordance with the requirements of section 143(1)(c) of the EPBC Act; being that the proposed variation is necessary or convenient for the protection of a matter of national environmental significance.

As delegate of the Minister for the Environment, I have decided to approve the variation to the conditions of the approval in accordance with the provisions of the EPBC Act. The action must now be undertaken in accordance with the varied conditions specified in the enclosed variation notification.

I note that the variation of conditions requires that a Borefield Environmental Management Plan (BEMP) is submitted for approval. I am advised that a BEMP was submitted to the Department in January 2015 and that this plan will require some minor amendments to meet the requirements of the varied approval conditions.

The variation of conditions of approval does not relieve the person to whom it has been granted from an obligation to comply with any other law of the Commonwealth, State or Territory that is applicable to do the action and to have any right, title or interest that is required to access land or waters and to do the action.

If you have any enquiries in relation to this matter, please contact Penny Godwin on 02 6275 9516.

S. Gaddes

Shane Gaddes
Assistant Secretary
Compliance & Enforcement Branch
Environment Assessment and Compliance Division

10 April 2015

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Australian Government
Department of the Environment

CORRECTION NOTIFICATION

VARIATION TO CONDITIONS ATTACHED TO APPROVAL

Banksia Beach Water Treatment Plant and Borefield, Bribie Island
(EPBC 2007/3396)

The variation to conditions attached to approval signed on 10/4/2015 contained an error.

The notice incorrectly stated "insert conditions 1-7".
The notice should read "insert conditions 1-6".

Person making correction

Name and position	Shane Gaddes Assistant Secretary Compliance and Enforcement Branch
signature	S.Gaddes
date of correction	17 April 2015

Australian Government
Department of the Environment

VARIATION TO CONDITIONS ATTACHED TO APPROVAL

Banksia Beach Water Treatment Plant and Borefield, Bribie Island (EPBC 2007/3396)

This decision to vary a condition of approval is made under section 143 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Approved action

Person to whom the approval is granted	Queensland Bulk Water Supply Authority **ABN 75 450 239 876**
Approved action	The Extraction of groundwater from Bribie Island to supply an incremental 5ML per day of drinking water to the existing Caboolture Shire Council delivery network, Queensland, (EPBC 2007/3396)

Variation

Variation of conditions of approval	The variation is: Delete conditions 1-8 and definitions and annexure 2 attached to the approval dated 7 April 2008, subsequently varied on 6 September 2011, and insert conditions 1-7 and definitions specified below
Date of effect	This variation has effect on the date the instrument is signed

Person authorised to make decision

Name and position	Shane Gaddes Assistant Secretary Compliance & Enforcement Branch
Signature	S Gaddes
Date of decision	10 April 2015

Conditions attached to the approval

1. The **approval holder** must submit for approval by the **Minister** a **BEMP** designed to protect the ecological character of the Moreton Bay Ramsar wetlands. Once approved, the **BEMP** must be implemented. The approved **BEMP** must be published on the **approval holder's** website, with a location and/or metadata that enables easy discovery by relevant web searches, within one month of approval by the **Minister**. The **approval holder** must notify the **Department** within five **business days** of publishing the BEMP on its website. The BEMP must remain on the website for the period the approval has effect.

2. In accordance with the yield identified in the **BEMP**, the **approval holder** must limit groundwater extraction from the **Northern Borefield** to no greater than an annual average of 4.32ML/day, at a maximum daily rate of 5ML/day and totalling no more than 1580ML/year, subject to the requirements of conditions 1, 4 and 5.

3. The **approval holder** must maintain accurate records of all measures taken to implement the **BEMP** according to the conditions of this approval, and must make these records available to the **Department** on request. Within 3 months of every anniversary of the commencement of the action, the **approval holder** must publish a Compliance Report on its website addressing implementation of the **BEMP**. The **approval holder** must also notify any non-compliance with this approval to the **Department** in writing within 10 business days of becoming aware of the non compliance. The **approval holder** must continue to annually publish the Compliance Report until such time as agreed in writing by the **Minister**. Such records may be subject to audit by the **Department** or be used to verify compliance with the conditions of the approval.

4. If the **approval holder** wishes to carry out any activity otherwise than in accordance with the **BEMP**, the person taking the action must submit to the **Department** for the **Minister's** written approval a revised version of the BEMP. The varied activity shall not commence until the **Minister** has approved the revised plan in writing. If the **Minister** approves the revised plan, that plan must be implemented in place of the plan originally approved. All revised plans approved by the **Minister** must be published on the **approval holder's** website within one month of their approval by the **Minister**.

5. If the **Minister** believes that it is necessary or convenient for the better protection of the relevant matters of environmental significance to do so, the **Minister** may request the **approval holder** to make specific revisions to the **BEMP** and submit the revised plan for the **Minister's** written approval. Once approved, the revised plan must be implemented. Unless the **Minister** has approved the revised plan, the **approval holder** must continue to implement the originally approved **BEMP**, as specified in the conditions.

6. Upon the direction of the **Minister**, the **approval holder** must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the **Minister**. The independent auditor and audit criteria must be approved by the **Minister** prior to the commencement of the audit. The audit report must address the criteria to the satisfaction of the **Minister**.

Definitions

Approval Holder – means the person to whom the approval is granted

BEMP – means the Borefield Environmental Management Plan, as required under condition 2 and as amended in accordance with condition 4 or condition 5. The BEMP must include detailed management arrangements for ongoing ecological and groundwater monitoring, and reporting to the Department.

Department – means the Australian Government Department responsible for administration of the *Environment Protection and Biodiversity Conservation* Act 1999.

Minister – means the Minister responsible for administration of the *Environment Protection Biodiversity Conservation* Act 1999.

Northern Borefield – means the area identified as the northern borefield in the BEMP.

7. Appendix B – Vegetation Surveys of the Groundwater Dependent Ecosystems (GDE)

Refer to attached report prepared by the consultant 3D Environmental (Internal Ref: D22/337266)

3D Environmental
Landscape & Vegetation Science

Bribie Island Borefield

Groundwater Dependent Ecosystems -

Annual Vegetation Monitoring Report - 2022

Prepared for Seqwater *by* 3D Environmental

Revision 2_Final – 20 November 2022

Document Control

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

Draft	Date Issued	Issued By	Review	Purpose
Revision 1	21 November 2022	David Stanton		Initial draft
Revision 2	29 November 2022	David Stanton		Final document following PW and Seqwater review

NOTICE TO USERS OF THIS REPORT

Purpose of the report: 3D Environmental has produced this report in its capacity as {consultants} for and on the request of the Queensland Bulk Water Supply Authority (T/A Seqwater) (the "Client"). The information and any recommendations in this report are particular to the Specified Purpose and are based on facts, matters and circumstances particular to the subject matter of the report and the specified purpose (Basic Ecological Assessment) at the time of production. This report is not to be used, nor is it suitable, for any purpose other than the Specified Purpose. 3D Environmental disclaims all liability for any loss and/or damage whatsoever arising either directly or indirectly as a result of any application, use or reliance upon the report for any purpose other than the Specified Purpose.

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Summary

This report represents a compilation and analysis of eight years' of structural and floristic data (2015 to 2022) 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).

From long-term temporal analysis of two survey localities at the southern (southern Control or Control Plots) and northern (Northern Impact or Impact Plos) 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 features including stem density. At commencement of the monitoring surveys in 2016, IPs generally have a higher shrub cover and stem density for shrubs of all size classes, coupled with a generally higher species richness reported in most survey events when compared to CPs. Soil moisture data also shows the the IPs are generally a wetter site, with a more sustained shallow groundwater table and shorter periods of drying in the shallow soil profile.

Throughout the period of the monitoring program, there have been structural and floristic changes to heathland at both monitoring sites including a reduction in species richness and woody stem counts over the monitoring period between April 2016 and November 2020, after which there has been a reversal of these trends for both parameters. While these trends have been complicated by a severe wildfire which impacted the IPs in August 2019, statistical analysis indicates these parameters are strongly correlated to rainfall trends, which are directly linked to groundwater and soil moisture fluctuations in shallow soil profile.

The monitoring period spans a full climatic cycle with declining rainfall and regular drying of the shallow soil profile down to depths of 950mm occurring from the April 2016 assessment to November 2020. Following this period, rainfall increased dramatically with a sharp rise in the rainfall mass curve (Cumulative Rainfall Data or 'CRD') and a number of extreme rainfall events in late 2021 and throughout 2022 have held the groundwater table near surface for most of the 2022 assessment period, as evidenced by soil moisture data from the Southern Soil Moisture Probe (SMP).

Statistical analysis indicates moderate positive correlation between CRD value in the year and month of survey for stem counts at the CPs (Site 5), although this correlation is not statistically significant. At the IPs (Site 6), the correlation between rainfall and stem counts is extremely strong and statistically significant. For the IPs, it is likely that the above average rainfall received post wildfire in August 2019 has stimulated rapid recruitment of shrubs, although there has been a complete loss of some shrub species including the originally dominant obligate seeder *Persoonia virgata* as well *Leptospermum liversidgei,* a resprouter species which suffered complete destruction of subterannean lignotubers which limited post fire regeneration. The shrub layer at the IPs is now strongly dominated by *Phyllota phylicoides,* and obligate seeder which was a minor component of the shrub counts in earlier surveys.

There is also an extremely strong positive correlation between species richness and rainfall at the CPs, and a moderate positive correlation for the IPs, with the latter having natural vegetative response to rainfall interrupted by the severe fire event. Despite higher species richness at the IPs compared to CPs prior to the wildfire event to April 2019, species richness remains lower at the IPs at completion of the most recent survey and recovery has been incremental and slow three years post fire. Forbs and shrub appear to be the lifeforms most affected by fire and suffered the most significant losses at the IPs. Grasses and sedges and grasstree appear to be relatively unaffected.

Data presented over an eight year monitoring period indicate that species richness and heath structure is strongly correlated to rainfall and by association soil moisture and groundwater levels. Groundwater and soil moisture are recharged directly and rapidly by rainfall in the high permeability sands which host the unconfined groundwater table that characterises the Bribie Island sand mass, and there is minimal lag between rainfall and groundwater response. The implications are that sustained periods of drying in the shallow soil profile will result in overall lower species richness, as well as structural changes to the shrub layer which may include a change of species dominance, or loss of some species. Prolonged periods of drying also render coastal heathlands more at risk from the impacts of severe wildfire. While changes to soil moisture and lowering of the unconfined groundwater table are associated with a drying climate, these affects may be compounded by groundwater abstraction in the absence of sufficient rainfall to recharge shallow groundwater tables. Although, Seqwater has not undertaken groundwater abstraction from the Banksia Beach Borefield since the Banksia Beach WTP went into Cold Standby in April 2014.

That the dataset spans both a drying and wetting climatic cycle 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 a drying soil profile. The drying soil profile will occur naturally during drought conditions, though it may be compounded by future 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 species richness, which suggests that a predictive ecological baseline is close to being established. There is an identified lag between increased rainfall and vegetative response in the current (2022) dataset. Giving consideration to this, it would be beneficial to complete at least an additional annual monitoring event to determine whether this lag closes in a delayed though ultimately rapid vegetative response, or if the response is gradual and drawn out over a more extended timeframe.

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1.0 Introduction

3d Environmental was engaged by Seqwater to complete the 2022 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 six subsequent reports prepared by 3d Environmental for the 2016, 2017, 2018, 2019, 2020 and 2021 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 first monitoring location is in an 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 second monitoring location is located in an area 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 2015. Ongoing vegetation monitoring events have occurred subsequent to 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 Vegetation 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 Vegetation 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 and 2021) to assist in the characterisation of the baseline condition of vegetation.

The current period (2022) is the first monitoring period where NDVI has not been included in the suite of monitoring parameters due to lack of any measureable correlation to field based indices. The 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 "Least Concern" status under Queensland's *Vegetation Management Act 1999*. 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 15 cm of soil, the portion of the profile most exposed to periodic cycles of wetting and drying in response to rainfall. There are also a number of deeper rooted species such as *Banksia aemula* and broad-leaf paperbark (*Melaleuca quinquenervia)* with the ability to adapt relatively rapidly to changing groundwater levels through accelerated root growth (Griffith et al 2015). The predicted shallow groundwater level reductions created as a result of borefield abstraction for both the average and dry weather conditions are relatively 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 are unlikely to promote any noticeable shift in the ecological state of vegetation within the drawdown area in the short term with detectible impacts likely 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 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 location of the fire relative to monitoring points is shown in **Figure 2**.

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

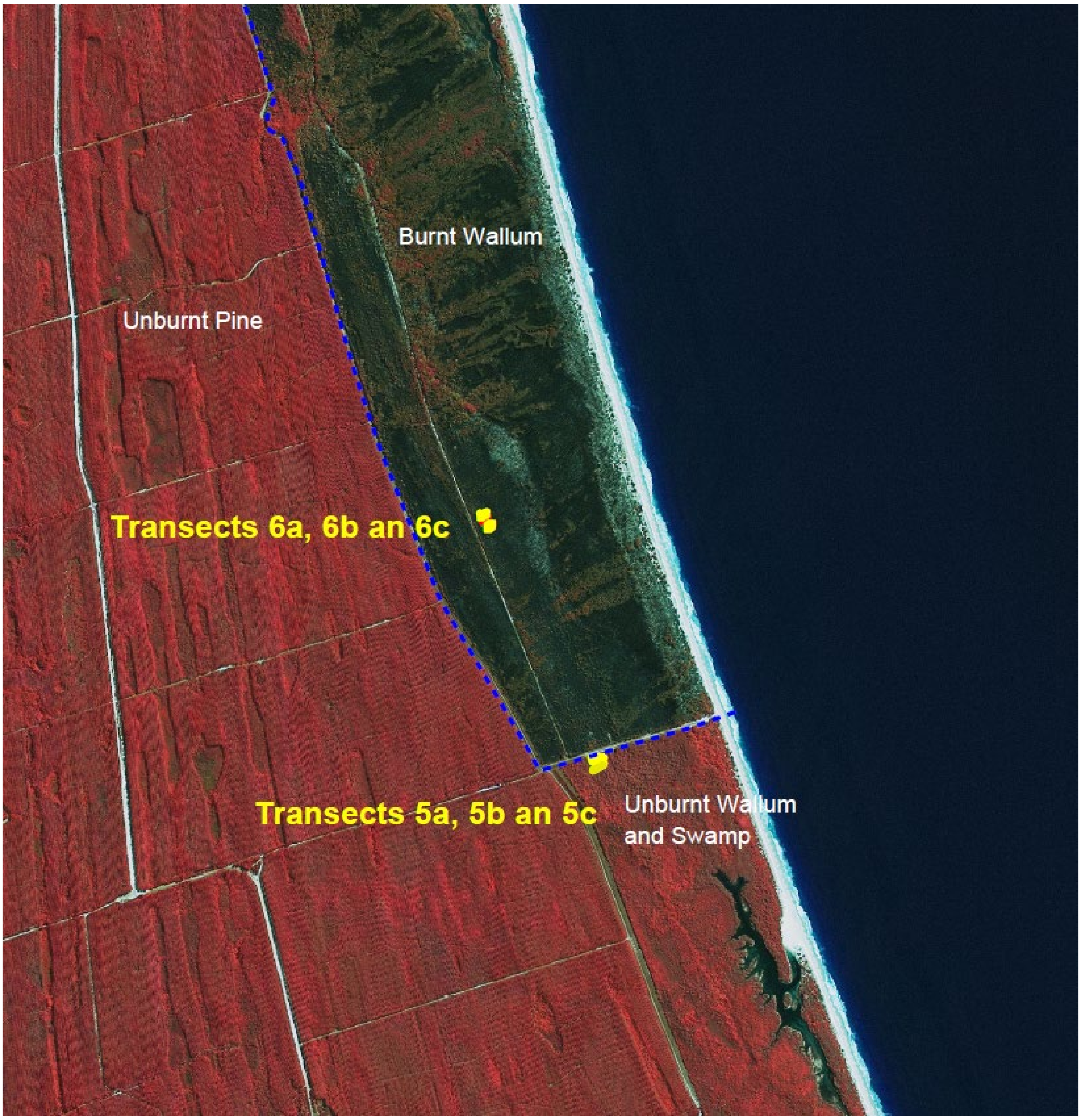

Figure 2. NDVI imagery showing the extent of fire scarring from September 7 Spot Imagery with delineation between burnt and unburnt vegetation indicated by blue dashed line. The area of red wash indicates living vegetation, noting that monitoring Site 5 has not been burnt.

2.0 Methods

2.1 Field Survey

Timing: The post wet season monitoring event was completed on 7th April, with the dry season monitoring event completed on the 6th October 2022. The post wet season assessment immediately followed a period of extreme flooding rainfall where ground conditions were extremely wet, the two months prior the the dry season event were relatively dry. Additional information on climate throughout the period of surveys is provided in **Section 2.4** and **Section 3.1.1**.

Transect Methods: Methods for vegetation assessment follow 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.

[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

- 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 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.**

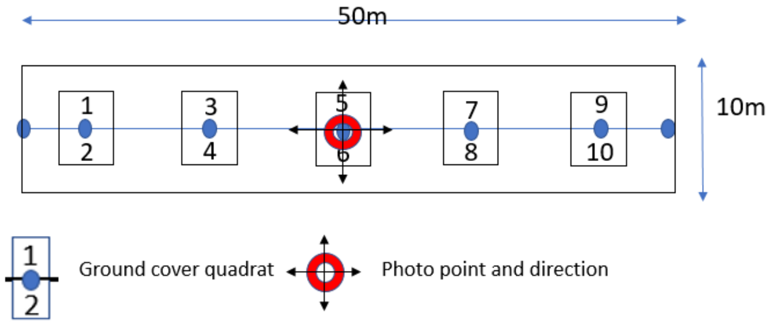

Figure 3. Survey plot layout.

In regard to 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 2021 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 the 2021 assessment and continued in the current (2022) 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. Weather recordings for the Southern AWS are complete only up to 10th May 2022, while the Northern AWS data is complete up to 21st August 2022. Where data gaps exist, 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 substituted, being relatively consistent with the Southern AWS due to a relatively close proximity. 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 loggers were installed at the location of the CPs (5a – 5c) (Southern SMP) and IPs (6a – 6c) (Northern SMP). 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 15 cm, 35 cm, 65 cm, 95 cm and 125 cm with automated readings provided up to late October 2022 for the southern impact site (Southern SMP). The soil moisture logger installed at the northern control site (Northern SMP) was destroyed during August 2019 wildfires 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 been erroneous from the date of installment in 2021 and hence have been excluded from the data analysis, following similar issues in the 2021 monitoring assessment. While Data gaps also occurred in the Southern SMP between the 22nd April and 17th August 2021, data recording at this SMP has been otherwise continuous up the latest monitoring event in October 2022.

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 Southern AWS for January to March, preceding the April 2022 survey was 1275mm, which is well above the long-term historical average of 584.5mm reported for those months from Beerburum State Forest (SF). February 2022 was particularly wet with 901mm recorded. While 107mm was reported from the Northern AWS for the month of July (approximately twice the long term average rainfall of 63.6mm), the two months preceding the October 2022 survey were dry with the Bribie Alert recording station reporting only 64mm. The Bribie Alert recording station provided consistent local context to regional rainfall data from the Beerburrum SF recording station, substituting for AWS data gaps. The 1275mm reported from Bribie Alert for February and March 2022 is close to the long-term annual average rainfall of 1414.3mm reported at the

Beerburrum SF recording station, which demonstrates the intensity and volume of rainfall reported during the initial quarter of 2022.

The long-term annual rainfall average from the Beerburrum SF is slightly greater than the 30yr average rainfall reported from the Bongaree Bowls Club (near the Bribie Island bridge) of 1211.7mm which was extracted from the SILO dataset (SILO 2022), suggesting the the climate of Bribie Island is slightly dryer than the mainland immediately to the west. A comparison of rainfall trends from the various recording stations 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 2022 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. There is a strong near vertical upkick in rainfall mass coinciding with the February 2022 rainfall event which indicates the intensity of rainfall over this period in the context of longer term trends. **Figure 5** also indicates that surveys completed at the Banksia Beach borefield cover both extended wetting and drying climatic cycles. This 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 is provided in **Table 2**.

