Banksia Beach Borefield

Annual Compliance Report 2018-2019

1st December 2019

SOURCE STORE SUPPLY

Contents

1. Executive Summary

This annual compliance report encompasses the fifth monitoring period of operation and management of the Banksia Beach Water Treatment Plant and Borefield under the Borefield Environmental Management Plan (BEMP) between the 1st September 2018 and 31st August 2019. This report addresses the requirements of conditions applied to the project under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

A detailed review of the previous monitoring program, incorporating the recommendations of the three-year review and the subsequent GDE orientated review of the monitoring network, was presented to the Commonwealth Department of the Environment (DotE) in January 2014. The EPBC approval 2007/3396 was updated and approved to reflect the changes to the BEMP with the new approval conditions activated on the 17th April 2015. On the 3rd of August 2015 Seqwater submitted the updated and revised BEMP to DotE and was approved by DotE on the 18th August 2015.

During this reporting period (2018–2019) all 6 conditions for the controlled action were active. The Banksia Beach Water Treatment Plant 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. Therefore, no extraction from the Borefield has occurred. The conditions active during this reporting period (2018–2019) 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 2.1 - 2.7.

The outcomes of the compliance assessment indicate no instances during this reporting period of any significant impact on EPBC Act listed species. Further, no incidents requiring notification to DotE have occurred during this reporting period (2018–2019). All ongoing active EPBC conditions of approval will continue to be implemented and audited during the operational phase of Banksia Beach Water Treatment Plant and Borefield.

2. 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, a new Part 8 was inserted in the *Water Regulation 2002*, outlining measures to be undertaken and outcomes to be achieved by service providers to ensure security of essential water supplies for the SEQ Region. One of the specified measures was the development of underground water resources at Bribie Island and in the area around Brisbane. Schedule 10B of the *Water Regulation 2002* required that this measure with respect to Bribie Island be completed by 31 December 2007, with the initial outcome of 10 megalitres (ML) of water production per day.

Investigation of the aquifer and groundwater modelling for Bribie Island clearly demonstrated that the sustainable combined production level at the proposed Banksia Beach water treatment plant (WTP) and the then existing Woorim WTP is limited to about 8 ML/d. The Queensland Government acknowledged this and the proposed extraction rate for the northern and southern borefields was formally revised on the 2nd November 2007 to 5 ML/day.

The Banksia Beach WTP was therefore developed for 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 WTP sources water from the associated northern borefield via a reticulation pipeline to convey water extracted from the lower (regional) sand mass aquifer. The WTP at Woorim was decommissioned in 2008 by Seqwater due to poor infrastructure condition and poor source water quality to the plant. The balance of supply to Bribie Island is dictated by the regional supply model which outlines the supply and bulk water transfer arrangements intended to meet forecast demands, water security and cost. This plan ensures supply on the island is adequately met via the Banksia Beach WTP, the bulk water supply network or a combination of the two depending on the current grid arrangement.

As this development lies in close proximity to a site of national environmental significance, namely the Moreton Bay Ramsar Wetland, the project was referred to the Commonwealth Department of the Environment and Water Resources (DEWR) (Subsequent to the Referral the Department of the Environment, Water, Heritage and the Arts (DEWHA) pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). Subsequently, DEWHA became the Department of Sustainability, Environment, Water, Populations and Communities - DSEWPaC, then, as of September 2013, became the Department of the Environment (DotE). The EPBC Act referral comprised a comprehensive Review of Environmental Factors. The DEWHA declared the project a controlled action under the *EPBC Act section 95a* under the controlling provision – Wetlands of international importance (sections 16 and 17B).

3. Conditions of Compliance

To demonstrate compliance with the individual EPBC Act conditions of approval, Table 1 summaries each condition number as per the controlled action approval notice of 17th April 2015. For Table 1, the status of the condition compliance is provided as well as a summary of condition compliance status. Further details of compliance status have been provided below this table. Please note that in some instances the conditions presented in Table 1 have been separated into lettered bullet points for ease of reference and visual presentation, the conditions may differ to the determination notice.

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.
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	Compliant.
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

On the 3rd August 2015 Seqwater submitted the updated and revised BEMP, designed to protect the ecological character of the Moreton Bay Ramsar wetlands. This was approved by DotE on the 18th August 2015. Implementation of the specific monitoring programs and other requirements can be found in section 3.

The BEMP was amended in February/March 2016 to include changes when the BBWTP is in cold standby shutdown (shutdown >12months) which are;

- No quarterly operational reports
- No CRG meetings unless specific issues arise
- No SWL and EC monitoring
- No quarterly assessment of meteorological data

Continuation of vegetation transects surveys, soil moisture monitoring and NDVI will occur until baseline is established (Note: baseline established once information from any future differential changes can be statistically assessed).

The changes to the monitoring requirements in the BEMP was published on Seqwater's website on the 30th March 2016 within one month of receiving approval form DotE (23rd March 2016). Notification to DotE occurred on the 30th of March 2016 within 5 days of publishing the BEMP on Seqwater's website. In accordance with condition 1 of the EPBC approval the BEMP is now available on Seqwater's website at https://www.seqwater.com.au/corporate-publications

Status – Compliant

3.2 EPBC Condition 2

The BBWTP 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 between 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.The Bribie Island Borefield Annual Vegetation Monitoring Report 2019 was completed and published to the Seqwater website on 29 November 2019. This report forms the critical monitoring element of the compliance evaluation and compliance with the intent of condition 3 has been achieved.

Status – Compliant

3.4 EPBC Condition 4

No activities otherwise than those in accordance to the BEMP were undertaken between the period of September 2018 and August 2019.

Status – Compliant.

3.5 EPBC Condition 5

No requests for revision of the BEMP by the Minister were received between the period of September 2018 and August 2019.

Status – Compliant.

2.6 EPBC Condition 6

No requests for an independent audit by the Minister were received between the period of September 2018 and August 2019.

Status – Compliant.

4. Implementation of the BEMP

a. Annual Monitoring Report

The Banksia Beach Water Treatment Plant 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. Therefore, an annual vegetation monitoring report on the groundwater dependant ecosystems (GDE's) was prepared covering the period from September 2018 to August 2019.

As the cold standby shutdown (shutdown >12months) has been triggered, it is expected that the ongoing vegetation monitoring events will establish baseline vegetation condition and determine the natural range of variation that occurs in terms of structure, composition and condition. Overall the surveys to date reveal that the impact and control sites have broad similarities in structural and floristic attributes. The impact site showed a strong trend of declining shrub cover in the size class (0.5 to <1m) coupled with a statistically significant decline in stem density. This has occurred to a point where it appears that shrub cover and stem density is subject to wholesale collapse. The contribution of soil drying to the decline in the shrub layer is unknown however may be attributed to a combination of factors, including lack of fire. Species diversity also declined steeply in 2019, dropping to the lowest levels recorded throughout the monitoring surveys. The decline in species diversity at the impact site was primarily attributable to bushfire. It is considered that the compounding influences of a relatively dry climatic cycle, prolonged drying of the shallow soil profile, coupled with a long-term absence of fire have all influenced the structure and floristic diversity of coastal heathland in the Banksia Beach Borefield assessment area. It is likely that long term monitoring will enable further understanding of the vegetation dynamics and ecological trends.

The full monitoring report can be found in Appendix B.

b. Community Reference Group (CRG)

The BEMP was amended in February/March 2016 to include changes when the BBWTP is in cold standby shutdown (shutdown >12months) which resulted in the CRG only being required to meet in the event that specific issues arise during cold standby shutdown.

No CRG meetings were held during the reporting period 2018-2019.

5. Conclusion

The BBWTP 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. Therefore, no extraction from the borefield has occurred between the period of September 2018 and August 2019. No instances occurred during this reporting period that had the potential to significantly impact EPBC Act listed species or matters of national significance.

Annual compliance reports will continue to be published on Seqwater's website in accordance to condition 1 of the EPBC approval. The required monitoring outlined within the BEMP will be collected by Seqwater and presented within the next annual compliance report to demonstrate continued compliance with the EPBC Act conditions of approval.

6. Appendix A – EPBC Approval Conditions (2007/3396)

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

GPO Box 787 Canberra ACT 2601 • Telephone 02 6274 1111 • Facsimile 02 6274 1666 • www.environment.gov.au

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	SGaddes
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.

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

Refer to report prepared by the consultant 3D Environment (Rex D19/173072).

3D Environmental
vegetation analysis and mapping specialists

Bribie Island Borefield:

Groundwater Dependent Ecosystems - Annual Vegetation Monitoring Report 2019

Prepared for Seqwater
by
3D Environmental

Final – 29 November, 2019

Document Control

Project No. 2018_193
Project Manager: David Stanton
Client: Seqwater
Purpose: Annual vegetation monitoring report for Groundwater Dependent Ecosystems – Bribie Island Borefield – 2019 Survey

Draft	Date Issued	Issued By	Checked	Purpose
Draft A	25 November 2019	Maddy Dyring	David Stanton	Initial draft
Final	29 November 2019	David Stanton		Final Version

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1.0 Introduction

3d Environmental has been engaged by Seqwater to complete the 2019 annual monitoring report for groundwater dependent vegetation (otherwise referred to as groundwater dependent ecosystems or GDEs) for Seqwater's Banksia Beach Borefield and Water Treatment Plant on Bribie Island.

The Water Treatment Plant has not been operational since April 2014 and no water extraction has occurred. This shutdown in operations has triggered a requirement for the long-term shutdown monitoring and sampling regime as outlined within the Borefield Environmental Management Plan (BEMP). This assessment forms a component of the Annual Compliance Report for the borefield, the first of which was issued in December 2015 to address conditions of approval under the Commonwealth Environmental Protection and Biodiversity Conservation Act (EPBC Act 1999). This report follows an initial GDE monitoring survey report prepared by Jacobs (2015) for the 2014 – 2015 reporting period and three subsequent reports prepared by 3d Environmental for the 2016, 2017 and 2018 reporting periods.

1.1 Previous Work and Assessment Approach

Two sites were selected for ongoing GDE vegetation monitoring in the Groundwater Model Refinement, GDE Assessment and Monitoring Review (SKM, 2013). One of these sites is located in an area where drawdown in the shallow aquifer potentially may occur (herein referred to as Site 6 or the 'Impact Site') and the second site is located in an area outside the predicted drawdown zone (herein referred to as Site 5 or the 'Control Site).

Jacobs (2015) established two permanent vegetation monitoring sites at both 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 is to provide a temporal analysis of natural variations in the structural and floristic composition of coastal heathland. This information is to provide a baseline against which the impacts of possible future groundwater abstraction on groundwater dependent vegetation can be measured. To accomplish this, the scope of the current assessment includes:

1) The field assessment of the existing vegetation monitoring sites established by Jacobs (2015) and 3d Environmental (2016) utilising methods compatible with previous assessments.
2) Facilitate capture of NDVI imagery to coincide with the two current survey events (April 2019 and September 2019).

3) Analyse floristic data collected during the current survey in conjunction with complementary datasets (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) to assist in the characterisation of the baseline condition of vegetation.

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 a "Least Concern" status under Queensland's Vegetation Management Act. 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). Many 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 following key points, relevant to this study, can be drawn from this long-term monitoring program:

- The response of terrestrial phreatophytes (species dependent on groundwater for survival) to declines in groundwater levels are unpredictable and variable.
- Phreatophytes associated with formerly shallow stable groundwater sources are likely to be more sensitive to groundwater decline than trees exposed to variable groundwater regimes.
- Rapid declines in groundwater are more likely to accelerate vegetation response with a threshold breach and rapid coversion of vegetation to an alternative ecohydrological state.
- Gradual reductions provide greater opportunity for recharge to occur and promotes gradual floristic transition.
- Protracted and extreme declines in groundwater may result in a change in species composition, as groundwater sensitive phreatophytes are replaced by species with a greater ability to adapt to a drying sub-surface environment, or those species with deeper rooting systems.

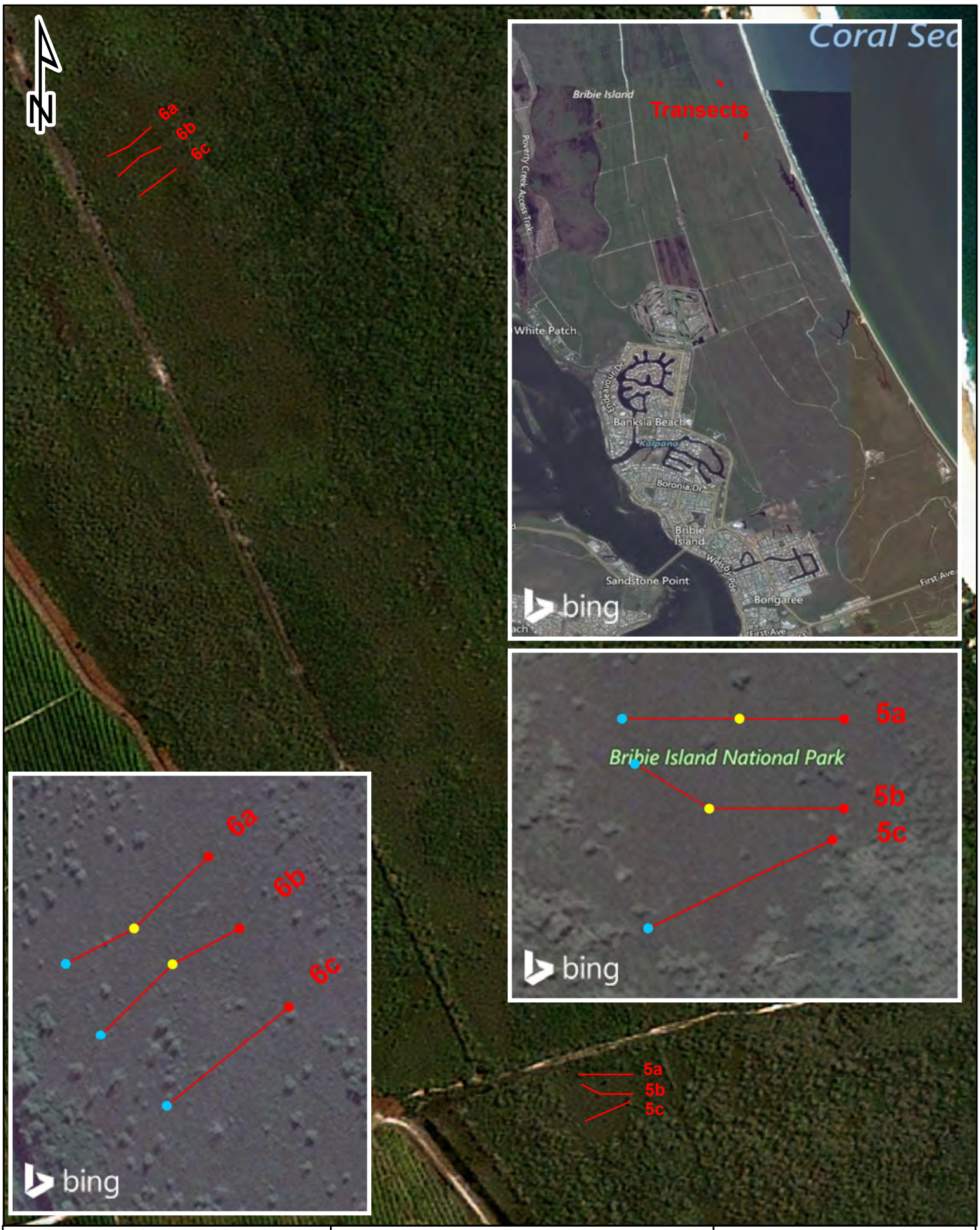
In the context of Bribie Island, the shallow-rooted heath vegetation will be formed by a mix of both phreatophytes and facultative phreatophyes (i.e utilise groundwater but can survive without it). Wet heath vegetation typically has rooting material, mostly from sedges herbs and small shrubs concentrated 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 el 2010), such minor reduction in groundwater levels are unlikely to promote any noticable 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).

1.4 Extenuating Circumstances

On 21st of August 2019, an extremely hot fire engulfed an extensive area within the northern portion of Bribie Island National Park including the Banksia Beach borefield. Due to containment lines, habitats at Site 5 (control site) were not burnt, though a vast tract of wallum heathland north of Site 5, including Site 6 (impact site) was combusted. Visual inspection of the area burnt indicates the fire was particularly hot and resulted in combustion of nearly all ground fuel. The location of the fire relative to monitoring points is shown in Figure 2.



Legend

Site

- Start Point
- Centre Point
- End Point
- Transects

Figure 1. Survey plot localities

Client: Seqwater

0 60 120 180 240

Metres

Scale	Drawn By	Checked	File Path	Date	
1:5,612	DG	DS	C:\Users\Owner\Documents\Clients\3D Environmental\Bribie\3d_Bribie_A4P.mxd	09-Nov-16	A4

3D Environmental

Vegetation Assessment
& Mapping Specialists

P. O. Box 959
Kenmore, Qld 4069
Phone: (07) 3411 9072
Phone: (07) 3878 4344
Mobile: 0447 8227 119
Mobile: 0409 426 916
www.3denvironmental.com.au

C:\Users\Owner\Documents\Clients\3D Environmental\Bribie\3d_Bribie_A4P.mxd

Figure 2. Extent of fire scarring from September 7 Spot Imagery with delineation between burnt and unburnt vegetation indicated by blue dashed line. Monitoring Site 5 has not been burnt.

2.0 Methods

2.1 Field Survey

Timing: The post-wet survey was completed on 4 April 2019 and the dry season survey was completed 1 – 2 October 2019.The timing of the dry season survey coincided with a fall of 19.2mm on the 29th September and 49.4mm on the 1st October, which was the most significant rainfall event for several months.

Transect Methods: Methods for vegetation assessment followed 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 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 (herbaceaous 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). Stem counts were completed in a 2m wide belt transect positioned either side of the centreline tape. This narrow width allows for the accuracy in stem counts required in repeat measure monitoring surveys.
- Groundcover of floristic lifeforms within 10 x 1m[2] quadrats placed at 10m intervals along the tape measure with the initial quadrat position (Q1) at the 4 – 5m interval on the left side of the tape measure and flipped to measure Q2 on the right. The final quadrats Q9 and Q10 were

[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

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.

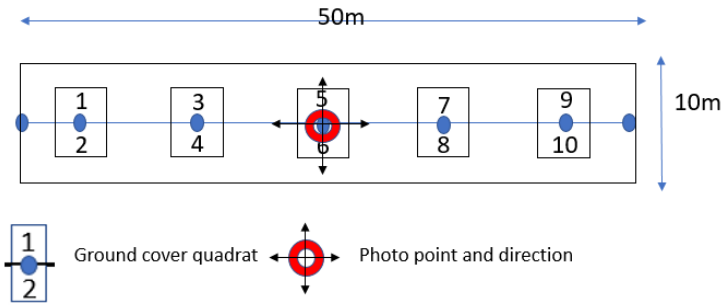


Figure 3. Survey plot layout.

