AECOM

Biodiversity Management Plan

Rix's Creek North
2018-2020

19-Aug-2016
Prepared for – Rixs Creek North Mine – ABN: 76000106972

Biodiversity Management Plan

Rix's Creek North

Client: Rix's Creek North Mine

ABN: 76000106972

Prepared by

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Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	21 April 2016	Draft for client review	James McIntyre	
B	19 Aug 2016	Final for Submission	John Hindmarsh Senior Environmental Officer Rixs Creek North	
C	15 December 2017	Final For Submission. Following DPE comments.	Chris Knight Environment Manager The Bloomfield Group	C Knight.

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Executive Summary

The Biodiversity Management Plan (BMP) outlines the actions required and personnel responsible in order for Rixs Creek North Mine (RCN) to effectively manage biodiversity at the Mine Complex, as well as, through the implementation of audits and reviews, establish a process for continual improvement of environmental performance. The Plan has been prepared in accordance with the Department of Planning of Infrastructure (DPI) document *Best Practice Guidelines for Biodiversity Offset Management Plans* ((NSW Dept Planning & Infrastructure, Jan 2014).

The key generic management strategies except for maintenance and monitoring for the vegetation communities that occur across the BOA are:

- Rehabilitation of vegetation corridors to establish linkages between the offset areas, the mine site and riparian vegetation;
- Planting of shrub species to increase understory abundance and diversity;
- All plants are to be sourced from local stock (where available);
- Promote passive regeneration from the soil seed bank through active weed control;
- Implement feral animal and weed control;
- Ensure that the BOAs are fenced appropriately and have restricted access;
- Management of *Acacia saligna;*
- Regular maintenance activities including weed control, fencing (as needed), replacement of plantings (as needed), and thinning (as needed) will be conducted in the BOAs over the life of the mine operations;
- Regular monitoring activities to detect the success/failure of the restoration works will be performed; and
- All areas of restoration will have restricted human access and be protected by exclusion fencing.

The two core Management Zones of the BOA – Habitat Management and Habitat Restoration are defined in the following Table.

Management Zone	Vegetation community	Condition[1]	Objective	Bridgman BOA	Martin's Creek BOA	Northern BOA	Southern BOA	Total
	Remnant woodland and forest							
Habitat management	Bull Oak Forests	Moderate - Good	Enhanced diversity of endemic flora species at all strata	0.1	23.5	2.8	10.0	36.4
	Swamp Oak Forest	Moderate - Good	Enhanced diversity of endemic flora species at all strata	8.9	12.4	28.4	0.0	49.7
Habitat management	Narrow-leaved Ironbark–Spotted Gum–Grey Box Open Forest	Moderate - Good	Enhanced diversity of endemic flora species at all strata	61.6	27.9	12.0	14.7	116.2

[1] (EMM prepared for Integra Coal Operations Pty Ltd, May 2014)

Management Zone	Vegetation community	Condition[1]	Objective	Bridgman BOA	Martin's Creek BOA	Northern BOA	Southern BOA	Total
	Remnant woodland and forest							
Sub-total remnant woodland and forest				70.6	63.8	43.2	24.7	202.3
Remaining areas								
Habitat restoration	Planted Rehabilitation	Moderate (over storey > 25% benchmark and 50% of the groundcover are native species)	Native vegetation community aligned to Narrow-leaved Ironbark–Spotted Gum–Grey Box Open Forest community	0.0	2.4	0.0	0.0	2.4
Habitat restoration	Derived Grassland/Native Pasture	Moderate (50% of the groundcover are native species)		15.8	33.3	36.2	1.9	87.2
Habitat restoration	Cleared Land/Exotic Grassland	N/A	Control of weed and feral animals with a native plant community	0.0	94.1	9.0	4.6	107.7
Sub-total remaining areas				15.8	129.8	45.2	6.5	197.3
Total				**86.4**	**193.5**	**88.4**	**31.2**	**399.5**

A summary of the management strategies for each Management Zone that are defined in the BMP are provided in the following Tables.

Vegetation Community	Management Strategy						
	Pathogen management	Cultural heritage	Fences, gates and signage	Access tracks	Waste management	Erosion, Sediment and soil management	Stock management
Narrow-leaved Ironbark—Spotted Gum—Grey Box Open Forest	Flora and fauna monitoring assesses for species decline and threat to biosecurity	In accordance with *Non-Aboriginal Heritage Management Plan* and the *Aboriginal Heritage Management Plan RCN Open Cut Project*	As per layout as shown Figure 6	As per layout as shown Figure 6	Waste removed from BOA and inspections and photo records completed and kept	Works undertaken in accordance *Permit to Disturb*	Restrict cattle access
Bull Oak Forest							
Swamp Oak Forest							
Derived Grassland / Native Pasture							Controlled grazing based on carrying capacity assessment
Planted Rehabilitation							
Cleared Land/Exotic Grassland							

Vegetation Community	Management Strategy				
	Seed collection and propagation	Habitat augmentation	Thinning / control of Casuarina species	Revegetation and regeneration	Weed control Feral animal control
Narrow-leaved Ironbark—Spotted Gum—Grey Box Open Forest	Revegetation works based on use of endemic species	Monitoring and maintenance of nest boxes	N/A	N/A	All noxious weeds will be managed and controlled as per the requirements of the Noxious Weeds Act 1993 Control of African Olive, Lantana, *Acacia saligna* and Coolatai Grass Monitoring and control programs for Wild Dogs, Foxes, Rabbits and cats
Bull Oak Forest			Review stem densities for BOA for *glauca and C. leuhmannii* and implement trial thinning		
Swamp Oak Forest					
Derived Grassland / Native Pasture		Monitoring and maintenance of nest boxes Salvage and reuse suitable fauna habitat		Defoliation of grasses using “patch” concept Planting of tubestock and direct seeding using “patch” concept Incorporation of locally harvested brush material Revegetation works based on use of endemic species	
Planted Rehabilitation	Over and mid storey species based on use of endemic species		N/A	Incorporation of locally harvested brush material Over and mid storey species based on use of endemic species	
Cleared Land/Exotic Grassland	Revegetation works based on use of endemic species		Review stem densities for BOA for *glauca and C. leuhmannii* and implement trial thinning	Defoliation of grasses using “patch” concept Planting of tubestock and direct seeding using “patch” concept Incorporation of locally harvested brush material Revegetation works based on use of endemic species	

1.0 Introduction

1.1 Background

The Biodiversity Management Plan (BMP) outlines the actions required and personnel responsible in order for Rixs Creek North Mine (RCN) to effectively manage biodiversity at the Mine Complex, as well as, through the implementation of audits and reviews, establish a process for continual improvement of environmental performance. The Plan has been prepared in accordance with the Department of Planning of Infrastructure (DPI) document *Best Practice Guidelines for Biodiversity Offset Management Plans* ((NSW Dept Planning & Infrastructure, Jan 2014).

Performance against this objective is measured through regular monitoring of flora, fauna and the rehabilitation process. The BMP addresses the management of the BOAs and together with the *Rehabilitation Management Strategy* (AECOM on behalf of Rix's Creek Mine, 2015) the management of biodiversity more broadly across the Complex, and outlines actions for the effective management of biodiversity at the Complex. The BMP will be reviewed every three years, following the results of monitoring and reporting.

The BOAs are currently managed under the previous BMP's ((Integra Coal Operations (Vale), 2013) and (Integra Coal Operations Pty Ltd, 14 Nov 2014)) which include a range of management measures to be implemented to improve the biodiversity values over time of the BOAs that were established under previous Project Approval Conditions. The current BMP (this document) builds on the preceding BMP's and incorporates best practice regeneration methods, with a particular focus on the commitment to regenerate a total of 87.2 ha of Derived Grassland/Native Pasture.

1.2 Statutory Requirements

The BMP has been developed in accordance with:

- the requirements of the Project Approval 08_0102 (Open cut) Modification 4 (dated 24 February 2016) Schedule 3 Condition 44,
- the NSW Department of Planning and Environment (DP&E) *Hunter Valley Coal Mines - Best Practice Guidelines for Biodiversity Offset Management Plans* (NSW Dept Planning & Infrastructure, Jan 2014); and
- incorporates where relevant the Integra Coal Operations Pty Ltd Biodiversity Management Plan (14 Nov 2014) which was approved by DP&E on 19 Nov 2014.

Table 1 list these Conditions and identifies where the relevant project Approval Conditions have been addressed in the BMP.

Table 1 Project Approval Conditions – Contents of the BMP

Condition	Section of BMP
44. The Proponent shall prepare and implement a Biodiversity Management Plan for the projects to the satisfaction of the Secretary. This plan must:	
(a) be prepared in consultation with OEH, and submitted to the Secretary for approval by 31 August 2016;	- Meetings held with OEH throughout the preparation of the BMP. - Draft BMP supplied to OEH for review and feedback prior to submission - Submitted prior to 31 Aug 2016
(b) describe how the implementation of the biodiversity offset strategy would be integrated with the overall rehabilitation of the site;	Section 2.6
(c) Include:	
- *a description of the short, medium, and long term measures that would be implemented to:*	Sections 2.3,2.6
• *implement the biodiversity offset strategy; and*	Sections 2.6, 2.7

Condition	Section of BMP
• *manage the remnant vegetation and habitat, both on site and in the biodiversity offset areas;*	
- *detailed performance and completion criteria for the implementation of the biodiversity offset strategy;*	Sections 2.6, 2.7
- *a detailed description of the measures that would be implemented over the next 3 years, including the procedures to be implemented for:*	
• *enhancing the quality of existing vegetation and fauna habitat in the biodiversity offset areas with ecological functions that are comparable with similar, undisturbed ecosystems;*	Section 2.6.11
• *restoring native vegetation and fauna habitat in the biodiversity offset areas through focusing on assisted natural regeneration;*	Section 2.6.12
• *targeting vegetation establishment including a program for active revegetation of 87.2 ha of Central Hunter Ironbark-Spotted Gum-Grey Box Forest EEC on the site and the timeframe in which this will be achieved;*	Section 2.6.12
• *introducing naturally scarce elements of fauna habitat (where practicable);*	Section 2.6.11
• *acquiring quantitative baseline data for existing ecosystems in the Appletree Flat Biodiversity Offset Area and on the site, including the Northern, Southern, Bridgeman and Martins Creek Biodiversity Offset areas – these must include habitat, flora and fauna baseline data;*	Sections 2.7
• *maximising salvage and beneficial use of resources in areas that are to be impacted, including vegetative, soil and cultural heritage resources;*	Section 2.6.112.6.4
• *protecting vegetation and soil outside the areas that are to be impacted;*	Sections 2.6.5, 2.6.6 2.6.8,
• *rehabilitating Bettys Creek and Main Creek;*	N/A – not incorporated in this report as this criteria relates to the operation of the underground mine
• *managing salinity;*	Section 2.6.8
• *conserving and reusing topsoil;*	Section 2.6.8
• *undertaking pre-clearance surveys;*	Section 2.7
• *managing impacts on fauna;*	Section 2.6
• *landscaping the site to minimise visual impacts;*	Section 2.6.12
• *collecting and propagating seed;*	Section 2.6.10
• *salvaging and reusing material from the site for habitat enhancement;*	Section 2.6.11
• *controlling weeds and feral pests, including terrestrial and aquatic species;*	Sections 2.6.13, 2.6.14
• *managing grazing and agriculture on site and in the biodiversity offset areas;*	Section 2.6.9
• *controlling access;*	Section 2.6.5, 2.6.6
• *bushfire management; and*	Section 2.6.15

Condition	Section of BMP
• *managing potential conflicts between the biodiversity offset areas and Aboriginal cultural heritage values;*	Section 2.6.4
- *a description of the potential risks to the successful implementation of the biodiversity offset strategy, and a description of the contingency measures that would be implemented to mitigate these risks;*	Section 2.6
- *a program to monitor the effectiveness of these measures, and progress against the performance and completion criteria; and*	Section 2.7
- *details of who would be responsible for monitoring, reviewing, and implementing the plan.*	Section 1.5

Additionally the BMP incorporates the requirements of the Project Approval_08_0101 and 08_0102 dated 24 Feb 2016 Schedule 5 Condition 2 pertaining to the requirement for the development of Management Plans. Table 2 list these Conditions and identifies where the relevant project Approval Conditions have been addressed in the BMP.