Table 2. Monthly CRD values calculated for the 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

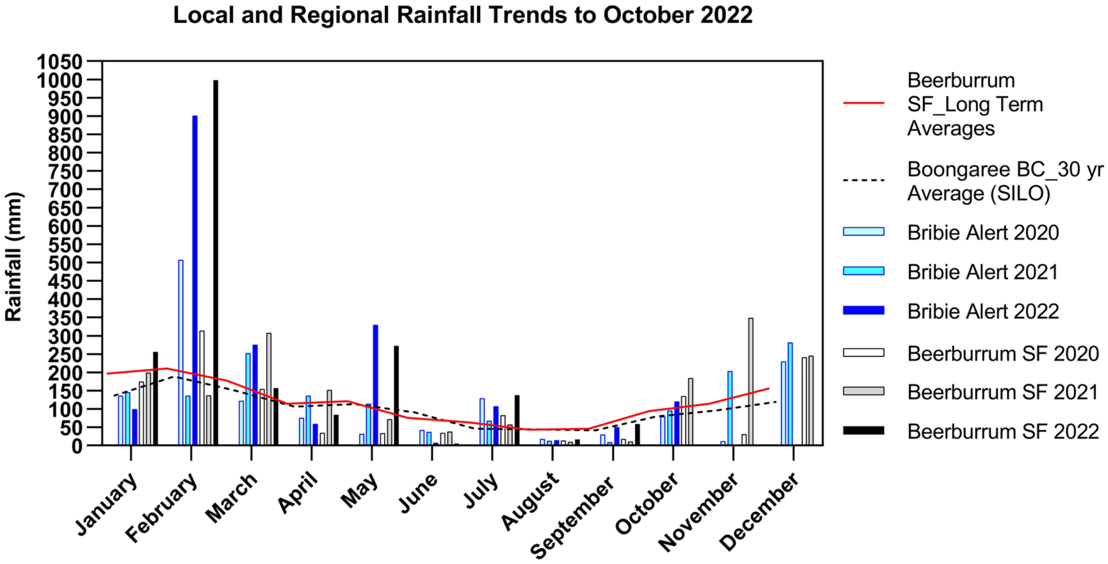

Figure 4. Regional rainfall recorded at Beerburum SF and Bribie Alert recording stations for January 2016 – October 2022.

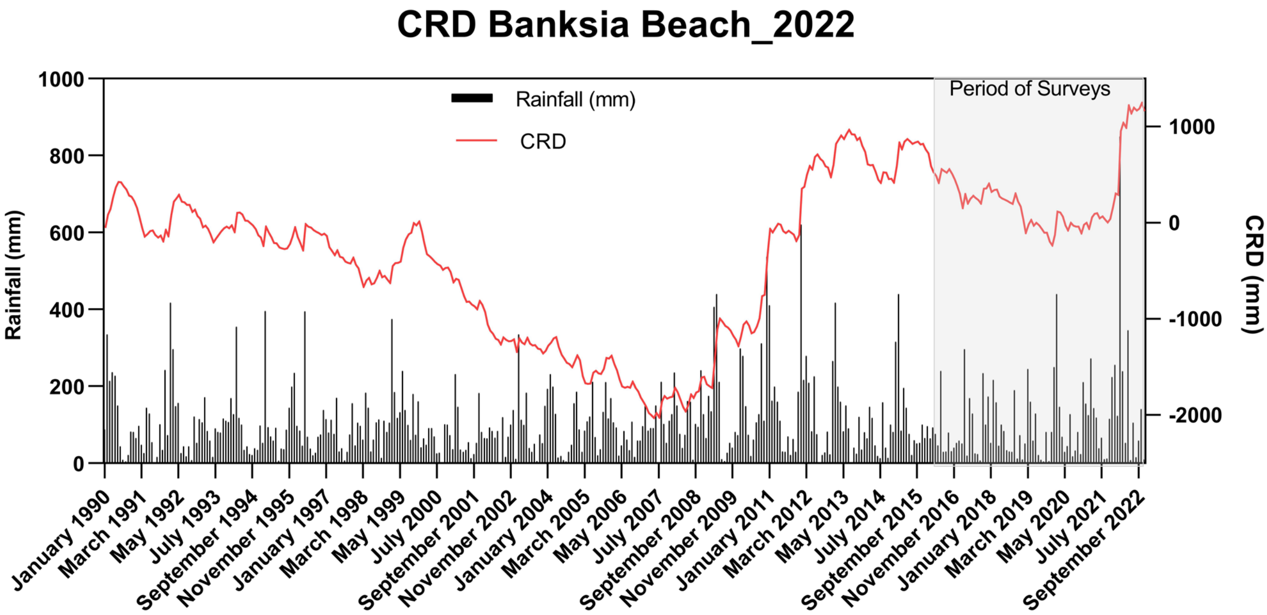

Figure 5. Cumulative rainfall departure calculated for the Boongaree Bowls Club (SILO 2021) with a strong upkick in the rainfall trend indicated in February 2022 coincident with an extremely strong rainfall event, and a transition into a wetter climatic regime post 2021.

3.1.2 Soil moisture data

As described in **Section 2.5**, the northern SMP adjacent to IPs (6a – 6c) was destroyed in an August 2019 wildfire and not replaced until April 2021, after which data produced from the 150mm, 350mm and 650mm has been erroneous and removed from ensuing data outputs. Post 17th August 2021, continuous data has been recorded for all depths at the Southern SMP, which is sufficient to confirm soil moisture trends at the Southern SMP, and make assumption in regard to soil moisture at the Northern SMP.

Following the September 2021 field assessment, soil moisture at the Southern 150mm and 350mm SMP remained depressed at values as low as 5.2% volumetric moisture content (VMC) up to 12th October when 21mm of rainfall initiated a gradual rise in VMC to 30th November 2021 when soil moisture were at 32.1% and 19.7% at the 350mm and 150mm sensors respectively following 40mm of rainfall. The soil profile at the 650mm sensor remained saturated at values >34% VMC throughout this period indicating that moisture fluctuations were restricted to shallow depths. While no data was reported for the Northern SMP throughout this interval, previous monitoring events suggest the soil profile at the Northern SMP is consistently wetter than the south, and it is expected that it would have remained saturated for longer periods.

From the end of November 2021, the 150mm sensor at the Southern SMP remained saturated at > 36% VMC through to August 18 (2022) when soil moisture content began a gradual decline, falling to 12% VMC on 6th October at completion of the late dry monitoring event. Soils at the 350mm sensor remained saturated from November 2021 to 29th September when if fell below 30%, with soil moisture content continuing to decline through to the late dry season survey when VMC was at 25.8%, and continued to fall throughout the remainder of October. Soil moisture trends from January 2020 through to the end of October 2022 in relation to the timing of four consecutive monitoring survey events is shown in **Figure 6**.

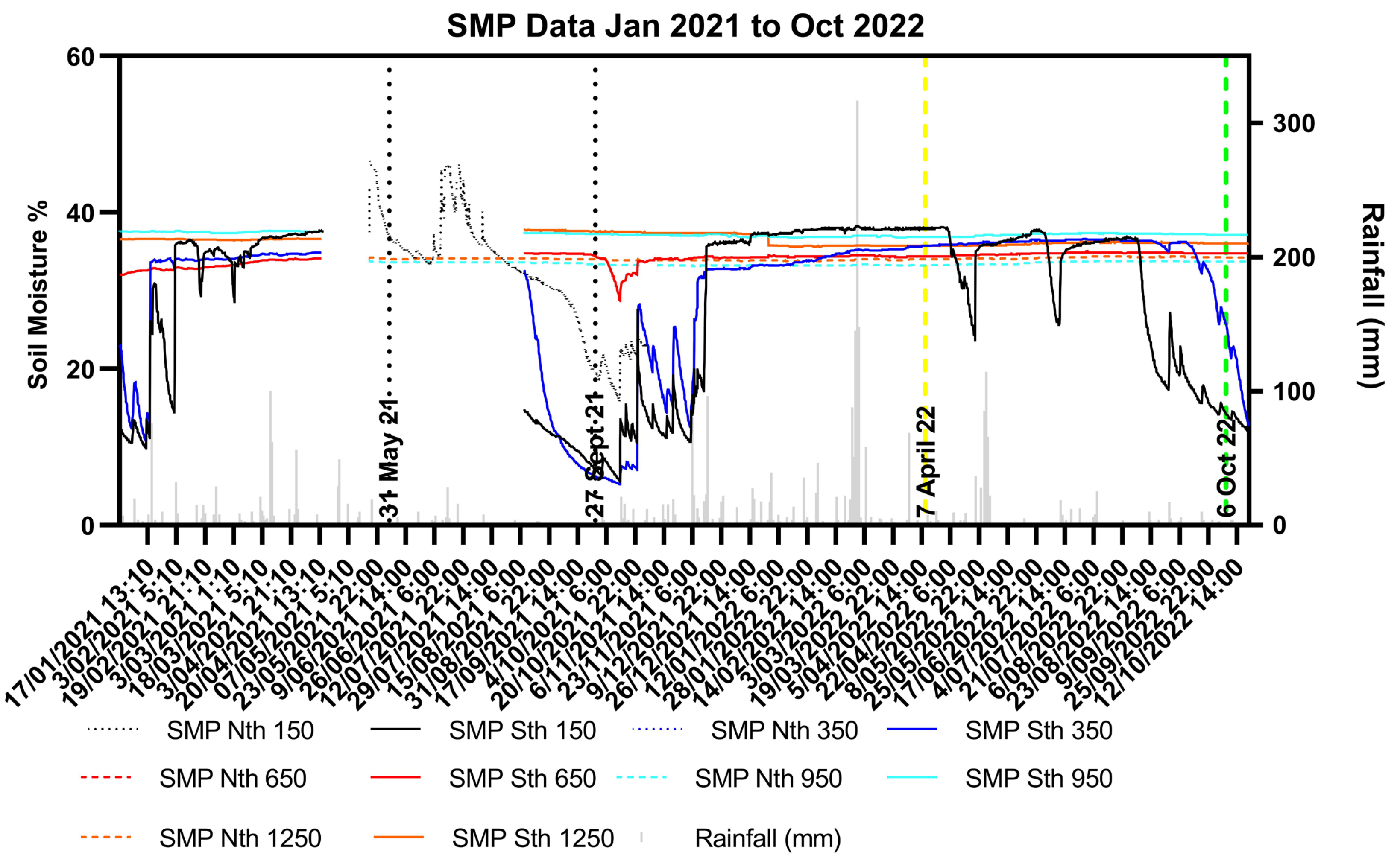

Figure 6. Soil moisture content (%) for a period covering four monitoring events from January 2020 to late October 2022 for both the southern and northern SMP's indicating significant data gaps, particularly at the northern SMP.

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 to the September 2019 after which cover values have been relatively stable with values ranging from 6.4% in September 2019 to 4.7% in October 2021. For the IPs, shrub cover demonstrates an erratic decline through the annual monitoring events through to May 2019, followed by almost complete destruction of this tallest shrub layer resultant from the August 2019 wildfire. Following the 2019 wildfire event, cover in the >1m category has gradually increased to 15.4% in the latest October 2022 assessment. This is compared to the previous high value of 26.67% cover reported in April 2018. The differences in cover values between survey events is statistically significant for both the CPs ($F_{13,26} = 9.46$, $P < 0.0001$) and the IPs ($F_{13,26} = 16.64$, $P < 0.0001$). 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 the obligate seeder *Phyllota phylicoides* which recruited prolifically following the August 2019 wildfire. Futher 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 in the most recent monitoring event (October 2022) reaching 5.6% cover, recovering from complete absence in the November 2020 assessment. While cover values of the lower shrub layer at the IPs has increased dramatically following complete absence in the September 2019 assessment, this recovery has been more erratic than the taller >1m size class, which is likely due to the migration of shrubs between size classes. Differences in cover values for the lower shrub layer between monitoring events are not statistically significant for either the CPs ($F_{13,26} = 1.81$, $P < 0.095$) or the IPs ($F_{13,26} = 1.88$, $P= 0.084$). This suggests that cover values of the lower shrub layer do not provide a suitable parameter for 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. There has been an overall 78.1% reduction in shrub stem counts for the the CPs from the April 2016 (210 stems) monitoring assessment through to October 21 (46 stems) after which there has been a rebound with 146 stems counted in the most recent October 2022 assessment. Prior to the August 2019 wildfire, stems at the IPs were declining with a 49.6% reduction between April 2016 (567 stems) and May 2019 (286 stems). The declining stem count affected most species with the possible exception of *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 occured with consistent increase in counts between monitoring events with 854 stems counted in the October 2022 assessment. 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 been similarly stimulated and remain largely absent from the species mix up to the most recent monitoring assessment (see **Appendix B**). The increase in stem count values from 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 moderate positive correlation between CRD value in the year and month of survey for stem counts at the CPs, although this correlation is not statistically significant (*r = 0.42, p=0.133*) (see **Figure 10**). Some species do however show a statistically significant positive correlation between CRD and stem counts including *Strangea linearis* (*r* = 0.56*, p*=0.03), *Baeckea frutescens (r = 0.66, p=0.01), Leptospermum polygalifolium* (*r* = 0.55*, p*=0.04), *Leptospermum semibaccatum* (*r* = 0.77*, p*=0.001) and *Homoranthus virgatus* (*r* = 0.68*, p*=0.01). The majority of these species are resprouters while *Strangea linearis* may employ both regeneration strategies. A simple correlation plot for CRD/stem counts is provided in **Figure 10**, which demonstrates the lag in stem counts behind CRD values in the 2022 monitoring period. The data also demonstrates that *Leptospermum semibaccatum* contributes the dominant proportion of recruiting shrubs and that other shrubs demonstrating a positive correlation have relatively low abundance in the stem counts.

For the IPs, an extremely strong statistically significant correlation is evident between CRD and total stems (*r = 0.842, p=0.001).* While this may be in part an artefact of the timing of the fire event prior a period of increasing rainfall, it may also be an indication that the above average rainfall received post fire has further stimulated rapid recruitment of shrub species. Species that contribute to this positive correlation include *Banksia aemula* (*r* = 0.65*, p*=0.01), *Banksia oblongifolia (r = 0.66, p=0.01), Leptospermum semibaccatum* (*r* = 0.68*, p*=0.01), *Leucopon leptospermoides (r = 0.70, p=0.005)*, *Phyllota phylicoides* (*r* = 0.68*, p*=0.01), and *Pultenaea paleacea* (*r* = 0.66*, p*=0.01). This includes a mix of both resprouters and obligate seeders including the two banksia species which are serotinous, whereby the seed banks stays in cones on the tree and where dispersal and germination may be stimulated by fire.

Stem count data is provided in **Appendix B** with summary statistics from the correlation assessment provided in **Appendix C**.

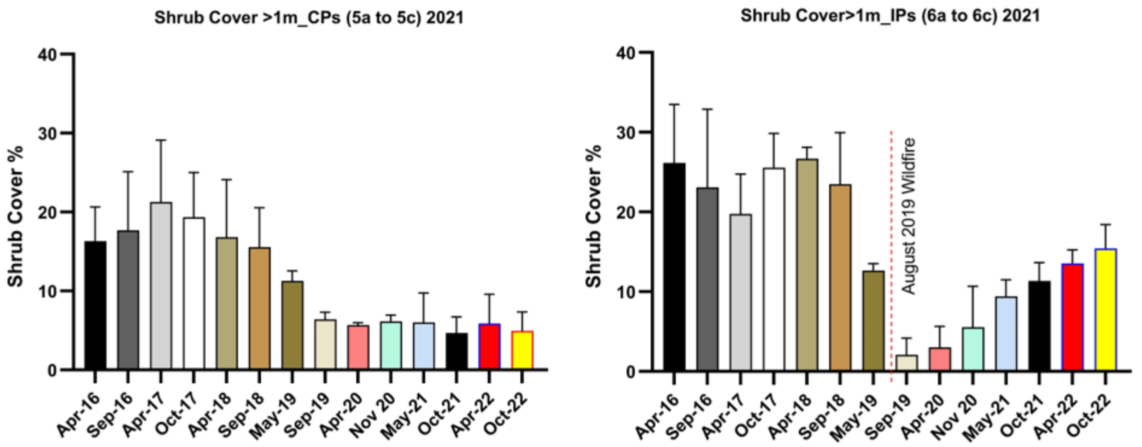

Figure 7. Average shrub cover values in the > 1m size class for the CPs (left) and IPs (right) showing strong declines in cover for both site localities up to May 2019.

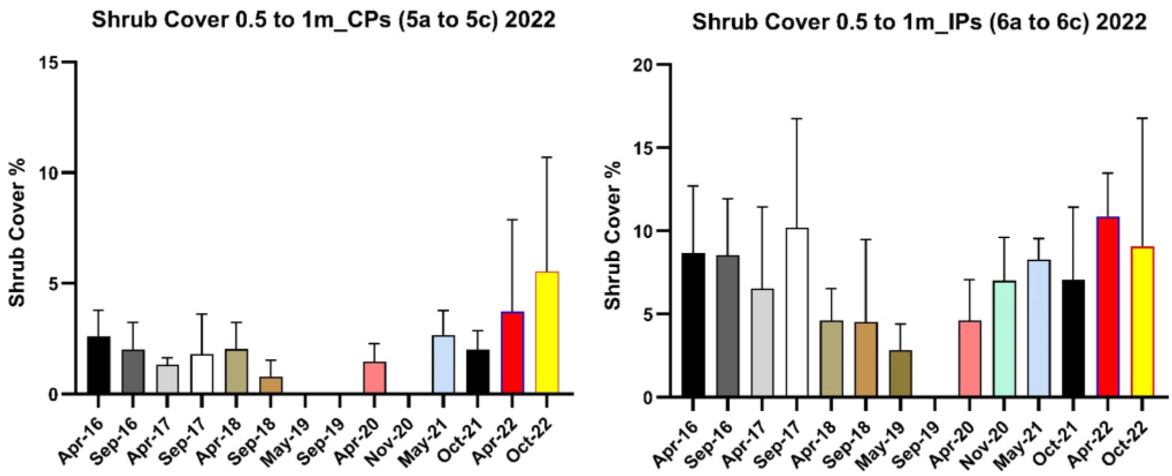

Figure 8. Average shrub cover values in the 0.5 to 1m size class for the CPs (left) and IPs (right) showing variable shrub cover values.

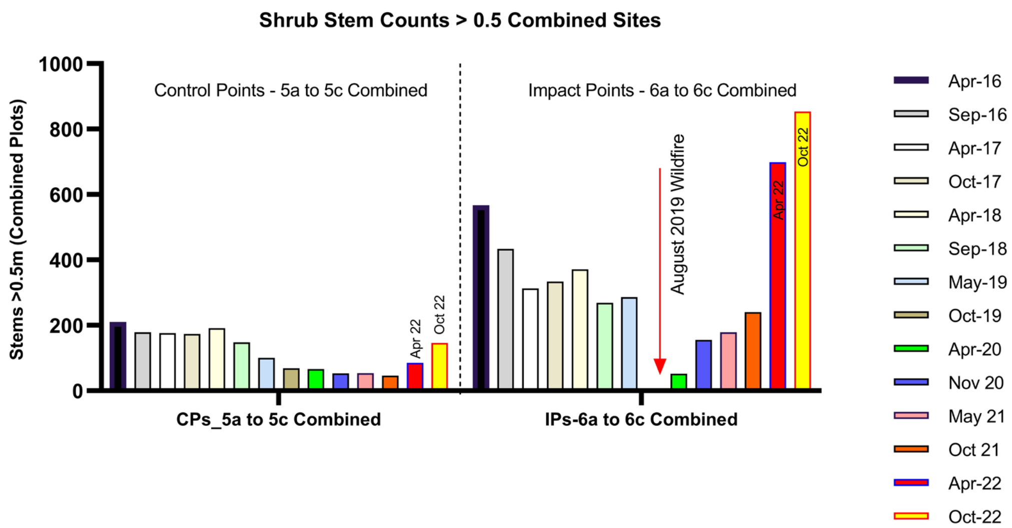

Figure 9. Stem counts for shrubs (> 0.5 m) combining data from individual transects to provide an overall stem count for both the CPs and the IPs (2016 – 2022). The strong rebound in stem counts following the August 2019 wildfire is evident for the IPs with a trend toward increasing stem counts for the CPs evident after the October 2021 assessment.