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 groundlayer, 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.

Monitoring Transect No.	Purpose of Site	Lat. / Long. Start	Lat. / Long. Centre	Lat. / Long. Finish	Date Established
5a	Control	-26.9942/ 153.1587	-26.9942/ 153.15905	-26.9942/ 153.15932	26 September 2014
5b	Control	-26.9943/ 153.15879	-26.9944/ 153.15898	-26.9944/ 153.159319	26 September 2014
5c	Control	-26.9946/ 153.15883	NA	-26.9944/ 153.15929	April 4 2016
6a	Impact	-26.985 / 153.15404	-26.9849 / 153.15425	-26.9847/ 153.154487	26 September 2014
6b	Impact	-26.9852/ 153.15415	-26.985 / 153.154376	-26.9849 / 153.15458	26 September 2014
6c	Impact	-26.9852/ 153.15415	NA	-26.9849 / 153.15458	April 4 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 April 2019 and October 2019 survey events have been compiled onto individual datasheets to allow for comparison between seasons (see Appendix A).

To allow an assessment of the natural variability of habitats within impact and control sites to be made, all transects were treated individually. A Levene's test to test for homogeneity of variance was completed on all data across all structural parameters. Analysis of Variance (ANOVA) was completed on parameters where Levene's test indicated equal variance. 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. A Repeat Measures ANOVA, using data from the eight survey events from (from 2016 through to 2019) was undertaken to evaluate the statistical significance of any changes over time in plant cover and richness data. It also allowed an assessment of whether there are consistent differences in any structural group abundance between Sites 5 and 6. Repeat Measures ANOVA was completed using the Q-macros extension in Excel under the 'ANOVA – Two Factors Without Replication' command. As standard practice, p-value < 0.05 was considered indicative of a significant difference in mean values or variance.

2.3 NDVI Analysis

Fresh capture Spot 6 (SPOT6 1.5m Panchromatic 4-band Pan + Bundle imagery) imagery from Geoimage Pty Ltd was acquired to coincide (as close as possible) with the timing of the field survey events. Images capture was completed on the 15 April and 9 September 2019 corresponding with periods that were relatively cloud free. Raw data from the two Spot 6 images were processed using the ArcGIS image server applying the following equation as standard process:

> *NDVI = arctangent((IR – R)/(IR+R))* where IR = pixel values from the infrared band, and; R = pixel values from the red band.

This produced a single-band dataset with negative values generated from water (and clouds), bare soil generating values of 0 and positive values produced by green/ living vegetation with greater NDVI values corresponding to varying abundance of green leafy biomass. NDVI values were measured in 1.5 m intervals along each transect for the April and October period with the same interval applied to previous capture periods to ensure consistency between datasets. All values were compiled into an Excel database for interpretation and graphical representation.

2.4 Climate Data

Automated weather stations are positioned at two locations on Bribie Island, being:

- National Park Weather Station (AWS Bribie NP) located at -27.028674°, 153.158484°
- WTP Weather Station at Bore 9 (AWS BBWTP) located at -26.968238°, 153.109549°

Rainfall data from both the Bribie NP and AWS BBWTP was collected for the period from 1st September 2019 through to 31st August 2019. Data from the dedicated Bribie Island weather stations was compared with annual and long-term rainfall recorded at Beerburrum Forest (-26.96, 152.967), a Bureau of Meteorology station located approximately 10 km west of the Island. Annual rainfall averages for this weather station date back to 1898 and were utilised during analysis of the climate data to supplement any identified information gaps.

2.5 Soil Moisture Data

Automated soil moisture loggers installed at the location of the control (southern SMP) and impact (northern SMP) monitoring sites were used to measure soil moisture in the shallow soil profile. 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 0 mm (surface), 15mm, 350mm, 650 mm, 950 mm and 1250 mm with automated readings provided between 1st September 2018 and 1st September 2019 for the southern impact site (Southern SMP). The soil moisture logger installed at the northern control site (Northern SMP) was destroyed during late August wildfires and the final reading for the monitoring period was on 21 August at 11:14 am, coincident with passing of an intense fire front.

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
- NDVI Analysis.

Comparisons between control and impact sites are made and where possible, comparisions 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

November 2018 through to the end of February 2019 were extremely dry, with rainfall from the AWS BBWTP_2018_2019 totalling only 127.5 mm for the hottest summer months (Figure 4). This compares to the long term average monthly rainfall of 764.4 mm for the months of November through February from the Beerburrum State Forest recording station (BOM 2019). Above average rainfall was recorded in the months of October 2018 (205.4mm), March 2019 (169.8mm) and June 2019 (83.6mm). Similar trends are recorded at the AWS Bribie NP.

Overall, the rainfall for the period from September 1 2018 to August 30 2019 at the AWS BBWTP_2018_2019 was 875.9 mm, a little over half the the long term average rainfall of 1414.2 mm measured at the Beerburrum State Forest recording station. This follows below average rainfall in the the preceding monitoring periods with 1293mm recorded for the 2017 – 2018 period and 986.2 mm falling in the 2016 – 2017 monitoring period at the AWS BBWTP_2018_2019.

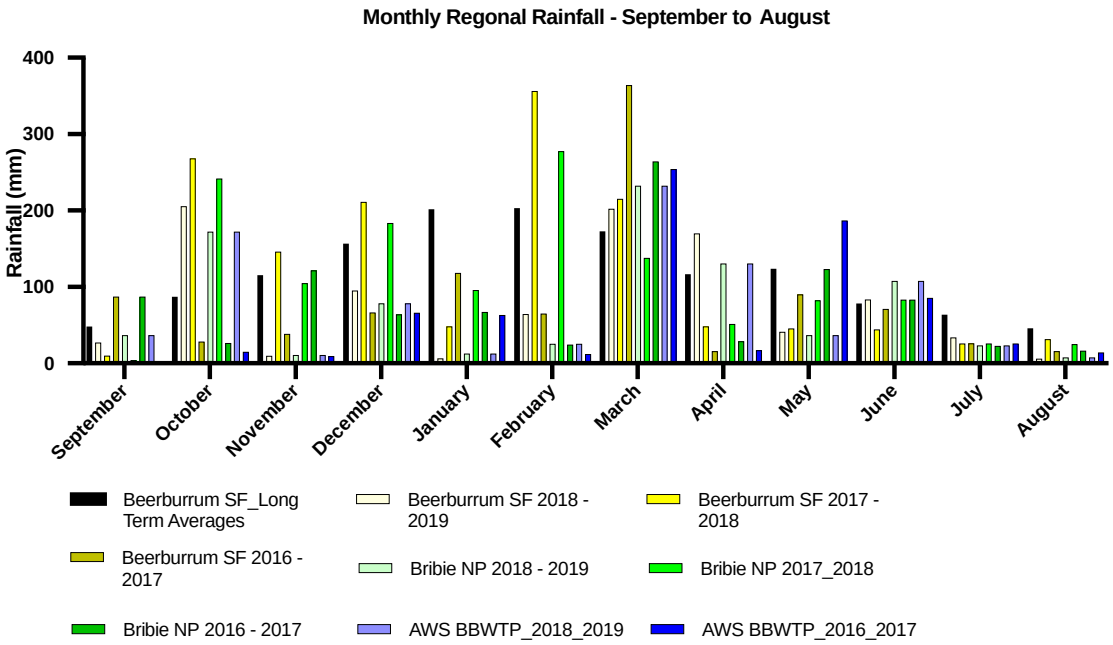


Figure 4. Average Monthly Rainfall at Bribie Island from September 2014 to September 2019

3.1.2 Soil moisture data

The northern SMP (impact site) (Figure 5) and the southern SMP (control site) (Figure 6) demonstrate sustained periods of saturation only in the deeper (125 cm) profile. At both SMPs, saturation of the shallow soil profile was irregular. The first major decrease in soil moisture potential occurred at 35 cm soil depth in November 2018. At 35cm, the northern SMP showed sustained periods of saturation (approximately 40% soil moisture content) until December 2018, after which soil moisture content dropped rapidly associated with a period with limited rainfall (see Section 3.1.1). Generally, soil moisture recharge occurred rapidly following rainfall. The soil profile at the southern SMP appears much drier than the north with extended periods of several weeks where shallow soil moisture (measured at 15cm) was below 20% total moisture content.

In February 2019 at the the southern SMP (control site)moisture content in soil profile at 95 cm depth dropped below saturation for the first time during the ongoing monitoring program. This resulted in a drop in total moisture content from 40% to <20% which was sustained over a period of about a month. Recharge at 95cm depth only occurred after 169.8 mm fell in March 2019 with two significant rainfall events occurring on 16 March 2019 (56.8mm) and 28 March (58.7mm).

At both sites, permanent saturation was recorded at 125 cm depth in the soil profile with the interval between 95cm likely to represent the capillary fringe. It is considered likely that evapotranspiration during a sustained dry period contributed significantly to drawdown in the shallow groundwater zone.

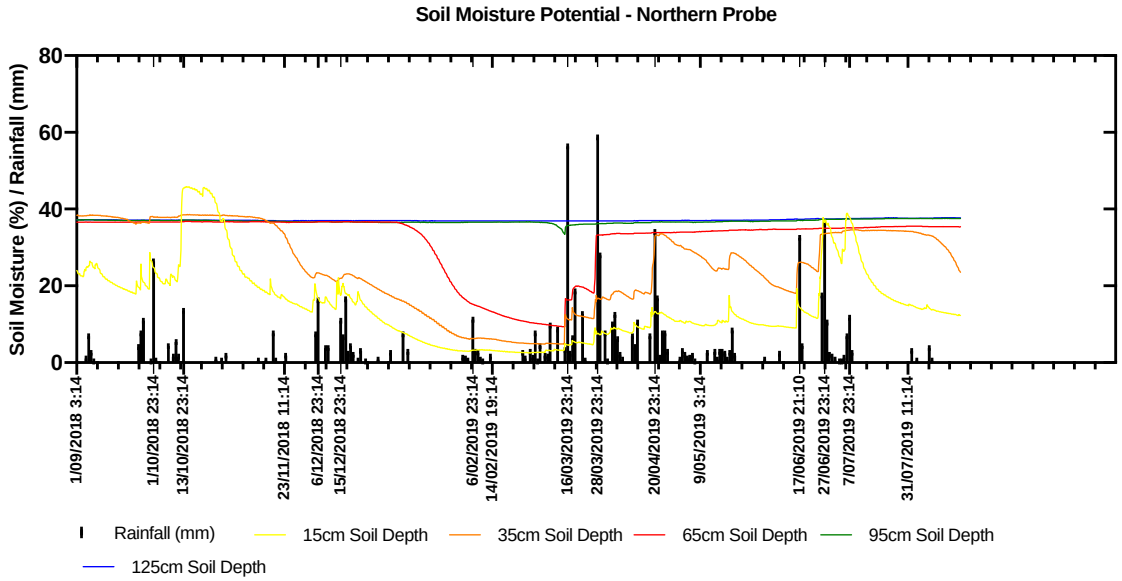


Figure 5. Northern Soil Moisture Potential Readings

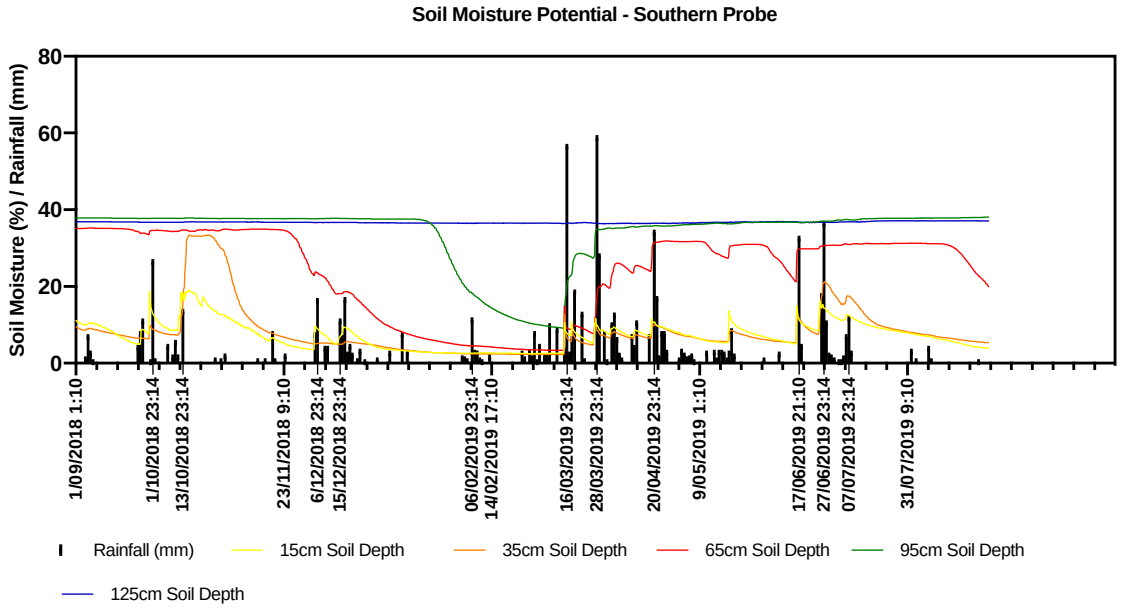


Figure 6. Southern Soil Moisture Potential Readings

3.2 NDVI data analysis

Average NDVI data values for 2016, 2017, 2018 and 2019 are provided in Figure 7. Full data plots for individual monitoring sites are provided in Figure 8. There is little consistency in NDVI trends and repeat measures ANOVA indicates no significant differences between monitoring treatments ($F_{1.3} = 9.5$; P=0.241) although there are significant differences in NDVI values occurring between survey plots ($F_{7,35} = 14.81$; P <0.0001). The most obvious trend is a general consistent increase in NDVI values between monitoring events that initiated in the April 2018 monitoring event and continued through to the April 2019 event, after which NDVI values decreased. The sharply negative value shift that has occurred in the impact site (Site 6) NDVI values in the October 2019 survey is due to combustion of living cover in the August 2019 wildfire.

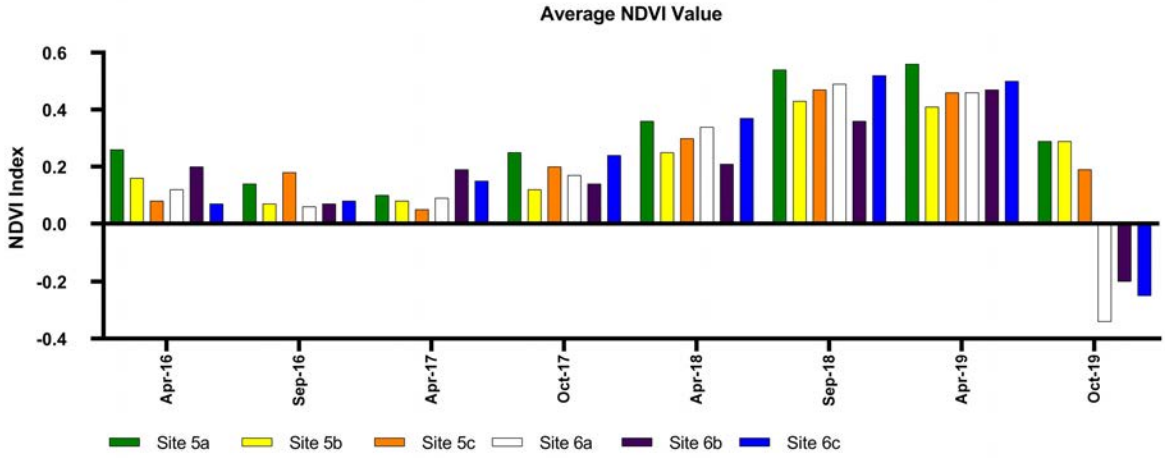


Figure 7. Average NDVI Values for the 2016, 2017, 2018 and 2019 survey periods.

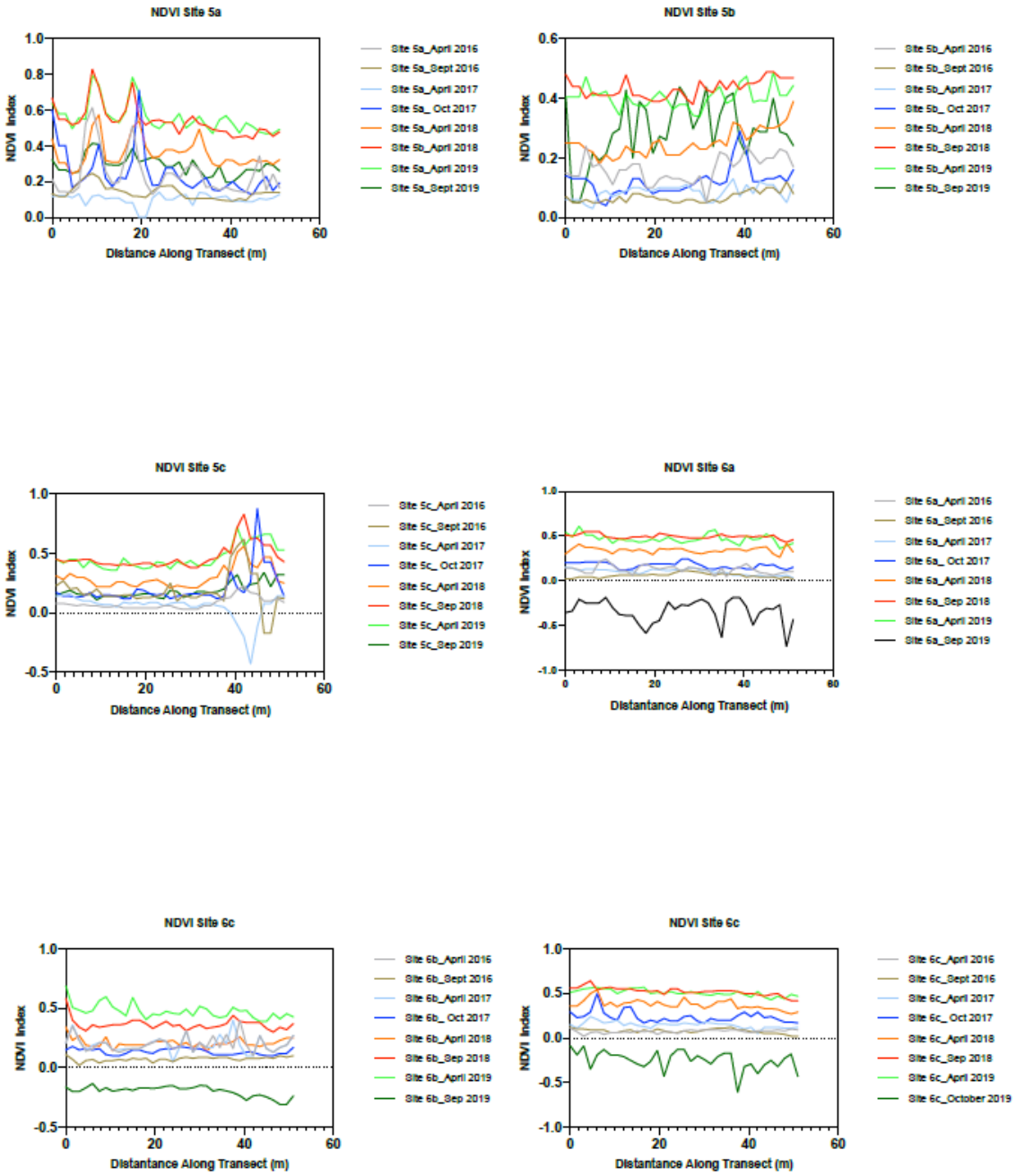


Figure 8. NDVI profiles for individual survey plots at different capture periods.