Table 2 Project Approval Conditions – Requirements for Management Plans

Condition	Section of BMP
2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
(a) detailed baseline data;	Section 2.4
(b) a description of:	
- *the relevant statutory requirements (including any relevant approval, licence or lease conditions);*	Section 1.2
- *any relevant limits or performance measures/criteria; and*	Section 2.6
- *the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the projects or any management measures;*	Section 2.6
(c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Section 2.6
(d) a program to monitor and report on the:	
- *impacts and environmental performance of the projects; and*	Section 2.7
- *effectiveness of any management measures (see (c) above);*	Section 4.0
(e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 2.6
(f) a program to investigate and implement ways to improve the environmental performance of the projects over time;	Section 2.6
(g) a protocol for managing and reporting any:	
- *incidents;*	Section 4.0
- *complaints;*	Section 4.0
- *non-compliances with the conditions of this approval and statutory requirements; and*	Section 4.0

Condition	Section of BMP
- *exceedances of the impact assessment criteria and/or performance criteria; and*	Section 4.0
(h) a protocol for periodic review of the plan.	Section 4.0
Note: The Secretary may waive some of these requirements if they are unnecessary or unwarranted for particular management plans.	

The Biodiversity Management Strategy make references to those Conditions that relate to the rehabilitation of Bettys and Main Creek and the impact of subsidence on the offset areas (Project Approval_08_0101 and 08_0102 dated 24 Feb 2016 Schedule 3 Condition 30 (h) (Extraction Plan)), however as these relate to the operation of the adjoining underground mine which is owned and managed by Glencore the details on these issues have not be addressed in any detail as they covered in separate documentation developed by Glencore.

1.3 Overall Objectives of the BMP

The objective of this BMP is to rehabilitate, revegetate and manage land for biodiversity within the biodiversity offset areas (BOAs) and align them to the works undertaken across the adjoining the mine site. This Plan in particular has been prepared to:

- Identify the land that will be required to be managed in accordance with this BMP;
- Provide a clear, concise and instructional working document outlining the management strategies and actions for the BOAs;
- Minimise the impacts of key threats to the site through specific management actions;
- commitment to regenerate a total of 87.2 ha of Derived Grassland/Native Pasture to Narrow-leaved Ironbark-Spotted Gum-Forest Red Gum Forest; and
- Outline the monitoring and reporting procedures that are to be implemented by RCN to maintain and improve the condition of the vegetation on the BOAs.

1.4 Consultation

Discussions were held between RCN and OEH personnel during the development of the BMP and a draft copy of this BMP was provided to OEH for review and comment. These recommendations were reviewed and incorporated into the document where applicable.

A final draft version of the document was provided to the Department of Planning and Environment for approval on 31 August 2016.

1.5 Roles and Responsibilities

The Bloomfield Group company directors will be responsible for the overall rehabilitation and environmental performance of the Mine including the works identified in this BMP. Senior Operational managers have direct responsibility for the rehabilitation process. The Environment Manager provides direction and advice to ensure site environmental compliance is maintained. The Environment Manager and Environmental Officers are responsible for the implementation of the works identified in this BMP. This involves ensuring all aspects of the rehabilitation and revegetation processes are followed and carried out.

Contact Details:
Rix's Creek Community and Blasting Hotline phone: 02 4930 2665
Rix's Creek Environment Department email: enviro@bloomcoll.com.au

2.0 Location Setting of the Biodiversity Offset Areas

2.1 Biodiversity Offset Locations

RCN has developed a strategy to offset impacts to biodiversity as a result of mining. The biodiversity offset strategy as defined in the Environmental Assessment (EMM prepared for Integra Coal Operations Pty Ltd, May 2014) includes the establishment and management of separate biodiversity offset area's (BOA's) (Figure 1 and Figure 4). The vegetation types in each BOA are outlined in Table 3.

Table 3 Lands encompassed by the BOA

Offset Area	Offset Type	ha
Northern BOA	Existing vegetation to be enhanced and restored to re-establish functioning ecosystems and additional vegetation to be established, including regeneration of a minimum of 87 ha of Derived Grassland/ Native Pasture to vegetation communities representative of the Central Hunter Ironbark Spotted Gum- Grey Box Forest EEC	88
Southern BOA		30
Bridgman BOA		86
Martins Creek		194
Apple tree Flat BOA	Existing vegetation to enhanced and restored to re-establish functioning ecosystems	216
TOTAL		614

2.1.1 Onsite BOA's

The onsite BOA comprise:

- Northern BOA: located to the north of the Complex, is bordered to the south by Stony Creek Road, to the north by Glennies Creek and Thomas Lane, and to the east by the Bridgman BOA;
- Bridgman BOA: located to the north of the Complex, is bordered to the north by Thomas Lane, to the south by Stony Creek Road, to the west by the Northern BOA and to the east by private land;
- Southern BOA: located within the Complex boundary, is bordered to the north by Stony Creek Road, and surrounded to the east, west and south by the open cut mine area; and
- Martin's Creek BOA: located on the eastern side of the Complex Open Cut access road.

2.1.2 Appletree Flat BOA

The Appletree Flat BOA contains 215.9 ha of native vegetation comprising five native vegetation communities and a regenerating community (Figure 4). The vegetation communities recorded are summarised in Table 4. While the Appletree Flat BOA does not contain any areas of Central Hunter Ironbark-Spotted Gum–Grey Box Forest EEC, it forms a vital part of regional remnant vegetation that links the habitats located between the Upper Hunter Valley and the coast. The conservation of the site would also assist with regional conservation aims, and will improve the quality and management of remnant vegetation at the site. The Apple tree Flat BOA is to be handed to OEH to add to their national park estate. As such the BMP does not include the land management and rehabilitation strategies for this BOA.

Table 4 Vegetation communities on the offsite Appletree Flat BOA

Vegetation community	Area (ha)
Narrabeen Goulburn Valley Exposed Woodland	60.0
Narrabeen Sheltered Blue Gum Forest	32.9
Narrabeen East Wollemi Sheltered Dry Forest	96.4
Sandstone Gorge Warm Temperate Rainforest	7.8
Remnant Shale Cap Forest	9.2
Regeneration	9.6
Total	215.9

2.2 Land Tenure and Land Uses - current

The BMP covers the lands defined in Project Approval 08_0102 Schedule 3 Condition 37 Table 14 dated 1 September 2017, as shown in Table 3 and Figure 1 and Figure 4. With the exception of land encompassed by easements managed by Ausgrid all BOA are located on land owned by RCN.

Access to all BOAs is limited to authorised personnel only and no permanent mining surface infrastructure exists within the areas.

The predominate land use in the vicinity of the RCN is mining, with;

- The Mt Owen Complex to the west and northwest;
- Ashton Mine to the west; and
- Rix's Creek to the south.

Other uses in the surrounding area include agriculture (including grazing and cropping, using irrigation), residential and rural-residential holdings and forestry to the west in the Ravensworth State Forest.

2.3 Land Security

2.3.1 Security of the Offsets

By 31 October 2016, or as otherwise agreed by the Secretary of OEH, RCN will make suitable arrangements to provide appropriate long term security for all the areas in the Biodiversity Offset Strategy to the satisfaction of the Secretary. This long term security will be provided by either Trust Agreements under the *Nature Conservation Trust Act* 2001, or Conservation Agreements under Section 69 of the National Parks and Wildlife Act 1974, as the application to modify the areas (Mod 4) was made prior to the current "NSW Biodiversity Offsets Policy for Major Projects" policy coming into effect on 1 October 2014.

2.3.2 Conservation Bond

A Conservation Bond will be lodged within six months of the approval of the BMP and in accordance with Schedule 3 Condition 42 of the Project Approval - Modification 7 dated 01 September 2017, as shown in Table 5. The Bond value will be based on all activities identified in the this BMP, for a period of three years, being the life of the plan and has calculated in accordance with the *Management Cost Conservation Template V.3* (NSW Dept Planning & Infrastructure, Jan 2014). The review date for this BMP will be August 2019.

Table 5 Conservation Bond - Schedule 3 Condition 42 of the Project Approval

Within 6 months of the approval of the Biodiversity Management Plan (see above), the Proponent shall lodge a conservation bond with the Department to ensure that the biodiversity offset strategy is implemented in accordance with the performance and completion criteria of the Biodiversity Management Plan.
The sum of the bond shall be determined by:
(a) calculating the full cost of implementing the biodiversity offset strategy (other than land acquisition costs); and
(b) employing a suitably qualified quantity surveyor to verify the calculated costs, to the satisfaction of the Secretary.
The calculation of the conservation bond must be submitted to the Department for approval at least 1 month prior to lodgement of the final bond.
If the biodiversity offset strategy is completed generally in accordance with the completion criteria in the Biodiversity Management Plan to the satisfaction of the Secretary, the Secretary will release the bond. If the biodiversity offset strategy is not completed generally in accordance with the completion criteria in the Biodiversity Management Plan to the satisfaction of the Secretary, the Secretary will call in all or part of the conservation bond and arrange for the satisfactory completion of the relevant works.
Notes:
• Alternative funding arrangements for long term management of the biodiversity offset strategy, such as provision of capital and management funding as agreed by OEH as part of a Biobanking Agreement or transfer to conservation reserve estate (or any other mechanism agreed with OEH) can be used to reduce the liability of the conservation bond.
• The sum of the bond may be reviewed in conjunction with any revision to the biodiversity offset strategy or the completion of major milestones within the approved plan

Figure 1 Location of Biodiversity Offset Areas

Figure to be inserted in final PDF version

N

Ravensworth
State Forest

JERRYS
PLAINS

Appletree Fla
BOA

Wollemi
National
Park

BULGA

SINGLETON

MILBRODALE

Yengo
National
Park

BROKE

0

10 km

LEGEND

- Rivers
- Roads
- Open Cut Project Area
- Biodiversity Offset Areas
- NPWS reserve
- State forest