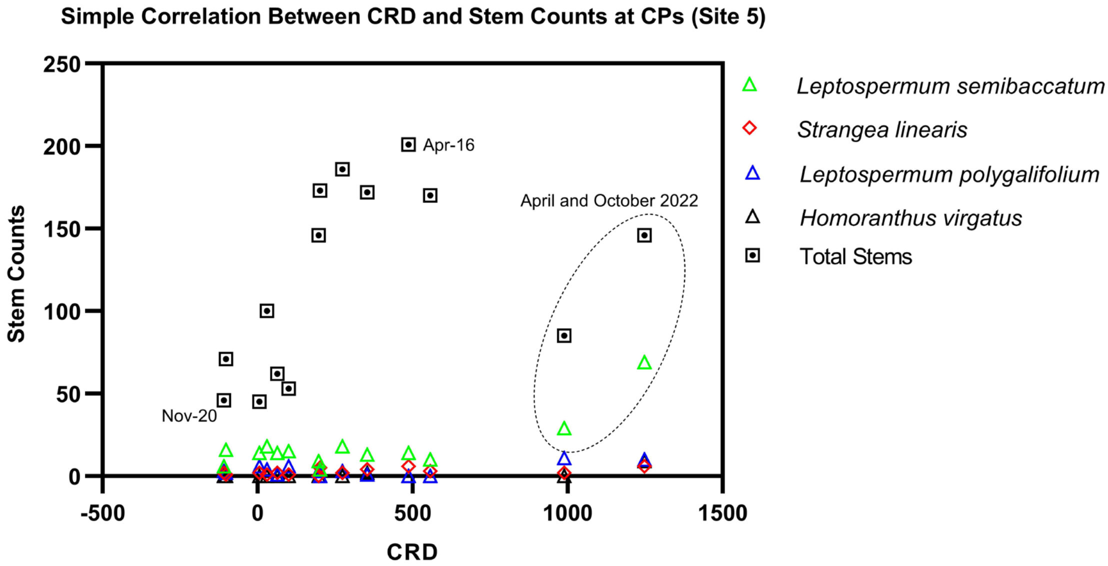

Figure 10. Simple XY correlation between CRD and shrub stem counts (>0.5m) at the CPs showing spike in Leptospermum semibaccatum in the 2022 assessment period consistent with CRD trends.

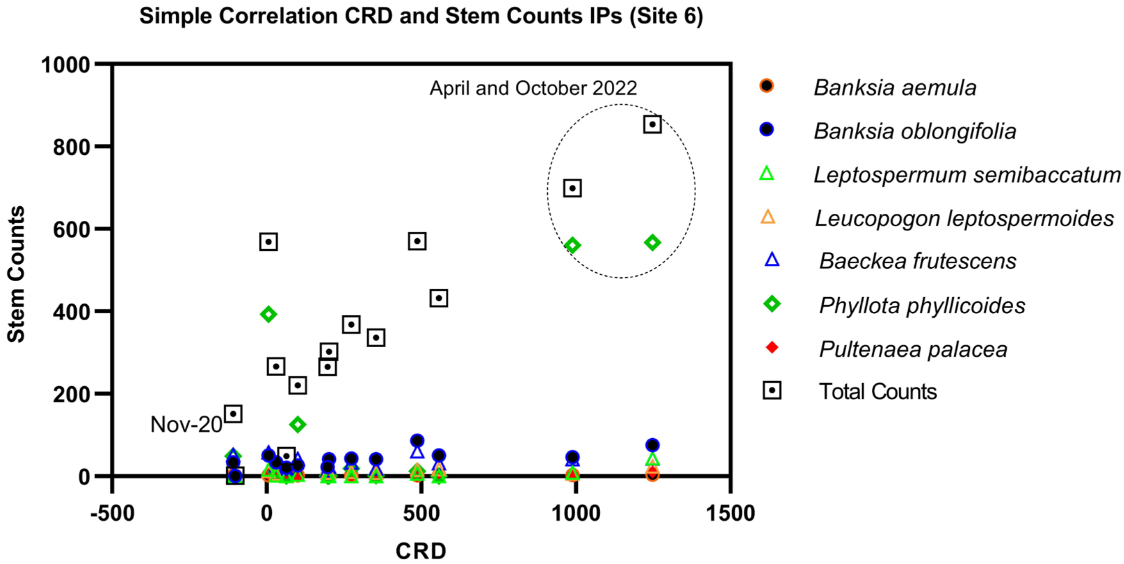

Figure 11. Simple XY correlation between CRD and shrub stem counts (>0.5m) at the IPs showing spike in stem counts dominated by *Phyllota phylicoides* in the 2022 assessment period consistent with CRD trends.

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 included extended periods when the upper 35cm of the soil profile has dried to < 5% soil moisture, notably between December 2018 and March 2019, September 2020 and January 2021 and also October to November 2022. Thoughout much of the current monitoring period extending from December 2021 to August 2022, the soil moisture profile at the Southern SMP was saturated at surface with resumption of drying trend at the 150mm and 350mm SMPs recorded in September and October 2022 (see **Section 3.1.2**) . Based on observations from previous monitoring events, the upper soil profile at the southern CPs (Site 5) drains and dries more rapidly after rainfall than the impact site (IPs or Site 6) with shorter periods of saturation and drying extending deeper into the soil profile. Hence while no data was collected for the 150mm and 350mm probes at the Northern SMP, it is assumed that saturation in the shallow soil profile was similarly sustained throughout much of the monitoring period

While these differences in the shallow soil profiles of the IPs and CPs have likely contributed to the subtle differences in vegetation composition between sites, hydrological regimes for the CPs and IPs are likely to have been similar throughought the 2022 monitoring period with sustained saturation of the shallow soil profile. This sustained shallow moisture would have a significant influence on moisture availability of the shallow rooted sedges, forbs and shrubs that form components of the groundcover. **Section 3.4.1** to **Section 3.4.6** provides an analysis of the composition, structure and floristic trends of groundcover components of the monitoring site. A statistical summary is provided in **Table 2** for all survey localities with contribution to total cover of various lifeforms over the 2016, 2017, 2018, 2019, 2020, 2021 and 2022 survey periods. 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 and southern sites over the extended monitoring period (see **Figure 12**) indicating that these lifeforms remain relatively resilient to extended periods of drying in the upper soil profile. This would have been most severe in the 2018 and 2019 monitoring events.

Grasses and sedges were completely combusted at the the IPs when the September 2019 monitoring event was completed due to the August 2019 fire, although these values had recovered to pre-fire levels by the May 2021 monitoring event. The CPs which were not impacted by fire have maintained similar grass and sedge cover (%) from April 2018 to April 2020, with an increase in cover values was recorded in November 2020, subsequently returning to standard levels in the more recent assessments.

ANOVA applied to 2016 – 2021 data for the CPs indicates that changes in native grass, sedge and rush cover are significant between survey events ($F_{13,26}$ = 3.094, P = 0.007). For the IPs alone, ANOVA demonstrates statistically signficant differences between monitoring events ($F_{13,26}$ = 7.66, P = <0.0001), which can be partially attributed to cover changes initiated by the August 2019 wildfire. While there is no correlation between grass and sedge cover and CRD for the CPs (r = 0.044, p=0.88), a weak non-significant correlation is detected for the IPs (r = 0.49, p=0.073) which may relate to post fire recovery of groundcover values in a dramatically wetting climatic period.

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, and the most recent October 22 monitoring event where shrub cover was at the lowest levels reported at 10.4% for the CPs and and 13.0% for the IPs (see **Figure 13**). The low groundcover shrub values reported in October 2022 may be in part to a migration of groundcover stems into a tall size class (>0.5m) where they contribute to woody shrub stem cover and stem counts rather than a groundcover component. This is matched with the increase in the density of shrubs >0.5m tall (**Fig 9**). The crown cover of the shrubs 0.5 to 1m also increased in CPs although the crown cover in the IPs is more variable.

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*. The measured changes to shrub cover values between survey events at the IPs are statistically significant ($F_{13,26}$=9.14, P<0.001), which can be attributed to stochastic perturbations linked to wildfire. Variation in groundcover shrub values at the CPs is however not considered statistically significant ($F_{13,26}$=0,87, P=0.594) indicating a relatively stable floristic parameter that is not significantly affected by drying soil moisture regimes. There is no correlation between groundcover shrub values (%) and CRD for either the CPs (*r* = -0.048*, p*=0.87) or the IPs (*r* = -0.014*, p*=0.96).

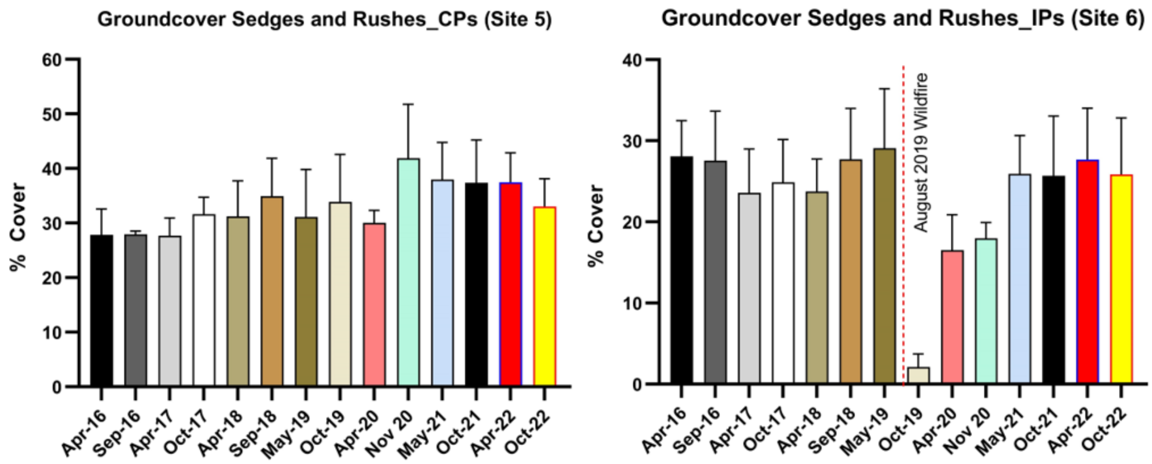

Figure 12. Cover (%) of native grasses, sedges and rushes in the CPs (left) and IPs (right) for all monitoring events.

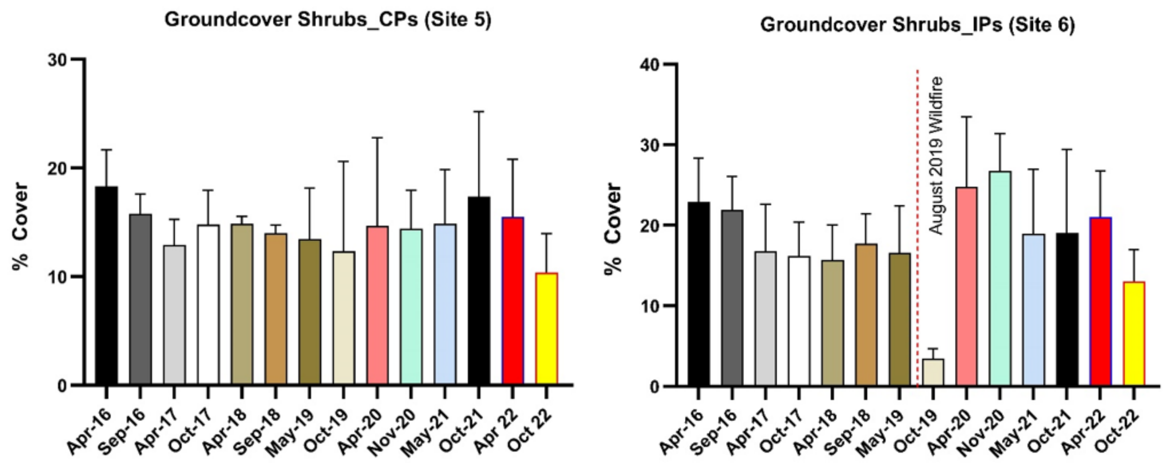

Figure 13. Cover (%) of groundcover shrubs (< 0.5 m) across all sites (2016 – 2021).

3.3.3 Groundcover forbs

The % cover of forbs within survey plots form a relatively small contribution to total groundcover values. Due to a general preference for mesic conditions, forb diversity and % cover are 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 assessment (4.2%) although consistent values were reported for the April 22 assessment (4.1%), with a decrease in the October 2022 assessment (3.13%) coincident with drying of the shallow soil profile (**Figure 14**). ANOVA indicates that the measured variation in forb cover between survey events is statistically significant for both the CPs ($F_{13,26}$= 6.028; P=0.0001) as well as the IPs ($F_{13,26}$= 5.42; P=0.0001). As would be expected, the groundcover composition of forbs is strongly correlated to CRD values at both the CPs (*r* = 0.604, *p*=0.02) and the IPs (*r* = 0.687, *p*=0.006). Further discussion in regard to the variation in the diversity and composition of forbs between survey events is provided in **Section 3.4.6**.

3.3.4 Grasstree cover

There remains considerable variation in grasstree % cover between sites and survey events. Consistent with previous assessments, there are no readily apparent trends with the variability in grass tree 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. ANOVA indicates that the variation in grasstree cover between seasonal survey efforts at the CPs is not statistically significant ($F_{13,26}$ =1.94; P=0.07), which differs from the previous assessment where statistically significant variation in cover was identified. The level of statistical significance is much stronger for the IPs ($F_{11.22}$= 6.87; P<0.001), a likely to result from ground cover changes that coincided with the August 2019 wildfire, rather than a consistent response to varying seasonal conditions. There is no correlation identified between grasstree cover values (%) and CRD for either the CPs (*r* = -0.2232, *p*=0.443) or the IPs (*r* = --0.2348, *p*=0.4191).

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 any strong indicators of seasonality in cover values. At completion of the October 2022 assessment, the average living cover value was 57.75% at the CPs and 52.4% at the IPs which are the two lowest values reported for any monitoring assessment, excluding the September 2019 post wildfire assessment at the IPs. 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 have had a negative influence. ANOVA indicates that the variation in living groundcover between seasonal survey efforts is statistically significant for both the CPs ($F_{13.26}$= 2.693; P=0.015) as well as the IPs ($F_{13.26}$= 21.0; P <0.001), although there is no correlation identified between living groundcover values (%) and CRD for either the CPs (*r* = 0.016, *p*=0.9564) or the IPs (*r* = 0.1547, *p*=0.5975). This would suggest that increasing rainfall does not stimulate increased living biomass in the groundcover layers, rather promotes increased vegetation productivity and biomass in the taller woody shrub layers.

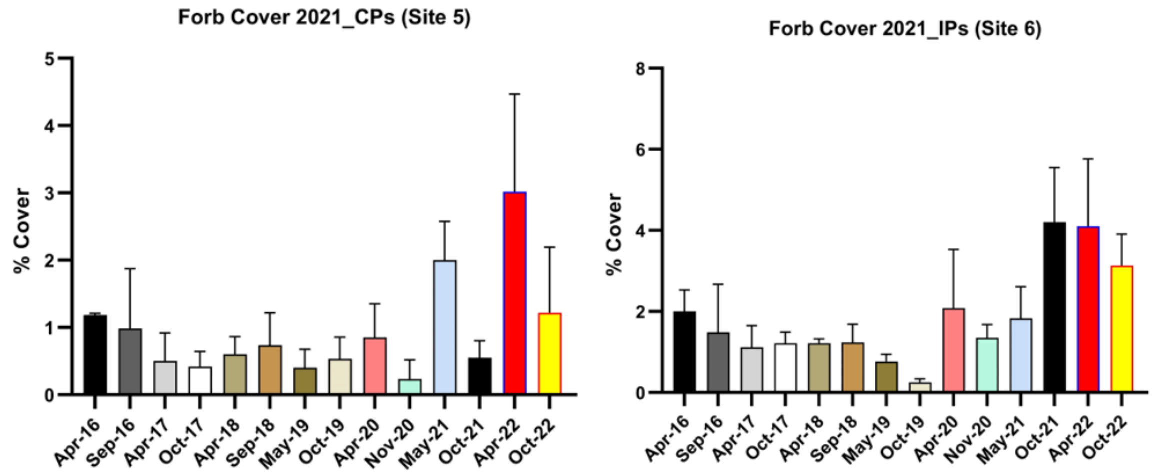

Figure 14. Forb cover (%) across all sites (2016 – 2022) with CPs shown on left, and IPs on right.

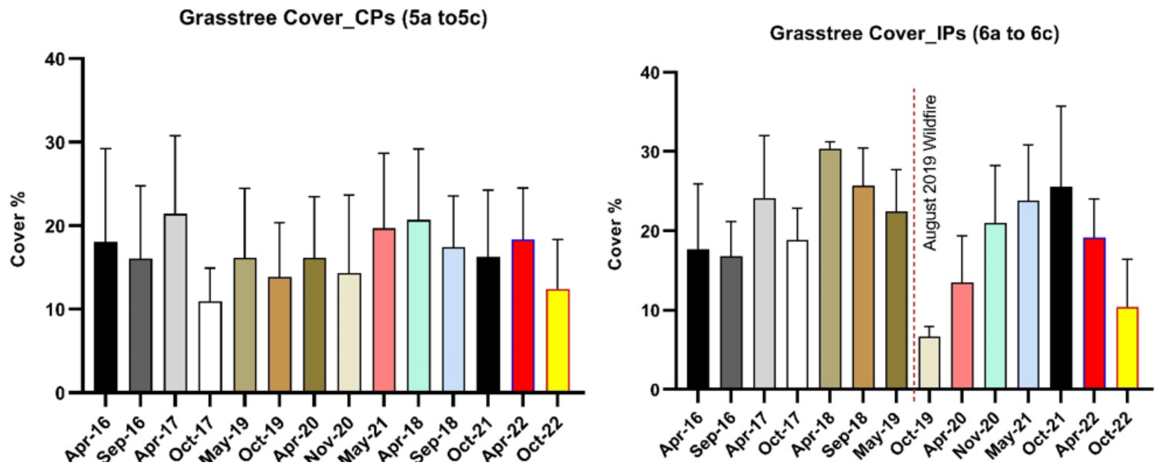

Figure 15. Grasstree groundcover (%) across CPs (left) and IPs (right) for the period from 2016 to 2022 **.**

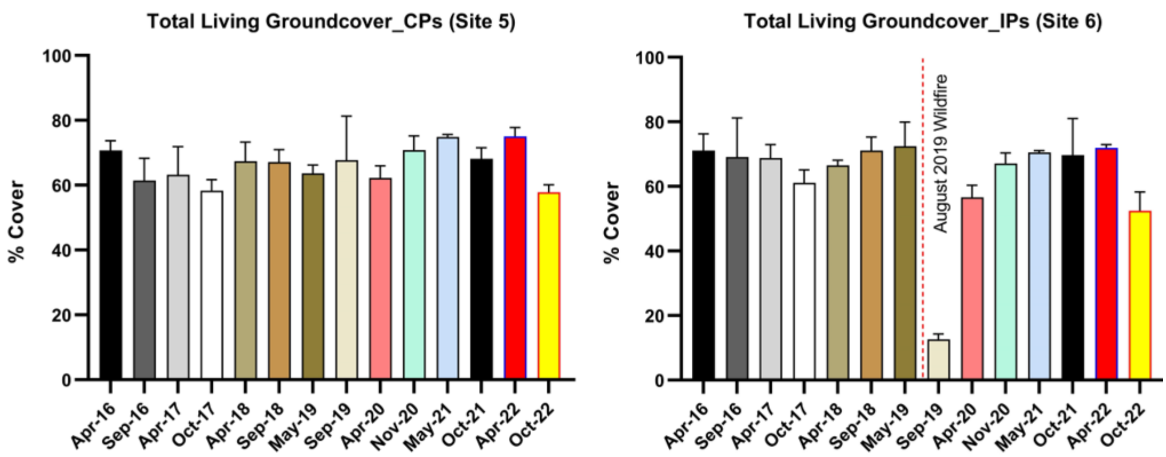

Figure 16. Living groundcover values (%) for CPs (left) and IPs (right) for the period from 2016 to 2022**.**

Table 3. Summary of groundcover contribution by various lifeforms over the assessment periods from 2016 to 2022.