3.3 Shrub Cover and Stem Density

Cover of shrubs > 1 m (%) has decreased in the recent survey events. All survey sites in the 2019 survey presented a much lower % cover which continued a trend observed from previous survey periods. There is considerable variation in the cover of shrubs >1m tall evident between survey periods for all survey sites and years (see Figure 9).

A Levene's test applied to both the control and impact sites indicates that across all sites that variance is equal. A Repeat Measures ANOVA indicates that the temporal variation in shrub cover demonstrated between survey events is highly significant across all sites ($F_{3.14, 15.69} = 15.91$, $P < 0.0001$) . It has previously been suggested that heavy utilisation by kangaroos may be having a significant impact on shrub structure (3d Environmental 2018). However in the October 2019 monitoring event, it was noted that many of the shrubs, particularly *Persoonia virgata,* were dead with no regeneration occurring from basal stems or epicormic growth. Senescence of shrubs between survey events is particularly noticeable in the site photographs (Appendix A). Similar decreases in stem density are indicated for shrubs in the 0.5m to <1m size class. Repeat Measures ANOVA indicates that temporal variations between survey periods is not statistically significant for this size class, despite almost complete loss of shrub cover in the October 2019 monitoring event ($F_{1.771, 8.853} = 4.085$; $P=0.058$) and a general trend toward decreasing shrub cover at both the impact site and control site (See Figure 10). It should be noted that the fire at the impact site (Site 6) has also had a significant impact, reducing shrub cover to nil in the October 2019 monitoring event.

As noted in previous assessments, Figure 11 indicates that sites associated with the impact area (6a, 6b, 6c) have a much higher stem density than those sites associated with the control areas (5a, 5b and 5). There is also an apparent consistent decrease in stem density that has occurred over the 3 survey events. Repeat Measures ANOVA indicates that the measured decrease in stem density between survey periods is statistically significant across all sites ($F_{1.194, 5.972} = 12.28$; $P=0.0113$), although much more significant for the impact site ($F_{1.248, 2.496} = 66.44$; $P=0.0072$) than for the control site ($F1_{.463, 2.92} = 10.33$; $P=0.049$).

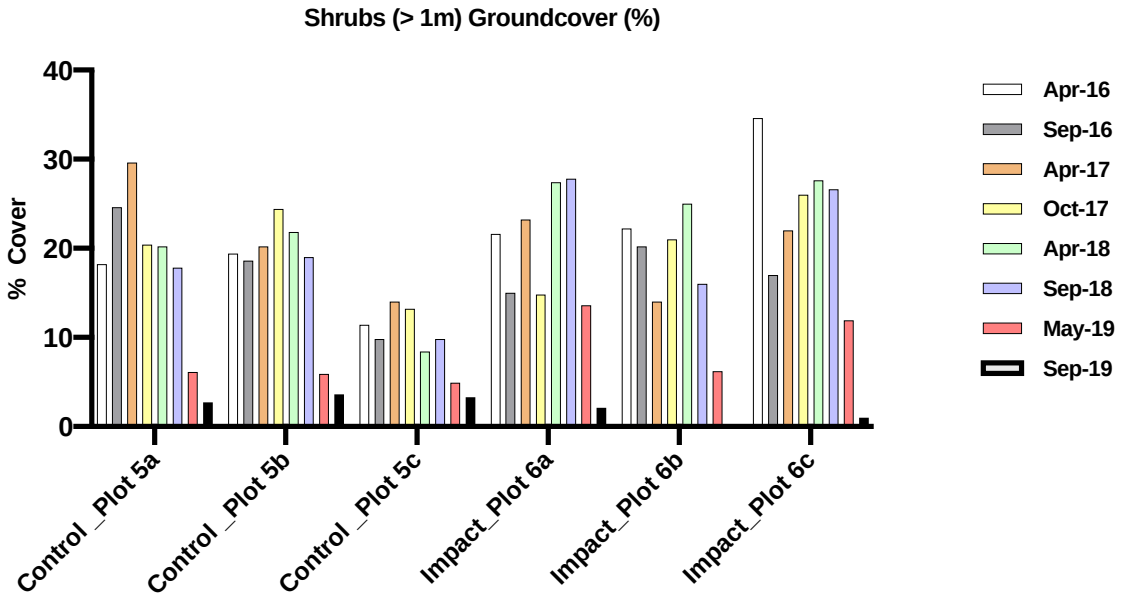


Figure 9. Groundcover (%) of shrubs > 1 m

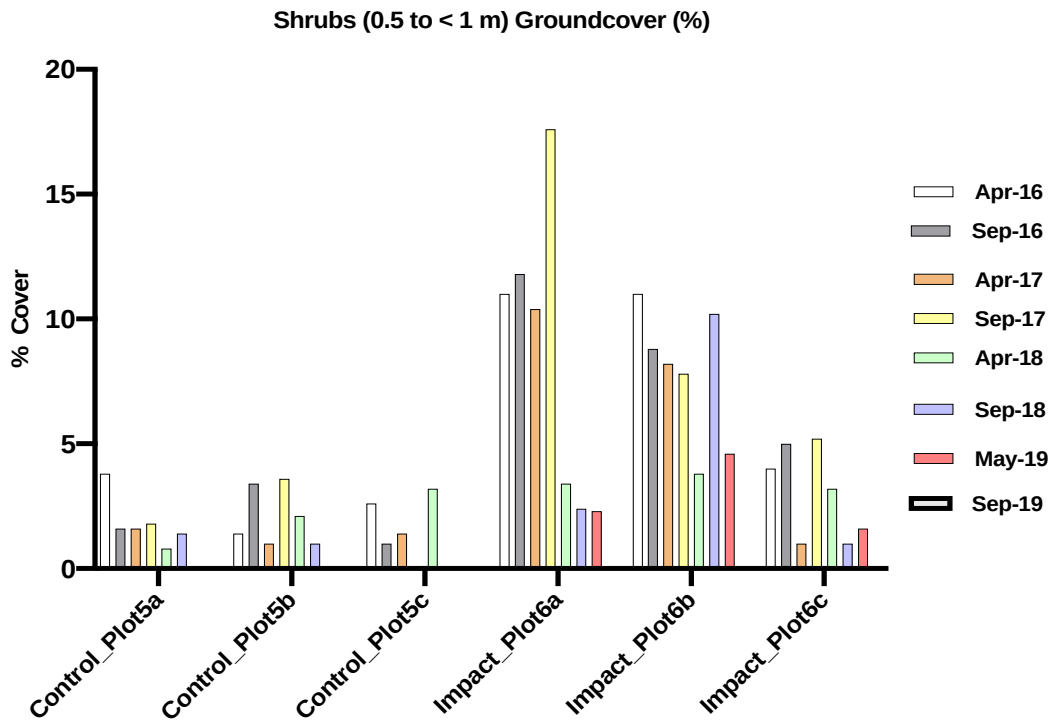


Figure 10. Groundcover (%) of shrubs 0.5 to > 1 m

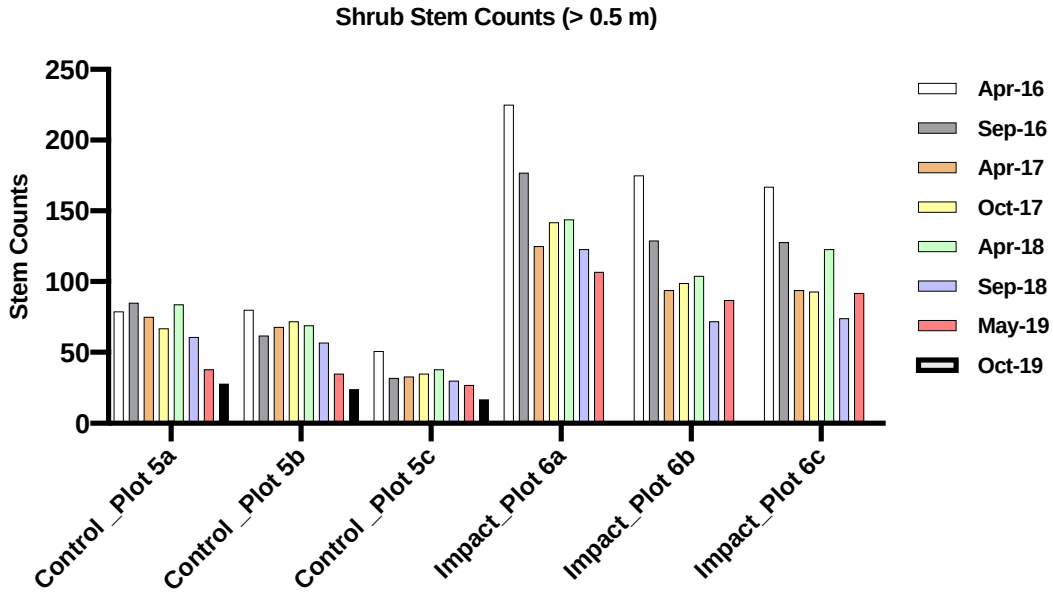


Figure 11. Stem counts for shrubs (> 0.5 m) across all sites (2016 – 2019)

3.4 Composition and Nature of Groundcovers

The vegetation at both impact and control sites exists in largely natural condition, lacking any significant elements of degradation that may be prompted through changes to hydrological regime, land disturbance and pervasive invasion of exotic species. It is thus considered that control and impact sites are readily comparable.

Sharp and sustained changes in soil moisture for both impact and control sites in the upper 65cm of the soil profile has occurred with extended periods when the upper 35cm of the soil profile has dried to <20% total soil moisture, dropping to < 5% soil moisture between December and March 2019. Consistent with observations from previous monitoring events, the upper soil profile of the control site drains and dries more rapidly after rainfall than the impact site with shorter periods of saturation (see Section 3.1.2) and drying extends deeper into the soil profile with drying at 95cm depth being sustained for a period of a month between February and March 2019 at soil moisture contents < 20% .

The hydrological differences in the upper soil profile of the control site would be expected to impart subtle differences in vegetation composition between sites. This would be particularly true in the shallow rooted groundcover layers which would be most exposed to drying in the upper soil profile. Sections 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 and contribution to total cover of various lifeforms over the 2016, 2017, 2018 and 2019 survey periods.

3.4.1 Native perennial grass / sedge / rush cover

The cover of living grass, sedge and rushes has changed subtly over a number of assessment periods (see Figure 12) indicating that the dominant rush species *Sporodanthus interruptus, Caustis recurvata* and *Baloskion tenuiculme* have remained relatively resilient despite an extended dry climatic event spanning the 2016, 2017, 2018 and 2019 monitoring periods. Change in native grass and sedge cover (%) was relatively unpredictable with some sites showing moderate increases in cover in the October 2019 monitoring event, although this was not consistent across all monitoring sites. At the impact site, native grass and sedge cover (%) reduced substantially between the May 2019 and October 2019 monitoring events due to combustion associated with an uncontrolled wildfire. Grass and sedges were not recorded in groundcover plots at Impact Plot 6c for the first time since monitoring commenced, on account of the recent fire. Control plots were not impacted by the fires, and have maintained similar grass and sedge cover (%) since April 2018. Control Plot 5b in October 2019 recorded the highest (%) sedge and rush cover since establishment of monitoring.

Levene's test indicates equal variance in sedge/ rush cover values over the three survey periods. Repeat Measures ANOVA applied to data for the 2016, 2017, 2018 and 2019 survey events suggests that the minor differences in cover detected between survey plots over time at both control and impact sites, are not significant and would be expected in line with natural variation ($F_{1.553,\ 7.766} = 2.17$ P = 0.189). If applied to the impact site alone, repeat measures ANOVA does indicate significant differences between monitoring events ($F_{1.982,\ 3.963} = 18.37$; P = 0.0099), most likely attributed to cover changes induced by the August 2019 wildfire.

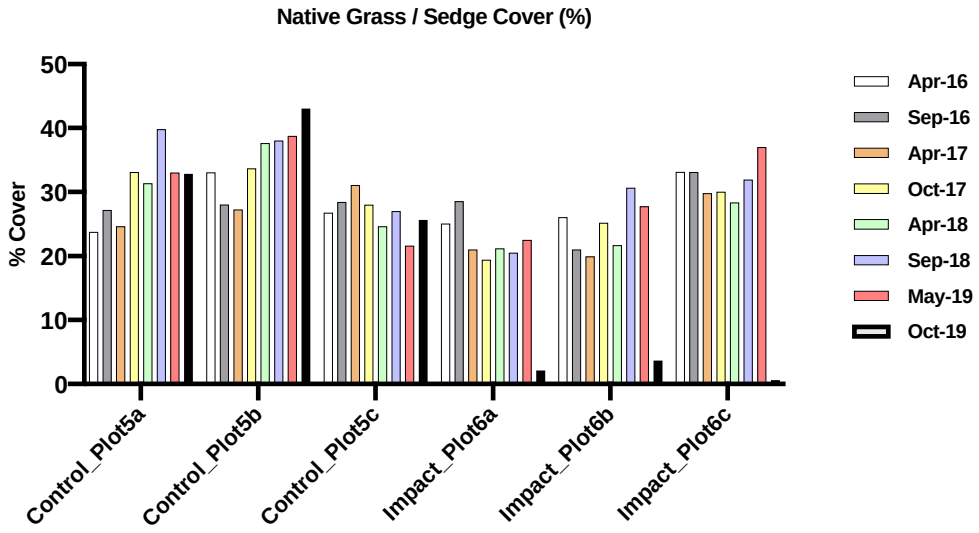


Figure 12. Cover (%) of native grasses, sedges and rushes with comparison between survey events.

3.4.2 Groundcover shrubs

Variations in the abundance of native shrubs in the groundcover (i.e <0.5m) did occur between survey events although there was no consistent trend observed except for an expected sharp decline in shrub cover at the impact site following the August 2019 wildfire (see Figure 13). Application of Levene's Test indicates that Variance between sites is equal. A Repeat Measures ANOVA applied to the impact site (Site 6) suggests that the observed reduction in shrub cover measured between the 2016 and 2019 surveys events is statistically significant ($F_{1.885, 3.769} = 21.10$; P=0.0092) consistent with the results of the 2018 monitoring event, although also influenced by the loss of groundcover shrubs associated with the August 2019 wildfire event. Change to groundcover shrub composition is however not considered statistically significant at the control site ($F_{1.379, 2.758} = 1.029$; P=0.426).

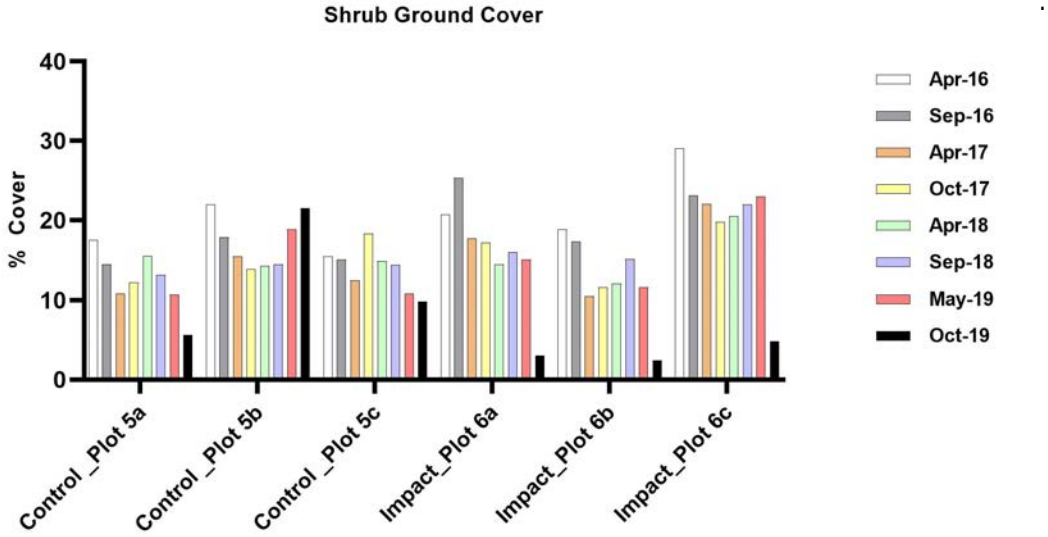


Figure 13. Composition of groundcover shrubs with a comparison made between survey events.

3.4.3 Groundcover forbs

Groundcover forbs form a relatively small proportion of the total groundcover across all plots. Due to a general preference for mesic conditions, it is expected that forb diversity and % cover will be highly sensitive to droughting and will vary markedly according to seasonal conditions.

The highest cover of forbs across all sites and monitoring events was recorded in the 2016 survey event which followed an extremely wet year in 2015 (Figure 14). Groundcover forb cover (%) reduced across all Impact Plots (6a, 6b and 6c) between the May 2019 to October 2019 monitoring event. Forb cover (%) increased slightly in Control Plots 5a and 5b from May 2019 to October 2019. Previous to the 2019 survey events, forb cover had been variable in response to rainfall, within a reasonably consistent range of values.

A Levene's test applied to both April and September 2018 data indicates forb cover Variance is equal across all sites while a Repeat Measures ANOVA indicates that the measured variation in forb cover between survey events for all sites is not significant ($F_{2.194, 10.97} = 3.624$; P=0.058). There is considerable variation in the diversity and composition of forbs between survey events however and this is discussed further in Section 3.4.6.