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FIGURE 1. LOCATION OF BIODIVERSITY OFFSET AREAS

SCALE 1 : 180,000 (A3)

DATE:29/7/2016

FILE: Integra 5 / BOA Overall

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Figure 2 Biodiversity Offset Area - Onsite

Figure to be inserted in final PDF version

Glennies Creek

Reedy Creek

N

W

E

S

Northern BOA

Bridgeman BOA

Falbrook Pit

Southern BOA

Stoney Creek

CHPP

Martin's Creek BOA

Blackwall Creek

0

1 km

LEGEND

- Bull Oak Forests of the Central Hunter Valley
- Cleared Land / Exotic Grassland
- Derived Grassland
- Grey Ironbark - Spotted Gum - Grey Box open forest on hills of the Hunter Valley, Sydney Basin
- Planted Rehabiltation
- Swamp Oak Forest - Central Hunter Valley, Sydney Basin
- Mining Leases
- Creeks
- Project Area

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FIGURE 2. BIODIVERSITY OFFSET AREAS ONISTE

SCALE 1 : 15,000 (A3)

DATE: 27/6/2016

FILE: Integra 5 / BOA Onsite

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Figure 3 Biodiversity Offset Area – Onsite – Land Ownership

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Glennies Creek
Reedy Creek
Stoney Creek
Martin's Creek
Blackwall Creek

Northern BOA

Bridgeman BOA

Southern BOA

Martin's Creek BOA

Falbrook Pit

CHPP

N
W
E
S

0
1 km

LEGEND

- Bloomfield Land Ownership
- Mining Leases
- Project Area
- Creeks
- Cadastial Information
- Bull Oak Forests of the Central Hunter Valley
- Cleared Land / Exotic Grassland
- Derived Grassland
- Grey Ironbark - Spotted Gum - Grey Box open forest on hills of the Hunter Valley, Sydney Basin
- Planted Rehabiltation
- Swamp Oak Forest - Central Hunter Valley, Sydney Basin

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FIGURE 3. BIODIVERSITY OFFSET AREA - ONSITE - LAND OWNERSHIP

SCALE 1 : 15,000 (A3)

DATE: 27/6/2016

FILE: Integra 5 / BOA Veg

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Figure 4 Apple Tree Flat Biodiversity Offset Area

Figure to be inserted in final PDF version

N
W
E
S

Wollemi National Park

Pirvate Land

Appletree Flat BOA

Road Corridor

Private Land

LEGEND

- Bloomfield Land Ownership
- Narrabeen East Wollemi Sheltered Dry Forest
- Narrabeen Goulburn Valley Exposed Woodland
- Narrabeen Sheltered Blue Gum Forest
- Regeneration
- Remnant Shale Cap Forest
- Sandstone Gorge Warm Temperate rainforest
- National Park Reserves

0 1 km

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FIGURE 4. APPLETREE FLAT
BIODIVERSITY OFFSET AREAS

SCALE 1 : 15,000 (A3)

DATE: 27/6/2016

FILE: Integra 5 / BOA Allpetree Flats Veg

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2.4 Baseline Environment

2.4.1 Land Use History

All BOAs are former grazing properties with varying amounts of remnant vegetation and regenerating woodlands. The areas that comprise the BOA's have had a long history of clearing and agricultural or pastoral land use which has resulted in considerable modification to native vegetation and faunal habitat. These activities have resulted in the areas of grasslands being devoid of trees and artificially induced open woodland with scattered mature trees dominating the current landscape.

2.4.2 Climatic Information

The Singleton area has a humid subtropical climate, with highest rainfall totals typically between October and March. Historical and monthly data averages for 2013 are provided in Table 6.

Table 6 Climatic data

Month	2015 Monthly Mean^		Total Rainfall (mm)^	Historical Averages*		Rainfall Median (mm)*
	Min Temp (^{0}C)	Max Temp (^{0}C)		Min Temp (^{0}C)	Max Temp (^{0}C)	
January	11.0	35.6	152	17.3	31.1	63.3
February	14.4	35	19.6	17.4	29.7	85.8
March	8.1	40	13.8	15.8	28.2	70.2
April	11.1	30.7	232	13.4	24.4	79.9
May	4.6	26.3	83.4	10.2	20.9	56.3
June	0	19.2	27.2	6.5	17.6	28.9
July	0	17.2	16.2	5.6	16.8	41
August	-6.0	25.2	52.8	6.4	18.8	49.2
September	0	25.2	16.8	8.7	22.3	47.1
October	3.1	34.5	35.6	11.5	25.5	81.2
November	10	37	101.6	13.6	27.2	78.8
December	13.4	36.1	144	15.7	29.4	66.7

^ Source: ICO Weather Station, located E326672m, N6404260m.

* Source: Bureau of Meteorology. 1981 - 2010 Climate Statistics for Singleton Army Site.

2.4.3 Landform, Geology, Soils, Salinity and Erosion

Erosion potential within the BOAs has not been exclusively measured, however studies conducted of the adjoining areas (including parts of the Western and Southern BOAs) as part of the 2007 Glennies Creek Open Cut Environmental Assessment (EA) found the soils to be generally stable. Erosion and sedimentation across the RCN complex including the BOA's is controlled under the *Water Management Plan* (WMP) (The Bloomfield Group - Rixs Creek North, 15 Feb 2016)and an *Erosion and Sediment Control Plan* (ESCP) (JP Environmental, 2010). Prior to the disturbance of land associated with any construction activities at the site, appropriate erosion and sediment controls are established and approved by the Environmental Officer. All erosion and sediment management and related control structures are consistent with the specifications contained in *Managing urban stormwater – soils and construction, Volume 1*, 4th edition (Landcom, 2004) and particularly *Volume 2E Mines and Quarries* (DECC, 2008).

Three creek lines exist in the BOAs;

- Glennies Creeks, a tributary of the Hunter River, borders the Supplementary and North BOAs to the north;

- Reedy Creek, which flows north-west through the Bridgman and Northern BOA into Glennies Creek; and
- Martins Creek, which runs through the north-west section of the Martins Creek BOA and enters in the C1 Clean Water Dam and is diverted via a clean water diversion off-site.

No major topographical features exist within the BOAs that would significantly affect revegetation or management activities.

Salinity has not been identified as an issue of concern within the RCN biodiversity offset areas to date. Given that these sites have high vegetation cover it is not likely to become a management issue. However, any evidence suggesting the land is affected by salinity will be documented and the appropriate management and remediation strategies implemented.

Table 6A Erosion, Sedimentation and Salinity Performance and Completion Criteria

Relevant Offset Area	Action	Performance Criteria			Completion Criteria
		Year 1	Year 2	Year 3	
All biodiversity offset areas	Undertake erosion and sediment inspection and map areas requiring remediation.	Complete inspection and mapping.			Appropriate erosion and sediment control measures required have been identified and implemented.
All biodiversity offset areas	Develop remediation plan and implement.			Remediation plan developed and commenced where practical.	There are no areas of significant erosion or sedimentation.
All biodiversity offset areas	Monitor completed erosion works and action repairs if required.			Monitor completed erosion works and action repairs if required.	Erosion control works are stable and successful.

2.4.4 Vegetation Communities

The Biodiversity Offset Strategy proposed by Integra under Modification 4, incorporates onsite and offsite BOAs. The onsite BOAs which surround the RCN, represent 399 ha. The remaining BOA is an in-holding within the Wollemi National Park, representing over 215 ha with the land owned by the Bloomfield Group.

The vegetation communities recorded in the onsite BOAs are provided in Table 7, shown in Figure 1 and described in the following section. Of the 399 ha within the onsite BOAs, three woodland or forest communities were identified, totalling approximately 202 ha. Derived Grassland/Native Pasture, Planted Rehabilitation and Cleared Land/Exotic Grassland occur in the remaining 197 ha.

Table 7 Vegetation Communities across the onsite BOA's

(Ref. Table 7.3 *Integra Mine Complex Modification 4 Environmental Assessment* (EMM prepared for Integra Coal Operations Pty Ltd, May 2014) and *Revised Biodiversity Offset Strategy* Section 4 -Table 4.2)

Vegetation community	Bridgman BOA	Martin's Creek BOA	Northern BOA	Southern BOA	Total
Remnant woodland and forest					
Bull Oak Forests	0.1	23.5	2.8	10.0	36.4
Narrow-leaved Ironbark–Spotted Gum–Grey Box Open Forest	61.8	27.9	12.0	13.9	115.6
Swamp Oak Forest	8.9	12.4	28.4	0.0	49.7
Sub-total remnant woodland and forest	**70.8**	**63.8**	**43.2**	**23.9**	**201.7**
Remaining areas					
Planted Rehabilitation	0.0	2.4	0.0	0.0	2.4
Derived Grassland/Native Pasture	15.8	33.3	36.2	1.9	87.2
Cleared Land/Exotic Grassland	0.0	94.1	9.0	4.6	107.7
Sub-total remaining areas	**15.8**	**129.8**	**45.2**	**6.5**	**197.3**
Total	**86.6**	**193.6**	**88.4**	**30.4**	**399.0**

A description of each of the nominated vegetation communities and the Condition rating as per the Revised Biodiversity Offset Strategy contained in Section 4 of the Environmental Assessment Modification 4 (EMM prepared for Integra Coal Operations Pty Ltd, May 2014) follows. A description of the Cleared Land / Exotic Grassland has been derived from an interpretation of site based knowledge, inspections and monitoring reports.

2.4.4.1 Bull Oak Forest

Vegetation formation (Keith 2002) Grassy Woodlands
Vegetation class (Keith 2002) Coastal Valley Grassy Woodlands
Vegetation type (Peake 2006) MU 32 Central Hunter Bulloak Forest Regeneration
Biometric vegetation type (BVT) ID (DECC 2008a)
HU668 Bull Oak Forests of the Central Hunter Valley
Threatened ecological community None
Dominant canopy species The canopy is 6-12 m in height and dominated by dense stands of Bull Oak (*Allocasuarina luehmannii*) with occasional Narrow-leaved Ironbark, Rough-barked Apple, Swamp Oak and Grey Box (PB 2012).
Dominant mid stratum species The shrub layer is generally absent.
Dominant ground stratum species A sparse ground cover of native grasses including Three-awn Speargrass (*Aristida ramosa*), Red Grass (*Bothriochloa macra*), Wallaby Grass (*Austrodanthonia bipartita*) and Shorthair Plumegrass (*Dichelachne micrantha*) (Vale 2013). The understorey has been invaded by exotic species, with *Melinis repens, Chloris gayana, Senecio madagascariensis*, and *Hypochaeris glabra* common (PB 2012).
Landscape position On undulating Permian sediments of the central Hunter Valley.
Percent cleared in CMA area 70%
Condition class Moderate-good
Description The Bull Oak Forests of the BOAs are regenerating from previous clearing and are considered to be in moderate to good condition.