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	67.25
Site 6_April 2016	0.85	33.15	37.15	9.5	0.25	19.1	0	0	100	80.65
Site 5_September 2016	1.2	28.45	15.05	24	1.2	30.05	0.05	0	100	68.75
Site 6_September 2016	1.8	33.1	21.2	13	0.2	30.6	0.1	0	100	69.2
Site 5_April 2017	1.05	31.1	12.5	28	0	27.35	0	0	100	72.65
Site 6_April 2017	0.85	29.8	22.05	16.5	0	30.8	0	0	100	69.2
Site 5_October 2017	0.7	28	18.3	10.7	1.5	40.7	0.1	0	100	57.8
Site 6_October 2017	1.2	30	19.8	14.5	0.75	33.75	0	0	100	65.5
Site 5_April 2018	0.8	24.65	14.85	24	0	35.7	0	0	100	64.3
Site 6_April 2018	1.3	28.35	20.5	31.35	0.5	18	0	0	100	81.5
Site 5_September 2018	0.2	27	14.4	23.5	2.5	32.3	0.1	0	100	65.2
Site 6_September 2018	0.95	31.95	22	24.1	3.5	17.5	0	0	100	79
Site 5_April 2019	0.45	21.6	10.8	31.5	1.55	34.1	0	0	100	64.35
Site 6_April 2019	0.6	37	23	16.25	0.75	22.4	0	0	100	76.85
Site 5_October 2019	0.4	25.65	9.8	20.5	1.5	42.05	0.1	0	100	56.45
Site 6_October 2019	0.3	5.1	4.85	7.9	10	71.85	0	0	100	18.15
Site 5_April 2020	0.85	28	9.2	22	15.4	24.55	0	0	100	60.05
Site 6_April 2020	1.35	14.7	34.75	7	19.05	23.15	0	0	100	57.8
Site 5_November 2020	0.55	30.6	13.1	25	5.25	25.5	0	0	100	69.25
Site 6_November 2020	1.3	16.5	32.05	14	33.65	2.5	0	0	100	63.85
Site 5_May 2021	2.05	30.25	15.45	26.5	4.8	20.95	0	0	100	74.25
Site 6_May 2021	1.6	24.85	28.2	16.5	24.25	4.6	0	0	100	71.15
Site 5_October 2021	0.8	28.55	10.3	15	6.25	39.1	0	0	100	54.65
Site 6_October 2021	5.1	28.1	30.95	14.25	14.65	6.95	0	0	100	78.4
Site 5_April 2022	3.7	32	12.4	23.5	6.35	21.85	0	0.2	100	71.8
Site 6_April 2022	3.4	30.75	24.35	14.5	17.35	9.65	0	0	100	73
Site 5_October 2022	2.15	27.6	7.4	18.5	16.65	27.6	0.1	0	100	55.75
Site 6_October 2022	3.7	24.05	14.1	4	17.3	36.85	0	0	100	45.85

3.3.6 Species richness

Species richness has been calculated through combination of seasonal data from the 2016 to 2021 surveys in conjunction with the most recent 2022 assessments. Calculation of species richness is based on combined data for the three monitoring transects at both the CPs and IPs. 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 were 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 impacts of the wildfire in August 2019 reduced species richness to extremely low values (12) in the post fire October 2019 monitoring event. Species richness at the IPs has recovered significantly following the wildfire, although the 45 species reported in the October 2022 monitoring assessment remains below peak species richness reported in October 2016, and remains lower than species richness at the CPs at completion of the most recent monitoring assessment despite initially higher base values. From this data, it is apparent that the wildfire has exerted an overall negative impact on species richness at the wet heath habitat at the IPs. A list of species recorded during the current 2022 survey period attributed to individual monitoring sites is provided in **Appendix D**.

The change in species richness recorded between survey events is statistically significant for both the CPs ($F_{13,52}$ = 2.63; P=<0.006) and the IPs ($F_{13,52}$ = 2.391; P=<0.01) indicating that the changes are occurring in response to variable site conditions, rather than random natural variation. There is also an extremely strong positive correlation between species richness and CRD at the CPs (Site 5) (*r* = 0.7622*, p*=0.001), and a moderate (non-significant) positive correlation (r = 0.469, p=0.09) for the IPs (Site 6). This correlation is shown in **Figure 18** which also shows the data outlier created by the wildfire at the IPs in the October 2019 assessment, a strong lag in species richness behind CRD in the 2022 monitoring assessment for both IPs and CPs, and the lower species richness in the IPs than CPs in the 2022 monitoring assessments.

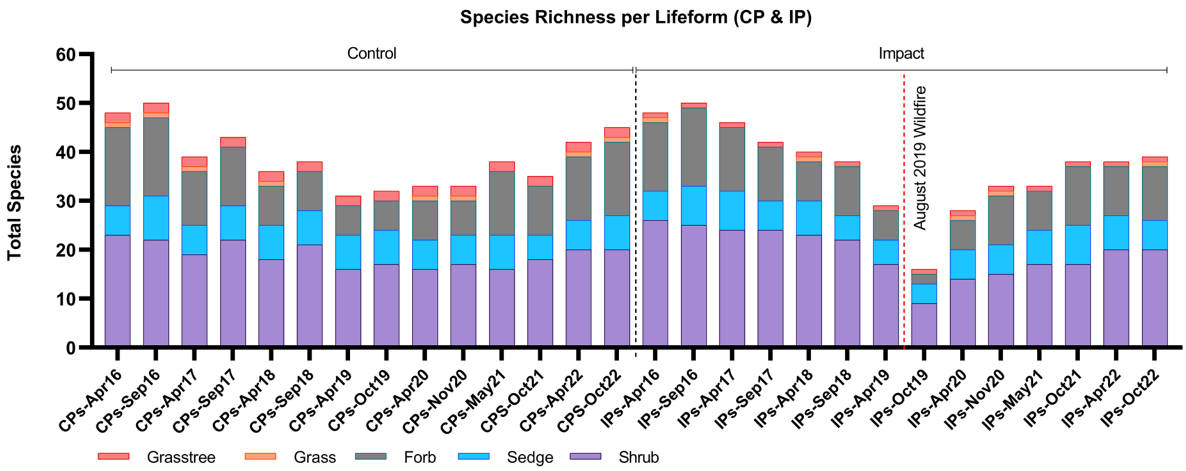

Figure 17. Number of species per lifeform for combined transects from the CPs (Site 5) and IPs (Site 6).

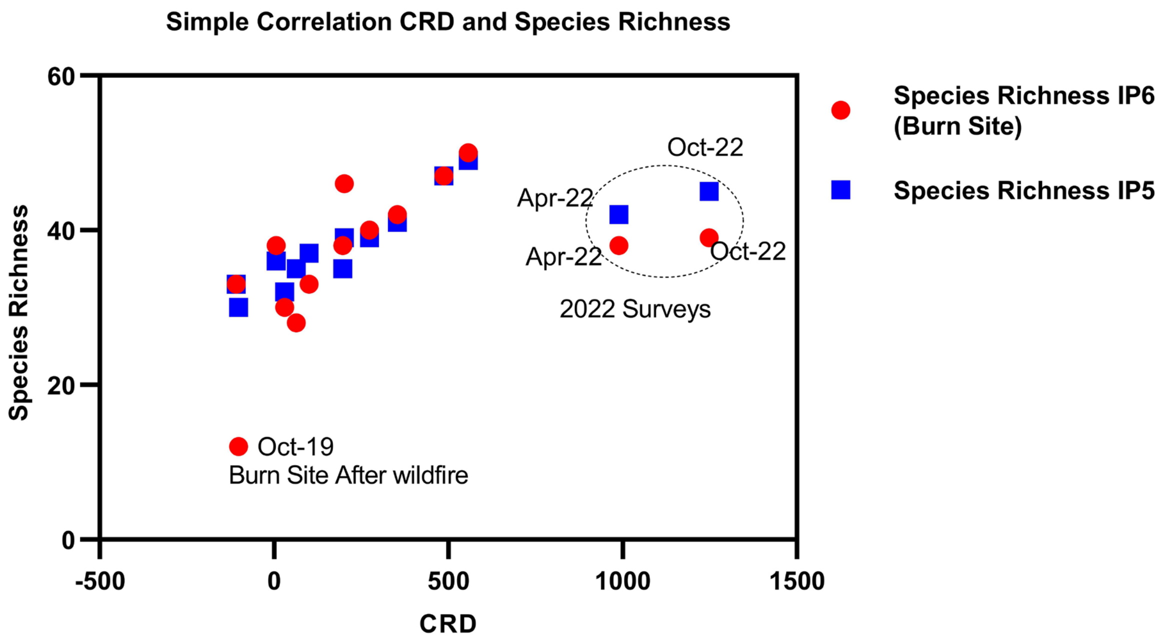

Figure 18. XY correlation plot comparing CRD to species richness for both the CPs (Site 5) and IPs (Site 6) showing the data outlier created by the wildfire (Oct 19 Burn Site after Wildfire) and species richness response lagging behind CRD in the 2022 monitoring events.

4.0 Discussion and Summary

This is the eight year of GDE vegetation monitoring at the Banksia Beach Borefield, and the seventh to be undertaken by 3d Environmental on behalf of Seqwater. Spanning the seven years of assessment, the major structural trends identified in the heathland monitoring sites are discussed in point form below.

1. Species richness for both the CPs (Site 5) and IPs (Site 6) remains highest in September 2016 monitoring assessment and lowest in the April 2019 assessment for the CPs. The lowest species richness at the IPs was reported in the October 2019 assessment which immediately followed an extreme wildfire event which combusted nearly all living vegetation and leaf litter. Following the trough in species richness in April and October 2019, species richness at both sites increased incrementally through to the most recent monitoring event in October 2022. Based on CRD calculations spanning 30 years of data, the highest levels of species richness followed a strong trend in increasing rainfall which spanned 2009 to 2015, after which annual rainfall declined with a trough in the CRD curve occurring in mid-2019 after which the rainfall mass curve began on an upward trajectory. Pearson correlation indicates that species richness is strongly correlated to the CRD value for month and year in which monitoring is undertaken. This is particularly valid for the CPs (Site 5), though the correlation is lesser for the IPs (Site 6) 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 including those forming the groundcover. These intense rainfall events initiated a a strong upkick in the CRD curve, although with an already extremely shallow soil profile, much of the excess rainfall would have been lost as surface runoff.

3. Groundcover forbs are usually mesic lifeforms and these demonstrate a strong positive correlation to rainfall and increased soil moisture content within the rooting zone. Other groundcover lifeforms including shrubs, sedges and grasses, and grasstree fail to demonstrate any correlation to rainfall expressed on the CRD curve. In contrast, woody stems (shrubs >0.5m) demonstrate moderate to strong positive correlation to rainfall and elevated groundwater tables (by association), with some shrubs demonstrating a stronger correlation than others. Shrubs which demonstrate a positive correlation to rainfall include:

   a. the resprouter species *Baeckea frutescens, Leptospermum polygalifolium*, *Leptospermum semibaccatum, Homoranthus virgatus, Leucopogon leptospermoides*

   b. obligate seeder species such as *Phyllota phylicoides, Pultenaea paleacea*, and

   c. Species which present both regeneration mechanisms including *Strangea linearis*, and serotinous species including *Banksia aemula* and *Banksia oblongifolia*.

4. It is likely that the post regeneration of a dense shrub layer of *Phyllota phylicoides ,, as well Banksia aemula* and *Banksia oblongifolia* at the IPs following the August 2019 wildfire has been promoted both by the stimulus of the stored seedbank provided by fire and the increased rainfall that has fallen in the post wildfire period, noting extremely strong rainfall in January and February 2020. However, while some species were apparently promoted by the wildfire, a number of species had populations reduced to a degree that it significantly altered heath structure including the obligate seeder species *Persoonia virgata*, *Boronia falcifolia* and *Leptospermum liversedgei* which is a previously dominant resprouter species. The wildfire that affected the IPs in August 2019 occurred within one of the driest periods in the monitoring program between February 2019 and December 2019 when CRD values were strongly negative, and only 23 mm of precipitation was reported in the the preceding month of July and 4 mm in the preceding weeks of August. Surface moisture in the upper soil profile (150 mm sensor) recorded at the northern SMS was at 12% total moisture content, 23.5% at the 350 mm sensor and saturated at the 650 mm sensor (35%). While soil moisture conditions in the northern SMS were above the lowest levels recorded in March 2019 (where soil moisture content at the 650 mm sensor fell as low as low as 9.3%), the intensity of the fire was sufficient to result in long-term alteration of the floristic composition of the wet heath at this locality with complete destruction of subterranean lignotubers of

Leptospermum liversidgei. This rooting material would otherwise have been protected if the wildfire had occurred under more moderate climatic conditions with higher moisture content in the upper soil profile.

5. Despite higher species richness at the IPs (northern Site 6) compared to CPs (southern Site 5) prior to the wildfire event in the wetter survey periods up to April 2019, species richness remains lower at the IPs in the most recent survey event and recovery has been incremental and slow three years after the fire event. Groundcover forbs appear to be the most affected lifeform with only 11 species reported for the IPs in October 2022 compared to 15 for the CPs. Shrub species richness has also been strongly impacted 26 species reported in the April 2016 at the IPs compared to 20 species reported in October 2022. In comparison at the CPs 23 shrub species were reported in April 2016 and 20 species reported in October 2022. Shrubs that have been entirely eliminated from the species list at the IPs include *Agiortia pedicellata, Aotus lanigera, Austromyrtus dulcis, Eleaocarpus reticulatus, Conospermum taxifolium* and *Persoonia virgata,* the latter being an originally dominant species. This post fire loss of species richness is contrary to the generally accepted paradigm that fire in heathland habitats is necessary for maintenance of species richness and diversity (Freestone et al 2015), and that species richness peaks shortly after a fire and then declines (Russell and Parsons 1978, Enright et al 1994). Given that the last recorded fire in the Bribie National Park prior to the 2019 event was in 2004, giving a 14 year burn interval, the deleterious impact of the wildfire event can only be attributed to fire intensity and dryness of surface soils which facilitated destruction of the soil seed bank, and allowed for destruction of subterranean lignotubers of previously dominant resprouter shrub species.

Summary: Ecological data collected over eight survey periods spanning 2015 to 2022 indicates that the CPs and IPs have broadly similar floristic attributes, with some variation in species composition and structural features including stem density. In the April 2016 assessment the IPs had almost double the shrub stem density of the CPs with 570 stems compared to 201 stems respectively. While at the CP, stem counts were dominated by the obligate seeder *Persoonia virgata* (124 stems) while the resprouter species *Leptospermum liversidgei* (125 stems) dominated the IPs. Following the April 2016 assessment, stem counts at both sites decreased incrementally and stem counts at both CPs and IPs had halved by April 2019 with 100 stems counted at the CPs and 266 stems counted at the IPs. In August 019, a wildfire combusted all living stems at the IPs while stem counts at the CPs continued to decline through to the November 2020 assessment (46 stems). Over this period, species richness similar trends with the 49 species reported at the CPs in September 2016 declining to 30 species by October 2019 and the 50 species reported at the IPs in September 2016 declining to 30 species in April 2019 prior to intense wildfire which reduced species richness to 12. Recovery of stem counts and species richness began in April 2020 at both the IPs and CPs and at completion of the October 2022 assessment, 146 stems were reported at the CPs and 854 stems at the IPs. Similarly, species richness increased from April 2020 at both monitoring sites and 45 species were reported at the CPs and 39 species at the IPs.

These structural and floristic changes are strongly correlated to rainfall trends which are directly linked to groundwater and soil moisture fluctuations in shallow soil profile. The monitoring period spans a full climatic cycle with declining rainfall and regular drying of the shallow soil profile down to depths of 950mm occurring from the April 2016 assessment to November 2020. Following this period, rainfall increased dramatically with a sharp rise in the rainfall mass curve and a number of extreme rainfall events in late 2021 and throughout 2022 have held the groundwater table near surface for most of the 2022 assessment period, as evidenced by soil moisture data from the Southern SMP.

Statistical analysis indicates moderate positive correlation between CRD value in the year and month of survey for stem counts at the CPs (Site 5), although this correlation is not statistically significant. At the IPs (Site 6), the correlation between rainfall and stem counts is extremely strong and statistically significant. For the IPs, this may indicate that the above average rainfall received post wildfire in August 2019 has stimulated rapid recruitment of shrubs. Notably for the IPs, there has been a complete loss of some shrub species following the wildfire including the originally dominant obligate seeder *Persoonia virgata* as well significant reduction of *Leptospermum liversidgei,* a resprouter species which suffered complete destruction of subterannean lignotubers which has limited post fire regeneration. The shrub layer at the IPs is now strongly dominated by *Phyllota phylicoides,* and obligate seeder which was a minor component of the shrub counts in earlier surveys.

There is also an extremely strong positive correlation between species richness and rainfall at the CPs (Site 5), and a moderate positive correlation for the IPs (Site 6), with the latter having natural vegetative response to rainfall interrupted by a severe fire event. Despite higher species richness at the IPs (northern Site 6) compared to CPs (southern Site 5) prior to the wildfire event in April 2019, species richness remains lower at the IPs in the most recent survey and recovery has been incremental and slow three years post fire. This is contrary to the generally accepted paradigm that fire in heathland habitats is necessary for maintenance of species richness and diversity, and that species richness peaks shortly after a fire and then declines. Forbs and shrub appear to be the lifeform most affected by fire suffered the most significant losses post fire at the IPs. Grasses and sedges and grasstree appear to be relatively unaffected.

Data presented over an eight year monitoring period indicate that species richness and heath structure is strongly correlated to rainfall and by association soil moisture and groundwater levels. Groundwater and soil moisture are recharged directly and rapidly by rainfall in the high permeability sands which host the unconfined groundwater table that characterises the Bribie Island sand mass, and there is minimal lag between rainfall and groundwater response. The implications are that sustained periods of drying in the shallow soil profile will result in overall lower species richness, as well as structural changes to the shrub layer which may include a change of species dominance, or loss of some species. Prolonged periods of drying also render coastal heathlands more at risk from the impacts of severe wildfire. While changes to soil moisture and lowering of the unconfined groundwater table are associated with a drying climate, these affects may be compounded by groundwater abstraction in the absence of sufficient rainfall to recharge shallow groundwater tables.

That the dataset spans both a drying and wetting climatic cycle 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 a drying soil profile. The drying soil profile will occur naturally during drought conditions, though it may be compounded by future 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 species richness, which suggests that a predictive ecological baseline is close to being established. There is an identified lag between increased rainfall and vegetative response in the current (2022) dataset. Giving consideration to this, it would be beneficial to complete at least an additional annual monitoring event to determine whether this lag closes in a delayed though ultimately rapid vegetative response, or if the response is gradual and drawn out over a more extended timeframe.