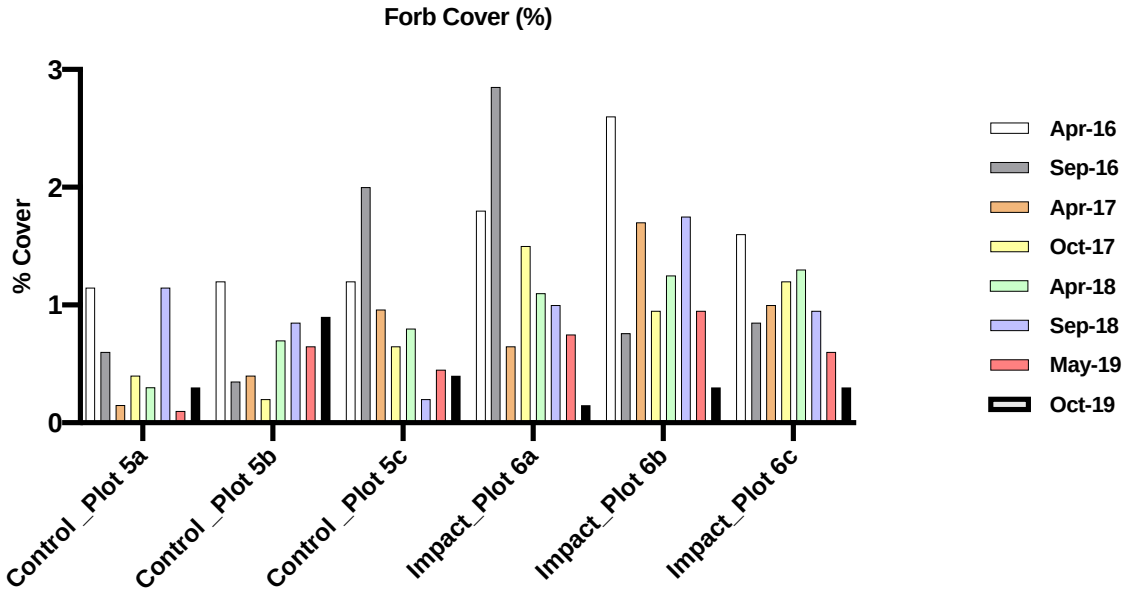


Figure 14. Forb cover (%) across all sites and years

3.4.4 Grasstree cover

There is considerable variation in grasstree cover between sites as well as variation between survey events. It is however difficult to identify any firm trends and the variability in grass tree cover values appears independent of site locality and seasonal survey effort (Figure 15). However, a decrease in the recorded % cover of grasstree within groundcover plots was apparent in the October 2019 event across all sites, with large decreases at the impact site related to groundcover combustion. Grasstrees formed

the most signicant groundcover recorded in impact sites (6a, 6b and 6c) in October 2019 indicating their relative resistance and capacity to rapidly regenerate from fire.

Application of a Levene's test indicates that Variance in grasstree cover values is equal across all site localities whilst a Repeat Measures ANOVA suggests that the variation in grasstree cover between seasonal survey efforts spanning the 2016, 2017, 2018 and 2019 survey periods is statistically significant ($F_{2.934, 14.67} = 6.164$), suggesting that the extent of grasstree cover is responding to seasonal conditions.

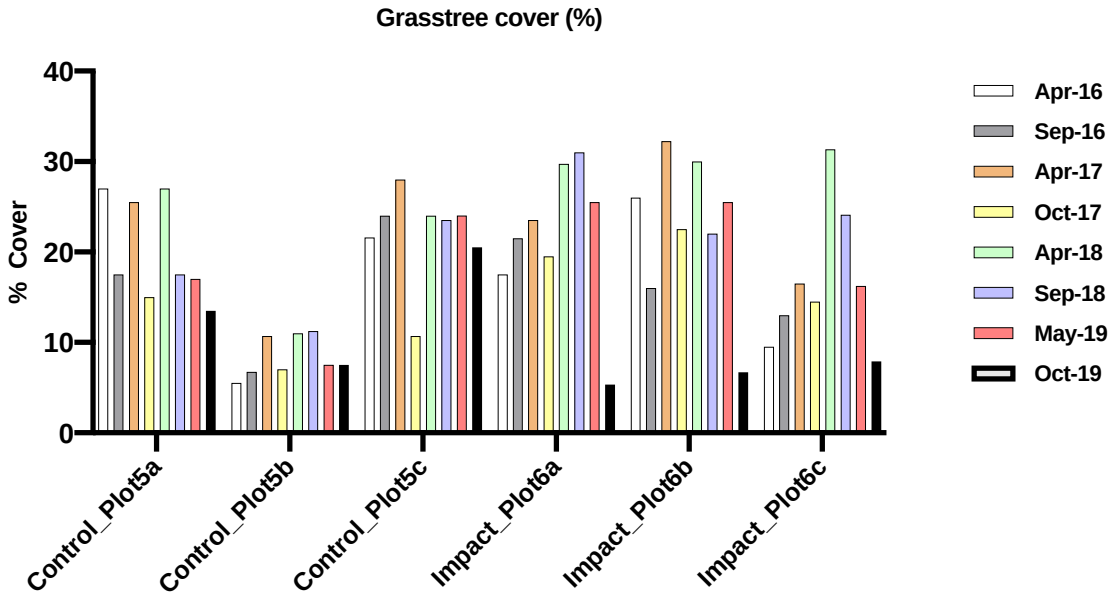


Figure 15. Grasstree groundcover (%) across all sites and years

Table 2. Summary of groundcover contribution by various lifeforms over the assessment periods from 2016 to 2019.

Plot Location / Survey Event	Forb % Cover	Sedge / Rush/ Grass % Cover	Shrub % Cover	Grasstree % Cover	Bare % Cover	Leaf % Cover	Exotics % Cover	Total % Cover
Plot 5a_April 2019	0.1	33.0	10.7	17	5	34.2	0	100
Plot 5a_October 2019	0.3	32.85	5.65	13.5	11.4	36.5	0	100
Plot 5a_April 2018	0.3	31.35	15.55	27	2.1	23.7	0	100
Plot 5a_September 2018	1.15	39.8	13.1	17.5	4.85	23.6	0	100
Plot 5a_April 2017	0.15	24.75	10.81	25.5	1.5	37.29	0	100
Plot 5a_October 2017	0.4	34	12.25	15	1.95	36.4	0	100
Plot 5a_April 2016	0.6	27.35	17.4	26	0.35	28.3	0	100
Plot 5a_September 2016	1.15	27.2	14.45	17.5	2.6	37.1	0	100
Plot 5b_April 2019	0.65	38.75	18.85	7.5	2.75	30.8	0	100
100Plot 5b_October 2019	0.9	43.05	21.55	7.5	3.4	22.9	0	100
Plot 5b_April 2018	0.7	37.65	14.2	11	2	34.45	0	100
Plot 5b_September 2018	0.85	38	14.45	11.25	4.5	30.95	0	100
Plot 5b_April 2017	0.4	29.1	15.45	10.7	1.25	43.1	0	100
Plot 5b_October 2017	0.2	33.7	13.8	7	4.5	40.6	0.2	100
Plot 5b_April 2016	0.35	45.05	22	5.5	4	23	0.1	100
Plot 5b_September 2016	1.2	28.55	17.85	6.75	4.25	40.65	0.75	100
Plot 5c_April 2019	0.45	25.65	4.9	24	1.55	34.1	0	100
Plot 5c_October 2019	0.4	21.6	3.3	20.5	1.5	42.05	0	100
Plot 5c_April 2018	0.8	24.65	14.85	24	0	35.7	0	100
Plot 5c_September 2018	0.2	27	14.4	23.5	2.5	32.3	0.1	100
Plot 5c_April 2017	1.05	31.1	12.5	28	0	27.35	0	100
Plot 5c_October 2017	0.7	28	18.3	10.7	1.5	40.7	0.1	100
Plot 5c_April 2016	2	28.5	15.5	21.25	0.5	32.25	0	100
Plot 5c_September 2016	1.2	28.45	15.05	24	1.2	30.05	0.05	100
Plot 6a_April 2019	0.75	21.2	15.05	25.5	2.4	34.05	0	100
Plot 6a_October 2019	0.15	2.15	3	3	8.5	80.85	0	100
Plot 6a_April 2018	1.1	21.2	14.45	29.75	0	33.5	0	100

Plot Location / Survey Event	Forb % Cover	Sedge / Rush/ Grass % Cover	Shrub % Cover	Grasstree % Cover	Bare % Cover	Leaf % Cover	Exotics % Cover	Total % Cover
Plot 6a_September 2018	1	20.5	16	31	0	32	0	100
Plot 6a_April 2017	0.65	23	17.75	23.5	0	35.1	0	100
Plot 6a_October 2017	1.5	19.45	17.2	19.5	1	41.35	0	100
Plot 6a_April 2016	2.9	25.06	20.71	17.51	0	33.82	0	100
Plot 6a_September 2016	1.8	26.05	25.3	19.5	0.2	27.15	0	100
Plot 6b_April 2019	0.95	27.75	11.65	25.5	0.75	33.4	0	100
Plot 6b_October 2019	0.3	3.7	2.4	6.7	4.9	82	0	100
Plot 6b_April 2018	1.25	21.7	31.35	30	1.25	33.7	0	100
Plot 6b_September 2018	1.75	30.65	24.1	22	3.25	27.25	0	100
Plot 6b_April 2017	0.85	29.8	22.05	16.5	0	30.65	0.15	100
Plot 6b_October 2017	1.2	30	19.8	14.5	0.75	33.75	0	100
Plot 6b_April 2016	1.51	27.05	18.36	26	0	27.08	0	100
Plot 6b_September 2016	2.3	21.3	17.35	16	0.5	42.55	0	100
Plot 6c_April 2019	0.6	37	23	16.25	0.75	22.4	0	100
Plot 6c_October 2019	0.3	0.5	4.85	7.9	10	71.85	0	100
Plot 6c_April 2018	1.3	28.35	20.5	31.35	0.5	18	0	100
Plot 6c_September 2018	0.95	31.95	22	24.1	3.5	17.5	0	100
Plot 6c_April 2017	0.85	29.8	22.05	16.5	0	30.8	0	100
Plot 6c_October 2017	1.2	30	19.8	14.5	0.75	33.75	0	100
Plot 6c_April 2016	0.85	33.15	37.15	9.5	0.25	19.1	0	100
Plot 6c_September 2016	1.8	33.1	21.2	13	0.2	30.6	0.1	100

3.4.5 Total living groundcover

Total living groundcover represents the portion of the groundcover that is living with capacity for photosynthesis. Living groundcover values are balanced by leaf litter and small patches of bare ground (humic sand) which form a minor cover component at some sites (Figure 16). Total living groundcover can be used as a measure of the health or vigour of a vegetation community at a given point in time. The proportion (%) of living groundcover for all sites is provided in Figure 16. Living groundcover was substantially reduced in impact plots due to the recent fire which almost completely destroyed the groundcover layer.

Continuing ongoing trends observed during previous assessment periods, subtle variations occur between survey events at all survey localities although it is difficult to identify any strong links to seasonality or differences between impact and control sites. A Repeat Measures ANOVA suggests that the variation in living groundcover between seasonal survey efforts spanning the 2016, 2017, 2018 and 2019 survey periods is not statistically significant ($F_{2.934, 14.67} = 6.164$). Despite intense drought and drying of the upper soil profile over multiple monitoring events, living groundcover values have remained relatively robust.

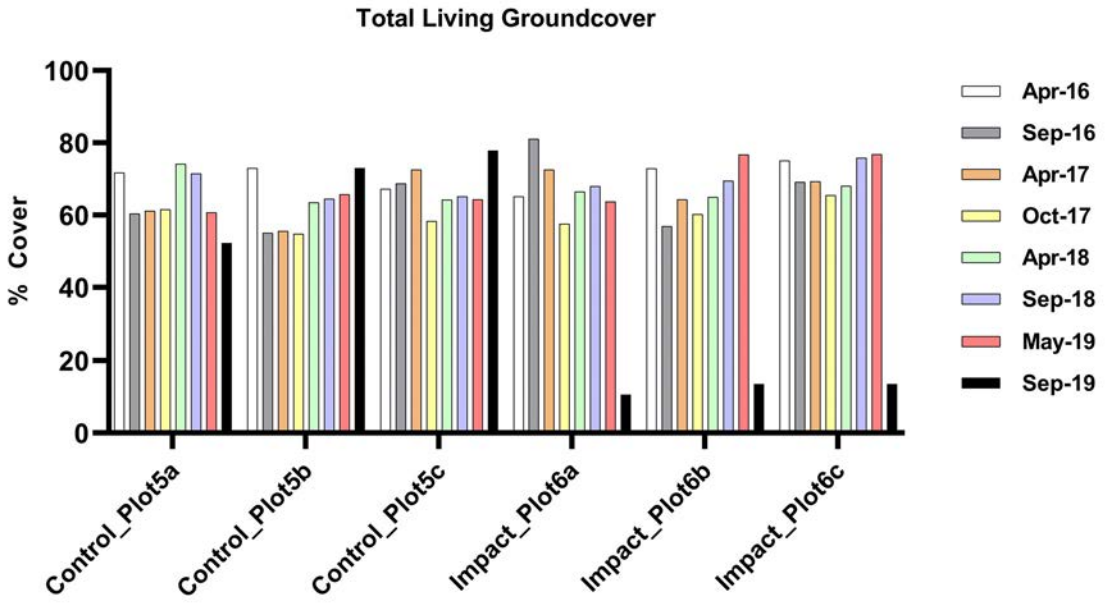


Figure 16. Total living groundcover values for all sites.

3.4.6 Species richness

Species richness has been calculated through combination of seasonal data for the 2016, 2017, 2018 and most recent 2019 assessment periods. For all sites and survey events, the highest species total diversity was recorded in the September 2016 survey event (Figure 17). Species diversity declined in April 2017 survey although this decline had largely stabilised throughout the 2018 survey period.

In the 2018 and 2019 survery periods, declines in species diversity have continued strongly with reductions at the control site (Site 5) dropping from a total of 38 species in the September 2018 monitoring event to 28 species in the October 2019 event (**Figure 18**). As noted during the 2017 survey event, the decline in species diversity recorded between September 2016 and April 2017 was typically in the range of 20 to 25% with a total of 43 species recorded in Survey Plot 6c (the most floristically diverse survey plot) in the September 2016 survey period, dropping to 32 species recorded in the April 2017 surveyand plummeting to 11 recorded species in the October 2019 monitoring event (**Figure 19**). The largest declines in cover are observed to be in shrubs and forbs, although all life forms have been attributed with some loss of species diversity. The dramatic plunge in species diversity between 2018 and 2019 monitoring events at the control site can be mostly attributed to the August 2019 wildfire.

The decrease in species diversity recorded between survey events is statistically significant across all sites as indicated by a Repeat Measures ANOVA (F1.247, 18.70 = 230.3; P=<0.0001). A list of species recorded during the 2016, 2017 and 2018 survey periods attributed to individual survey plots is provided in **Appendix B**.

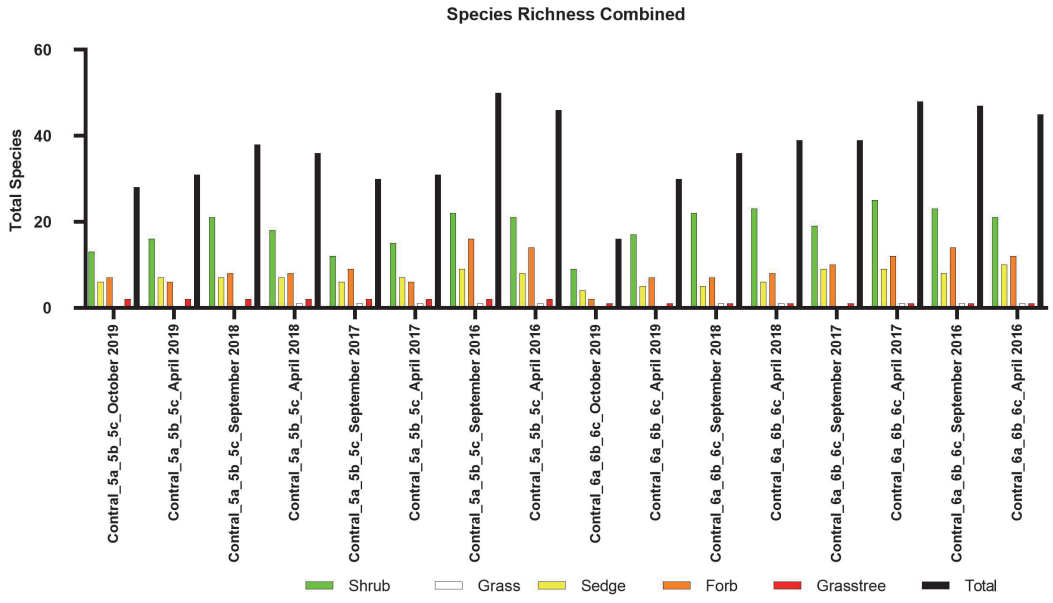


Figure 17. Species richness per life form and overall species richness for all survey plots .

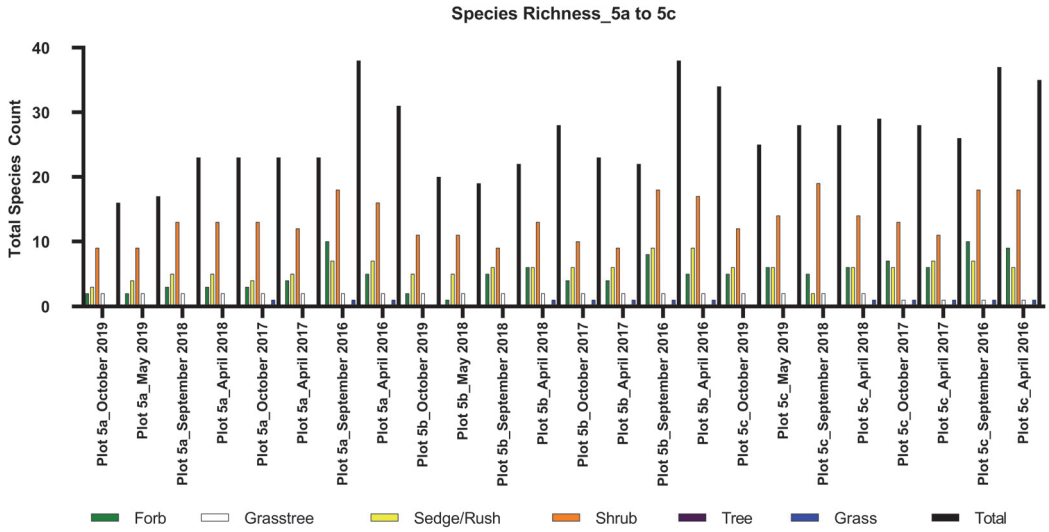


Figure 18. Species richness per life form and overall species richness for impact plots (Site 5).