Plate 1 Bull Oak Forest

2.4.4.2 Narrow-leaved Ironbark—Spotted Gum—Grey Box Open Forest

Vegetation formation (Keith 2002) Dry Sclerophyll Forests (Shrub/grass subformation)
Vegetation class (Keith 2002) Hunter-Macleay Dry Sclerophyll Forests
Vegetation type (Peake 2006) MU 27 Central Hunter Ironbark – Spotted Gum – Grey Box Gum
Biometric vegetation type (BVT) ID
(DECC 2008a)
HU556 Grey Ironbark–Spotted Gum–Grey Box open forest on hills of the Hunter Valley, Sydney Basin
Threatened ecological community Central Hunter Ironbark–Spotted Gum–Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions endangered ecological community (EEC)
Dominant canopy species The canopy is sparse, with a mixture of Forest Red Gum (*Eucalyptus tereticornis*), Grey Box (*E. molucanna*), Spotted Gum (*Corymbia maculata*), Rough-barked Apple (*Angophora floribunda*), Narrow-leaved Ironbark (*E. crebra*) and Broad-leaved Ironbark (*E. fibrosa*) (PB 2012).
Dominant mid stratum species The shrub layer includes Butterbush (*Pittosporum angustifolium*), Broom Bitter-pea
(*Daviesia genistifolia*), *Pultenaea retusa, Cassinia aculeata* and Fan Wattle (*Acacia amblygona*) (PB 2012).
Dominant ground stratum species The ground cover varies in density across this community and includes Slender Rats Tail Grass (*Sporobolus creber*), *Eragrostis cilianensis*, Narrawa Burr (*Solanum cinereum*), Native Bluebell (*Wahlenbergia gracilis*), *Lomandra longifolia*, Barbed Wire Grass (*Cymbopogon refractus*), *Stipa sp.*, Bristly Cloak Fern (*Cheilanthes distans*) and Kidney Weed (*Dichondra repens*) (Vale 2013).
Landscape position Occurs on crests and ridges on undulating hills and rises of the central Hunter Valley.
Percent cleared in CMA area 60%
Condition class Moderate-good
Description The Narrow-leaved Ironbark–Spotted Gum–Grey Box Open Forest in the BOAs was in moderate to good condition. It is largely restricted to isolated remnant patches, with the exception of the Bridgman BOA which contains a large continuous stand of the community, extending into the Northern BOA.

Plate 2 Narrow-leaved Ironbark - Spotted Gum - Grey Box Open Forest

2.4.4.3 Swamp Oak Forest

Vegetation formation (Keith 2002) Forested Wetlands
Vegetation class (Keith 2002) Coastal Swamp Forests
Vegetation type (Peake 2006) MU 28 Central Hunter Swamp Oak Forest
Biometric vegetation type (BVT) ID
(DECC 2008a)
HU634 Swamp Oak forest of the central Hunter Valley, Sydney Basin
Threatened ecological community Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East
Corner Bioregions EEC
Dominant canopy species Swamp Oak (*Casuarina glauca*) dominates the canopy, with the occasional Roughbarked Apple and Forest Red Gum.
Dominant mid stratum species The shrub layer is sparse, with Eastern Cottonbush (*Maireana microphylla*) and Blackthorn (*Bursaria spinosa*) occurring where tree cover is sparse.
Dominant ground stratum species Ground cover species include Three-awn Speargrass (*Aristida ramosa*) and the weed Tiger Pear (*Opuntia aurantiaca*) (Vale 2013).
Landscape position Occurs mostly along alluvial flats and creek banks, although it may occur away from these areas in some places.
Percent cleared in CMA area 95%
Condition class Moderate–good
Description The Swamp Oak Floodplain Forest in the BOAs is in moderate to good condition. The canopy is generally regrowth with a dense understorey of exotic and native species in areas (PB 2012).

Plate 3 Bulloak Forest

2.4.4.4 Planted Rehabilitation

Vegetation class (Keith 2002) None
Vegetation type (Peake 2006) None
Biometric vegetation type (BVT)
ID (DECC 2008a)
None
Threatened ecological community None
Dominant canopy species Grey Box (*E. molucanna*) forms a monoculture from previous planting into the overburden (note trees were juvenile with no fruit available to confirm identification).
Dominant mid stratum species None
Dominant ground stratum species Native and exotic groundcovers have encroached in some areas, including African Feather Grass, Rhodes Grass Slender Rat's Tail Grass and Three-awn Speargrass.
Landscape position On an overburden slope in the Martin's Creek BOA.
Percent cleared in CMA area N/A
Condition class Moderate (over storey cover is greater than 25% of benchmark and 50% of the groundcover is native species)
Description The Planted Rehabilitation area occurs in the northern part of the Martin's Creek BOA. Tree species indicative of the Narrow-leaved Ironbark–Spotted Gum–Grey Box Open Forest community have been directly sown into the overburden in this location and occur with groundcover that is very sparse to absent. Grey Box is the dominant species planted, with the trees up to 15m in height, however the area lacks diversity in the understorey, most likely as a result of the lack of topsoil.

2.4.4.5 Derived Grassland/Native Pasture

Vegetation formation (Keith 2002) Dry Sclerophyll Forests (Shrub/grass subformation)–derived grassland
Vegetation class (Keith 2002) Hunter-Macleay Dry Sclerophyll Forests–derived grassland

Vegetation type (Peake 2006) MU 27 Central Hunter Ironbark – Spotted Gum – Grey Box Gum – derived grassland
Biometric vegetation type (BVT) ID
(DECC 2008a)
HU556 Grey Ironbark–Spotted Gum–Grey Box open forest on hills of the Hunter Valley, Sydney Basin–derived grassland
Threatened ecological community None
Dominant canopy species Where present, the regenerating or remnant paddock trees are similar to those identified within the Narrow-leaved Ironbark–Spotted Gum–Grey Box Open Forest or in some smaller areas, Bull Oak Forest.
Dominant mid stratum species Shrubs were generally absent, however there was occasional Fan Wattle (*Acacia falcata*) and the exotic Eastern Cottonbush (*Gomphocarpus fruticosus*) in areas. Regenerating eucalypts and Bull Oak was also present in numerous locations.
Dominant ground stratum species Groundcover is generally greater than 50% native species, with common pasture species such as Paspalum (*Paspalum dilatatum*) and naturalised and native grasses including Common Couch (*Cynodon dactylon*), Slender Rat's Tail Grass, Barbed Wire Grass (*Cymbopogon refractus*), Three-awn Speargrass (*Aristida ramosa*), Bristly Cloak Fern (*Cheilanthes distans*), Common Fringe Sedge (*Fimbristylis dichotoma*), Common Everlasting (*Chrysocephalum apiculatum*), Hairy Panic (*Panicum effusum*), Speargrass (*Stipa sp.*), Shorthair Plumegrass (*Dichelachne micrantha)* and Native Bluebell (*Wahlenbergia gracilis*). Exotic species were also common in some areas and included Fireweed (*Senecio madagascariensis*), Purpletop (*Verbena bonariensis*), African Feather Grass (*Pennisetum macrourum*) and Rhodes Grass (*Chloris gayana*).
Landscape position Occurs on crests and ridges on undulating hills and rises of the BOAs that have been previously cleared and grazed.
Percent cleared in CMA area N/A
Condition class Moderate (50% of the groundcover is native species)
Description Derived Grassland/Native Pasture areas within the BOAs were observed in varying stages of natural regeneration as a result of the removal of cattle. In general, these areas contain similar species composition to the Narrow-leaved Ironbark–Spotted Gum–Grey Box Open Forest, with the canopy absent or in some areas, present as occasional remnant paddock trees or regenerating as juvenile saplings.

Plate 4 Derived Grassland/Native Pasture

2.4.4.6 Cleared Land/Exotic Grassland

These are areas where a tree layer is absent (scattered paddock trees may remain); native and exotic perennial grasses dominate, more prostrate (low-growing) grasses than unfertilised pastures and fewer large tussock grasses; medics and clovers often present in winter– spring; low to moderate diversity of native and exotic forbs.

Plate 5 Cleared Land/Exotic Grassland

2.4.5 Threatened Species and Migratory Species

No threatened flora species were impacted by the approved project (EMM prepared for Integra Coal Operations Pty Ltd, May 2014).

The approved BOS (EMM prepared for Integra Coal Operations Pty Ltd, May 2014) was developed to, amongst other matters; compensate for potential impacts on the following nine TCS Act listed threatened fauna species:

- Microbats: Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*), Eastern Freetail Bat (*Mormopterus norfolkensis*) and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*);
- Grey-headed Flying Fox (*Pteropus poliocephalus*);
- Brush-tail Phascogale (*Phascogale tapoatafa*);
- Squirrel Glider (*Petaurus norflokensis*);
- Spotted-tailed Quoll (*Dasyurus maculatus*) (K.Brickhill *pers comm*); and
- Woodland birds: Grey-crowned Babbler (*Pomatostomus temporalis temporalis*), Speckled Warbler (*Pyrrholaemus saggitatus*) and Brown Treecreeper (*Climacteris picumnus victoriae*).

2.4.6 Introduced Species

2.4.6.1 Weeds

A number of weed species, including four species of noxious weeds, have been identified across the BOA's and surrounding areas during flora surveys conducted between 2003 and 2007. The four noxious species recorded were: African Boxthorn (*Lycium ferocissimum*); Green Cestrum (*Cestrum parqui*); Mother of Millions (*Bryophyllum delagoense*); and Prickly Pear (*Opuntia stricta*) / Tiger Pear (*Opuntia aurantiaca*).

Environmental weeds recorded include *Melinis repens*, Rhodes grass *Chloris gayana*, Fireweed *Senecio madagascariensis*, and *Hypochaeris glabra*, Eastern Cottonbush (*Gomphocarpus fruticosus*), African Feather Grass (*Pennisetum macrourum*), Purpletop (*Verbena bonariensis*). The 2015 flora monitoring also recorded Coolatai Grass (*Hyparrhenia hirta*) occurring within the Martins Creek, Supplementary and Western BOAs.

The 2015 round of flora monitoring (Eastcoast Flora Survey for Interga Coal Operations Pty Ltd, Feb 2016) recorded noticeable changes in the distribution, density and diversity of weed species across the BOA's. These changes were predominantly attributed to the change in landuse and the removal of cattle from these areas.

As in previous years, weed species were most prevalent and comprised the highest cover abundance in Grassland, and particularly so in the Grassland (Swamp Oak) . The majority of weed cover in grassland areas was explainable by the presence of pasture grass species (e.g. Carpet Grass, Paspalum), and in some areas the invasive weed Coolatai Grass. (Eastcoast Flora Survey for Interga Coal Operations Pty Ltd, Feb 2016).