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6.0 Appendix

Appendix A - Monitoring Transects

Survey Locality 5a

Date of Assessment: 7.04.2022 / 06.10.2022
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

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

April 2022

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
13 – 14.4	*Agiortia pedicellata*	1.4	1.9		
17.8 – 18.8	*Agiortia pedicellata*	2.0	2.5		
23.2 – 24.8	*Agiortia pedicellata*	1.6	1.8		
Total Cover		5.0		0	
Median Height			2.0		NA

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

October 2022

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
13.0 – 13.9	*Agiortia pedicellata*	0.9	2.0		
17.8 – 19.0	*Agiortia pedicellata*	1.2	2.5		
23.0 – 24.6	*Agiortia pedicellata*	1.6	1.8		
Total Cover		3.7			
Median Height			2.1	0	NA

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

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2022	50 m x 4 m Stems (50x4m) October 2022
	S2	
Leptospermum semibaccatum	5	19
Agiortia pedicellata	7	7
Baeckea frutescens		3
Leucopogon leptospermoides	4	4
*Pinus elliottii***		1
Melaleuca quinquenervia	1	1
Strangea linearis		1
Totals	17	36

**projected count over 50 x 10m

Ground Cover %- 1 x 1m Sub-plots

April 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Native perennial grass / sedges	*Caustis recurvata*	40	20	10	20	15	10	20	30	25	30	42.75
	Sporodanthus interuptus					10	25	15	1.5	20	30	
	Lomandra elongata		5		2.5				5	2.5	2.5	
	Baloskion tenuiculme	5	20	20	40	2.5						
	Eriachne pallescens var. gracilis					1						
Native forbs and other spp.	*Pimelea liniifolia*										0.5	1.35
	Pseudanthus orientalis							2.5	2.5			
	Cassytha glabella					1			2	1		
	Drosera binata				1			1	1		1	
Native shrubs ,<1m	*Leucopogon leptospermoides*	0.5	2.5				5		5			12.5
	Baeckea imbricata	2.5		0.5	1.0							
	Baeckea frutescens						2.5	20	5	2.5	2.5	
	Strangea linearis		2.5		2.5			5			2.5	
	Leptospermum semibaccatum		5			10	5	15	20			
	Dilwynnia floribunda		1									
	Boronia falcifolia		1									
	Ochrosperma lineare							1.0	5			
Grass Tree	*Xanthorrhoea fulva*	30	20	50		30	20	10		25	15	20
Cryptogams					1		1		1			0.3
Bare Ground		12	13	0	15	20.5	21.5	0.5	17	5	6	11.05
Exotic Shrubs												
Leaf litter		10	10	19.5	17	10	10	10	5	19	10	12.05
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

October 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean October 2022
Native perennial grass / sedges	*Caustis recurvata*	30	5	10	25	15	15	20	20	10	15	37.75
	Sporodanthus interuptus								2.5	5	2.5	
	Lomandra elongata		2.5		2.5							
	Eriachne pallescens var. gracilis		0.5		0.5							
	Baloskion tenuiculme	15	20	30	30	10	10	10	20	15	20	
Native forbs and other spp.	*Pimelea liniifolia*	0.5				0.5		1	1	0.5	1	0.2
	Laxmannia compacta				0.5							
Native shrubs ,<1m	*Leucopogon leptospermoides*					0.5	2.5		10	2.5	1	9.35
	Baeckea frutescens		0.5		10					5		
	Strangea linearis		2.5	1	5			2.5	0.5		0.5	
	Leptospermum semibaccatum		0.5			10	2.5		10			
	Dilwynnia floribunda								1			
	Ochrosperma lineare	1	1	1			2.5	2.5	1			
	Homoranthus virgatus	1			1			10	2.5			
	Boronia falcifolia	1		1								
Grass Tree	*Xanthorrhoea fulva*	20	20	25		15	15	5		20		12
Cryptogams			2.5	2.5	2							0.7
Bare Ground		26.5	37	23.5	21.5	39.5	42.5	40	27.5	36.5		29.45
Exotic Shrubs			1	1						1	0.5	0.35
Leaf litter		5	10	5	5	10	10	10	5	5	37	10.2
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:

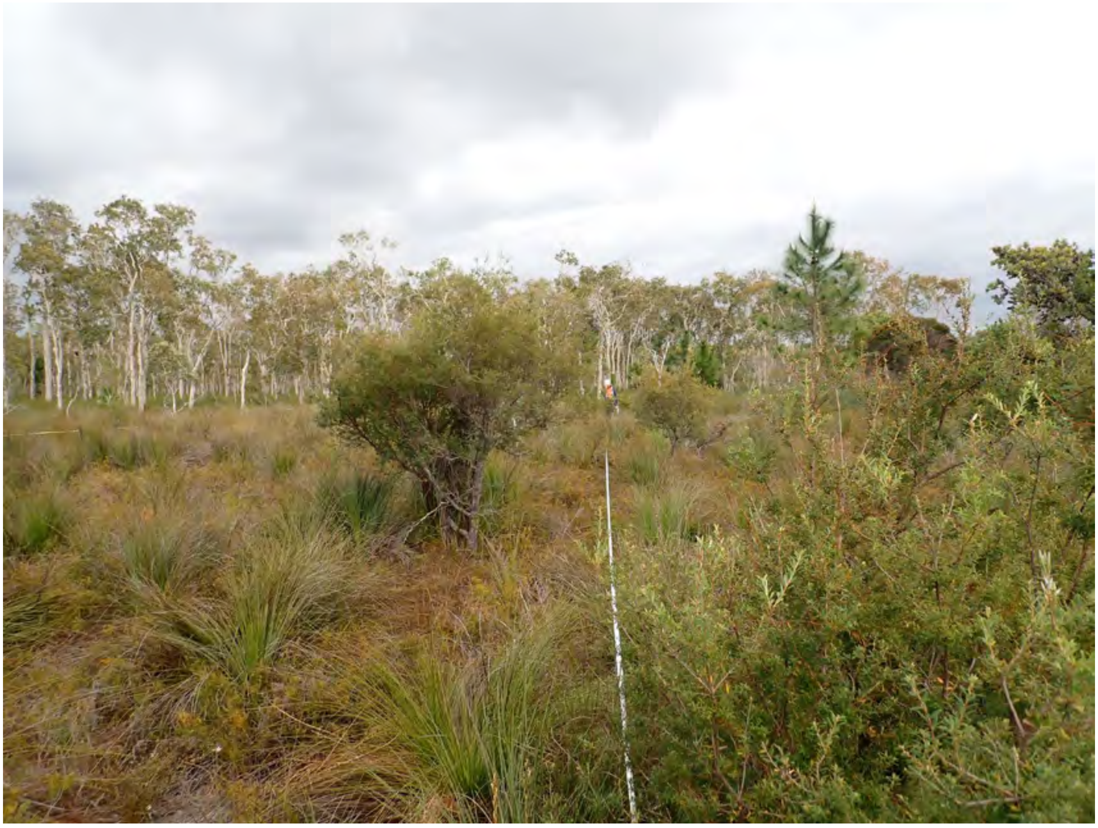
Acacia baueri, Hypolaena fastigiata, Schoenus calostachys. Epacris oblongifolia, Stackhousia nuda, Burchardia umbellata, Patersonia sericea, Drosera binata

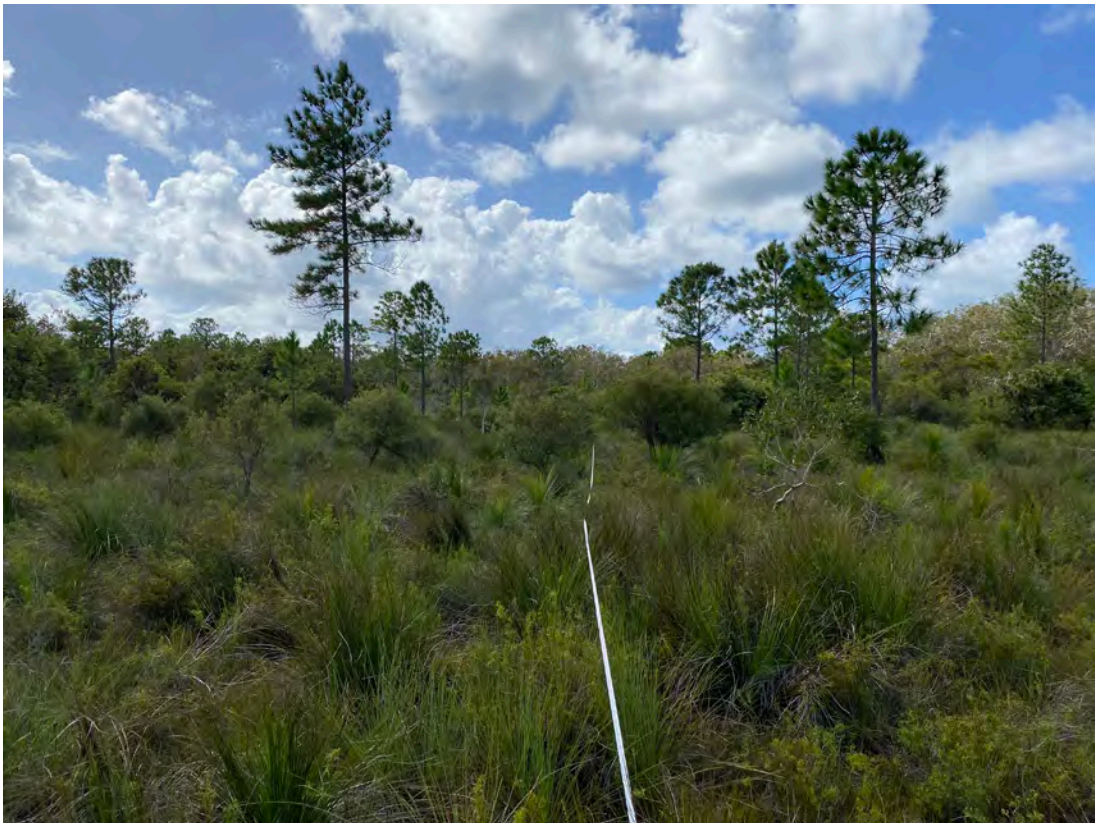
Structural / Floristic Summary

BioCondition Attribute		April 2022	Oct 2022
Native Plant Species Richness	Tree:		
	Shrub:	11	
	Grass Tree	2	
	Grass / Sedge / Rush	5	
	Forbs and other:	8	
Total Species No.**		26	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	10.0	7.4
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	0	0
	Median Height >1m	2.0	2.1
Native Ground cover (%):	Native perennial grass / sedge cover (%):	42.75	37.75
	Native shrubs (%)	12.5	9.35
	Grass tree	20	12
	Organic litter cover (%):	12.05	10.2
	Native forb cover	1.4	0.3
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	0.35

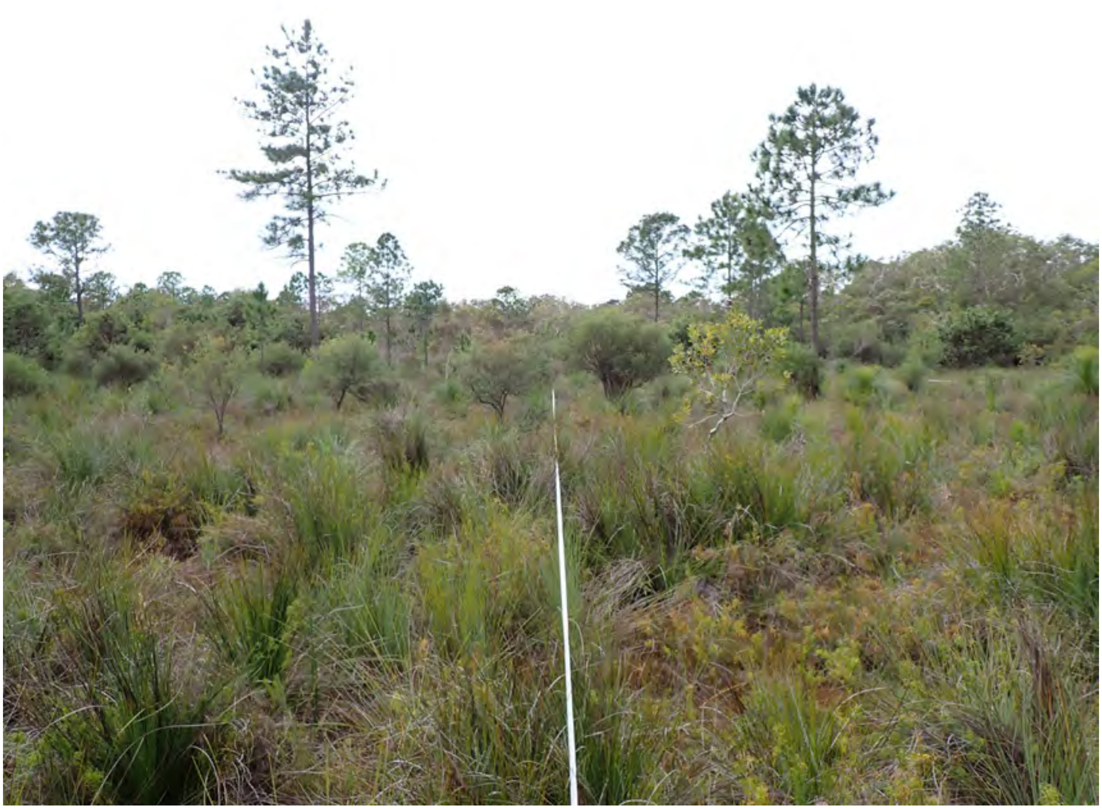
**Excludes Exotic Species

Plot 5a – Centre to Start; April 2022 (Above) and October 2022 (below).





Plot 5a – Centre to End; April 2022 (Above) and October 2022 (below).



Plot 5a – Centre to North; April 2022 (Above) and October 2022 (below).

Plot 5a – Centre to South: April 2022 (Above) and October 2022 (below).

Survey Locality 5b

Date of Assessment: 7.04.2022 / 06.10.2022
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)

April 2022

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
17.0 – 18.4	*Xanthorrhoea johnsonni*	1.4	1.0		
18.8 – 19.4	*Leptospermum semibaccatum*			0.6	0.7
20.0 – 20.9	*Leptospermum semibaccatum*			0.9	0.6
22.9 – 23.3	*Leucopogon leptospermoides*			0.4	0.5
31.0 – 31.9	*Leptospermum semibaccatum*			0.9	0.6
38.7 – 39.0	*Strangea linearis*			1.3	0.6
Total Cover		1.4		4.1	
Median Height			1.0		0.6

** Shrubs > 1m

October 2022

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
14.4 – 15.2	*Leptospermum semibaccatum*			0.8	0.6
17.0 – 18.3	*Xanthorrhoea johnsonni*	1.3	1.0		
18.7 – 19.4	*Leptospermum semibaccatum*			0.7	0.7
20.1 – 20.8	*Leptospermum semibaccatum*			0.7	0.8
22.9 – 23.4	*Leucopogon leptospermoides*			0.5	0.8
28.0 – 29.3	*Leptospermum semibaccatum*			1.3	0.6
31.0 – 31.8	*Leptospermum semibaccatum*			0.8	0.6
38.7 – 39.0	*Strangea linearis*			0.3	0.6
Total Cover		1.3		5.1	
Median Height			1.0		0.7

** Shrubs > 1m

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2022	50 m x 4 m Stems (50x4m) October 2022
	S2	S2
Persoonia virgata	1	1
Leucopogon leptospermoides	3	3
Ochrosperma lineare	2	2
Boronia falcifolia		2
Leptospermum semibaccatum	20	29
Sprengelia sprengelioides		
Strangea linearis	2	2
Acacia flavescens	1	1
Epacris pulchella		
Agiortia pedicellata	3	4
Baeckea frutescens	1	2

Xanthorrhoea johnsoni (from top of trunk	1	1
Leptospermum polygalifolium	2	2
Dillwynia floribunda	1	
*Pinus elliottii**	1	1
Totals	37	48

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

Ground Cover %- 1 x 1m Sub-plots

April 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Native perennial grass / sedges	*Caustis recurvata*	20	25	10	30	10	15	15	15	20	30	37.7
	Sporodanthus interuptus	20										
	Baloskion tenuiculme	5	20	10	10	10	15	15	10	20	15	
	Lomandra elongata			2.0	2.0		5					
	Eriachne pallescens var. gracilis		5									
	Hypolaena fastigiata			2.5	1		2.5	2.5	2	5	2.5	
Native forbs and other spp.	*Pimelea liniifolia*	1	2	1	1				2.5		1	4
	Cassytha glabella		1			1		1		2		
	Patersonia sericea		5									
	Drosera binata		1	1	1	1	1	1	1		1	
	Pseudanthus orientalis		1	2.5	2	1	2.5			2.5	2	
Native shrubs ,<1m	*Leucopogon leptospermoides*	2.5				2.5		5		5	5	21.6
	Strangea linearis	2.5		2.5	1	10					5	
	Leptospermum semibaccatum			20	10	20	30	40	15	2	5	
	Homoranthus virgatus											
	Baeckea frutescens	0.5				2.5	2.5			2.5		
	Ochrosperma lineare			2.5	2	2.5		2.5	5	2.5	2.5	
	Acacia baueri				1							
	Epacris obtusifolia				2.5							
	Leptospermum polygalifolium									2		
Grass Tree	*Xanthorrhoea fulva*	20	15	30		20				15	15	11.5
Cryptogams				10	5							1.5

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Bare Ground		14.5	5	1	20	14.5	21.5	13	10	5	6	11.05
Exotic Shrubs	*Pinus elliottii***											
Leaf litter		14	20	5	11.5	5	5	5	34.5	16.5	10	12.65
Timber (>/= 10cm)												
Total		100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

Additional Species: *Microtus parviflora, Stackhousia nuda, Cassytha glabella, Epacris pulchella, Patersonia sericea, Dillwynia floribunda*

October 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Oct 22
Native perennial grass / sedges	*Caustis recurvata*	15	5	5	20	10	10	5	10	10	5	33.65
	Sporodanthus interuptus											
	Baloskion tenuiculme	20	50	10	15	20	15	15	10	15	50	
	Lomandra elongata		5	2.5								
	Schoenus calostachys		5									
	Hypolaena fastigiata			1	2.5	1	1	1	2.5			
Native forbs and other spp.	*Pimelea liniifolia*	1	1	1		1	2.5		1	1		1.3
	Laxmannia compacta					0.5	1		1			
	Pseudanthus orientalis						*1*			*0.5*	*0.5*	
Native shrubs ,<1m	*Leucopogon leptospermoides*	2.5			10			2.5			1	14.35
	Strangea linearis			5	1	10		5			1	
	Leptospermum semibaccatum			20	10	2.5	20	15	10		1	
	Homoranthus virgatus	1	1			2.5		1	5	1		
	Olax retusa	1			1							
	Baeckea frutescens									2		
	Ochrosperma lineare				1	1	1	1	5		0.5	
	Boronia falcifolia										1	
	Acacia baueri				1							
Grass Tree	*Xanthorrhoea fulva*	20	2.5	10		20				10	5	6.75
Cryptogams				2.5		1		1				0.45
Bare Ground		33.5	27	38	32.5	20	46	47.5	45.5	39.5	34	36.35
Exotic Shrubs	*Pinus elliottii***	1	1		1	0.5		1		1	1	0.65
Leaf litter		5	2.5	5	5	10	2.5	5	10	20		6.5
Timber (>/= 10cm)												
Total		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Additional Species: *Cassytha glabella, Stackhousia nuda, Patersonia sericea, Mirbellia rubifolia*

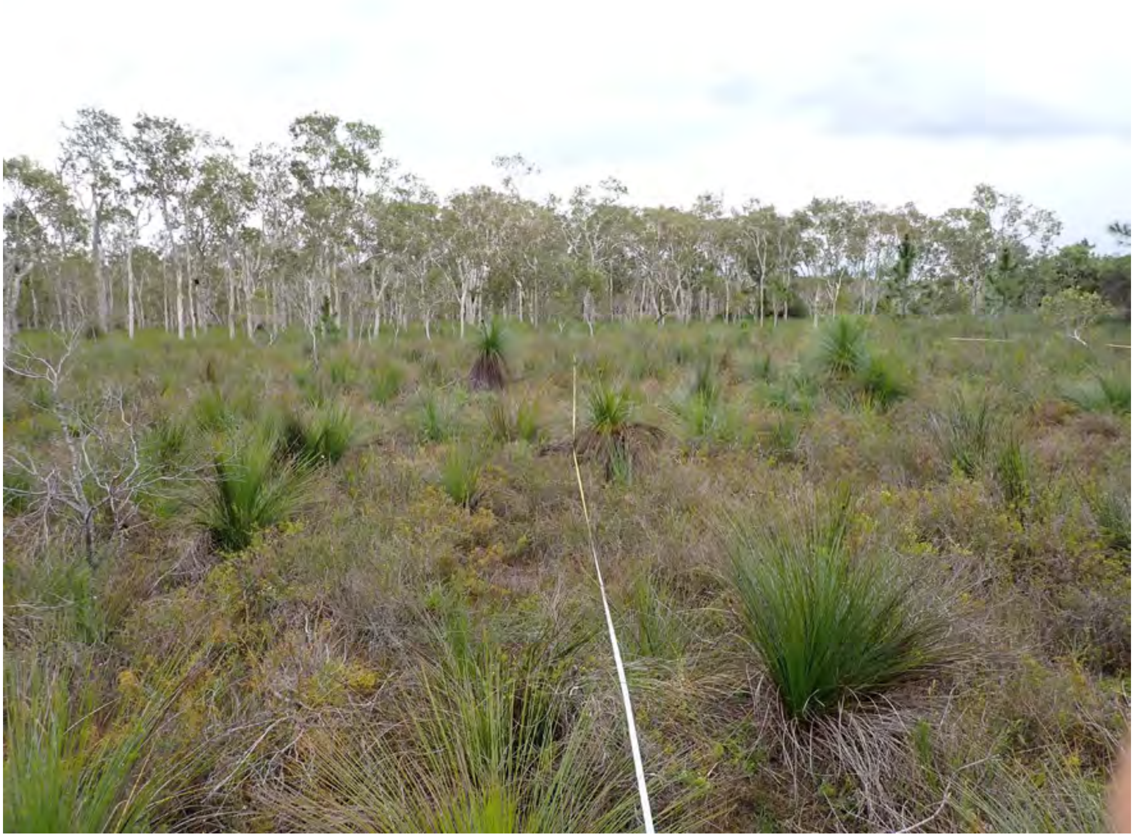
Structural / Floristic Summary

BioCondition Attribute	April 2022	October 2022

BioCondition Attribute		April 2022	October 2022
Native Plant Species Richness	Tree:		
	Shrub:	16	
	Grass Tree	2	
	Grass / Sedge	7	
	Forbs and other:	9	
Total Species No.**		34	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	2.8	2.6
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	8.2	10.2
Native Ground cover (%):	Native perennial grass / sedge cover (%):	37.7	43.75
	Native shrubs (%)	21.6	17.15
	Grass tree	11.5	9.5
	Organic litter cover (%):	12.6	18.7
	Native forb cover (%)	4	0.55
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	0.35

** Excludes Exotic Species

Plot 5b Centre to Start: April 2022 (above) and October 2022 (below).