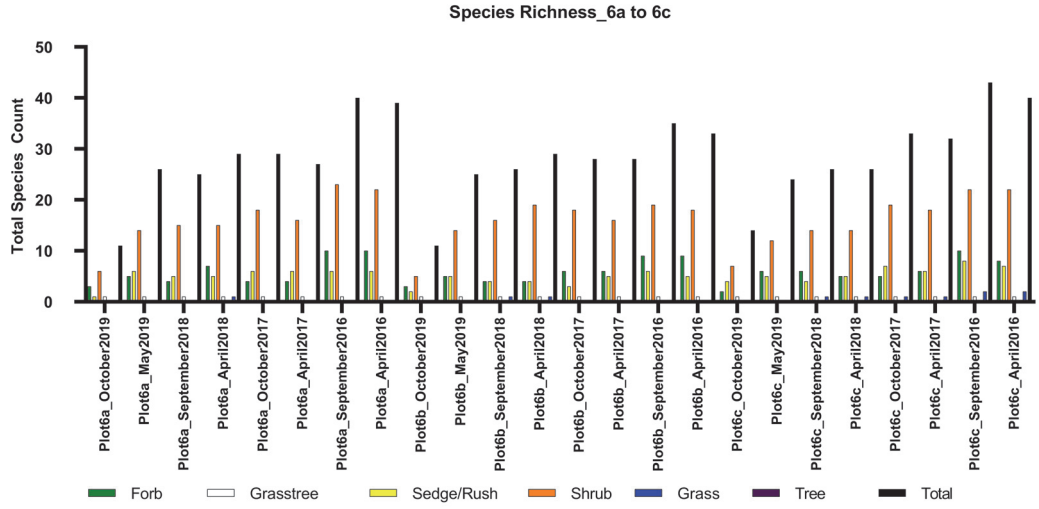


Figure 19. Species richness per life form and overall species richness for control plots (Site 6)

4.0 Discussion and Summary

This is the fifth year of vegetation monitoring assessment undertaken at the Banksia Beach Borefield.and the fourth to be undertaken by 3d Environmental on behalf of Seqwater. Spanning the five years of assessment, the major structural trends identified in the heathland monitoring sites include:

1. A strong increase in floristic diversity noted in the 2016 survey event over the original 2015 assessment with 47 species recorded at the impact site and 50 species at the control site when compared compared to the 2015 survey event survey where 34 species were recorded at both the control and impact sites. This coincided with a very wet 2015 where 1538mm fell at the AWS Bribie NP compared to a long term average rainfall of 1406mm.

2. A subsequent strong decrease in floristic diversity is noted in the 2017 surveys coinciding with below average rainfall recorded in 2016 and 2017 survey periods (1158mm and 930mm of rainfall falling respectively). During this survey event, 39 species were recorded at the impact site and 30 species at the control site.

3. Floristic diversity in 2018 was relatively stable following slightly below average rainfall (1293mm) falling during the assessment period although decreased sharply in the current 2019 monitoring event with total species counts dropping to 28 species at the control site and 16 species at the impact site. The reduction of species diversity at the impact site is attributed largely to the passing of an intense wildfire in August 2019 which scorched all structural layers.

4. Across all monitoring events, a statistically significant decrease in the density of shrubs in size classes >0.5m has been ongoing at both impact and control sites. Total shrub stem densities in the 2019 monitoring period are the lowest of any survey event, although total destruction of shrub cover and stems occurred at the impact site in association with the late August 2019 wildfire.

5. Aligning with decreases in stem density are major decreases in shrub cover occurring across each consecutive monitoring event from 2016 to 2019. Cover of shrubs in the >1m size class at the control site in October 2019 had decreased to levels of around 3%, reducing from 30% cover at the control site in April 2017. This loss of shrub cover was directly observable on the ground with dead stems evident, mostly *Persoonia falcata,* and no visible sign of recruitment or stem regeneration. The 2019 monitoring event saw an almost total collapse of shrubs in the 0.5m to <1m size class.

Ongoing from the 2018 monitoring event, there is also considerable variability across a range of measured structural and floristic parameters including sedge and rush cover, grasstree and forb cover. This variability occurs between individual sites as well as between seasonal survey efforts and often shows little consistency. This variability is considered an intrinsic feature of the coastal heathland habitat which respond in a complex manner to varying stimuli including rainfall, fire and their interaction with the soil seed bank.

As identified above, statistically significant changes in species richness has occured between seasonal survey efforts continuing those trends observed in 2018 monitoring event into the current 2019 monitoring event. A Repeat Measures Anova identify highly significant reduction in species diversity across all life forms ((F1.247, 18.70 = 230.3; P=<0.0001). Consistent with this observation, it is considered that the compounding influences of changes in soil moisture in the upper soil profile to depths of 95cm, influence by varying seasonal rainfall, drought, plus long term absence of fire from the heathland habitat are likely to be influencing floristic diversity (Tozer et al, 2002. It will be interesting to note what influence the August 2019 wildfire will have on species diversity in the 2020 monitoring event, and there is a perfect scenario for comparison between burnt impact site and unburnt site.

Rainfall and Soil Moisture: The well below average rainfall in the 2019 monitoring period resulted in drying of the soil profile at 95cm depth at the control site where total soil moisture content fell from saturation (approx.. 40% total moisture content) to <20% for a period of approximately one month between February and March 2019. This is the first time that drying of soils at 95cm depth has occurred at any time at any site since the monitoring program commenced in 2015. The drying is also in contrast to the previous 2018 survey event where permanent saturation of the soil profile occurred at 95cm depth and fluctuation in deeper soil moisture occurred at depths of between 65cm and 95cm, the region in the soil profile which was inferred to represent the capillary fringe. The extended dry period moving into 2019 indicates a phase shift with periodic drying of deeper regions in the soil profile than has previously occurred, resultant from lack of recharge. It is likely that reduction in soil moisture content in deeper regions of the soil profile has been influenced by evapotranspiration associated with deeper rooted shrub species including *Banksia aemula, Leptospermum polygalifolium* and *Melaleuca quinquenervia* which are all identified as known or potential facultative phreatophytes. The severe dieback of the previously dominant shrub *Persoonia falcata* noted in the 2019 monitoring event across all survey sites is potentially a result of drying in deeper portions of the soil profile, although the patterns of water use for this species and rooting capacity are unknown and it is impossible to draw firm conclusions. Despite the extended depression of soil moisture content at 95cm depth in the soil profile of the control site, soil moisture recharge occurrs rapidly following sufficient rainfall and subsurface moisture conditions vary on scales that mimic the incumbent climatic regime. Recharge of groundwater to saturation at 95cm depth occurred at the control site after two relatively intense rainfall events in where approximately 86mm of rainfall fell over space of a week in March 2019.

Forbs, sedges and rushes and the more delicate shrub species are likely to be exposed to fluctuations in the shallow soil moisture profile and would therefore be much more sensitive to seasonal and annual drying cycles. Furthermore, the comparative dryness of the upper soil profile at the control site would render this location much more sensitive to fluctuations in rainfall than the impact site and the drier soil profile remains the mostly likely causal factor for the consistently lower measured floristic diversity at the control site.

NDVI Data: The relationship between NDVI signature, vegetation structure and floristic diversity remains unclear. The incremental increase in NDVI signatures measured between the 2017 and 2018 monitoring events with subsequent strong reduction in NDVI values in the 2019 monitoring event can only be related to drying soil moisture conditions. These varying soil moisture conditions will affect both shallow rooting sedges, forbs and shrubs reliant on moisture in the shallow soil profile and deeper

rooting, or more mature shrubs influence by drying in the deeper portion of the soil profile. The measured NDVI values is responding to the 'greenness' or productivity of the living biomass which has most likely decreased in the 2019 survey event, particularly in the sedges and forbs which have been affected by extended periods when the upper soil profile was extremely dry. This may have also influenced changes in dominance of particular species or a particular structural layer with varying levels of 'greeness'.

Summary: Ecological data collected over several survey periods spanning 2015 to 2019 indicates that the control (Site 5a to 5c) and impact sites (Site 6a to 6c) are broadly similar in structural and floristic attributes. The major structural differences between the control and impact sites is a significantly higher shrub cover and stem density for shrubs of all size classes at the impact site, coupled with a generally higher species diversity. The strong trend toward reducing shrub cover in the lower size class (0.5 to <1m) at the impact site, coupled with a statistically significant decline in stem density over several monitoring periods has persisted into the current monitoring event to a point where it appears shrub cover and stem density is subject to wholesale collapse. It is currently unknown to what degree drying soil conditions are controlling the structure and diversity of the shrub layer and the trend may be resultant from a combination of factors, of which lack of fire is likely to be another major influence.

The major trend identified at completion of the 2019 survey event, apart from collapse of the taller shrub layers is a dramatic reduction in species diversity, falling from high points in the 2016 survey to the lowest levels of species diversity recorded from all monitoring events in the October 2019 assessment. Observations made in 2018 is that a return to average rainfall conditions will have little influence over species diversity and it may take a period of prolonged wet, or a sequence of seasons with higher than average rainfall to initiate structural and floristic rebound. It is also likely that fire, or the lack of fire, is also having a significant impact on vegetation structure and diversity. The August 2019 wildfire event, which burnt the impact site (Site 6) and left the control (Site 5) unscathed, will provide a unique opportunity to monitor the influence of fire on heathland structure and ecology in conjunction with the monitoring of groundwater and soil moisture fluctuations . As previously postulated, it is considered that the compounding influences of a relatively dry climatic cycle, prolonged drying of the shallow soil profile, coupled with a long-term absence of fire are all influencing the structure and floristic diversity of coastal heathland in the Banksia Beach Borefield assessment area.

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6.0 Appendix

Appendix A - Monitoring Transects

Survey Locality 5a

Date of Assessment: 5 /04 / 2019 and 01/10 /2019
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 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
18 – 19.5	*Agiortia pedicellata*	1.5	2		
23.4 – 24.6	*Agiortia pedicellata*	1.2	1.4		
37.0 – 38.5	*Persoonia virgata*	1.5	2.0		
44.7 – 45.8	*Persoonia virgata*	1.1	1.8		
47.2 – 48.0	*Persoonia virgata*	0.8	2.1		
Total Cover		6.1			
Average Height			1.86		

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

October 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
23.5 – 24.6	*Agiortia pedicellata*	1.1	1.3		
45.0 – 45.9	*Persoonia virgata*	0.9	1.6		
47.3 – 48.0	*Persoonia virgata*	0.7	2.1		
Total Cover		2.7			
Average Height			1.66		

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

Stem Counts (50 x 4) – Shrubs > 0.5m

April 2019

Species	50 m x 4 m Stems (50x4m) April 2019	50 m x 4 m Stems (50x4m) October 2019
	S2	
Persoonia virgata	19	7
Leptospermum semibaccatum	7	4
Agiortia pedicellata	2	7
Baeckea frutescens	1	1

Leucopogon leptospermoides	7	7
*Pinus elliottii***	1	1
Melaleuca quinquenervia	1	1
Totals	38	28

**projected count over 50 x 10m

Ground Cover %- 1 x 1m Sub-plots

April 2019

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 18
Native perennial grass / sedges	*Caustis recurvata*	30	5	5	15	15	10	35	15	15	30	33
	Sporodanthus interuptus	5						5			5	
	Lomandra elongata				5				2.5		15	
	Lomandra sp.											
	Baloskion tenuiculme		15	20	25	15	15	5		20	2.5	
Native forbs and other spp.	*Pimelea liniifolia*	.		0.5					1			0.1
Native shrubs ,<1m	*Leucopogon leptospermoides*			1		1	5		10	5		10.7
	Baeckea frutescens				5					2.5	5	
	Strangea linearis		5		5						2.5	
	Leptospermum semibaccatum					10	10		15			
	Dilwynnia floribunda										1	
	Ochrosperma lineare		10	2.5	2.5			10				
Grass Tree	*Xanthorrhoea fulva*	50	15	30		25	10	10		20	10	17
Cryptogams												
Bare Ground		5	10	5	5	5	5	2.5	10	2.5	0	5
Exotic Shrubs												
Leaf litter		10	40	36.5	37.5	29	45	32.5	46.5	35	30	34.2
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

September 2019

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

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	
Native perennial grass / sedges	*Caustis recurvata*	20		10	15	20	10			10	20	32.85
	Sporodanthus interuptus								5	5	2	
	Lomandra elongata				10				2	2.5	15	
	Lomandra sp.		2									
	Baloskion tenuiculme	15	20	20	30		20	20	10	25	20	
Native forbs and other spp.	*Pimelea liniifolia*											0
Native shrubs ****,<1m	*Leucopogon leptospermoides*	1					1			5		5.65
	Homoranthus virgatus			1			1	2.5		2		
	Baeckea frutescens										1	
	Strangea linearis		5		10			2.5		2		
	Leptospermum semibaccatum					10		2.5	2.5			
	Ochrosperma lineare		5					2.5				
Grass Tree	*Xanthorrhoea fulva*	40	15	15		30	10	5		10	10	13.5
Cryptogams												
Bare Ground		5	30	5	30	10	10	5	15	2	2	11.4
Exotic Shrubs			1									0.1
Leaf litter		19	22	49	5	30	48	60	65.5	36.5	30	36.5
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100

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

Epacris pulchella, Patersonia sericea, Cassytha filiformis, Boronia falcifolia

Structural / Floristic Summary

BioCondition Attribute		April 2019	September 2019
Native Plant Species Richness	Tree:		
	Shrub:	10	
	Grass Tree	1	
	Grass / Sedge / Rush	4	
	Forbs and other:	3	
Total Species No.**		18	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	6.1	2.7

BioCondition Attribute		April 2019	September 2019
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	0	0
	Average Height >1m	1.86	1.66
Native Ground cover (%):	Native perennial grass / sedge cover (%):	33.0	32.85
	Native shrubs (%)	10.7	5.65
	Grass tree	17	13.5
	Organic litter cover (%):	34.2	36.5
	Native forb cover	0.1	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

**Excludes Exotic Species

Plot 5a – Centre to Start; April 2019 (Above) and October 2019 (Below).

Plot 5 – Centre to End; April 2019 (above) and October 2019 (below).

Plot 5a – Centre to Left; April 2019 (Above) and October 2019 (Below).

Plot 5a – Centre to Right: April 2019 (Above) and October 2019 (Below).

Survey Locality 5b

Date of Assessment: 5.04.2019; 1.10.2019
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 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
7.3 – 7.7	*Persoonia virgata*	0.4	1.5		
17.6 – 18.6	*Xanthorrhoea johnsonni*	1.0	1.0		
21.8 - 22.5	*Persoonia virgata*	0.7	1.3		
34.2 – 35.0	*Persoonia virgata*	0.8	1.5		
36.0 – 37.7	*Persoonia virgata*	1.7	1.6		
43.4 – 44.7	*Persoonia virgata*	1.3	2.5		
Total Cover		5.9		0	
Average Height			1.56		0

** Shrubs > 1m

October 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
7.7 – 8.7	*Persoonia virgata*	1	1.2		
37.0 – 38.4	*Persoonia virgata*	1.4	1.0		
43.8 – 45.0	*Persoonia virgata*	1.2	2.5		
Total Cover		3.6		0	
Average Height			1.56		0

** Shrubs > 1m

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2019	50 m x 4 m Stems (50x4m) October 2019
	S2	S2
Persoonia virgata	15	7
Leucopogon leptospermoides	4	3
Ochrosperma lineare		
Boronia falcifolia		
Leptospermum semibaccatum	6	8
Sprengelia sprengelioides		
Strangea linearis	2	
Acacia flavescens	1	1
Epacris pulchella		
Agiortia pedicellata	3	2
Baeckea frutescens	1	
Xanthorrhoea johnsoni (from top of trunk	2	2
Leptospermum polygalifolium	2	1
Totals	35	24

**projected count over 50 x 10m

Ground Cover %- 1 x 1m Sub-plots

April 2018

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 17
Native perennial grass / sedges	*Caustis recurvata*	25	10	5	20	10	0	15	10	15	15	38.75
	Sporodanthus interruptus						2.5				10	
	Baloskion tenuiculme	30	35	5	15	20	15	10	10	20	10	
	Lomandra elongata		15		5	10	10					
	Hypolaena fastigiata			5	5			10	10	5	5	
Native forbs and other spp.	*Pimelea liniifolia*		1	1						1		0.65
	Cassytha glabella						2.5					
	Pseudanthus orientalis					0.5					0.5	
Native shrubs ,<1m	*Leucopogon leptospermoides*	10			10		2.5		2.5	1		18.85
	Strangea linearis			2.5								
	Leptospermum semibaccatum			30	15	5	20	20	15	5	10	
	Baeckea frutescens	2.5				5						
	Ochrosperma lineare	2.5	1				1	2.5	1	10	5	
	Boronia falciformis										2.5	
	Acacia bauerii				0.5		0.5					
	Persoonia virgata										1	
Grass Tree	*Xanthorrhoea fulva*	15		15		10	10		15	10		7.5
Cryptogams					2.5	1	2.5					0.7

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 17
Bare Ground			10		10	2.5	5					2.75
Leaf litter		15	28	36.5	17	36	28.5	42.5	35.5	33	36	30.8
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

October 2019

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 17
Native perennial grass / sedges	*Caustis recurvata*	10	5	5	20	15	5		30	10	10	43.05
	Sporodanthus interruptus							10			5	
	Baloskion tenuiculme	60	60	10	10	10	10	10	10	25	30	
	Lomandra elongata		10		10					2.5		
	Hypolaena fastigiata			2	10	1	10	10	10	5		
Native forbs and other spp.	*Pimelea liniifolia*	2		2								0.9
	Pattersonia sericea		5									
Native shrubs ,<1m	*Leucopogon leptospermoides*	10			10							21.55
	Strangea linearis			5	2.5				5			
	Leptospermum semibaccatum						1	1		2.5		
	Baeckea frutescens											
	Ochrosperma lineare											
	Boronia falciformis											
	Homoranthus virgatus			10	2.5	5	20	20	15	2.5	10	
	Persoonia virgata								2			
Grass Tree	*Xanthorrhoea fulva*	20	10	5	5	10			5	20		7.5
Cryptogams												
Bare Ground			4	5	5	5	10	5				3.4
Exotic Shrubs	*Pinus elliottii***			2								0.2
Leaf litter		2	5	34	32.5	34	33	30	18	20.5	20	22.9

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 17
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

Additional Species: *Cassytha glabella, Conospermum taxifolium*

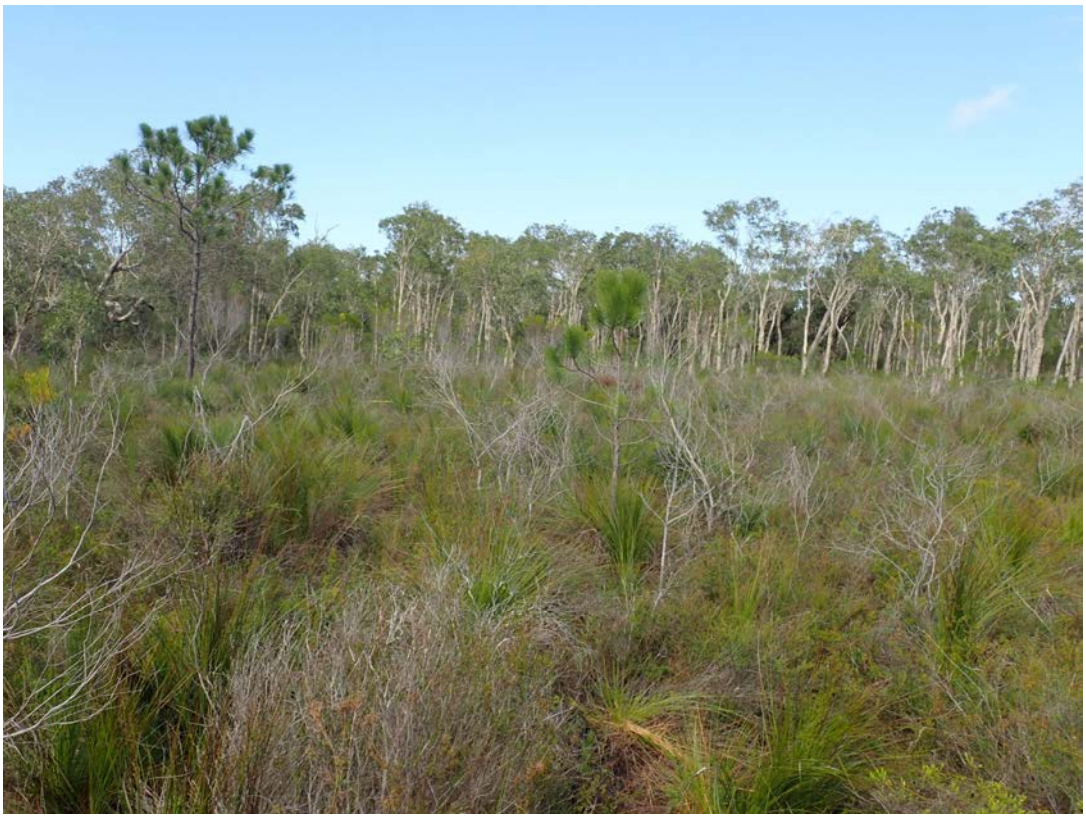
Structural / Floristic Summary

BioCondition Attribute		April 2018	September 2018
Native Plant Species Richness	Tree:		
	Shrub:	12	
	Grass Tree	2	
	Grass / Sedge	5	
	Forbs and other:	3	
Total Species No.**		22	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	5.9	3.6
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	0	0
Native Ground cover (%):	Native perennial grass / sedge cover (%):	38.75	43.05
	Native shrubs (%)	18.85	21.55
	Grass tree	7.5	7.5
	Organic litter cover (%):	30.8	22.9
	Native forb cover (%)	0.65	0.9
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	0.2

** Excludes Exotic Species

Plot 5b Centre to Start: April 2018 (left) and September 2018 (right).