A marked increase was recorded in weed abundance in the Grassland (Bulloak) and Grassland (Spotted Gum) MUs, but a significant decrease in the Grassland (Grey Box). The latter drop in weed species abundance may be due to the complete removal of cattle from the Bridgeman Road BOA, and the resurgence of native grass species. The increase in weeds in the Grassland (Spotted Gum) and Grassland (Bulloak) MUs is largely a result of the expansion of Coolatai Grass and Paspalum in those areas. All other areas showed negligible changes in overall weed abundance. (Eastcoast Flora Survey for Interga Coal Operations Pty Ltd, Feb 2016).

As the monitoring program is based on the collection of data from defined transects potential exists for weed species to occur outside these areas or timeframes that the monitoring program is implemented. Acknowledging this, any site inspection undertaken by RCN environment will be vigilant for sleeper weeds e.g. St John's Wort or previously unrecorded infestations.

2.4.6.2 Invasive Native Plant Species

The 2015 round of flora monitoring (Eastcoast Flora Survey for Interga Coal Operations Pty Ltd, Feb 2016) recorded the presence of Golden wreath wattle (*Acacia saligna*) and Swamp oak (*Casuarina glauca*). Whilst these species are native to Australia they are not endemic to the BOA's. In context of management of the BOA both species have their own inherent environmental risks.

Golden wreath wattle (*Acacia saligna*)

This species has historically been used in the direct seeding mixes as part of the revegetation program across post mined lands including those impacted by coal mining of the Hunter valley. Currently the species has not established as dense thickets and should be controlled to mitigate the risk of it colonising and spreading in terms of density and distribution across the BOA's. Of greatest concern is the species ability to produce an extensive seed bank where it dominates and successful control will require management over several years and especially post any fire event.

Swamp oak (*Casuarina glauca*)

In the absence of repeated fire events, which are known to reduce the spread of many Casuarina species (ID, 1998), species such as *Casuarina glauca* and *C. leuhmannii* have become invasive and impacted on adjoining eucalypt forests and woodlands. This issue is recognised in context of the management of the BOA with the review of direct seeding and tubestock planting lists focused on enhancing other overstorey species. This is especially the case for the BOA's where Swamp Oak Forests occur i.e. Bridgman, Martins creek and Northern BOA's.

2.4.6.3 Vertebrate pest Species

A number of feral animals have also been recorded during monitoring programs across the BOA's that can impact on native fauna and flora. These include the Red Fox (*Vulpes vulpes*), Wild Dog / Dingo (*Canis lupus*), European Rabbit (*Oryctolagus cuniculus*), and Feral Cat (*Felis catus*).

2.5 BOA Management Zone Stratification

The two core Management Zones of the BOA – Habitat Management and Habitat Restoration are defined in Table 8. Further details on the activities that underpin these Zones are provided in Section 2.6.

Table 8 BOA Management Zones

Management Zone	Vegetation community	Condition[2]	Objective	Bridgman BOA	Martin's Creek BOA	Northern BOA	Southern BOA	Total
Remnant woodland and forest								
Habitat management	Bull Oak Forests	Moderate - Good	Enhanced diversity of endemic flora species at all strata	0.1	23.5	2.8	10.0	36.4
	Swamp Oak Forest	Moderate - Good	Enhanced diversity of endemic flora species at all strata	8.9	12.4	28.4	0.0	49.7
Habitat management	Narrow-leaved Ironbark–Spotted Gum–Grey Box Open Forest	Moderate - Good	Enhanced diversity of endemic flora species at all strata	61.6	27.9	12.0	14.7	116.2
Sub-total remnant woodland and forest				70.6	63.8	43.2	24.7	202.3
Remaining areas								
Habitat restoration	Planted Rehabilitation	Moderate (over storey > 25% benchmark and 50% of the groundcover are native species)	Native vegetation community aligned to Narrow-leaved Ironbark–Spotted Gum–Grey Box Open Forest community	0.0	2.4	0.0	0.0	2.4

[2] (EMM prepared for Integra Coal Operations Pty Ltd, May 2014)

Management Zone	Vegetation community	Condition[2]	Objective	Bridgman BOA	Martin's Creek BOA	Northern BOA	Southern BOA	Total
	Remnant woodland and forest							
Habitat restoration	Derived Grassland/Native Pasture	Moderate (50% of the groundcover are native species)		15.8	33.3	36.2	1.9	87.2
Habitat restoration	Cleared Land/Exotic Grassland	N/A	Control of weed and feral animals with a native plant community	0.0	94.1	9.0	4.6	107.7
Sub-total remaining areas				15.8	129.8	45.2	6.5	197.3
Total				**86.4**	**193.5**	**88.4**	**31.2**	**399.5**

Figure 5 Management Zones in the BOA

Figure to be inserted in final PDF version

Glennies Creek

N
W
E
S

0
1 km

Northern BOA

Reedy Creek

Bridgeman BOA

Falbrook Pit

Southern BOA

Stoney Creek

Martin's Creek BOA

Martin's Creek

CHPP

Blackwall Creek

LEGEND

- Habitat Revegetation Areas - 81 ha
  To - Central HunterIronbark-Spotted Gum -Grey Box Forest
- Habit Restoration Areas - 84 ha
  To - Central HunterIronbark-Spotted Gum -Grey Box Forest
- Creeks
- Project Area
- Bull Oak Forests of the Central Hunter Valley
- Cleared Land / Exotic Grassland
- Derived Grassland
- Ironbark - Spotted Gum - Grey Box open forest on hills of the Hunter Valley, Sydney Basin
- Planted Rehabiltation
- Swamp Oak Forest - Central Hunter Valley, Sydney Basin

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FIGURE 5. MANAGEMENT ZONES IN BIODIVERSITY OFFSET AREAS

SCALE 1 : 15,000 (A3)

DATE: 21/7/2016

FILE: Integra 5 / BOA Mgt Zones

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2.6 Land Management Strategies and Completion Criteria

2.6.1 Risks to the Biodiversity Offset Strategy

Risks and issues that may impact on the ability to successfully implement the BMP include:

- Insufficient resourcing to implement the defined works;
- Unauthorised clearing within BOAs;
- Lack of availability of locally occurring species to be either seeded or planted in rehabilitation or regeneration areas;
- Weed infestation;
- Feral animal species;
- Grazing of livestock within prohibited areas;
- Erosion and sedimentation of BOAs; and
- Unauthorised access into BOAs.

These risks will be mitigated by the implementation of the measures aligned to the performance indicators and criteria as defined in this Section of the BMP.

2.6.2 Land Management Strategies

Revegetation of the BOAs will be undertaken where required to create a mosaic of habitats that are connected by vegetated corridors to maximise use of the landscape by native fauna.

Reconstructing habitat in areas of native derived grassland will be used to link existing areas of high conservation value. This will result in improved connectivity of remnants and will benefit wildlife populations. Revegetation can also be used to create buffer zones around existing areas of high conservation value that will help minimise or remove edge effects and increase the condition of these areas.

The key generic management strategies except for maintenance and monitoring for the vegetation communities that occur across the BOA are:

- Rehabilitation of vegetation corridors to establish linkages between the offset areas, the mine site and riparian vegetation;
- Planting of shrub species to increase understory abundance and diversity;
- All plants are to be sourced from local stock (where available);
- Promote passive regeneration from the soil seed bank through active weed control;
- Implement feral animal and weed control;
- Ensure that the BOAs are fenced appropriately and have restricted access;
- Management of *Acacia saligna;*
- Regular maintenance activities including weed control, fencing (as needed), replacement of plantings (as needed), and thinning (as needed) will be conducted in the BOAs over the life of the mine operations;
- Regular monitoring activities to detect the success/failure of the restoration works will be performed; and
- All areas of restoration will have restricted human access and be protected by exclusion fencing.
- Poor spoils/substrate material inhibiting plant establishment and growth; Inadequate landform design leading to unstable landform; Weed infestation within BOAs and rehabilitation areas; Feral animal species within BOAs and rehabilitation areas; Grazing of cattle within prohibited areas; Erosion and sedimentation of BOAs; and Unauthorised access into BOAs and rehabilitation areas.
- The mitigation measures that will be implemented to address these risks are outlined in the sections below

The key management strategies for the Zones as identified in Section 2.5 and Table 8 are provided in Table 9. Further details on each of these strategies, together with relevant performance indicators and criteria and completion criteria are provided in Section 2.6.

Table 9 Specific Management Strategies for Management Zones

Vegetation Community	Management Strategy						
	Pathogen management	Cultural heritage	Fences, gates and signage	Access tracks	Waste management	Erosion, Sediment and soil management	Stock management
Narrow-leaved Ironbark—Spotted Gum—Grey Box Open Forest	Flora and fauna monitoring assesses for species decline and threat to biosecurity	In accordance with *Non-Aboriginal Heritage Management Plan* and the *Aboriginal Heritage Management Plan RCN Open Cut Project*	As per layout as shown Figure 6	As per layout as shown Figure 6	Waste removed from BOA and inspections and photo records completed and kept	Works undertaken in accordance *Permit to Disturb*	Restrict cattle access
Bull Oak Forest							
Swamp Oak Forest							
Derived Grassland / Native Pasture							Controlled grazing based on carrying capacity assessment
Planted Rehabilitation							
Cleared Land/Exotic Grassland							

Table 10 Specific Management Strategies for Management Zones - continued

Vegetation Community	Management Strategy				
	Seed collection and propagation	Habitat augmentation	Thinning / control of Casuarina species	Revegetation and regeneration	Weed control Feral animal control
Narrow-leaved Ironbark—Spotted Gum—Grey Box Open Forest	Revegetation works based on use of endemic species	Monitoring and maintenance of nest boxes	N/A	N/A	All noxious weeds will be managed and controlled as per the requirements of the Noxious Weeds Act 1993 Control of African Olive, Lantana, *Acacia saligna* and Coolatai Grass Monitoring and control programs for Wild Dogs, Foxes, Rabbits and cats
Bull Oak Forest			Review stem densities for BOA for *glauca and C. leuhmannii* and implement trial thinning		
Swamp Oak Forest					
Derived Grassland / Native Pasture		Monitoring and maintenance of nest boxes Salvage and reuse suitable fauna habitat		Defoliation of grasses using “patch” concept Planting of tubestock and direct seeding using “patch” concept Incorporation of locally harvested brush material Revegetation works based on use of endemic species	
Planted Rehabilitation	Over and mid storey species based on use of endemic species		N/A	Incorporation of locally harvested brush material Over and mid storey species based on use of endemic species	
Cleared Land/Exotic Grassland	Revegetation works based on use of endemic species		Review stem densities for BOA for *glauca and C. leuhmannii* and implement trial thinning	Defoliation of grasses using “patch” concept Planting of tubestock and direct seeding using “patch” concept Incorporation of locally harvested brush material Revegetation works based on use of endemic species	

2.6.3 Pathogen Management and Hygiene

The management of the introduction or spread of pathogens within the BOA depends on the level of risk to the BOA and the presence of known infestations either within the BOA or in the nearby area. Whilst there have not been any recorded occurrences of disease or fungal issues across the BOA inherent risks include, though are not limited to, Chytrid fungus, Myrtle Rust (*Uredo rangelii*) or Phytophthora (*Phytophthora cinnamomi*). To ensure familiarity with indicators of the potential presence of these disease / fungal infestation site environmental staff will periodically reference the following and updated versions of the:

- *Myrtle rust: Myrtle rust* – Uredo rangelii *Prime Fact 1017* ((NSW Dept Primary Industries, 2010);
- *Chytrid fungus: Hygiene protocol for the control of disease in frogs* ((NSW Dept of Climate and Conservation, 2008b); and
- *Phytophthora: Phytophthora dieback – fact sheet* ((Royal Botanic Ggardens, 2011).