Plot 5b – Centre to End: April 2022 (above) and October 2022 (below).

Plot 5b – Centre to South; April 2022 (above) and October 2022 (below).

Plot 5b – Centre to North: April 2022 (above) and October 2022 (below).

Survey Locality 5c

Date of Assessment: 7.04.2022 / 06.10.2022

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

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

April 2022

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
35.7 - 36	*Leptospermum polygalifolium*			0.3	0.6
37.1 – 38.0	*Leptospermum polygalifolium*	0.9	1.2		
39.8 – 40.2	*Baeckea frutescens*			0.4	0.65
47.0 – 47.8	*Leucopogon leptospermoides*			0.8	0.6
48.5 - 50	*Agiortia pedicellata*	1.5	3.0		
Total Cover		2.4		1.5	
Median Height			2.4		0.6

*** Tree not included in cover calculation

October 2022

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
22.8 - 23	*Homoranthus virgatus*			0.2	0.6
35.7 - 36	*Leptospermum polygalifolium*			0.3	0.6
37.1 - 38	*Leptospermum polygalifolium*	0.9	1.2		
39.7 – 40.2	*Homoranthus virgatus*			0.3	0.6
42.6 - 43	*Homoranthus virgatus*			0.4	0.6
43.6 – 43.9	*Leptospermum semibaccatum*			0.3	0.6
44.9 – 45.2	*Leptospermum semibaccatum*			0.3	0.6
44.9 – 45.2	*Leptospermum semibaccatum*			0.3	0.6
45.5 – 45.8	*Leptospermum semibaccatum*			0.3	0.6
47.0 – 47.8	*Leucopogon leptospermoides*			0.8	0.7
48.5 – 50.0	*Agiortia pedicellata*	1.5	3.0		
Total Cover		2.4		3.2	
Median Height			2.4		0.6

*** Tree not included in cover calculation

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2022	50 m x 4 m Stems (50x4m) October 2022
Persoonia virgata	2	
Leucopogon leptospermoides	1	3
Leptospermum semibaccatum	4	21

Strangea linearis		3
Agiortia pedicellata	4	3
Leptospermum polygalifolium	9	8
Homoranthus virgatus		9
Baeckea frutescens	6	11
Melaleuca pachyphyllus	1	3
Melaleuca quinquenervia	4	1
Totals	30	62

Ground Cover %- 1 x 1m Sub-plots

April 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Native perennial grass / sedges	*Caustis recurvata*			10	10	15	20	15	20	25	15	32
	Hypolaena fastigiata					2.5		2.5	2.5		2.5	
	Gahnia seiberiana		15									
	Sporodanthus interruptus	10	15	15	30	25	25			5		
	Baloskion tenuiculme								15	5	10	
	Lomandra elongata			1	1							
	Eriachne pallescens var. gracilis			2.5	1					2	2.5	
Native forbs and other spp.	*Pimelea liniifolia*	5		0.5	1	1			1		1	3.7
	Cassytha glabella	1			2	1		1				
	Hibbertia salicifolia		2.5						2.5	2.5		
	Cryptostylis erecta	1										
	Drosera bipinnata	1			1		1	1	1	1	1	
	Gonocarpus micranthus				1							
	Pseudanthus orientalis					2.5						
	Patersonia sericea							2.5				

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Native shrubs ,<1m	*Leucopogon leptospermoides*			2.5			1	15	10	2	10	12.4
	Strangea linearis			5	2	1			2.5	5	1	
	Leptospermum semibaccatum						2.5	10		5	10	
	Baeckea frutescens	15	10									
	Baeckea imbricata									2.5		
	Dyllwynia floribunda									2.5		
	Ochrosperma lineare			2.5		1						
	Homoranthus virgatus						1				5	
Grass Tree	*Xanthorhoea fulva*	40	15	15	50	20	20	10	10	25	30	23.5
Cryptogams										1	1	0.2
Bare Ground		5		5		5	5		30.5	3	10	6.35
Exotic Shrubs	*Pinus elliottii***											0
Leaf litter		22	42.5	41	1	26	24.5	43	5	12.5	1	21.85
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

<u>Additional Species:</u> *Burchardtia umbellata, Hibbertia salicifolia, Banksia aemula, Blechnum cartiligineum, Melaleuca quinquenervia, Xanthorrhoea johnsonni, Melaleuca pachyphyllus, Austromyrtus dulcis, Laxmannia compacta, Stackhousia nuda*

<u>October 2022</u>

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Oct 2022
Native perennial grass / sedges	*Caustis recurvata*			5	2.5	10	10	10	10	10	5	27.6
	Hypolaena fastigiata							1	2.5	2.5		
	Gahnia seiberiana		20									
	Sporodanthus interruptus	15	10	25	5	5	2.5	5	5		5	
	Baloskion tenuiculme			5	10	15	15	10	20	10	20	

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Oct 2022
	Lomandra elongata			2.5								
	Eriachne pallescens var. gracilis			2.5								
Native forbs and other spp.	*Pimelea liniifolia*	1		1			0.5			11		2.15
	Cassytha glabella	1		1	1							
	Pseudanthus orientalis			1								
	Gonocarpus micranthus				1							
	Mirbelia rubiflora			1					1			
	Patersonia sericea							1				
Native shrubs ,<1m	*Leucopogon leptospermoides*			1		2.5		10	5			7.4
	Strangea linearis			2		2.5			5	2.5		
	Leptospermum semibaccatum					5	5	10		2.5		
	Baeckea frutescens	10										
	Boronia falcifolia			1	1							
	Ochrosperma lineare					1			1			
	Homoranthus virgatus						1		1		1	
	Dillwynia floribunda								0.5	2.5	1	
Grass Tree	*Xanthorhoea fulva*	40	25	10	50	10	10	10		25	5	18.5
Cryptogams												
Bare Ground		5		32	19.5	19	51	10	15	5	10	16.65
Exotic Shrubs	*Pinus elliottii***										1	0.1
Leaf litter		28	45	10	10	30	5	33	34	29	52	27.6
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

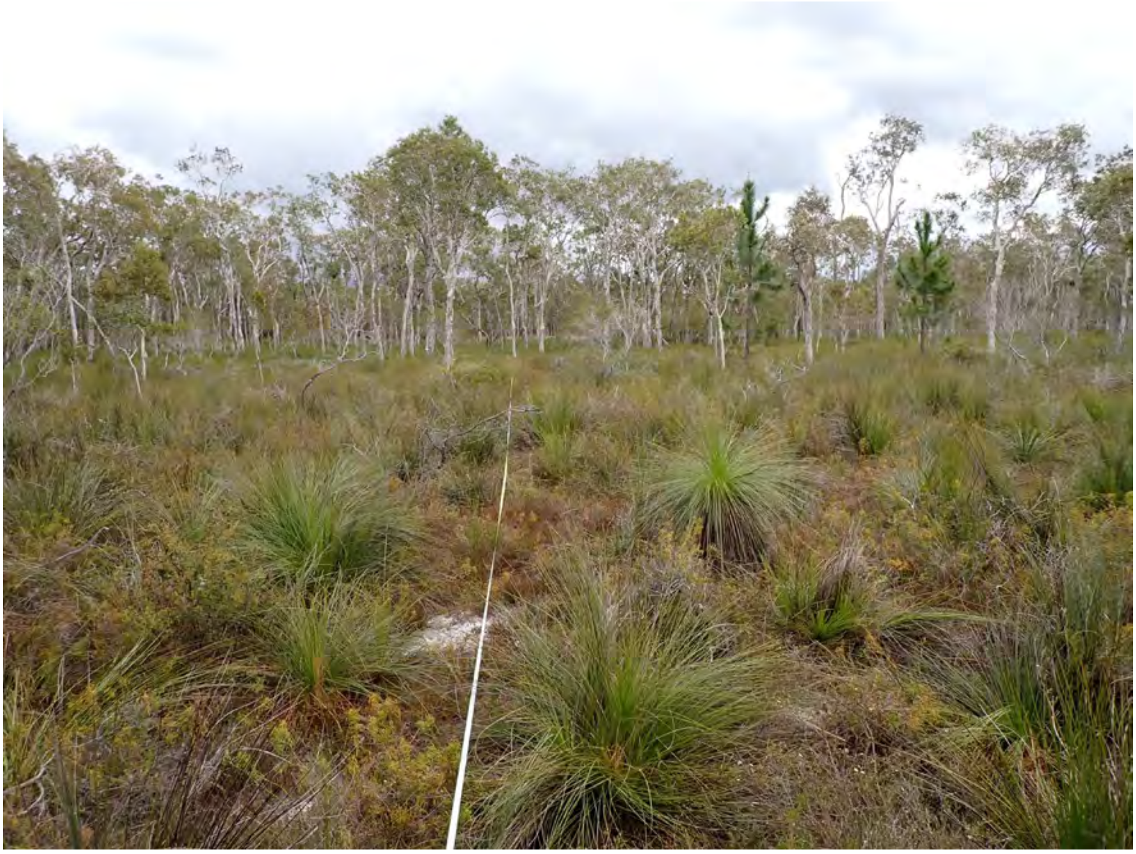
<u>Additional Species:</u> *Burchardtia umbellata, Hibbertia salicifolia, Banksia aemula, Blechnum cartiligineum, Melaleuca quinquenervia, Xanthorrhoea johnsonni, Melaleuca pachyphyllus, Xyris complanata, Mitrasacme alsinoides, Austromyrtus dulcis,Drosera binnata, Stackhousia nuda, Laxmannia compacta*

Structural / Floristic Summary

BioCondition Attribute		April 2022	October 2022
Native Plant Species Richness	Tree:	.	
	Shrub:	15	
	Grass Tree	2	
	Grass / Sedge	6	
	Forbs and other:	17	
Total Species No.**		40	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	4.8	4.8
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	3	6.4
Native Ground cover (%):	Native perennial grass / sedge cover (%):	32	27.6
	Native shrubs (%)	12.4	7.4
	Grass tree	23.5	18.5
	Organic litter cover (%):	21.85	27.6
	Native forb cover (%)	3.7	2.15
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	0.1

** Excludes Exotic Species

Plot 5c – Centre to Start: April 2022 (Above) and October 2022 (Below).



Plot 5c – Centre to End: April 2022 (Above) and October 2022 (Below).

Plot 5c – Centre to Right: April 2022 (Above) and October 2022 (Below).

Plot 5c – Centre to Left: April 2022 (Above) and October 2022 (Below).

Survey Locality 6a

Date of Assessment: 7.04.2022 / 06.10.2022
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

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

April 2022

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
3.4– 5.5	*Banksia aemula*	2.1	3.5		
10.4 – 11.1	*Baeckea frutescens*	0.7	1.5		
12.0 – 13.2	*Baeckea frutescens*	1.2	1		
15.5 - 16.5	*Baeckea frutescens*	1.0	1		
22.5 – 24.0	*Banksia oblongifolia*	1.5	1		
25.7 – 26.3	*Pultenaea paleaceae*			0.6	0.8
28.5 – 29.1	*Phyllota phyllocoides*			0.8	0.5
29.9 – 30.7	*Phyllota phyllocoides*	0.4	1.1.		
31.9 – 32.5	*Banksia oblongifolia*			0.6	0.6
34.3 – 34.6	*Phyllota phyllocoides*	0.3	1.0		
37.0 – 37.2	*Phyllota phyllocoides*	0.2	1.0		
38.2 – 38.8	*Phyllota phyllocoides*			0.6	0.6
39.3 – 39.5	*Phyllota phyllocoides*			0.2	0.8
40.8 – 41.0	*Phyllota phyllocoides*			0.2	0.7
46.1 - 46.3	*Phyllota phyllocoides*	0.2	1.0		
46.4 – 47.2	*Banksia oblongifolia*			0.8	0.8
48.5 – 48.8	*Leptospermum liversedgei*			0.3	0.6
Total Cover		7.6		4.1	
Median Height			1.8		0.7

*** Tree not included in cover calculation

October 2022

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
2.9– 5.3	*Banksia aemula*	2.4	3.5		
7.6 – 8.6	*Baeckea frutescens*			1.0	0.6
10.3 – 11.0	*Baeckea frutescens*	0.7	1.5		
12.0 – 12.8	*Baeckea frutescens*	0.8	1.0		
13.3 – 16.5	*Baeckea frutescens*	3.2	1.0		
17.2 – 17.9	*Banksia oblongifolia*			0.7	0.6
22.3 – 23.7	*Banksia oblongifolia*			1.4	0.7
25.9 – 26.1	*Pultenaea paleaceae*			0.2	0.7
28.3 – 29.4	*Phyllota phyllocoides*	1.1	1.2		
31.3 – 31.6	*Pultenaea paleaceae*	0.3	1.0		
34.2 – 34.5	*Phyllota phyllocoides*	0.3	1.1		
36.1 – 36.3	*Phyllota phyllocoides*			0.2	0.8

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
37.1 – 37.6	*Phyllota phyllocoides*			0.5	0.9
38.1 – 38.8	*Phyllota phyllocoides*			0.7	0.9
39.3 – 39.5	*Phyllota phyllocoides*			0.2	0.8
40.6 – 40.8	*Phyllota phyllocoides*			0.2	0.8
46.0 – 46.6	*Phyllota phyllocoides*	0.6	1.0		
46.8 – 47.2	*Banksia oblongifolia*			0.4	0.9
48.4 – 48.7	*Leptospermum liversedgei*			0.3	0.7
Total Cover		9.2		1.1	
Median Height			1.8		0.7

*** Tree not included in cover calculation

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2022	50 m x 4 m Stems (50x4m) Oct 2022
	S2	
Persoonia virgata		
Banksia aemula	1	1
Banksia oblongifolia	21	25
Epacris pulchella		
Leptospermum liversidgei	3	5
Leptospermum semibaccatum	4	17
Boronia falcifolia		9
Sprengelia sprengeliodes		
Leucopogon leptospermoides	1	5
Baeckea frutescens	7	6
Dilwynnia floribunda		
Epacris obtusifolia		1
Strangea linearis		1
Phyllota phyllocoides	141	135
Sprengelia sprengelioides		1
Pultenaea paleacea	2	7
Leptospermum polygalifolium	1	2
Totals	181	215

<u>Ground Cover %- 1 x 1m Sub-plots</u>
<u>*April 2022*</u>

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Native perennial grass / sedges	*Caustis recurvata*	5	2.5	2.5	2.5					5		20.35
	Sporodanthus interruptus	20	15	5	20	25	30	15	10	20	15	
	Lomandra longifolia					1				2.5		
	Lomandra elongata		1	15								
	Baloskion tenuiculm			20								
Native forbs and other spp.	*Pimelea liniifolia*	1	1	1	1		1	1	1		1	2.9
	Cassytha glabella			1		0.5						
	Selaginella uliginosa									1		
	Burchardia umbellata									1		
	Drosera binata	1	1	1			1			1		
	Gonocarpus micranthus									2.5		
	Hibbertia salicifolia							2.5	2.5	2.5	2.5	
Native shrubs ,<1m	*Boronia falcifolia*	2.5	5	5	5	10	5	1		10	5	24.3
	Baeckea imbricata				1	2.5	2.51			15		
	Leucopogon leptospermoides											
	Banksia oblongifolia								20			
	Leptospermum semibaccatum	20	15		20							
	Strangea linearis				15	5	10					
	Leptospermum liversidgei					5					2.5	
	Sprengelia sprengelioides	1			1	2.5		2.5	2.5			
	Dillwynnia floribunda	15		2.5	2.5	2.5	1		2.5	2.5		
	Pultenaea paleaceae					5	2.5	1	1			
	Baeckea frutescens							1	10			
	Phyllota phylicoides										2.5	
Grass Tree	*Xanthorrhoea fulva*	2.5		10	10	30	15	60	30	25	60	24.25
Cryptogam												

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Bare Ground			5	5	17	10	32	31	15.5	19.5	11.5	14.65
Exotic Shrubs												
Leaf litter		32	57	34.5	5	2			5			13.55
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

October 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Oct 2022
Native perennial grass / sedges	*Caustis recurvata*			2.5	5							19.95
	Sporodanthus interruptus	25	20	10	15	15	5		30	25	10	
	Baloskion tenuiculme			20	5							
	Hypolaena fastigiata	1	1									
	Lomandra elongata			10								
Native forbs and other spp.	*Pimelea liniifolia*	1		1		1		0.5	1		1	2.25
	Cassytha glabella								1			
	Hibbertia salicifolia								1	1	5	
	Pseudanthus orientalis			1	0.5							
	Burchardia umbellata						1					
	Selaginella uliginosa							1	1	2.5		
	Patersonia sericea					1						
	Gonocarpus micranthus									1		
Native shrubs ,<1m	*Boronia falcifolia*		1	5	5	10	5	0.5	1	10	2.5	16.3
	Baeckea imbricata	2.5		1	1	1	2.5					
	Dylwynnia floribuna	1										
	Leptospermum semibaccatum	15	15	5	10							
	Strangea linearis				5	2.5	1					
	Homoranthus virgatus	2.5	5	0.5	1	0.5						
	Sprengelia		1	1	1	2.5		1	1	1		

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Oct 2022
	sprengelioides											
	Olax retusa						1		1		1	
	Pultenaea paleaceae					2.5		5				
	Baeckea frutescens							2,5	10	10	10	
	Epacris pulchella					1						
	Ochrosperma lineare	1										
Grass Tree	*Xanthorrhoea fulva*			5		15	10	60	20	10	40	16
Cryptogam												
Bare Ground	Bare			33	46.5	43	69.5	27	23	34.5	15.5	29.2
Exotic Shrubs												
Leaf litter	Leaf	51	57	5	5	5	5	5	10	5	15	16.3
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

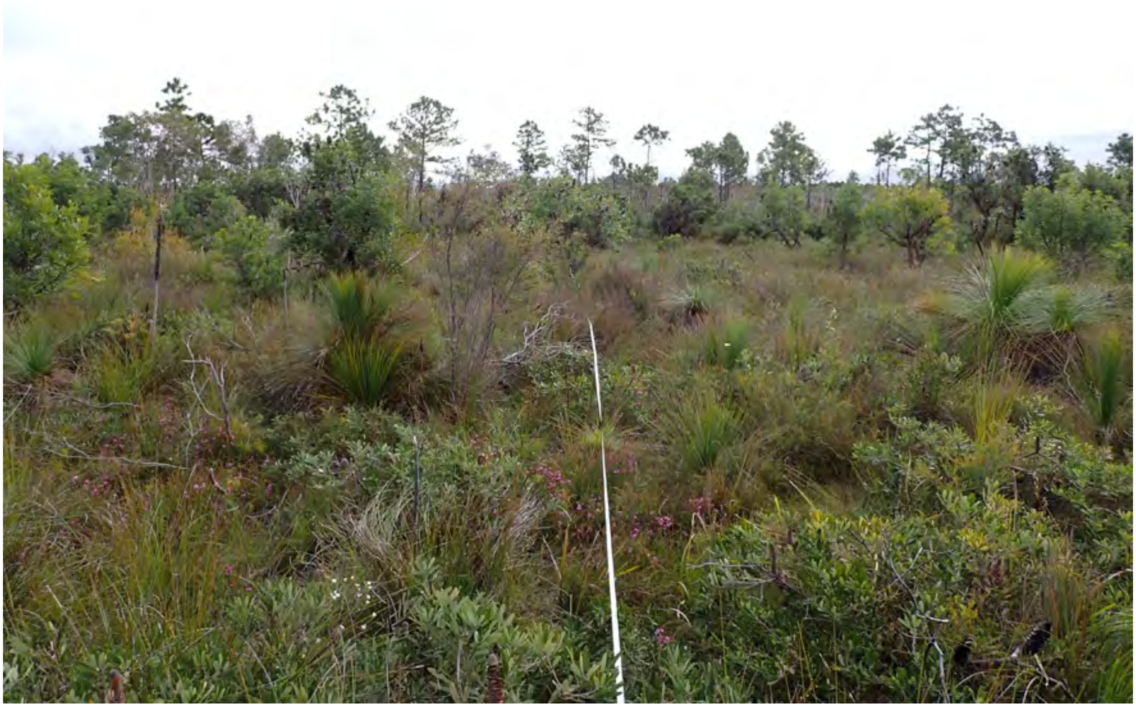
Additional Species: *Stackhousia nuda, Xyris complanata, Lomandra longifolia, Cassytha glabella, Epacris pulchella*