Plot 5b – Centre to End: April 2017 (Above) and October 2017 (Below).



Plot 5b – Centre to Right; April 2017 (left) and October 2017 (right).

Plot 5b – Centre to Left: April 2019 (Above) and October 2019 (Below).

Survey Locality 5c

Date of Assessment: 5.04.2019; 01.10.2019
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 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
1.4 – 2.1	*Persoonia virgata*	0.7	1.8		
8.5 – 10.0	*Persoonia virgata*	1.5	1.5		
12.9 – 13.8	*Persoonia virgata*	0.9	1.8		
15.0 – 16.2	*Persoonia virgata*	1.2	1.6		
49.4 – 50.0	*Leucopogon leptospermoides*	0.6	3.0		
Total Cover		4.9			
Average Height			1.94		

*** Tree not included in cover calculation

October 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
9.0 – 9.6	*Persoonia virgata*	0.6	1.2		
13.0 – 13.6	*Persoonia virgata*	0.6	1.6		
15.3 – 16.0	*Persoonia virgata*	0.7	1.6		
38.3 – 38.7	*Leucopogon leptospermoides*	0.4	1		
48.0 – 48.5	*Persoonia virgata*	0.5	2.2		
49.0 – 50.0	*Agiortia pedicellata*	0.5	2.8		
Total Cover		3.3		0	
Average Height			1.7		0

*** Tree not included in cover calculation

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2018	50 m x 4 m Stems (50x4m) September 2018
	S2	
Persoonia virgata	13	10
Leucopogon leptospermoides	5	2
Leptospermum semibaccatum	3	1
Dillwynia floribunda		
Strangea linearis		

Epacris pulchella	1	
Agiortia pedicellata	1	1
Leptospermum polygalifolium	2	1
Baeckea frutescens	1	1
Melaleuca pachyphyllus	1	1
Totals	27	17

Ground Cover %- 1 x 1m Sub-plots

April 2019

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 16
Native perennial grass / sedges	*Caustis recurvata*			5	5	10	20	15	20	10	5	21.6
	Hypolaena fastigiata							2.5	2.5		2.5	
	Gahnia seiberiana		15									
	Sporodanthus interruptus		10	10				2.5	5	5		
	Baloskion tenuiculme			10	15	15	15				5	
	Lomandra elongata				2.5				5			
	Lomandra sp. (Strappy)											
	Eriachne pallescens var. gracilis											
Native forbs and other spp.	*Pimelea liniifolia*	1									1	0.45
	Cassytha glabella											
	Hibbertia salicifolia		2.5									
Native shrubs ,<1m	*Leucopogon leptospermoides*			1				10	15		10	10.8
	Strangea linearis					2.5			2.5	2.5		
	Epacris pulchella											
	Leptospermum semibaccatum					5	5	10		10	10	
	Baeckea frutescens	10	10									
	Ochrosperma lineare								2.5			

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 16
	Persoonia virgata				1					1		
Grass Tree	*Xanthorhoea fulva*	50	50	20	50	20	25	40	10	30	20	24
Cryptogams												
Bare Ground				2.5		3		3		5	2	1.55
Exotic Shrubs	*Pinus elliottii***											
Leaf litter		39	12.5	51.5	24	44.5	35	17	37.5	35.5	39	34.1
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

October 2019

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Sept 18
Native perennial grass / sedges	*Caustis recurvata*			2.5	2.5	5	20	15	5	5	2	25.65
	Hypolaena fastigiata					2	2.5	1	5	2.5	5	
	Gahnia seiberiana		10									
	Sporodanthus interruptus	2	10	20	30	15	2.5	.	5	5		
	Baloskion tenuiculme			10	.	5	25	5		10	15	
	Lomandra elongata				2				10			
Native forbs and other spp.	*Pimelea liniifolia*	1									1	0.4
	Hibbertia salicifolia		1									
	Cryptostylis erecta	1										
Native shrubs ,<1m	*Leucopogon leptospermoides*			.		2	2	.	7.5	5	2.5	9.8
	Strangea linearis			1	2.5	2.5	1		10	2.5		
	Leptospermum semibaccatum			1			2	5	1	15	5	
	Baeckea frutescens	10	10	1	1							
	Homoranthus virgatus						1			2.5	2.5	

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean Sept 18
	Persoonia virgata					2.5						
Grass Tree	*Xanthorrhoea fulva*	50	50	10	20	15	5	5		50		20.5
Cryptogams												
Bare Ground				2.5				5	5		2.5	1.5
Exotic Shrubs	*Pinus elliottii***				1							0.1
Leaf litter		36	19	52	41	51	39	64	51.5	2.5	64.5	42.05
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

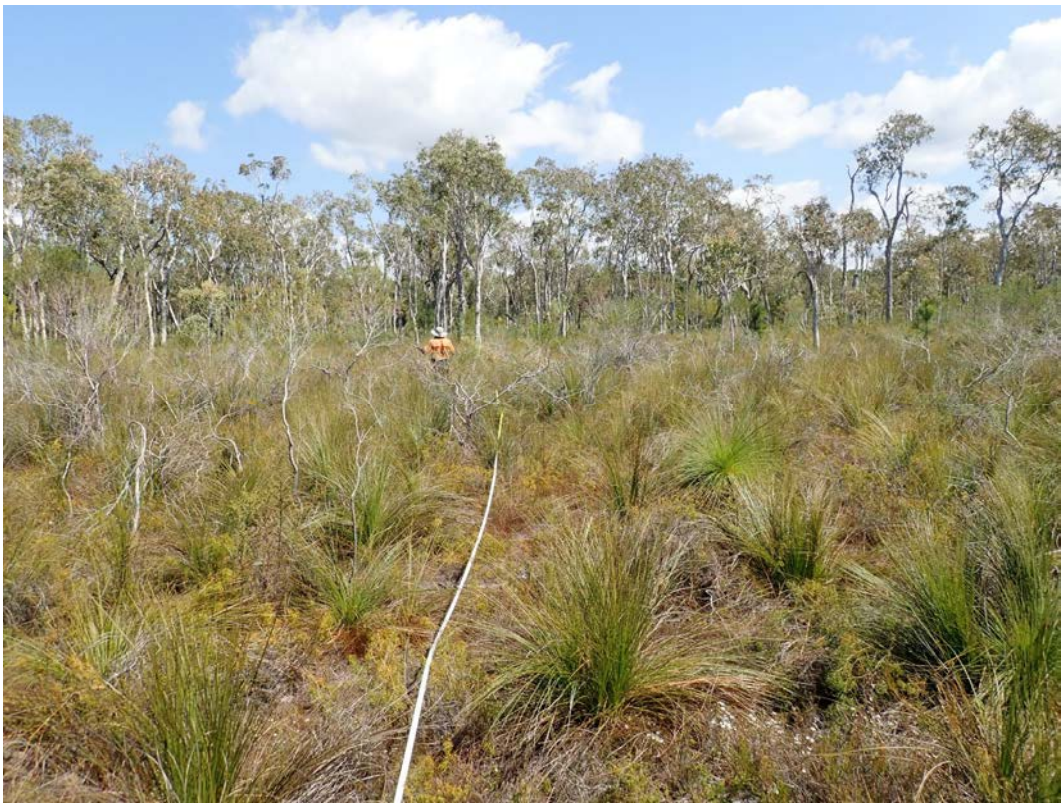
Additional Species:, *Blechnum cartilagineum, Banksia aemula, Melaleuca quinquenervia, Melaleuca pachycalyx, Patersonia sericea, Hibbertia salicifolia, Xanthorrhoea johnsonni, Cassytha glabella*

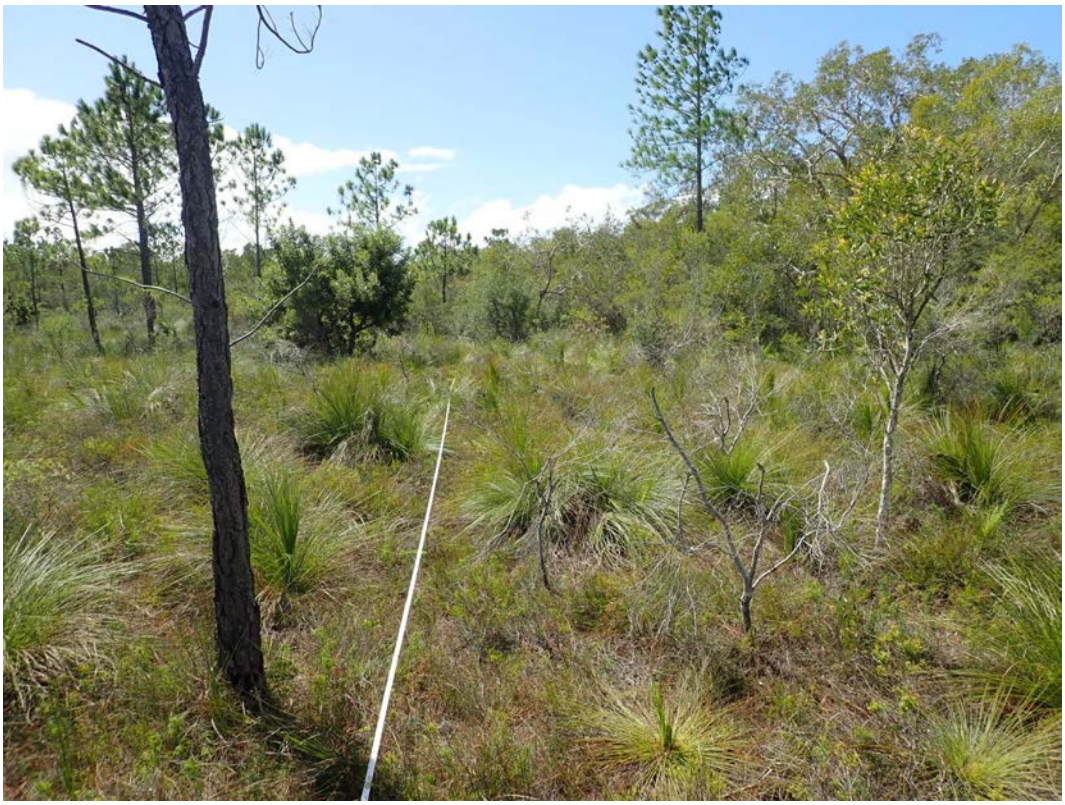
Structural / Floristic Summary

BioCondition Attribute		April 2018	September 2018
Native Plant Species Richness	Tree:	. .	
	Shrub:	15	
	Grass Tree	2	
	Grass / Sedge	6	
	Forbs and other:	3	
Total Species No.**		26	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	4.9	3.3
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	0	0
Native Ground cover (%):	Native perennial grass / sedge cover (%):	21.6	25.65
	Native shrubs (%)	10.8	9.8
	Grass tree	24	20.5
	Organic litter cover (%):	34.1	42.05
	Native forb cover (%)	0.45	0.4
Coarse woody debris:	Total length (m) of debris ≥ 10cm diameter and ≥0.5m in length per hectare	0	0
Non-native plant cover	Non-native Grasses%	0	0
	Non-native shrubs %	0	0

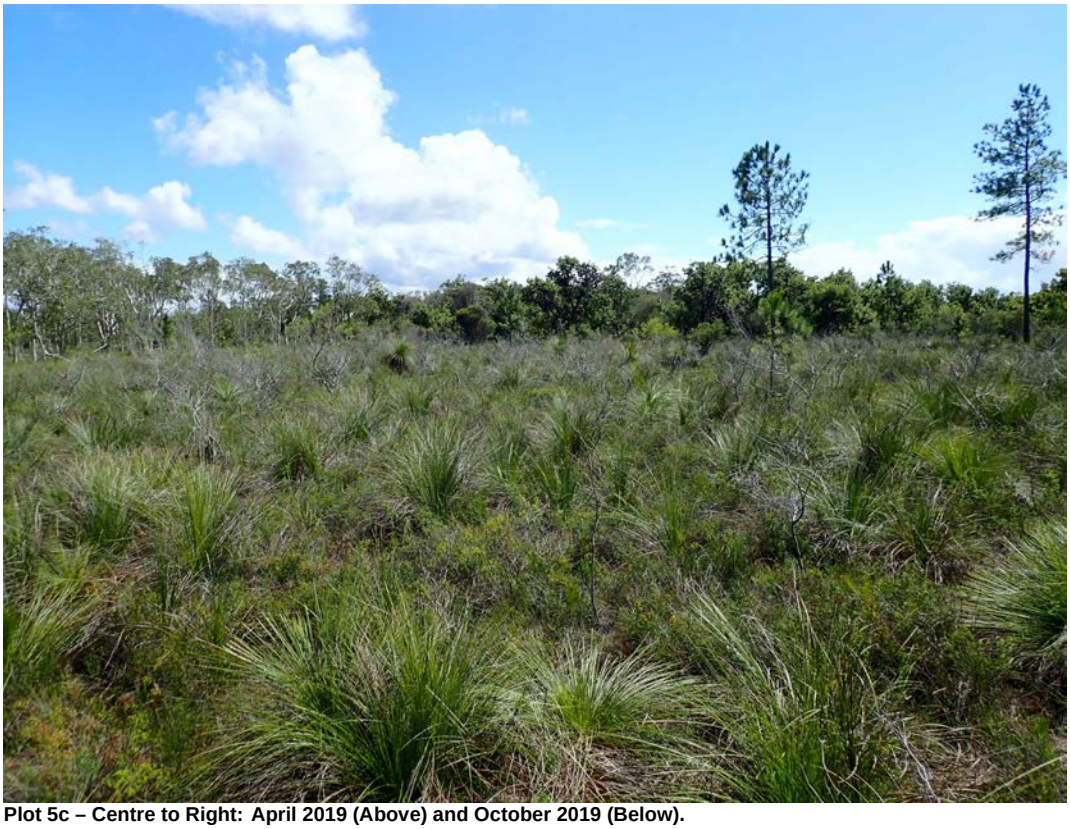
** Excludes Exotic Species

Plot 5c – Centre to Start: April 2019 (Above) and October 2019 (Below).





Plot 5c – Centre to End: April 2019 (Above) and October 2019 (Below).



Plot 5c – Centre to Right: April 2019 (Above) and October 2019 (Below).

Plot 5c – Centre to Left: April 2019 (Above) and October 2019 (Below).