Table 11 Disease Management Performance Criteria and Completion Criteria.

Action	Year 1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Review information related to potential disease and fungal infestations that may pose biosecurity risk to the BOA	To be completed	To be completed	Every three years	Every three years	All reviews completed
Flora monitoring includes assessment of plant decline that may be an indicator of disease	To be completed	To be completed	Every three years	Every three years	All reviews completed
Fauna monitoring includes review of disease that may pose a threat to the biosecurity of the BOA	To be completed	To be completed	Every three years	Every three years	All reviews completed

2.6.4 Cultural heritage Management

Aboriginal and cultural heritage at the RCN site is managed under the *Aboriginal Heritage Management Plan RCN Open Cut Project* (Integra Coal Operations, 4 June 2012). This document sets out the procedures for the protection of Aboriginal sites as well as the salvage and care of Aboriginal objects found within the operational activities including those associated with the management of the BOA. Additional objectives of the Plan are:

- To establish an ongoing Aboriginal stakeholder consultation process;
- To describe the manner in which certain Aboriginal sites will be salvaged;
- To provide a summary research design and work plan for the sub surface excavation of select sites and areas;
- the importance of ongoing consultation with Aboriginal stakeholders during mining; and

- To describe a program for Aboriginal site survey and assessment in areas not addressed by the original EA.

Additionally any works undertaken on site that require the clearing of vegetation and or the disturbance of the soil surface will be undertaken in accordance with the site *Land Disturbance Management Procedure* (Bloomfield Group, Oct 2012).

2.6.4.1 European Heritage

A *Non-Aboriginal Heritage Management Plan* (Integra Coal Operations, 11 Oct. 2012) addresses management of non-Aboriginal heritage at the RCN. No known European heritage sites have been identified or have been listed across the BOA's.

Table 12 Cultural Heritage Management Performance Criteria and Completion Criteria

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
The location of known cultural heritage items are recorded on site GIS to avoid any potential risks from works associated with the management of the BOA	To be completed	Update mapping with any new finds	Update mapping with any new finds	Update mapping with any	Final map providing all cultural heritage finds
Develop cultural heritage protocols for inclusion in risk assessments for site personnel and contractors Protocols include reporting all potential finds to the supervisor	To be completed	Review and revise protocols as necessary	Review and revise protocols as necessary	Review and revise protocols as necessary	Protocols developed and implemented

2.6.5 Fencing, Gates and Signage

A review of the location of fencing and gates throughout the BOA will be undertaken with an objective of allowing free movement of, and prevent fence related injuries to, fauna but sufficient to manage/discourage any inappropriate or unauthorised access such as grazing by stock (unless required for management). The location of the fences, gates, signage and access tracks – current and redundant is shown on Figure 6.

Plate 6 BOA Signage - currently in use

Table 13 Fencing, gate and signage Management Performance Criteria and Completion Criteria

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Fence mapping showing fence and gate types, redundant fences and fences to be retained	Complete	Update mapping with any amendments	Update mapping with any amendments	Update mapping with any amendments	Final map providing location of all fences, gates and signage
Gate and fence installations	To be completed	To be completed	To be completed	To be completed	All annual inspection's completed
Fences in areas of known Glider habitat will be reviewed with a view to replacing barb with plain wires	To be completed	To be completed			Fences replaced
Redundant fence removed	Completed				All redundant fences removed
Signage erected	Signs checked for damage and	Signs checked for damage and	Signs checked for damage and	Signs checked for damage and	All signs intact

informing site users and to mitigate unauthorised access of the BOA and biodiversity value	need for replacement	need for replacement	need for replacement	need for replacement	
Annual fence inspections and any breaches rectified within 4 weeks	To be completed annually	To be completed annually	To be completed annually	To be completed annually	Annual inspections and maintenance works complete

Figure 6 Location of required and redundant fences; gates, signage and access tracks

Figure to be inserted in final PDF version

N
W
E
S

Glennies Creek

Reedy Creek

Northern BOA

Bridgeman BOA

Falbrook Pit

Southern BOA

Stoney Creek

CHPP

Martin's Creek BOA

Martin's Creek

Blackwall Creek

0

1 km

LEGEND

- Gates
- Fence to be Erected
- Fence with Top Wire to be Replaced
- Fences to be removed
- Fence with Plain Top Wire
- Creeks
- Bull Oak Forests of the Central Hunter Valley
- Cleared Land / Exotic Grassland
- Derived Grassland
- Grey Ironbark - Spotted Gum - Grey Box open forest on hills of the Hunter Valley, Sydney Basin
- Planted Rehabiltation
- Swamp Oak Forest - Central Hunter Valley, Sydney Basin

RIXS CREEK PTY LTD

FIGURE 6. LOCATION OF REQUIRED & REDUNDANT FENCES, GATES, SINAGE & ACCESS TRACKS

SCALE 1 : 15,000 (A3)

DATE: 7/7/2016

FILE: Integra 5 / BOA Fencing

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2.6.6 Access Tracks

Tracks within the BOA will form an important role not only for providing access to allow for the implementation of management actions but also for bushfire control and asset protection. The location of the access tracks are strategic and have been kept to a minimum to reduce secondary impacts such as edge effects, weed encroachment and erosion. Access tracks within the BOA will not be used as a thoroughfare for mine vehicles of for storage/parking of mine equipment. The tracks will be routinely inspected and maintained to ensure they are to standard, fit for purpose.

The location of the access tracks – current and redundant is shown on Figure 6.

Table 14 Access Tracks Management Performance Criteria and Completion Criteria

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Access tracks mapping showing track types, redundant tracks and tracks to be retained	To be completed	To be completed	To be completed	To be completed	Final map providing location of all tracks
Annual track inspections and any maintenance issues rectified	To be completed annually	To be completed annually	To be completed annually	To be completed annually	Annual inspections and maintenance works complete

2.6.7 Waste Management and Conflicting Uses

As a function of historical agricultural practices building refuse, redundant fences and structures occur across the BOA's. These will be removed and the site rehabilitated to align to the surrounding vegetation community.

Table 15 Waste Management Performance Criteria and Completion Criteria

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Building waste to be removed from BOA in accordance with *RCN Waste Management Plan* (Rixs Creek North, 3 Feb 2016)	Waste removed from BOA Photo record of waste removed and areas to be revegetated				Waste removed from BOA and inspections and photo records completed and kept
Rehabilitation to natural vegetation similar to surroundings	Revegetation works completed using local stock where possible	Progress of revegetation and regeneration works monitored and reported			Regeneration works complete and monitoring/inspection records kept
Waste resulting from unauthorised dumping will be removed	Waste removed from BOA	Waste removed from BOA	Waste removed from BOA	Waste removed from BOA	Waste removed from BOA and inspections and photo records completed and kept

2.6.8 Erosion, Sediment and Soil Management

The following management action will be implemented to ensure the mitigation of risk associated with sediment and erosion and the handling of growing media:

- Soil physical disturbance will be avoided or minimised in doing so reducing the potential for weed seed colonisation;
- If the soil is disturbed for necessary works, the area will be rehabilitated. Rehabilitation may include levelling the soil, removing weed species that germinate on the area and sowing, or encouraging natural recruitment of, at least the native plant species that dominate the adjacent vegetation;
- Vehicle traffic will be limited, where possible to defined traffics in doing so reducing soil compaction;
- Cattle will be excluded from sensitive areas outside of the mine area and this will assist erosion control in those areas; and
- Soil testing will be undertaken to assess the need for fertiliser or other soil ameliorants prior to them being applied. The use of fertilisers high in phosphorous and nitrogen will be carefully assessed prior to use to ensure that they do not provided a competitive advantage to exotic plant species.

Table 16 Erosion, Sedimentation and Soil Management Performance Criteria and Completion Criteria

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Permit to Disturb System implemented to ensure no unauthorised clearing occurs	System implemented, maintained and records kept throughout the life of the project				No unauthorised clearing occurs in the Project area
Inspections verify disturbed areas are in accordance with approved disturbance areas. Any unauthorised disturbance is investigation and remediated	Inspections carried out annually Investigations completed and remediation undertaken as necessary	Inspections carried out annually Investigations completed and remediation undertaken as necessary	Inspections carried out annually Investigations completed and remediation undertaken as necessary	Inspections carried out annually Investigations completed and remediation undertaken as necessary	No disturbance of non-authorised areas Investigations and remediation work recorded and kept
Site inspection undertaken after any localised flooding or significant storm event to assess for the presence of erosion or storm damage and any maintenance issues rectified within 4 weeks	As required	As required	As required	As required	Inspection undertaken and maintenance works complete

2.6.9 Stock Management

Whilst cattle will be restricted from accessing the remnant woodland forest BOA's (refer Table 7), controlled grazing will be undertaken on the remaining areas as a technique for the defoliation of native grasses and forbs. Further details are provided in Section 2.6.12.1. Cattle will be restricted from entering revegetated areas where there is a risk of them damaging direct seeded / planted sites.

Table 17 Stock Management Performance Criteria and Completion Criteria

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Assessment of stocking rates and carrying capacity	Information obtained from onsite and analogue pasture assessments is used to inform decision making	Assessment of stocking rate and carrying capacity in BOA of Derived Grasslands and Cleared Land/Exotic Grassland	Assessment of stocking rate and carrying capacity in BOA of Derived Grasslands and Cleared Land/Exotic Grassland	Assessment of stocking rate and carrying capacity in BOA of Derived Grasslands and Cleared Land/Exotic Grassland	Agistee undertakes assessment of stocking rate and carrying capacity in BOA of Derived Grasslands and Cleared Land/Exotic Grassland
Crash grazing in BOA of Derived Grasslands and Cleared Land/Exotic Grassland	Decision to undertake crash grazing is based on findings of pasture assessment	Decision to undertake crash grazing is based on findings of pasture assessment	Decision to undertake crash grazing is based on findings of pasture assessment	Decision to undertake crash grazing is based on findings of pasture assessment	Agistee decision to undertake crash grazing is based on findings of pasture assessment
	Crash grazing is undertaken in consultation with agistee with due consideration to No Go Areas	Crash grazing is undertaken in consultation with agistee with due consideration to No Go Areas	Crash grazing is undertaken in consultation with agistee with due consideration to No Go Areas	Crash grazing is undertaken in consultation with agistee with due consideration to No Go Areas	Crash grazing is undertaken by agistee with due consideration to No Go Areas

2.6.10 Seed Collection and Propagation

The revegetation program will utilise locally sourced seed, where practically available at the time required, to ensure locally endemic species are incorporated into revegetation areas in the BOAs. The target revegetation species list in context of their suitability for direct seeding and or tubestock planting for is provided in Table 18.