Structural / Floristic Summary

BioCondition Attribute		April 2022	October 2022
Native Plant Species Richness	Tree:		
	Shrub:	19	
	Grass Tree	1	
	Grass / Sedge	6	
	Forbs and other:	11	
Total Species**		37	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	15.2	18.4
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	8.2	2.2
Native Ground cover (%):	Native perennial grass / sedge cover (%):	20.35	19.95
	Native shrubs (%)	24.3	16.3
	Grass tree	24.25	16
	Organic litter cover (%):	13.55	16.3
	Native forb cover (%)	2.9	2.25
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

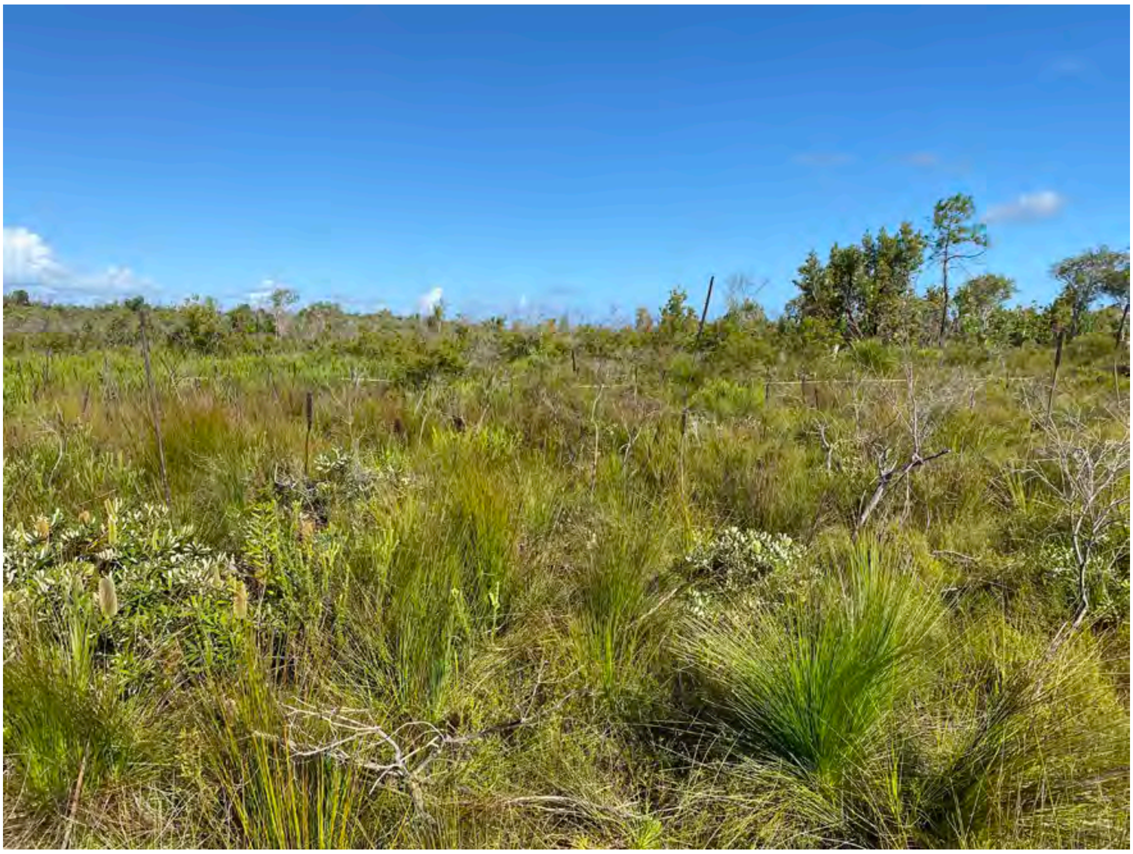
**Excludes Exotic Species

Plot 6a – Centre to Start; April 2022 and October 2022 (Below).



Plot 6a – Centre to End: April 2022 and October 2022 (Below).

Plot 6a – Centre North: April 2022 (Above) and October 2022 (Below)



Plot 6a – Centre to South: April 2022 (Above) and October 2022 (Below).

Survey Locality 6b

Date of Assessment: 7.04.2022 / 06.10.2022.
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)

April 2022

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
3.9- 4.3	*Banksia oblongifolia*			0.4	0.5
7.9 – 8.7	*Banksia oblongifolia*			0.8	0.5
12.7 – 13.9	*Banksia oblongifolia*			1.2	0.5
14.8-15.2	*Leptospermum semibaccatum*			0.4	0.5
16.5 – 18.4	*Banksia oblongifolia*			0.9	0.5
18.8 – 19.2	*Leptospermum polygalifolium*	0.4	1		
21.7 – 22.6	*Baeckea frutescens*			0.9	0.6
28.7 – 29.3	*Phyllota phyllocoides*			0.6	0.7
28.9 – 30.9	*Phyllota phyllocoides*	1.0	1		
33.4 – 34.6	*Phyllota phyllocoides*	1.2	1.2		
34.9 – 35.3	*Leptospermum liversidgei*	0.5	1.0		
35.3 – 36.1	*Phyllota phyllocoides*			0.8	0.8
36.7 – 37.3	*Phyllota phyllocoides*	0.6	1.0		
39.3 – 39.6	*Phyllota phyllocoides*	0.3	1.0		
42.9 – 43.6	*Phyllota phyllocoides*			0.7	0.8
47.5 – 49.4	*Phyllota phyllocoides*	1.9	1.0		
Total Cover		5.9		6.7	
Median Height			1.0		0.7

*** Tree not included in cover calculation

October 2022

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
3.9- 4.3	*Banksia oblongifolia*			0.4	0.7
7.9 – 8.7	*Banksia oblongifolia*			0.8	0.6
12.7 – 13.9	*Banksia oblongifolia*			1.2	0.6
14.8-15.2	*Leptospermum semibaccatum*			0.6	0.6
16.5 – 18.4	*Banksia oblongifolia*			1.9	0.8
18.8 – 19.4	*Leptospermum semibaccatum*			0.6	0.7
21.1 – 22.4	*Baeckea frutescens*			1.3	0.7
22.6 – 23.1	*Boronia falcifolia*			0.5	0.7
26.4 – 27.0	*Banksia oblongifolia*			0.6	0.9
28.8 – 29.3	*Phyllota phyllocoides*			0.5	0.9
29.9 – 31.1	*Phyllota phyllocoides*	0.2	1.0		
32.3 – 32.6	*Phyllota phyllocoides*			0.3	0.8
33.8 – 34.8	*Phyllota phyllocoides*	1.0	1.2		
35.1 – 35.5	*Leptospermum liversidgei*	0.4	1.1		
36.1 – 36.4	*Phyllota phyllocoides*	0.3	1.0		

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
37.0 – 37.8	*Phyllota phyllocoides*	0.8	1.1		
38.6 – 38.9	*Phyllota phyllocoides*	1.3	1.0		
41.6 – 42.0	*Phyllota phyllocoides*	0.3	1.0		
43.0 – 44.0	*Phyllota phyllocoides*	1.0	1.0		
47.6 – 48.5	*Phyllota phyllocoides*	0.9	1.1		
Total Cover		6.2		8.7	
Median Height			1.0		0.6

*** Tree not included in cover calculation

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2022	50 m x 4 m Stems (50x4m) October 2022
	S2	
Persoonia virgata		
Banksia aemula	1	2
Banksia oblongifolia	15	37
Leptospermum liversidgei	3	2
Boronia falcifolia	1	22
Leucopogon leptospermoides	3	15
Baeckea frutescens	24	18
Dillwynnia floribunda	1	1
Olax retusa		1
Epacris obtusifolia		1
Phyllota phyllocoides	296	304
Pultenaea paleacea		3
Strangea linearis		4
Leptospermum polgalifolium	4	4
Leptospermum semibaccatum	1	15
Totals	349	429

Ground Cover %- 1 x 1m Sub-plots

April 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Native perennial grass / sedges	*Caustis recurvata*	2.5				1						31.9
	Sporodanthus interruptus	35	40	40	35	45	25	40	25	10	10	
	Baloskion tenuiculme						2.5					
	Schoenus calostachys							1			2	
	Lomandra longifolia	5										
Native forbs and other spp.	*Drosera binata*			1	1	1	1					6
	Pimelea linifolia	1	2.5	1	1	2.5	1		1	1	1	
	Burchardia umbellata			1	2.5	2.5	20					
	Cassytha glabella	1	1	1	2	2	1					
	Selaginella uliginosa					1						
	Hibbertia salicifolia							1	2.5	2.5	1	
	Pseudanthus orientalis					1						
	Gonocarpus micranthus										1	
Native shrubs ,<1m	*Boronia falcifolia*		5	5	5	2.5	10	1	2.5		5	14.5
	Baeckea imbricata					2.5	10				1	
	Leucopogon leptospermoides		5		1	2.5						
	Strangea linearis			2.5								
	Banksia oblongifolia		10				5					
	Leptospermum semibaccatum	2.5		25	5	1	5					
	Baeckea frutescens									2.5	15	
	Dyllwynia floribunda	2.5	2.5			1						
	Acacia baueri								2.5			
	Sprengelia sprengeliodes							1	1	1		
	Phyllota phylicoides									1	1	
Grass Tree	*Xanthorrhoea fulva*	20	10	10	15	5	2.5	10	30	60	25	18.75
Cryptogams												

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Bare Ground	Bare	5	24	5	25	28.5	15	23	18	11	38	19.25
Exotic Shrubs	*Exotic*											
Leaf litter	Leaf	25.5		8.5	7.5	1	2	23	17.5	11	0	9.6
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

Additional species: *Ochrosperma lineare, Pultenaea paleaceae, Olax retusa*

October 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean October 2022
Native perennial grass / sedges	*Caustis recurvata*					1						33.55
	Sporodanthus interruptus	15	25	50	50	40	20	30	25	10	20	
	Lomandra longifolia	10	10							2.5	2	
	Baloskion tenuiculme					10	10					
	Lomandra elongata			0.5								
	Lomandra sp.									2.5	2.0	
Native forbs and other spp.	*Pimelia liniifolia*	1	2.5	1	1		1		1	1	1	3.45
	Selaginella uliginosa					1						
	Hibbertia salicifolia		0.5						1	2.5		
	Cassytha glabella	1		1								
	Patersonia sericea				2.5	2.5	10	1				
	Gonocarpus micranthus										2	
Native shrubs ,<1m	*Boronia falcifolia*		1	1	2.5	5	2.5				0.5	8.7
	Baeckea imbricata					1	5				0.5	
	Leucopogon leptospermoides			1			.52					
	Homoranthus virgatus			1								
	Banksia oblongifolia		25									
	Leptospermum semibaccatum		1	1	2.5	5	2.5		1		1	
	Baeckea									2.5	10	

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean October 2022
	frutescens											
	Sprengelia sprengelioides	1						0.5	1			
	Homoranthus virgatus											
	Dyllwynia floribunda	2		1	1							
	Phyllota phylicoides								2.5		5	
Grass Tree	*Xanthorrhoea fulva*	15		20	15	5	2.5	10	15	20	10	11.25
Cryptogams												
Bare Ground	Bare	10	1	5	20.5	5	41	2.5	5	54	35	17.9
Exotic Shrubs												
Leaf litter	Leaf	45	34	17.5	5	24.5	5	56	48.5	5	11	25.15
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

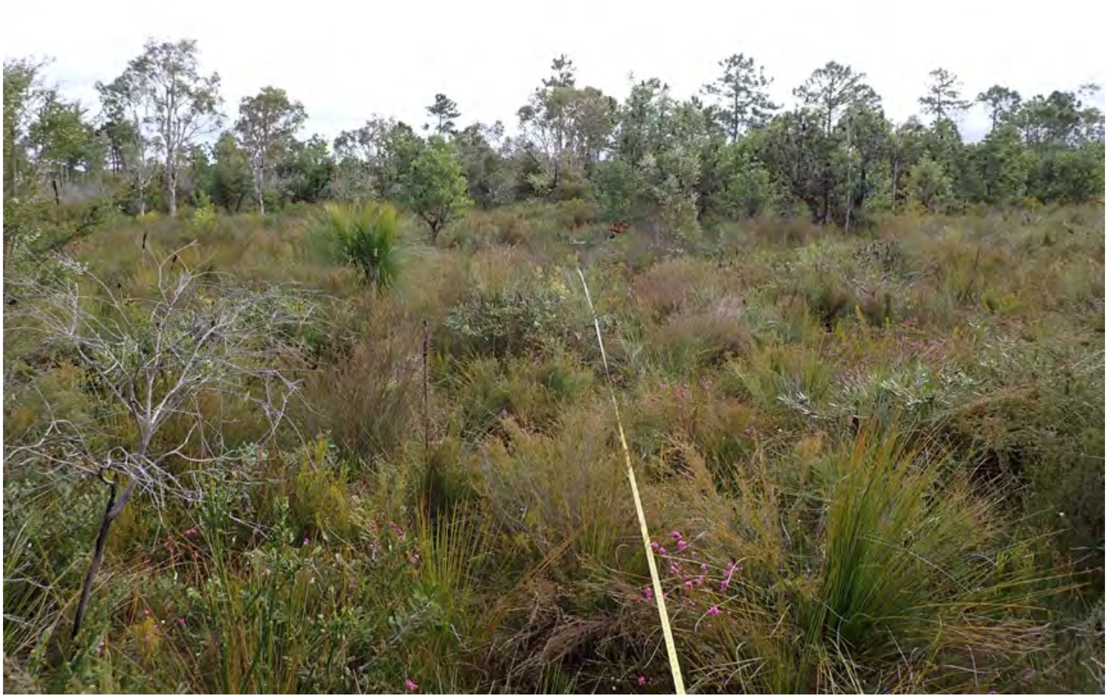
Additional Species: *Burchardia umbellata, Ochrosperma lineare, Olax retusa*

Structural / Floristic Summary.

BioCondition Attribute		April 2022	October 022
Native Plant Species Richness	Tree:		
	Shrub:	19	
	Grass Tree	1	
	Grass / Sedge	7	
	Forbs and other:	9	
Total Species No.**		38	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	11.8	12.4
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	13.4	17.4
Native Ground cover (%):	Native perennial grass / sedge cover (%):	31.9	33.55
	Native shrubs (%)	14.5	8.7
	Grass tree	18.75	11.25
	Organic litter cover (%):	9.6	25.15
	Native forb cover (%)	6	3.45
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: April 2022 and October 2022 (Below)



Plot 6b – Centre to End: April 2022 and October 2022 (Below)

Plot 6b – Centre to North: April 2022 and October 2022 (Below)

Plot 6b – Centre to South: April 2022 and October 2022 (Below).

Survey Locality 6c

Date of Assessment: 7.04.2022 / 06.10.2022.
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)

April 2022

	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
1.6 – 1.8	*Phyllota phyllocoides*	0.2	1.0		
2.1 – 2.8	*Baeckea frutescens*			0.7	0.6
12.8 – 15.1	*Baeckea frutescens*			2.3	0.9
16.6 – 17.9	*Phyllota phyllocoides*	1.3	1.0		
19.0 – 19.8	*Phyllota phyllocoides*	0.8	1.0		
20.8 – 21.4	*Phyllota phyllocoides*	0.6	1.0		
22.3 – 23.7	*Melaleuca quinquenervia*	1.4	3.3		
24.5 – 25.8	*Banksia oblongifolia*			1.3	0.9
25.9 – 26.4	*Phyllota phyllocoides*			0.5	0.9
30.3 – 31.4	*Leptospermum polygalifolium*	1.1	1.4		
33.0 – 33.4	*Baeckea frutescens*			0.4	0.6
46.5 – 46.8	*Leucopogon leptospermoides*			0.3	0.6
48.6 – 50.0	*Banksia aemula*	1.4	3.5		
Total Cover		6.8		5.5	
Median Height			3.0		0.7

October 2022

	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
1.4 – 1.7	*Phyllota phyllocoides*	0.3	1.0		
2.3– 2.8	*Phyllota phyllocoides*			0.5	0.8
5.2 – 5.6	*Leptospermum semibaccatum*			0.5	0.8
6.5 – 6.8	*Phyllota phyllocoides*			0.3	0.5
7.3 – 7.7	*Phyllota phyllocoides*			0.4	0.6
12.7 – 14.1	*Baeckea frutescens*	1.3	1.0		
14.6 - 15	*Phyllota phyllocoides*			0.4	0.6
16.5 – 17.8	*Phyllota phyllocoides*	0.3	1.0		
18.9 – 19.9	*Phyllota phyllocoides*	1.0	1.0		
20.2 – 21.3	*Phyllota phyllocoides*	1.1	1.0		
23.1 – 23.9	*Melaleuca quinquenervia*	0.8	3.5		
24.3 – 25.8	*Banksia oblongifolia*			1.5	0.9
25.8 – 26.5	*Phyllota phyllocoides*	0.7	1.0		
30.2 – 31.4	*Leptospermum polygalifolium*	1.2	1.3		
46.5 – 46.7	*Leucopogon leptospermoides*			0.2	0.6
49.0 - 50	*Banksia aemula*	1.0	4.0		
Total Cover		7.7		3.8	
Median Height			2.5		0.8

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2022	0 m x 4 m Stems (50x4m) October 2022
	S1 – S2	
Persoonia virgata		
Banksia oblongifolia	10	13
Leucopogon leptospermoides	2	4
Boronia falcifolia	4	18
Phyllota phyllocoides	123	128
Baeckea frutescens	10	19
Leptospermum liversidgei	4	3
Leptospermum polygalifolium	9	9
Leptopspermum semibaccatum	4	12
Melaleuca quinquenervia	1	1
Banksia aemula	1	1
Strangea linearis	1	2
Epacris pulchella		
Totals	169	210

Ground Cover %- 1 x 1m Sub-plots

April 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Native perennial grass / sedges	*Caustis recurvata*	30	15	10		2.5	5		5	5	20	30.75
	Sporodanthus interruptus	10	20	30	30	30	30	5	10	10	15	
	Lomandra longifolia				5	5	2.5			2.5		
	Baloskion tenuiculme											
Native forbs and other spp.	*Pimelea liniifolia*	1	1	2.5				1			1	3.4
	Cassytha glabella	1	2	0.5	1	1	1		1	1	1	
	Sellaginella uliginosa		2	2.5	2.5			1		0.5		

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
	Burchardia umbellata			1	2.5							
	Drosera binata				1		1	1				
	Pseudanthus orientalis						1	1				
	Gonocarpus micranthus						1					
Native shrubs ,<1m	*Boronia falcifolia*	2.5		2.5	5	5	5	5	2.5	2.5	10	24.35
	Baeckea imbricata		1						1	1	1	
	Baeckea frutescens										10	
	Dyllwinia floribunda						1	2.5	2.5	2.5		
	Leucopogon leptospermoides			1	5				1			
	Persoonia virgata						1					
	Banksia oblongifolia							10	50		10	
	Strangea linearis	10			2.5							
	Leptospermum semibaccatum	10	10			2.5	2.5	1				
	Pyllota phyllocoides		5			5					2.5	
	Agiortia pedicellata						1					
	Sprengelia sprengelioides	1										
Grass Tree	*Xanthorrhoea fulva*	15	15	5		50	10	10	5	25	15	14.5
Bare Ground	Bare	14.5	27	44	45.5		20	7.5	15	0	0	17.35
Leaf litter	Leaf	5	2	1	0	4	18	5	7	40	14.5	9.65
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

October 2022

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
Native perennial grass / sedges	*Caustis recurvata*	15	10	5		1				2.5	10	24.05
	Sporodanthus interruptus	10	10	15	30	25	15		10	20	20	
	Eriachne							1				

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 2022
	pallescens var. gracilis											
	Lomandra elongata											
	Lomandra longifolia					2.5	2.5	2	5	2.5	1	
	Baloskion tenuiculme				20			15				
Native forbs and other spp.	*Pimelea liniifolia*	1	1	1	1	2.5	2.5	12.5	1		1	3.7
	Cassytha glabella				1	0.5	1		0.5			
	Sellaginella uliginosa		1	2.5	2.5			2	1	1		
	Patersonia sericea				1			2				
	Pseudanthus orientalis						1			0.5		
Native shrubs ,<1m	*Boronia falcifolia*	1	2.5	5	2.5	2.5	2.5	5	1	1	2.5	14.1
	Baeckea imbricata		1							1		
	Baeckea frutescens				1							
	Dyllwinia floribunda	1	1					1	1	2.5	2.5	
	Leucopogon leptospermoides	1		5	1		1	1	1			
	Banksia oblongifolia							2	60			
	Strangea linearis	5			5	1					1	
	Leptospermum liversidgei		5									
	Leptospermum semibaccatum	2.5		2.5	1		2.5	1	0.5			
	Phyllota phyllocoides		1			2.5					1	
Grass Tree	*Xanthorrhoea fulva*	10	10				5	5	5		5	4
Bare Ground		10	52.5	5	30	53	5	5	2.5	5	5	17.3
Leaf litter		43.5	5	65	5	10	64.5	47.5	12	64	52	36.85
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