Survey Locality 6a

Date of Assessment: 28.04.2018: 15:09.2018
Plot Size:50 m linear transect (Canopy Cover); 50 x 4m transect for S2 shrubs >0.5m; 10 x 1m x 1m quadrats for Ground Cover.
Location (Plot Centreline): *Start* -26.985 / 153.1540431; Centre -26.9849 / 153.1542562 *Finish* - 26.9847/ 153.1544874
Structure: Heath

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

April 2018

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
3.4 – 5.6	*Banksia aemula*	2.2	2.5		
10.7 – 11.3	*Baeckea frutescens*	0.6	1		
11.4 – 11.7	*Boronia falcifolia*			0.3	0.8
12.4 – 12.5	*Boronia falcifolia*	1.2	1	0.1	0.8
15.3 – 16.4	*Baeckea frutescens*			1.1	0.9
20.5 – 21.0	*Boronia falcifolia*	0.5	1		
22.5 – 24.0	*Banksia oblongifolia*	1.5	1		
28.4 – 29.0	*Phyllota phylocoides*	0.6	1.1		
30.0 – 31.0	*Persoonia virgata*	1.0	1.9		
32.5 – 34.0	*Persoonia virgata*	1.5	1.5		
34.9 – 35.5	*Leptospermum liversedgeii*	0.6	1.5		
38.0 – 40.0	*Persoonia virgata*	2.0	2.0		
40.4 – 41.6	*Persoonia virgata*	1.2	1.8		
46.3 – 47.0	*Banksia oblongifolia*	0.7	1.1		
49.2 – 50.0	*Leptospermum liversedgeii*			0.4	0.6
Total Cover		13.6		2.3	
Average Height			1.5		0.8

*** Tree not included in cover calculation

October 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
3.75 – 5.4	*Banksia aemula*	2.1	3		
Total Cover		2.1		0	
Average Height			3		0

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2019	50 m x 4 m Stems (50x4m) October 2019
	S2	
Persoonia virgata	31	
Banksia aemula	1	1
Banksia oblongifolia	15	
Epacris pulchella		
Leptospermum liversidgei	22	
Leptospermum semibaccatum		
Boronia falcifolia	33	
Sprengelia sprengeliodes		
Leucopogon leptospermoides	2	
Baeckea frutescens	7	
Dilwynnia floribunda		
Epacris obtusifolia		
Olax retusa		
Phyllota phyllocoides	5	
Aotus lanigera		
Pultenaea palacea		
Leptospermum polygalifolium	1	
Totals	107	1

Ground Cover %- 1 x 1m Sub-plots

April 2019

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 18
Native perennial grass / sedges	*Caustis recurvata*	5	5	5		10	5					22.5
	Sporodanthus interruptus	40	30	20	20	10	15	2.5	20	10	5	
	Lomandra elongata			15			5					
Native forbs and other spp.	*Pimelea liniifolia*	1										0.75
	Cassytha glabella	1	1		1					1		
	Hibbertia salicifolia								2.5			
Native shrubs ,<1m	*Boronia falcifolia*	2.5			5	1		2.5	5		5	15.05
	Baeckea imbricata			2.5	1		1		2.5			
	Leucopogon leptospermoides		5			2.5						
	Banksia oblongifolia						10	2.5	10			
	Leptospermum semibaccatum	10	10	20	5		2.5					
	Strangea linearis				5		2.5					
	Baeckea frutescens							10	5	10	10	
	Phyllota phylicoides									2.5		
Grass Tree	*Xanthorrhoea fulva*			10	5	30	30	70	30	30	50	25.5
Cryptogams												
Bare Ground		4		5	10	5						2.4
Exotic Shrubs												
Leaf litter		36.5	49	22.5	48	41.5	29	12.5	25	46.5	30	34.05
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

October 2019

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 17
Native perennial grass / sedges	*Caustis recurvata*	1		1	1	1	1		1	1	0.5	2.15
	Sporodanthus interruptus	1		2	1					1		
	Lomandra longifolia		2									
	Lomandra elongata	2,5	2	2.5								
Native forbs and other spp.	*Unid. seedling*							1		0.5		0.15
	Hibbertia salicifolia											
	Pattersonia sericea											
Native shrubs ,<1m	*Baeckea imbricata*	1		1	1							3
	Leucopogon leptospermoides											
	Banksia oblongifolia								5			
	Leptospermum semibaccatum				1							
	Strangea linearis	1			1	1	1					
	Leptospermum liversedgeii					1	1	2	2	5	5	
	Persoonia virgata					1						
Grass Tree	*Xanthorrhoea fulva*		1	10	2.5	15	5	5	5	5	5	5.35
Cryptogams												
Bare Ground		20	10	15	10	5	5	5	5	5	5	8.5
Exotic Shrubs												
Leaf litter		73.5	85	68.5	82.5	76	87	87	82	82.5	84.5	80.85
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100

Additional Species: *Dillwynia floribunda, Selaginella uliginosa, Baloskion tenuiculm, Aotus lanigera, Lomandra longifolia, Epacris pulchella, Stackhhousia nuda,*

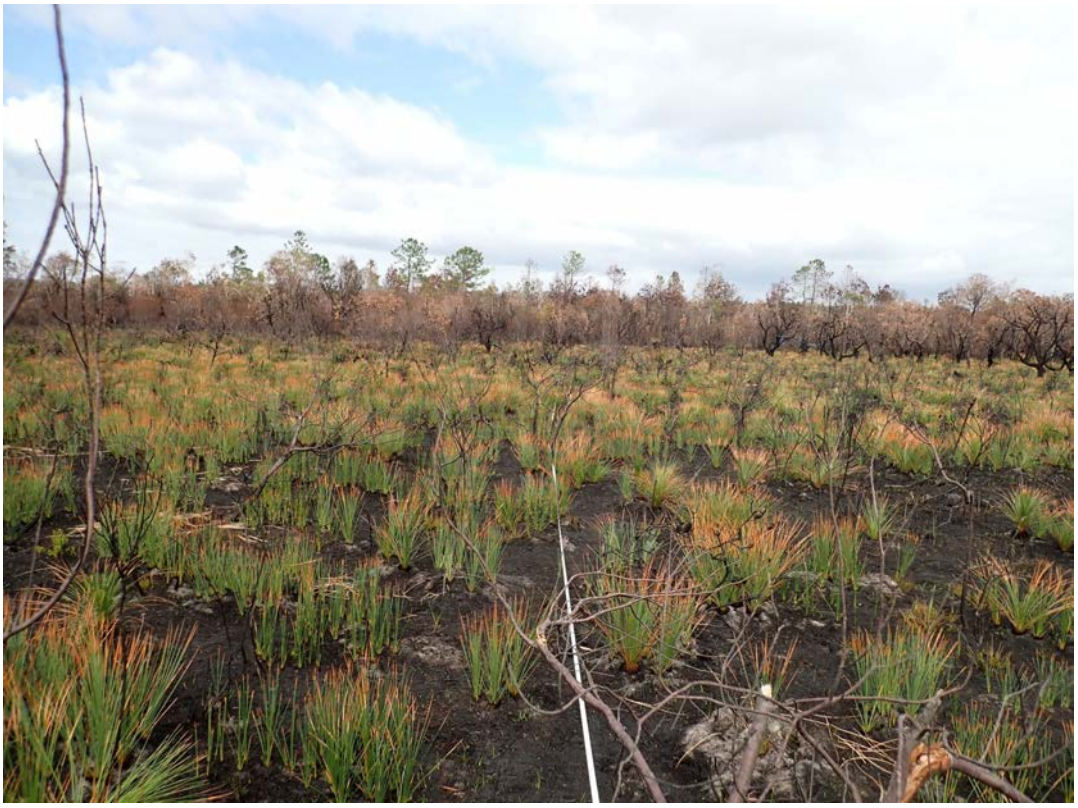
Structural / Floristic Summary

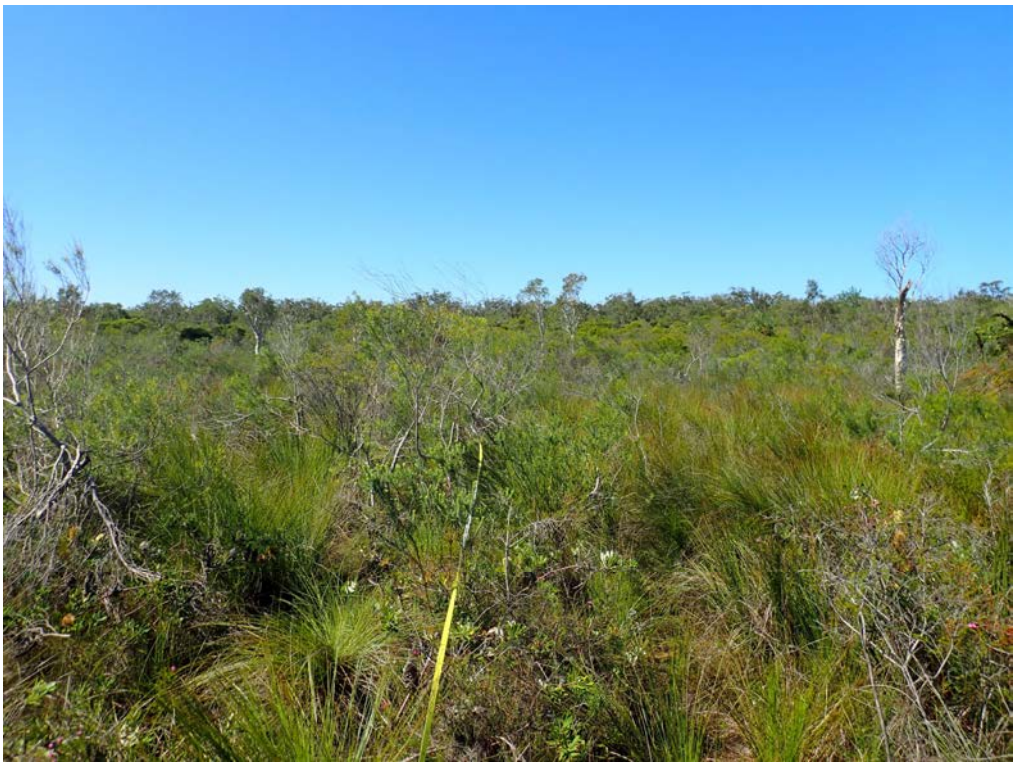
BioCondition Attribute		April 2018	September 2018
Native Plant Species Richness	Tree:		
	Shrub:	14	
	Grass Tree	1	
	Grass / Sedge	5	
	Forbs and other:	3	
Total Species**		23	
Native Shrubs	Projected Canopy Cover –	13.6	2.1

BioCondition Attribute		April 2018	September 2018
	Shrubs > 1m (%)		
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	3.4	2.4
Native Ground cover (%):	Native perennial grass / sedge cover (%):	21.2	20.5
	Native shrubs (%)	15.05	3
	Grass tree	25.5	3
	Organic litter cover (%):	34.05	80.85
	Native forb cover (%)	0.75	0.15
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

**Excludes Exotic Species

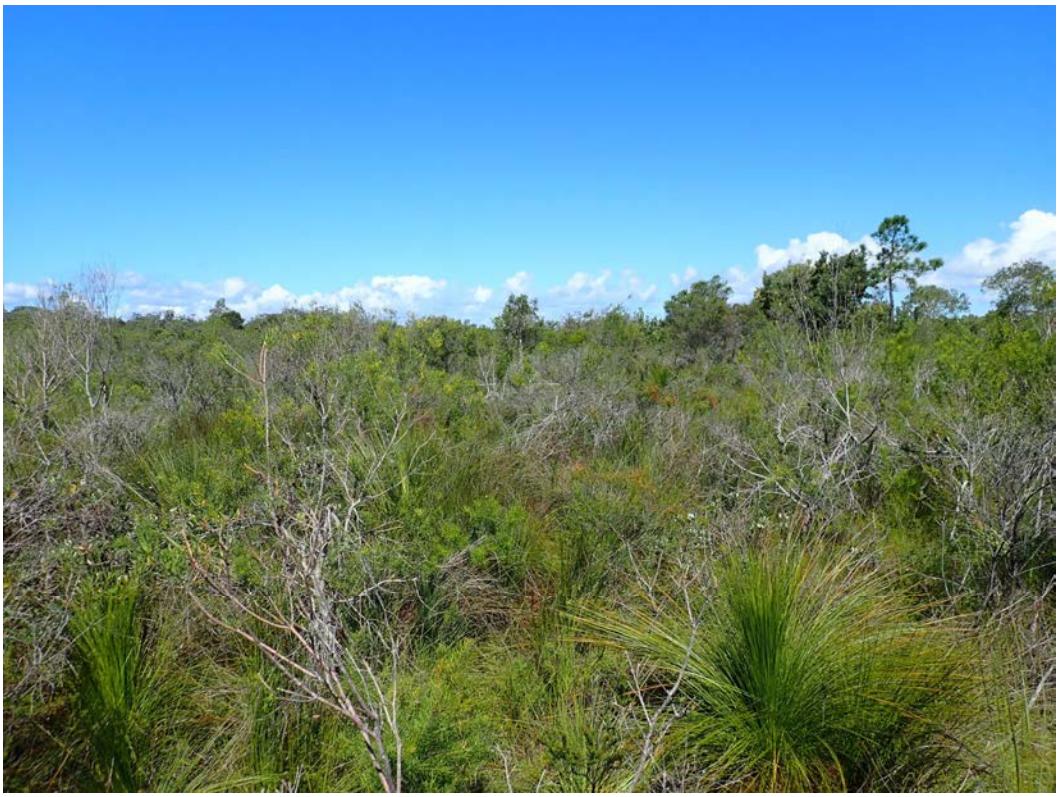
Plot 6a – Centre to Start; April 2019 (Above) and October 2019 (Below).





Plot 6a – Centre to End: April 2019 (Above) and October 2019 (Below).

Plot 6a – Centre Left: April 2019 (Above) and October 2019 (Below).



Plot 6a – Centre to Right: April 2019 (Above) and October 2019 (Below).

Survey Locality 6b

Date of Assessment: 05.04.2019; 01.10.2019.
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 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
2.3 – 2.8	*Banksia oblongifolia*			0.5	0.9
3.5 – 4.3	*Banksia oblongifolia*			0.8	0.8
8.0 – 9.0	*Persoonia virgata*	1.0	2.3		
16.2 – 16.6	*Boronia falcifolia*			0.4	1.0
17.0 – 18.4	*Persoonia virgata*	1.4	2.0		
18.7 – 19.2	*Leptospermum polygalifolium*			0.5	1.0
21.5 – 21.9	*Boronia falcifolia*			0.4	0.8
24.7 – 25.4	*Persoonia virgata*	0.7	1.2		
26.2 – 27.3	*Persoonia virgata*	1.1	1.7		
29.3 – 30.3	*Persoonia virgata*	1.0	2.0		
30.4 – 31.0	*Boronia falcifolia*			0.6	1.0
36.7 – 37.4	*Banksia oblongifolia*			0.7	0.8
38.0 – 40.0	*Persoonia virgata*	1.0	1.8		
43.2 – 43.5	*Leptospermum liversdgeii*			0.3	0.8
44.6 – 47.0	*Leptospermum liversdgeii*			0.4	0.8
Total Cover		6.2		4.6	
Average Height			1.8		0.7

*** Tree not included in cover calculation

October 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
0	*NA*				
Total Cover		0		0	
Average Height			0		0

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2018	50 m x 4 m Stems (50x4m) September 2018
	S2	
Persoonia virgata	31	0
Banksia aemula	1	0

Banksia oblongifolia	11	0
Leptospermum liversidgei	15	0
Boronia falcifolia	9	0
Leucopogon leptospermoides	2	0
Baeckea frutescens	9	0
Dilwynnia floribunda	2	0
Epacris pulchella	0	0
Epacris obtusifolia	0	0
Phyllota phyllocoides	4	0
Leptospermum polgalifolium	2	0
Leptospermum semibaccatum	1	0
Totals	87	0

Ground Cover %- 1 x 1m Sub-plots

April 2019

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 16
Native perennial grass / sedges	*Caustis recurvata*	10	15	2.5		40	5					27.75
	Sporodanthus interruptus	20	25	40	40	0	20	10	5		5	
	Lomandra sp. (divided)					2.5	5			2.5		
	Lomandra elongata											
	Lomandra longifolia	5	10									
	Balloskion tenuiculme						15					
Native forbs and other spp.	*Burchardia umbellata*											0.95
	Cassytha glabella		1				1					
	Hibbertia salicifolia											
	Stackhousia nuda							2.5	2.5	2.5		
	Selaginella uliginosa											
	Aotus											
Native shrubs ,<1m	*Boronia falcifolia*			5	2.5	5	5				2.5	11.65
	Baeckea imbricata											

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 16
	Persoonia virgata											
	Leucopogon leptospermoides	2.5	5				2.5					
	Banksia oblongifolia		10									
	Strangea linearis			2.5								
	Leptospermum liversidgei				2.5							
	Leptospermum semibaccatum	2.5	2.5	20	5	5						
	Baeckea frutescens				5			2.5	10	5	10	
	Epacris pulchella					1					0.5	
	Phyllota phylicoides							2.5				
Grass Tree	*Xanthorrhoea fulva*	30		5	20			60	30	70	40	25.5
Cryptogams												
Bare Ground				2.5		5						0.75
Exotic Shrubs												
Leaf litter		30	31.5	22.5	25	41.5	46.5	22.5	52.5	20	42	33.4
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

October 2019

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 16
Native perennial grass / sedges	*Caustis recurvata*	0.5		0.5	0.5	2	2.5	1		1		3.7
	Sporodanthus interruptus			10		2	2.5					
	Lomandra sp. (divided)	5	2						1			
	Lomandra elongata		1	2.5	2		1					
Native forbs and other spp.	*Burchardia umbellata*			1								0.3
	Unid. forb					1	1					
Native shrubs <1m	*Leucopogon leptospermoides*				1							2.4
	Banksia oblongifolia	2.5	5									

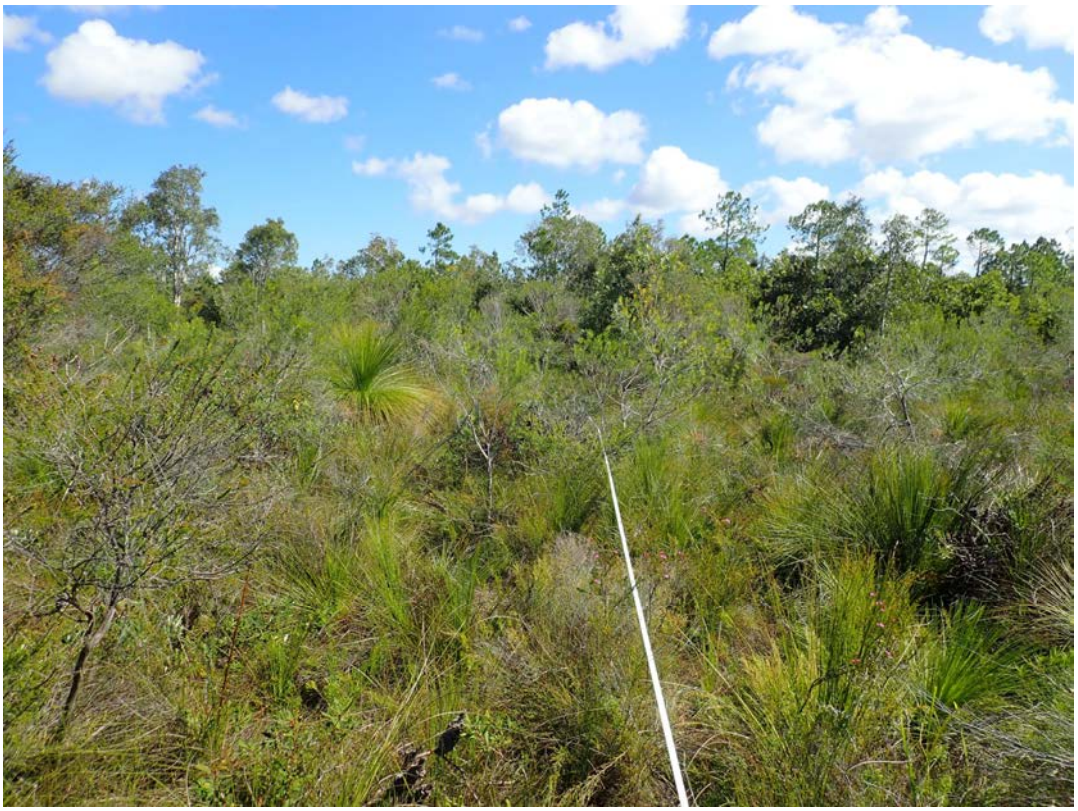
Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 16
	Leptospermum liversidgei				2.5			1	1	1	4	
	Leptospermum semibaccatum			3								
	Leptospermum polygalifolium		3									
Grass Tree	*Xanthorrhoea fulva*	5		5	10	1	1	10	15	10	10	6.7
Cryptogams												
Bare Ground		10	5	5	5	5	5	3	5	3	3	4.9
Exotic Shrubs												
Leaf litter		77	84	73	79	89	87	85	78	85	83	82
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100

Additional Species: *Melaleuca quinquenervia, Dilwynnia floribunda, Pimelia liniifolia, Pinus elliottii**, Selaginella uliginosa, Commosperma sphaericum*