Table 18 Revegetation Species List

Species	Direct Seeded	Tubestock
Groundcover and understorey species		
Agrostis avenacea var. avenacea		x
Aristida spp.	x	x
Austrodanthonia spp.	x	x
Austrostipa verticillata	x	x
Bothriochloa macra	x	x

Species	Direct Seeded	Tubestock
Chloris ventricosa	x	x
Cymbopogon refractus	x	x
Dichanthium sericeum	x	x
Dichelachne micrantha	x	x
Enteropogon acicularis	x	x
Poa spp.	x	x
Themeda australis	x	x
Other groundcover species		
Brunoniella australis		x
Calocephalus citreus		x
Calotis lappulacea		x
Chrysocephalum apiculatum		x
Dianella spp.		x
Dichondra repens		x
Einadia nutans		x
Eremophila debilis		x
Glycine spp.		x
Goodenia spp.		x
Hardenbergia violacea		x
Lomandra spp.		x
Maireana microphylla		x
Pomax umbellata		x
Senecio quadridentatus		x
Wahlenbergia spp.		x
Xerochrysum bracteatum		x
Mid Storey		
Acacia amblygona[1]	x	x
Acacia decora[1]	x	x
Acacia falcata	x	x
Acacia implexia[1]	x	x
Acacia terminalis[1]	x	x
Dodonaea triquetra[1]	x	x

Species	Direct Seeded	Tubestock
Indigofera australis	x	x
Overstorey		
Allocasuarina leuhmannii		x
Allocasuarina verticillata		x
Angophora floribunda		x
Callistemon sp.		x
Casuarina cunninghamiana		x
Casuarina glauca		x
Corymbia maculata	x	x
Eucalyptus blakleyi	x	x
Eucalyptus camaldulensis	x	x
Eucalyptus crebra	x	x
Eucalyptus fibrosa	x	x
Eucalyptus moluccana	x	x
Eucalyptus paniculata	x	x
Eucalyptus tereticornis	x	x
Melaleuca styphelioides		x

Table 19 Seed collection and Propagation Management Performance Criteria and Completion Criteria

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Revegetation species will be consistent with vegetation communities on-site	Species as per BMP lists are used as the basis for revegetation works	Species as per BMP lists are used as the basis for revegetation works	Species as per BMP lists are used as the basis for revegetation works	Species as per BMP lists are used as the basis for revegetation works	Only species from BMP are used in revegetation of BOA's
Develop list of required numbers of tubestock	Completed				Completed
Develop list of required seed resource	Completed				Completed
Order required seed and tubestock for primary and maintenance works	Completed	Order for maintenance works as required	Order for maintenance works as required	Order for maintenance works as required	Completed

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Survival rates are defined for patch plantings	Complete within 4-6 weeks then 6 months of initial planting	Complete within 4-6 weeks then 6 months of initial planting	Complete within 4-6 weeks then 6 months of initial planting	Complete within 4-6 weeks then 6 months of initial planting	

2.6.11 Habitat Augmentation

To maximise the habitat value of the BOA; for a wide variety of fauna, the areas will be managed to maintain or enhance the diversity of its structure and species composition. The areas of native grassland provide shelter for small animals in the form of grass tussocks and inter tussock spaces, soil cracks and holes, rocks, shrubs, trees and their bark, fallen timber and litter. In turn each of these niches provides places for small native fauna to shelter from the elements, predators and fire. Accordingly, the more niches there are and the more species of fauna shelter within the grassland the greater the abundance and variety of food for other species of fauna.

The following actions will be implemented to enhance structural diversity and shelter particularly in the areas of the grassland based BOA:

- allowing for a diversity of grass types, tussock form and structure;
- leaving fallen large woody debris in situ;
- leaving rock material in situ;
- utilising woody debris, mulch and rock material harvested from the adjoining mining operations for optimal placement associated with the patch plantings;
- minimising site access during the warmer months where ever possible – this is the time when small fauna are most active;
- optimising the number of shallow depressions which assist in water movement and retention across the site;
- using plant species that provide a diversity of flowering and seeding times, the availability of flaky bark and woody debris;
- maintain nest and roost boxes utilising the results from the bi- annual fauna monitoring reports;
- where necessary install species specific nest and roost boxes

The number and location of the nest / roost boxes in the BOA based on the results of the November 2015 fauna monitoring report (Forest Fauna Surveys Pty Ltd, 8 Feb 2016) are provided in Table 20. Details on the repair / replacement requirement will be undertaken in accordance with the findings of the bi -annual fauna monitoring.

Table 20 Nest Boxes installed across BOA – Nov 2015

Transect	BOA	Nest Style Type			Total Boxes
		Possum / Bird	Bat	Phascogale / Glider	
3	Northern	3	3	10	16
4	Northern	1	6	12	19
6	Northern	4	3	10	17
7	Southern	4	8	8	20
8	Bridgman	6	11	13	30
9	Martins Creek	7	-	-	7

Table 21 Habitat Augmentation Management Performance Criteria and Completion Criteria

Action	Year 1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Monitoring of nest boxes	Bi -annual monitoring program assesses usage and maintenance requirements	Bi -annual monitoring program assesses usage and maintenance requirements	Fauna monitoring is undertaken every three years	Fauna monitoring is undertaken every three years	Nest boxes in place and being monitored and maintained
	Photographic evidence of nest boxes and fencing is included in each monitoring report (when applicable).	Photographic evidence of nest boxes and fencing is included in each monitoring report (when applicable).	Photographic evidence of nest boxes and fencing is included in each monitoring report (when applicable).	Photographic evidence of nest boxes and fencing is included in each monitoring report (when applicable).	
Nest box maintenance	Replacement nest boxes will be selected based on species specific design and quality of construction	Replacement nest boxes will be selected based on species specific design and quality of construction	Replacement nest boxes will be selected based on species specific design and quality of construction	Replacement nest boxes will be selected based on species specific design and quality of construction	
	Repairs and replacement will be undertaken in accordance with the findings of the bi - annual fauna monitoring	Repairs and replacement will be undertaken in accordance with the findings of the bi- annual fauna monitoring	Repairs and replacement will be undertaken in accordance with the findings of the fauna monitoring	Repairs and replacement will be undertaken in accordance with the findings of the fauna monitoring	
	Maintenance works will be completed within eight weeks of receipt of the bi - annual fauna monitoring report	Maintenance works will be completed within eight weeks of receipt of the bi - annual fauna monitoring report	Maintenance works will be completed within eight weeks of receipt of the fauna monitoring report	Maintenance works will be completed within eight weeks of receipt of the fauna monitoring report	
Salvage and reuse suitable fauna habitat from cleared areas	Salvage and reuse to occur during the life of project as clearing occurs on the adjoining mine site				Maximum reuse of fauna habitat achieved Evidence and records of reuse kept

2.6.12 Revegetation and Rehabilitation

The following practical, sustainable, active (rather than passive) and cost effective revegetation measures are proposed as the basis of the revegetation and rehabilitation program. These measures are designed to target a program for the revegetation of a minimum of 87.2 ha of Central Hunter Ironbark-Spotted Gum-Grey Box Forest EEC.

The main revegetation steps will include:

- Species selection;
- Sowing rates and species proportions;
- Review of previously undertaken direct seeding and tubestock planting programs;
- Tube stock densities;
- Consideration of habitat augmentation;
- Seed pre-treatment requirements;
- Seed spreading and planting techniques;
- Soil amelioration and fertiliser requirements;
- Use of temporary cover crops to assist soil stabilisation;
- Protection from vertebrate pest species, domesticated stock and unauthorised access; and
- Maintenance requirements.

Table 18 provides further details on the species, the vegetation communities to which they align and the revegetation technique that is proposed.

Table 22 Revegetation and Regeneration Management Performance Criteria and Completion Criteria

Action	Y1 2018	Y3 2020	Y6 2023	Y9 2026	Completion Criteria
Map areas of where revegetation works have previously been undertaken	Completed				Completed
Monitor plant density and diversity in areas of previous revegetation		Completed			
Map areas of where revegetation works will be undertaken	Completed				Completed
Define which plant species will be introduced via seed and or tubestock and or from soil born seed resource	Completed				Completed
Location of patch planting sites are defined in the grassland based BOA's and recorded on site GIS	Completed				RCN GIS records show location of patch plantings
Undertake revegetation – direct seeding and tubestock planting using "patch" concept	50% completed	100% completed			Completed
Monitor revegetation "patches" for survival rates of tubestock and germination / survival rates of seed	Completed	Completed	Completed Vegetation cover and diversity trending towards Central Hunter Ironbark-Spotted Gum-Grey Box Forest		Vegetation cover and diversity reflects Central Hunter Ironbark-Spotted Gum-Grey Box Forest Patch plantings have > 80% success rate for all strata
Maintenance plantings are undertaken	Undertaken as required dependent on	Undertaken as required dependent on	Undertaken as required dependent on	Maintenance plantings are undertaken	

Action	Y1 2018	Y3 2020	Y6 2023	Y9 2026	Completion Criteria
	monitoring results	monitoring results	monitoring results		

2.6.12.1 Defoliation

To encourage the growth of native grasses and forbs in the and in turn the maintenance of structure and botanical composition of native grasslands some form of defoliation of grasses is required. This work will focus on the zones of Derived Grassland / Native Pasture and Cleared Land / Exotic Grassland. The main focus is to remove the excess herbage mass allowing for the colonisation of non-grass plant species in the inter tussock spaces. This defoliation may be undertaken by a range of techniques including grazing, mowing and burning. Once the fence lines have been installed and upgraded to ensure the control of cattle, recognising the timing of flower and seed set of the native grasses is to be avoided and with a knowledge of the carrying capacity and stocking rates of these area then grazing is to be implemented – ideally in late summer and autumn. Any cattle that are to be used for this purpose are to be rested prior to entry to the BOA to ensure that they are not vectors for the spread of weed seed via their manure.

Where grazing is not possible e.g. due to the potential presence of desired native grasses and or forbs or in areas where previous revegetation works have been completed, then selective mowing, slashing and harvesting of resultant grass material may be used as a management technique. Any windows of clippings are to be removed in doing so removing the risk that this material could smother/ shade out other plants.

2.6.12.2 Revegetation

Table 23 provides further details on the species, their relevance in terms of the revegetation program and the revegetation technique that are proposed. Due to recalcitrant nature of many of the ground and under storey species and the need to define the density and diversity of direct seeding and revegetation works previously undertaken, the revegetation technique has not been defined and the reintroduction of these species is dependent on the outcome of monitoring of previous works, the availability of adequate seed supplies and the ability of the species to be propagated by specialist native plant nurseries to tubestock.