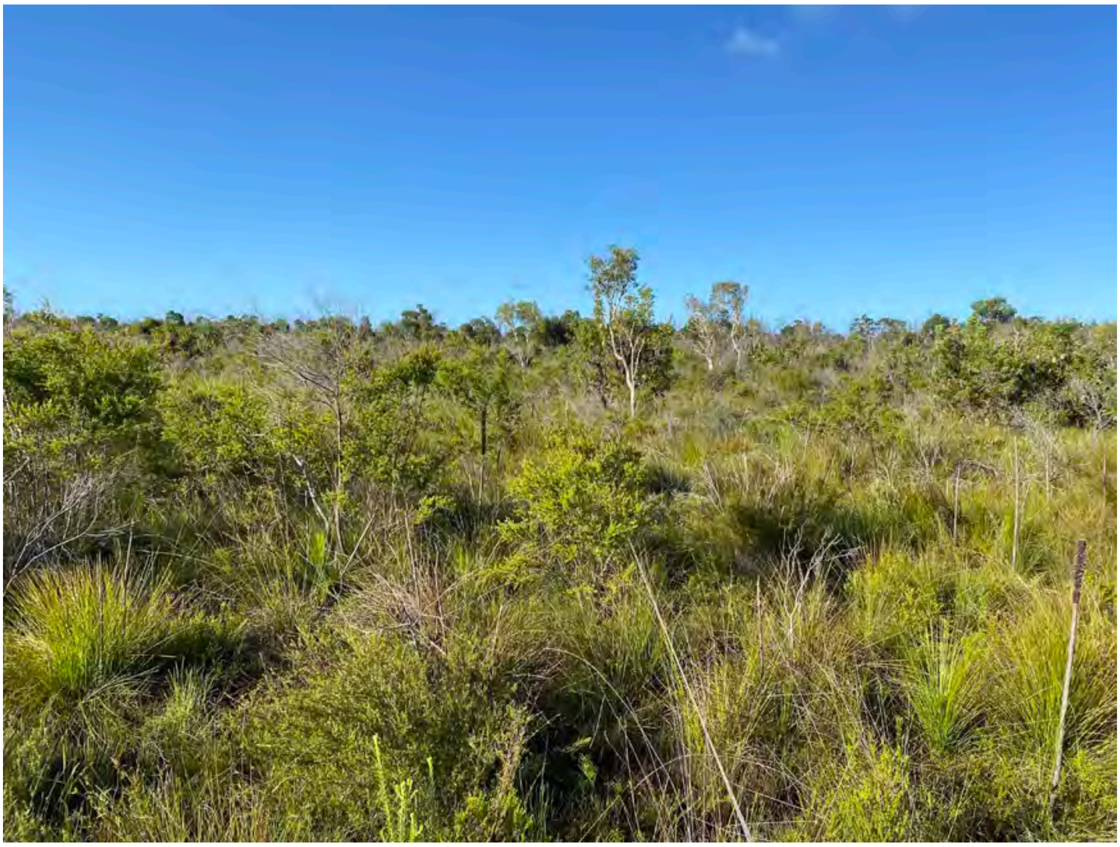
Additional Species: *Hypolaena fastigiata, Stackhousia nuda, Epacris pulchella, Olax retusa*

Structural / Floristic Summary

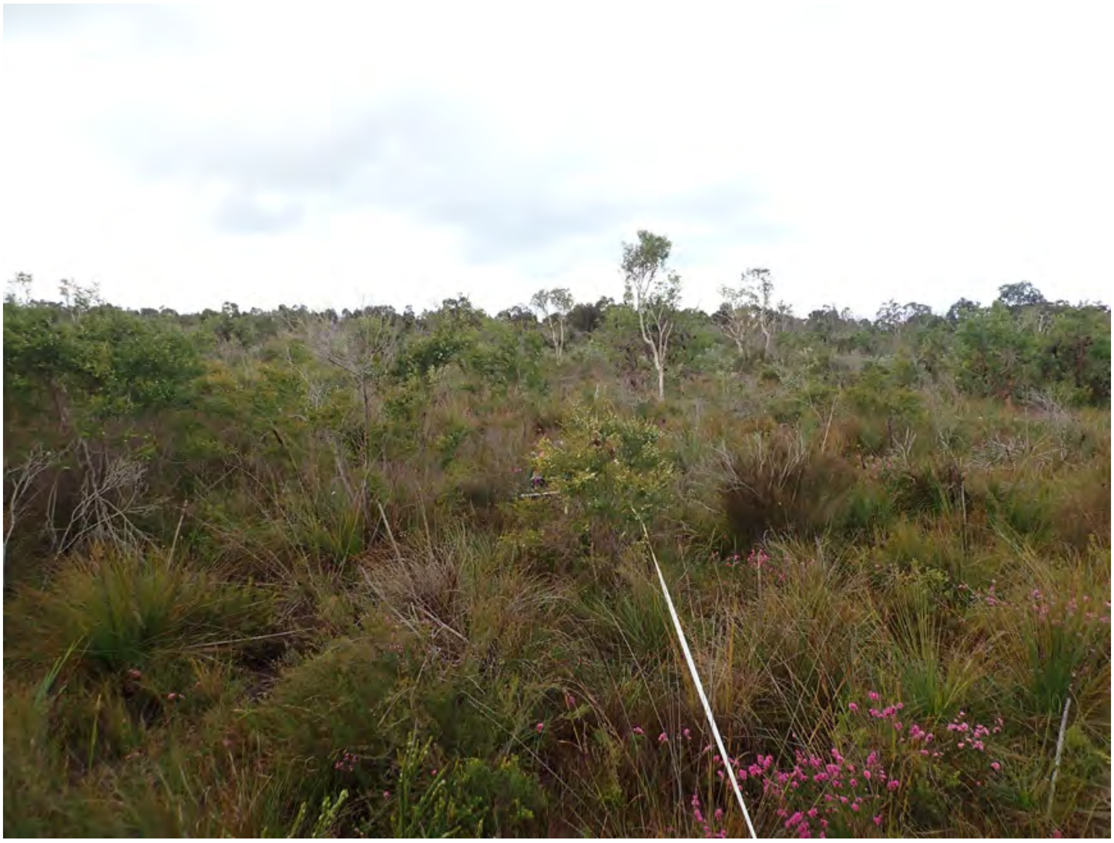
BioCondition Attribute		April 2022	October 2022
Native Plant Species Richness	Tree:	.	.
	Shrub:	18	
	Grass Tree	1	
	Grass / Sedge	6	
	Forbs and other:	9	
Total Species No**		34	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	13.6	15.4
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	11	7.6
Native Ground cover (%):	Native perennial grass / sedge cover (%):	30.75	24.05
	Native shrubs (%)	24.35	14.1
	Grass tree	14.5	4
	Organic litter cover (%):	9.65	36.85
	Native forb cover (%)	3.4	3.7
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: April 2022 (Above) and October 2022 (Below).



Plot 6c Centre to End – April 2022 (Above) and October 2022 (Below)..



Plot 6c – Centre to North: April 2022 (Above) and October 2022 (Below)..


Plot 6c – Centre to South: April 2022 (Above) and October 2022 (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 polygaliifolium	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**

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		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	3	1	3	1	0	1	0	0	0	0	**170**
Apr-17	Site 5	Event 3	137	4	19	0	1	4		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	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	0	1	3	0	2	4	0	1	1	**100**
Sep-19	Site 5	Event 8	24	10	12	0	0	16	0	0	1	0	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**

Appendix C – Pearson Correlation Analysis for Stem Counts and CRD

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	0.009430	0.1020	0.07314	0.4305	0.4055	0.7683	0.09760	0.1299	0.5673	0.3630	0.1461	0.6552	0.1299	-0.1020	0.5461	0.6791	0.5036	0.5052	0.4213
95% confidence interval	-0.5238 to 0.5373	-0.4531 to 0.6001	-0.4759 to 0.5812	-0.1297 to 0.7824	-0.1594 to 0.7703	0.4013 to 0.9227	-0.4566 to 0.5973	-0.4303 to 0.6179	0.05255 to 0.8439	-0.2076 to 0.7493	-0.4168 to 0.6280	0.1909 to 0.8799	-0.4303 to 0.6179	-0.6001 to 0.4531	0.02190 to 0.8348	0.2321 to 0.8892	-0.03682 to 0.8161	-0.03473 to 0.8168	-0.1408 to 0.7780
R squared	8.893e-005	0.01041	0.005349	0.1853	0.1644	0.5902	0.009526	0.01687	0.3218	0.1318	0.02136	0.4292	0.01687	0.01041	0.2983	0.4611	0.2536	0.2552	0.1775
P values																			
P (two-tailed)	0.9745	0.7285	0.8038	0.1244	0.1503	0.0013	0.7399	0.6581	0.0344	0.2021	0.6181	0.0110	0.6581	0.7285	0.0433	0.0076	0.0664	0.0654	0.1336
P value summary	ns	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	Yes	No	No	Yes	No	No	Yes	Yes	No	No	No
Number of XY Pairs	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14

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	-0.003620	0.6514	0.6608	0.1136	0.1565	0.6818	0.3533	0.1517	0.7020	0.2568	0.2224	0.3053	0.3453	0.6751	0.4767	-0.04914	0.4150	0.1801	-0.3021	0.09264	0.6577	-0.2172	0.8482
95% confidence interval	-0.5332 to 0.5280	0.1847 to 0.8784	0.2005 to 0.8821	-0.4437 to 0.6076	-0.4080 to 0.6344	0.2370 to 0.8903	-0.2181 to 0.7444	-0.4121 to 0.6314	0.2731 to 0.8981	-0.3170 to 0.6930	-0.3494 to 0.6735	-0.2688 to 0.7194	-0.2268 to 0.7403	0.2251 to 0.8877	-0.07212 to 0.8039	-0.5650 to 0.4943	-0.1482 to 0.7749	-0.3875 to 0.6487	-0.7176 to 0.2721	-0.4606 to 0.5940	0.1952 to 0.8809	-0.6705 to 0.3542	0.5776 to 0.9509
R squared	1.310e-005	0.4244	0.4366	0.01291	0.02449	0.4649	0.1248	0.02300	0.4928	0.06595	0.04947	0.09324	0.1192	0.4557	0.2272	0.002414	0.1722	0.03243	0.09126	0.008583	0.4325	0.04716	0.7195
P value																							
P (two-tailed)	0.9902	0.0116	0.0101	0.6989	0.5931	0.0072	0.2152	0.6048	0.0051	0.3755	0.4447	0.2884	0.2266	0.0081	0.0848	0.8675	0.1401	0.5378	0.2938	0.7528	0.0106	0.4558	0.0001
P value summary	ns	*	*	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	No	No	No	No	No	No	Yes	No	Yes
Num. of XY Pairs	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14

Appendix D – Site / Species Table

Habit	Fire Regeneration Strategy	Family	Species	Site 6_Presence / Absence April 2022	Site 5_Presence / Absence April 2022	Site 6_Presence / Absence Oct 2022	Site 5_Presence / Absence Oct 2022
Forb	Re-sprouter	Blechnaceae	*Blechnum cartiligineum*	*0*	*1*	*0*	*1*
Forb	Re-sprouter	Colchicaceae	*Burchardia umbellata*	*1*	*1*	*1*	*1*
Forb	Unknown	Lauraceae	*Cassytha glabella*	*1*	*1*	*1*	*1*
Forb	Re-sprouter	Polygalaceae	*Commosperma sphaericum*	*0*	*0*	*0*	*0*
Forb	Re-sprouter	Orchidaceae	*Cryptostylis erecta*	*0*	*1*	*0*	*1*
Forb	Re-sprouter	Droseraceae	*Drosera binata*	*1*	*1*	*1*	*1*
Forb	Re-sprouter	Haloragaceae	*Gonocarpus micranthus*	*1*	*1*	*1*	*1*
Forb	Re-sprouter	Dilleniaceae	*Hibbertia acicularis*	*0*	*0*	*0*	*0*
Forb	Re-sprouter	Dilleniaceae	*Hibbertia salicifolia*	*1*	*1*	*1*	*1*
Forb	Re-sprouter	Laxmanniaceae	*Laxmannia compacta*	*0*	*1*	*0*	*1*
Forb	Re-sprouter	Orchidaceae	*Microtus parviflora*	*0*	*1*	*0*	*0*
Forb	Obligate Seeder	Fabaceae	*Mirbellia rubiifolia*	*0*	*0*	*0*	*1*
Forb	Unknown	Sprigeliaceae	*Mitrasacme alsinoides*	*0*	*0*	*0*	*1*
Forb	Re-sprouter	Iridaceae	*Patersonia sericea (fragilis)*	*0*	*1*	*1*	*1*
Forb	Re-sprouter	Thymeleaceae	*Pimelea linifolia*	*1*	*1*	*1*	*1*
Forb	Unknown	Picrodendraceae	*Pseudanthus orientalis*	*1*	*1*	*1*	*1*
Forb	Unknown	Selaginellaceae	*Selaginella uliginosa*	*1*	*0*	*1*	*0*
Forb	Unknown	Laxmanniaceae	*Sowerbaea juncea*	*0*	*0*	*0*	*0*
Forb	Unknown	Stackhousiaceae	*Stackhousia nuda*	*1*	*1*	*1*	*1*
Forb	Unknown	Stylidiaceae	*Stylidium trichopodom*	*0*	*0*	*0*	*0*
Forb	Re-sprouter	Xyridaceae	*Xyris complanata*	*1*	*0*	*1*	*1*
Grass	Re-sprouter	Poaceae	*Eriachne pallescens var. gracillis*	*0*	*1*	*1*	*1*

Habit	Fire Regeneration Strategy	Family	Species	Site 6_Presence / Absence April 2022	Site 5_Presence / Absence April 2022	Site 6_Presence / Absence Oct 2022	Site 5_Presence / Absence Oct 2022
Grass	Re-sprouter	Poaceae	*Themeda triandra*	*0*	*0*	*0*	*0*
Grass tree	Re-sprouter	Xanthorrhoeaceae	*Xanthorrhoea fulva*	*1*	*1*	*1*	*1*
Grass tree	Re-sprouter	Xanthorrhoeaceae	*Xanthorrhoea johnsonii*	*0*	*1*	*0*	*1*
Sedge / Rush	Re-sprouter	Restionaceae	*Baloskion heterophylla*	*0*	*0*	*0*	*0*
Sedge / Rush	Re-sprouter	Restionaceae	*Baloskion tenuiculme*	*1*	*1*	*1*	*1*
Sedge / Rush	Re-sprouter	Restionaceae	*Caustis recurvata*	*1*	*1*	*1*	*1*
Sedge / Rush	Unknown	Cyperaceae	*Cyperus sp. (gracilis?)*	*0*	*0*	*0*	*0*
Sedge / Rush	Re-sprouter	Cyperaceae	*Gahnia seiberiana*	*0*	*1*	*0*	*1*
Sedge / Rush	Re-sprouter	Cyperaceae	*Hypolaena fastigiata*	*1*	*1*	*1*	*1*
Sedge / Rush	Re-sprouter	Restionaceae	*Leptocarpus tenax*	*0*	*0*	*0*	*0*
Sedge / Rush	Re-sprouter	Laxmanniaceae	*Lomandra elongata*	*1*	*1*	*1*	*1*
Sedge / Rush	Re-sprouter	Laxmanniaceae	*Lomandra longifolia*	*1*	*0*	*1*	*0*
Sedge / Rush	Re-sprouter	Cyperaceae	*Schoenus calostachys*	*1*	*0*	*0*	*1*
Sedge / Rush	Re-sprouter	Cyperaceae	*Schoenus scabripes*	*0*	*0*	*0*	*0*
Sedge / Rush	Re-sprouter	Restionaceae	*Sporodanthus interuptus*	*1*	*1*	*1*	*1*
Shrub	Obligate seeder	Mimosaceae	*Acacia baueri*	*1*	*1*	*0*	*1*
Shrub	Re-sprouter	Mimosaceae	*Acacia flavesecens*	*0*	*1*	*0*	*1*
Shrub	Re-sprouter	Ericaceae	*Agiortia pedicellata*	*1*	*1*	*0*	*1*
Shrub	Re-sprouter	Fabaceae	*Aotus lanigera*	*0*	*0*	*0*	*0*
Shrub	Re-sprouter	Myrtaceae	*Austromyrtus dulcis*	*0*	*1*	*0*	*1*
Shrub	Re-sprouter	Myrtaceae	*Baeckea frutescens*	*1*	*1*	*1*	*1*

Habit	Fire Regeneration Strategy	Family	Species	Site 6_Presence / Absence April 2022	Site 5_Presence / Absence April 2022	Site 6_Presence / Absence Oct 2022	Site 5_Presence / Absence Oct 2022
Shrub	Re-sprouter	Myrtaceae	*Baeckea imbricata*	*1*	*1*	*1*	*1*
Shrub	Re-sprouter	Proteaceae	*Banksia aemula*	*1*	*1*	*1*	*1*
Shrub	Re-sprouter	Proteaceae	*Banksia oblongifolia*	*1*	*0*	*1*	*0*
Shrub	Obligate Seeder (?)	Rutaceae	*Boronia falcifolia*	*1*	*1*	*1*	*1*
Shrub	Obligate Seeder (?)	Proteaceae	*Conospermum taxifolium*	*0*	*0*	*0*	*0*
Shrub	Obligate Seeder (?)	Fabaceae	*Dillwynia floribunda*	*1*	*1*	*1*	*1*
Shrub	Obligate Seeder (?)	Ericaceae	*Epacris obtusifolia*	*0*	*1*	*1*	*0*
Shrub	Obligate Seeder (?)	Ericaceae	*Epacris pulchella*	*0*	*1*	*1*	*1*
Shrub	Re-sprouter	Myrtaceae	*Homoranthus virgatus*	*0*	*1*	*1*	*1*
Shrub	Re-sprouter	Myrtaceae	*Leptospermum liversidgei*	*1*	*0*	*1*	*0*
Shrub	Re-sprouter	Myrtaceae	*Leptospermum polygalifolium*	*1*	*1*	*1*	*1*
Shrub	Re-sprouter	Myrtaceae	*Leptospermum semibaccatum*	*1*	*1*	*1*	*1*
Shrub	Re-sprouter	Ericaceae	*Leucopogon leptospermoides*	*1*	*1*	*1*	*1*
Shrub	Re-sprouter	Myrtaceae	*Melaleuca pachyphyllus*	*0*	*1*	*0*	*1*
Shrub	Re-sprouter	Myrtaceae	*Melaleuca quinquenervia*	*1*	*1*	*1*	*1*
Shrub	Re-sprouter	Myrtaceae	*Ochrosperma lineare*	*1*	*1*	*1*	*1*
Shrub	Re-sprouter	Olacaceae	*Olax retusa*	*1*	*0*	*1*	*1*
Shrub	Obligate seeder	Proteaceae	*Persoonia virgata*	*1*	*1*	*0*	*1*
Shrub	Obligate seeder	Fabaceae	*Phyllota phylicoides*	*1*	*0*	*1*	*0*
Shrub	Obligate seeder_A	Fabaceae	*Pultenaea paleaceae*	*1*	*0*	*1*	*0*
Shrub	Obligate seeder_A	Fabaceae	*Pultenaea robusta*	*0*	*0*	*0*	*0*
Shrub	Obligate seeder	Ericaceae	*Sprengelia sprengelioides*	*1*	*0*	*1*	*0*
Shrub	Re-sprouter	Proteaceae	*Strangea linearis*	*1*	*1*	*1*	*1*
Tree	Re-sprouter	Elaeocarpaceae	*Elaeocarpus*	*0*	*0*	*0*	*0*

Habit	Fire Regeneration Strategy	Family	Species	Site 6_Presence / Absence April 2022	Site 5_Presence / Absence April 2022	Site 6_Presence / Absence Oct 2022	Site 5_Presence / Absence Oct 2022
			reticulatus				

? indicates a low level of confidence on regeneration strategies.