Structural / Floristic Summary

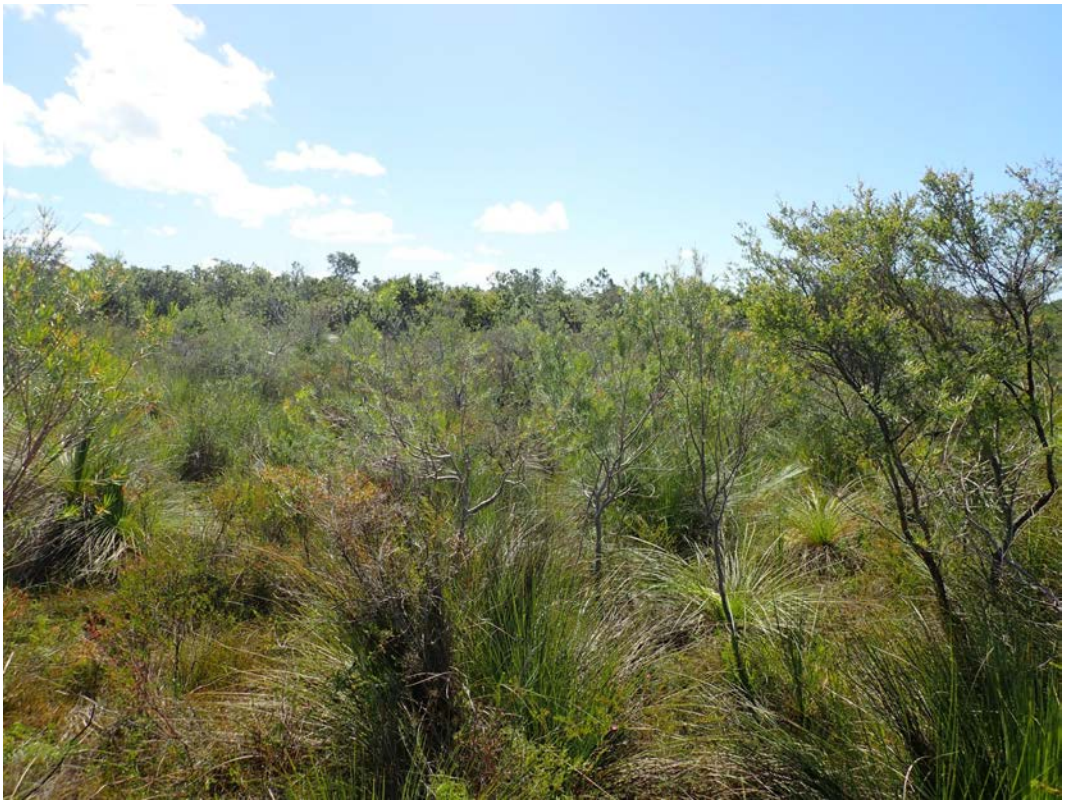
BioCondition Attribute		April 2018	September 2018
Native Plant Species Richness	Tree:		
	Shrub:	13	
	Grass Tree	1	
	Grass / Sedge	5	
	Forbs and other:	7	
Total Species No.**		26	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	12.4	0
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	9.2	0
Native Ground cover (%):	Native perennial grass / sedge cover (%):	27.75	3.7
	Native shrubs (%)	11.65	2.4
	Grass tree	25.5	6.7
	Organic litter cover (%):	33.4	82
	Native forb cover (%)	0.95	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

** Excludes Exotic Species



Plot 6 b Centre to Start: April 2017 (Above) and October 2017 (Below).

Plot 6b – Centre to End: April 2016 (Above) and September 2016 (Below).



Plot 6b – Centre to Left: April 2019 (Above) and October 2019 Below).

Plot 6b – Centre to Right: April 2017 (Above) and October 2017 (Below).

Survey Locality 6c

Date of Assessment: 05.04.2019: 01.10.19
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 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
12.0 – 12.9	*Persoonia virgata*	0.9	1.5		
13.4 – 14.0	*Persoonia virgata*	0.6	1.8		
17.0 – 17.9	*Persoonia virgata*	0.9	1,8		
17.8 – 18,8	*Agiortia pedicellata*	1.0	1.6		
21.5 – 24.0	*Melaleuca quinquenervia*	2.5	3.5		
30.8 – 31.6	*Leptospermum polygaliifolium*	0.8	2.8		
33.4 – 34.5	*Persoonia virgata*	1.1	2.4		
36.4 – 37.2	*Persoonia virgata*	0.8	1.5		
41.8 – 42.1	*Boronia falcifolia*			0.3	1.0
43.3 – 44.0	*Leptospermum polygalifolium*	0.7	1.2		
44.2 – 44.9	*Persoonia virgata*			0.7	1.0
45.0 – 45.7	*Leptospermum polygaliifolium*	0.7	1.2		
48.1 – 48.8	*Persoonia virgata*	0.7	2.0		
48.6 – 49.5	*Leptospermum polygaliifolium*	0.9	1.6		
49.5 – 50.0	*Banksia aemula*	0.5	2.0		
Total Cover		11.9		1.60	
Average Height			1.6		1.0

October 2019

Intercept (m)	Species	Shrubs > 1m		Shrubs >0.5 to <1m	
		Intercept S1	Height (M)	Intercept S1	Height (M)
49.0 – 50.0	*Banksia aemula*	1.0	2		
Total Cover		1.0		0	
Average Height			2		0

Stem Counts (50 x 4) – Shrubs > 0.5m

Species	50 m x 4 m Stems (50x4m) April 2018	50 m x 4 m Stems (50x4m) September 2018
	S1 – S2	
Persoonia virgata	23	0
Banksia oblongifolia	8	0
Leucopogon leptospermoides	2	0
Boronia falcifolia	6	0

Species	50 m x 4 m Stems (50x4m) April 2018	50 m x 4 m Stems (50x4m) September 2018
	S1 – S2	
Phyllota phyllocoides	1	0
Baeckea frutescens	10	0
Leptospermum liversidgei	20	0
Leptospermum polygalifolium	14	0
Eleocarpus reticulatus	1	0
Melaleuca quinquenervia	2	0
Banksia aemula	1	0
Agiortia pedicellata	3	0
Epacris pulchella	1	0
Totals	92	0

Ground Cover %- 1 x 1m Sub-plots

April 2018

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 16
Native perennial grass / sedges	*Caustis recurvata*	30	20	2.5		5		5	5	10	15	37
	Sporodanthus interruptus	10	30	20	40	10	40	20	20	30	20	
	Lomandra sp. (divided)						2.5	5				
	Lomandra longifolia					5	5		5			
	Baloskion tenuiculme							5		5	5	
Native forbs and other spp.	*Pimelea liniifolia*								1			0.6
	Cassytha glabella						1		1			
	Sellaginella uliginosa							0.5				
	Commosperma sphaericum		2.5									
Native shrubs ,<1m	*Boronia falcifolia*	5							5			23
	Baeckea imbricata		2.5						1	5	1	
	Baeckea			40	5	10					10	

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean April 16
	frutescens											
	Leucopogon leptospermoides	2.5			15				1		1	
	Banksia oblongifolia			10				30	51	10		
	Strangea linearis	10			5	5						
	Leptospermum semibaccatum	2.5	2.5									
Grass Tree	*Xanthorrhoea fulva*	25	20			50	10	2.5	10	20	25	16.25
Bare Ground		5									2.5	0.75
Leaf litter		10	22.5	27.5	35	15	41.5	32	0	20	20.5	22.4
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100%

October 2019

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean September 2018
Native perennial grass / sedges	2.5	1	2				2	2.5	1	1	2.5	0.5
							2.5			0.5		
					2	2		1				
	2.5		1	2				25		0.5	2.5	
Native forbs and other spp.				1			1					0.3
										1		
Native shrubs ,<1m				2				1	1			4.85
	2.5			3	2.5						2.5	
			3			2.5			1			
		1										
			5					10	10			
							4					
Grass Tree	10	10			40	2	2	5	5	5	10	7.9
Bare Ground	20	5	5	10	10	10	5	10	10	15	20	10
Leaf litter	62.5	83	84	82	45.5	83.5	83.5	45.5	72	77	62.5	71.85

Ground Cover Type	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Mean September 2018
Timber (>/= 10cm)												
Total		100	100	100	100	100	100	100	100	100	100	100

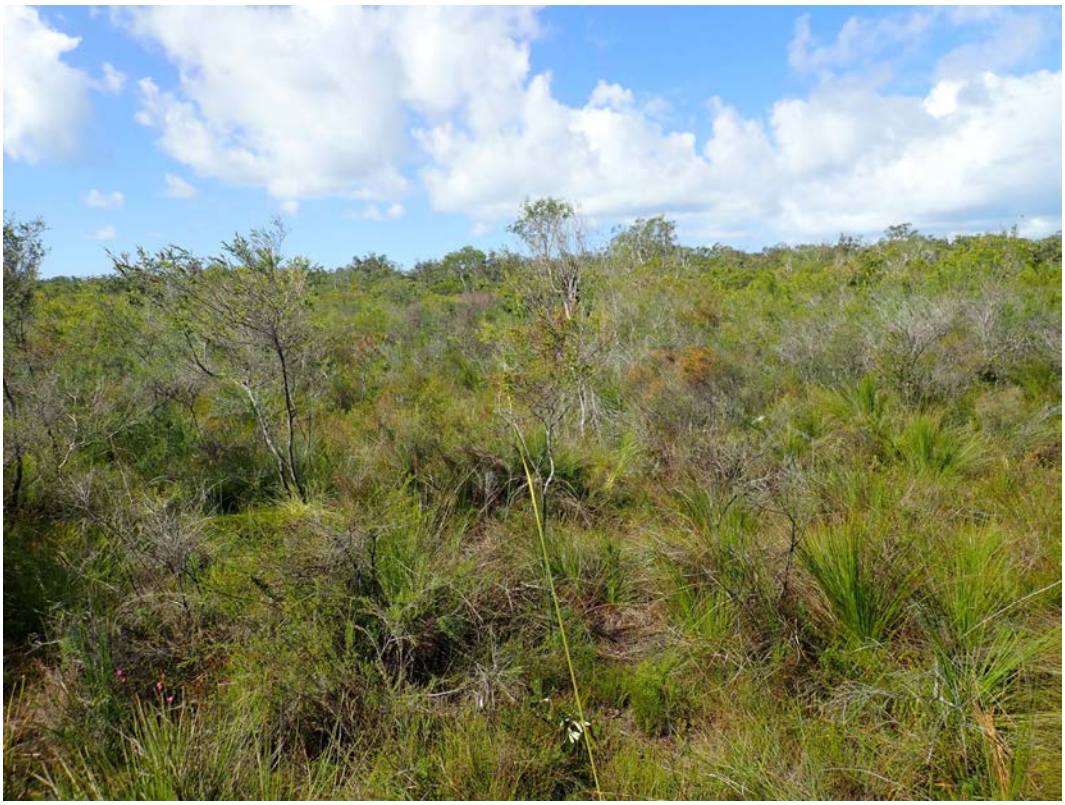
Additional Species: *Stachousia nuda, Epacris pulchella, Hibbertia salicifolia, Dillwynia floribunda*

Structural / Floristic Summary

BioCondition Attribute		April 2018	October 2018
Native Plant Species Richness	Tree:	.	.
	Shrub:	13	
	Grass Tree	1	
	Grass / Sedge	5	
	Forbs and other:	7	
Total Species No**		26	
Native Shrubs	Projected Canopy Cover – Shrubs > 1m (%)	23.8	3.2
	Projected Canopy Cover – Shrubs >0.5 to <1m (%)	3.2	0
Native Ground cover (%):	Native perennial grass / sedge cover (%):	37	0.5
	Native shrubs (%)	23	4.85
	Grass tree	16.25	7.9
	Organic litter cover (%):	22.4	71.85
	Native forb cover (%)	0.6	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

**Excludes Exotic Species

Plot 6c – Centre to Start: April 2018 (Above) and September 2018 (Below).



Centre to End - April 2019 (Above) and October 2019 (Below).

Plot 6c – Centre to Left: April 2019 (Above) and October 2019 (Below).

Plot 6c – Centre to Right: April 2018 (Above) and September 2018 (Below).

Appendix B – Site / Species Table

Habit	Family	Species	Site 5a_April 2019	Site 5b_April 2019	Site 5c_April 2019	Site 6a_April 2019	Site 6b_April 2019	Site 6c_April 2019	Site 5a_October 2019	Site 5b_October 2019	Site 5c_October 2019	Site 6a_October 2019	Site 6b_October 2019	Site 6c_October 2019
Forb	Blechnaceae	*Blechnum cartiligineum*			*						*			
Forb	Colchicaceae	*Burchardia umbellata*				*								
Forb	Dilleniaceae	*Hibbertia acicularis*												
Forb	Dilleniaceae	*Hibbertia salicifolia*			*	*	*	*			*	*	*	
Forb	Droseraceae	*Drosera binata*							*	*	*	*	*	*
Forb	Fabaceae	*Mirbellia rubiifolia*								*				
Forb	Iridaceae	*Patersonia sericea (fragilis)*		*	*				*	*		*		
Forb	Lauraceae	*Cassytha glabella*	*		*	*	*	*		*	*	*		*
Forb	Laxmanniaceae	*Laxmannia compacta*												
Forb	Laxmanniaceae	*Sowerbaea juncea*												
Forb	Orchidaceae	*Cryptostylis erecta*												
Forb	Phormiaceae	*Dianella caerulea (sic)*												
Forb	Picrodendraceae	*Pseudanthus orientalis*								*	*			*
Forb	Polygalaceae	*Commosperma sphaericum*						*						
Forb	Selaginellaceae	*Selaginella uliginosa*				*	*	*				*	*	
Forb	Stackhousiaceae	*Stackhousia nuda*			*	*	*	*				*		*
Forb	Thymeleaceae	*Pimelea linifolia*	*	*	*	*	*	*	*	*	*	*	*	*
Forb	Xyridaceae	*Xyris complanata*												
Grass	Poaceae	*Eriachne pallescens var. gracillis*			*					*	*	*	*	*
Grass	Poaceae	*Themeda triandra*												
Grass tree	Xanthorrhoeaceae	*Xanthorrhoea fulva*	*	*	*	*	*	*	*	*	*	*	*	*
Grass tree	Xanthorrhoeaceae	*Xanthorrhoea johnsonii*		*	*					*	*			
Sedge / Rush	Cyperaceae	*Cyperus sp. (gracilis?)*												
Sedge / Rush	Cyperaceae	*Gahnia seiberiana*			*						*			
Sedge / Rush	Cyperaceae	*Hypolaena fastigiata*		*	*					*	*	*		
Sedge /	Cyperaceae	*Schoenus calostachys*												

Habit	Family	Species	Site 5a_April 2019	Site 5b_April 2019	Site 5c_April 2019	Site 6a_April 2019	Site 6b_April 2019	Site 6c_April 2019	Site 5a_October 2019	Site 5b_October 2019	Site 5c_October 2019	Site 6a_October 2019	Site 6b_October 2019	Site 6c_October 2019
Rush														
Sedge / Rush	Laxmanniaceae	*Lomandra elongata*		*	*	*	*	*	*	*	*	*	*	*
Sedge / Rush	Laxmanniaceae	*Lomandra longifolia*	*			*	*	*	*	*	*	*	*	*
Sedge / Rush	Restionaceae	*Baloskion heterophylla*												
Sedge / Rush	Restionaceae	*Baloskion tenuiculme*	*	*	*	*	*	*	*	*				*
Sedge / Rush	Restionaceae	*Caustis recurvata*	*	*	*	*	*	*	*	*	*	*	*	*
Sedge / Rush	Restionaceae	*Leptocarpus tenax*												
Sedge / Rush	Restionaceae	*Sporodanthus interuptus*	*	*	*	*	*	*	*	*	*	*	*	*
Shrub	Ericaceae	*Agiortia pedicellata*	*	*	*				*	*	*			*
Shrub	Ericaceae	*Epacris obtusifolia*										*		*
Shrub	Ericaceae	*Epacris pulchella*	*		*	*	*	*	*	*	*	*		.
Shrub	Ericaceae	*Leucopogon leptospermoides*	*	*	*	*	*	*	*	*	*	*	*	*
Shrub	Ericaceae	*Monotoca scoparia##*												
Shrub	Ericaceae	*Sprengelia sprengelioides*							*	*		*	*	
Shrub	Fabaceae	*Aotus lanigera*					*						*	*
Shrub	Fabaceae	*Dillwynia floribunda*				*	*	*	*	*	*		*	
Shrub	Fabaceae	*Phyllota phylicoides*				*	*	*					*	*
Shrub	Fabaceae	*Pultenaea palaceae*										*	*	
Shrub	Fabaceae	*Pultenaea robusta*												
Shrub	Mimosaceae	*Acacia baueri*		*										
Shrub	Mimosaceae	*Acacia flavesecens*		*						*				
Shrub	Mimosaceae	*Acacia sp,*												
Shrub	Myrtaceae	*Austromyrtus dulcis*									*			
Shrub	Myrtaceae	*Baeckea frutescens*	*		*	*	*	*	*	*	*	*	*	*
Shrub	Myrtaceae	*Baeckea imbricata*				*		*	*			*	*	*

Habit	Family	Species	Site 5a_April 2019	Site 5b_April 2019	Site 5c_April 2019	Site 6a_April 2019	Site 6b_April 2019	Site 6c_April 2019	Site 5a_October 2019	Site 5b_October 2019	Site 5c_October 2019	Site 6a_October 2019	Site 6b_October 2019	Site 6c_October 2019
Shrub	Myrtaceae	*Homoranthus virgatus*		*	*				*	*				
Shrub	Myrtaceae	*Leptospermum liversidgei*				*	*	*				*	*	*
Shrub	Myrtaceae	*Leptospermum polygalifolium*		*	*	*	*	*		*	*		*	*
Shrub	Myrtaceae	*Leptospermum semibaccatum*	*	*	*	*	*	*	*	*	*	*	*	
Shrub	Myrtaceae	*Melaleuca pachyphyllus*			*						*			
Shrub	Myrtaceae	*Melaleuca quinquenervia*	*		*		*				*		*	*
Shrub	Myrtaceae	*Ochrosperma lineare*	*	*	*				*	*	*		*	
Shrub	Olacaceae	*Olax retusa*										*	*	
Shrub	Proteaceae	*Banksia aemula*			*	*	*	*			*	*	*	*
Shrub	Proteaceae	*Banksia oblongifolia*				*	*	*				*	*	*
Shrub	Proteaceae	*Conospermum taxifolium*												
Shrub	Proteaceae	*Persoonia virgata*	*	*	*	*			*	*	*	*	*	*
Shrub	Proteaceae	*Strangea linearis*	*	*	*	*	*	*	*	*	*	*	*	
Shrub	Rutaceae	*Boronia falcifolia*		*	*	*	*	*	*			*	*	*
Tree	Elaeocarpaceae	*Elaeocarpus reticulatus*												*
Tree	Pinaceae	*Pinus elliottii***	*	*	*		*							