Table 23 Revegetation Species Mix for Derived Grassland /Native Pasture and Cleared Land / Exotic Grassland

Species[3]	Category	Direct seeding	Tubestock
Ground and under storey			
Brachyscome multifida	Primary coloniser	x	
Brunoniella australis			x
Calotis cuneifolia	Primary coloniser	x	
Cheilanthes sieberi subsp. *seiberi*			x
Chrysocephalum apiculatum	Primary coloniser	x	
Cymbopogon refractus	Primary coloniser Shade tolerant Tussock forming	x	
Desmodium varians		x	
Dianella revoluta var. revoluta	Tussock forming		x
Dichondra repens		x	
Entolasia stricta	Shade tolerant	x	

[3] Based on NSW Scientific Committee – final determination http://www.environment.nsw.gov.au/determinations/centralhunterironbarkFD.htm (NSW Office of Environment and Heritage)

Species[3]	Category	Direct seeding	Tubestock
	Tussock forming		
Glycine clandestina	Nitrogen fixing shrubs/climbers	x	
Glycine tabacina	Nitrogen fixing shrubs/climbers	x	
Hypericum gramineum		?	?
Laxmannia gracilis			x
Lomandra multiflora subsp. *multiflora*	Tussock forming		x
Melichrus urceolatus	Specialist pollinator – parasitic wasp		?
Microlaena stipoides var. *stipoides*	Primary coloniser Shade tolerant Tussock forming	x	
Opercularia diphylla		?	?
Paspalidium distans	Primary coloniser	x	
Pomax umbellata	Primary coloniser		x
Pratia purpurascens	Shade tolerant		?
Solanum prinophyllum		?	
Stackhousia viminea	Specialist pollinators		? Division of clumps
Themeda australis	Primary coloniser	x	
Vemonia cinerea var. cinerea	Primary coloniser	?	
Wahlenbergia communis	Known to compete with exotic grass species	x	
Wahlenbergia gracilis		x	
Mid storey			
Acacia falcata	Small trees nitrogen fixing Primary coloniser	x	
Acacia parvipinnula	Small trees nitrogen fixing Primary coloniser	x	
Breynia oblongifolia		x	
Bursaria spinosa subsp. *spinosa*	Primary coloniser	x	
Daviesia ulicifolia subsp. *ulicifolia*	Primary coloniser Nitrogen fixing shrubs/climbers	x	
Echinopogon caespitosus var. *caespitosus*	Primary coloniser	x	
Eremophila debilis			x
Hakea sericea			x
Pultenaea spinosa	Small trees nitrogen fixing Primary coloniser	x	

Species[3]	Category	Direct seeding	Tubestock
Lissanthe strigosa	Specialist pollinator – parasitic wasp		?
Overstorey			
Allocasuarina luehmanii	Sub-dominant tall trees		x
Corymbia maculata	Dominant tall trees	x	x
Eucalyptus crebra	Dominant tall trees	x	x
Eucalyptus fibrosa	Dominant tall trees	x	x
Eucalyptus glaucina	Sub-dominant tall trees	x	x
Eucalyptus moluccana	Dominant tall trees	x	x
Eucalyptus tereticornis	Sub-dominant tall trees	x	x

The focus of the work for the grassland based plant communities is to enhance previous revegetation programs and to replicate to the greatest degree possible the entire range of plant types (including trees, shrubs, grasses and wildflowers) that grow in the ecosystems upon which these vegetation communities were initially derived i.e. the Central Hunter Ironbark – Spotted Gum – Grey Box Forest.

To optimise the use of tubestock material the plantings are to occur as either:

- enhancement plantings to the previously established direct seeded / planted strips; and
- to the patches across the landscape i.e. areas of 20m x 20m with a planting density of 5m for overstorey, 2m for mid storey and 1m for ground cover / understorey.

All tubestock is to be watered in on the day of planting using an average of 2 litres / plant.

The areas are to be delineated by e.g. the use of tree guards which may also assist in restricting predation by herbivores and also offering protection from frost and strong winds.

To enhance the biodiversity value of these patch planted areas they may be located across the landscape in proximity to habitat augmentation e.g. the placement of large woody debris and or rock material and the placement of previously harvested brush material.

2.6.12.3 Brush material

If this material that results for the cutting of grass and ground cover species is deemed weed free then it can be “harvested” and respread as a thin layer on areas to assist in enhancing localised seed loads. To avoid introducing weed seed from another site, mowing equipment should be reasonably clean of clippings and seed before use.

Brush material may also be harvested from lineal corridors e.g. powerlines, road verges or in association with clearing for the mining operations of RCN and the adjoining Rix’s creek mine where weed free stands of suitable species occur. This material is to be harvested post flowering to optimise the collection of fruit and encapsulated seed.

2.6.12.4 Fire

Fire may be a powerful tool in the management of native regenerating grasslands. However, as the BOA’s are located in comparatively close proximity to the town of Singleton, the use of large scale fire as a regeneration technique will not be used due to health concerns from the air born particulates that would result from the smoke.

However patch burning may be used in areas where exotic grass and or weed species have been previously controlled and there is an opportunity to encourage dormant soil born native seed. These fires would be limited to areas less than 200m^2. Fires should only be lit when the soil is reasonably moist and the temperature and wind conditions will allow the fire to be kept under control. This timing will also help managers comply with fire regulations and reduce the risk of wildfires. (Eddy, 2002). This work may be undertaken in consultation with the local Rural Fire Service (RFS) who are suitably qualified and competent in the activity.

Due to the risk of fire encouraging the germination of soil born seed of *Acacia saligna* the use of this technique would be limited to the Bridgman Road BOA and Northern BOA as these areas do not currently have *Acacia saligna*.

2.6.13 Weed management

All noxious weeds will be managed and controlled as per the requirements of the *Noxious Weeds Act 1993*. Control of weeds will be undertaken in direct consultation with the Local Land Services, Singleton Council and Upper Hunter Weeds Authority staff using a combination of mechanical, biological and chemical controls.

Particular attention will be paid to the control of African Olive (*Olea europaea* L *subsp cuspidate*) and Lantana (*Lantana camara*) across the site should it be recorded, and exotic native grasses especially Coolatai Grass *(Hyparrhenia hirta*), as the invasion of these species are listed as key threatening process to the Central Hunter Ironbark-Spotted Gum-Grey Box Forest under the *Threatened Species Conservation Act* 1995.

Whilst a number of environmental weeds have been recorded across the BOA's (refer 2.4.6.1) the majority are annual or biennial grasses or forbs which are not especially of concern as long as their populations are managed. These species will be managed by enhancing and maintaining a dense groundcover of native plants especially during late autumn and winter when many of the weed species are germinating and establishing.

The following mitigation measures will be used to mitigate the risk of introduction and subsequent spread of weeds:

- Livestock will be quarantined in yards etc. before entering the BOA;
- Vehicles will be cleaned and visually assessed for the presence of weed seed and propagules prior to entering the BOA;
- Soil or vegetative material will be assessed for the presence of weed seed and propagules prior to being used across the BOA; and
- Signage will notify site users of the ecological value of the area and remind all parties to consider biosecurity issues such as weed and disease control prior to entry.

Table 24 Weed Management Performance Criteria and Completion Criteria

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Management of *Acacia saligna* from BOA	Define extent of infestation	Implement control program in early spring when species is in flower	Follow up control program to eradicate remnant specimens	Monitor for presence of isolated plants and implement seasonal control	Remnant / residual *Acacia saligna* population in the BOA is readily managed by agistee
Control of *Casuarina glauca and C. leuhmannii*	Define distribution and density of both species in Bridgman, Martins Creek and Northern BOA	Both species are not used in revegetation programs Revegetation lists are enhanced with use of other preferred overstorey species			Vegetation density and diversity reflects that of target vegetation community
Review stem densities for BOA for *glauca*	2015 flora monitoring report reviewed	Trial thinning of canopy program of both	Vegetation density and diversity reflects		Vegetation density and diversity reflects

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
and C. leuhmannii	in context of potential for canopy thinning for C. *glauca and C. leuhmannii*	species in areas where stem density >2000stems / ha[4]	that of target vegetation community		that of target vegetation community
Weed control program for noxious and environmental weeds developed	Weed distribution and density recorded using site GIS Weed control program developed	Weed distribution and density updated using site GIS Weed control program reviewed and updated	Weed distribution and density updated using site GIS Weed control program reviewed and updated		Vegetation density and diversity reflects that of target vegetation community
Weed control program for noxious and environmental weeds developed implemented	Annual control program	Annual control program	Control program implemented	Control program implemented	

2.6.14 Vertebrate Pest Species

An annual feral animal management and control program will also be carried out across the BOA's. All work will be implemented in close liaison with the staff of the Local Land Services and in close communication with adjoining land users to ensure a coordinated approach to pest management.

Table 25 Vertebrate Pest Management Performance Criteria and Completion Criteria

Action	Y1 2018	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Monitoring of presence and impact of pest species	Bi -annual monitoring program as part of the fauna monitoring program and includes the use of remote sensing field cameras Stable or down-ward trend in population size		Monitoring program includes the use of remote sensing field cameras Stable or down-ward trend in population size		Monitoring reports completed Stable or down-ward trend in population size
Implementation of control program – includes report showing control measures used and take / capture rate	Annual baiting for Wild dog, Fox. Trapping for cats should they be recorded on site Baiting for rabbits/hares should they be recorded on site		Trapping for cats should they be recorded on site Baiting for rabbits/hares, wild Dogs and Foxes should they be recorded on site		All control events complete and reported

[4] Kerle ((Kerle, July 2005) contains useful background information on this process from throughout eastern Australia, while OEH & Parks Victoria (NSW Office of Environment and Heritage (Scientific Services, May 2012) describe the project design for ecological thinning of River Red Gum reserves which may be used as a model.

2.6.15 Bushfire Management

Bushfire risk is managed across the BOA's through ameliorative actions as well as management safeguards. Whilst the use of fire for weed control or to enhance flora diversity have been considered in the preparation of this BMP, it has been discounted due to the health issues that the resultant smoke may cause for the surrounding communities and from a safety perspective in terms of the proximity of the BOA's to ventilation shafts for underground mines.

Ameliorative actions:

- Ensuring site based activities that have the potential to cause ignition such as sparks from vehicles, are managed.
- Ensuring vegetation does not interfere with power lines.
- Undertake slashing along fence lines and road edges to assist in controlling fuel loads and enhancing these areas as potential fire breaks.

Management safeguards:

- The provision of firefighting equipment at RCN and RCS mine.
- Fire training for staff and on site fire-fighting team.
- Suppression of any bushfire outbreaks.
- Set up appropriate communication strategies to ensure all employees, contractors and service providers are aware of fire emergency policies and procedures as well as any NSW Rural Fire Services Fire Bans.
- Maintenance of appropriate fire breaks, access tracks and perimeter trails.

Table 26 Bushfire Management Performance Criteria and Completion Criteria

Action	Year 1 2018	Y2 2019	Y3 2020	Y 6 2023	Y9 2026	Completion Criteria
Vegetation is cleared to ensure it does not interfere with powerlines	Annual inspection Liaison with power supplier to ensure clearing works are undertaken					Powerlines are not a source for bushfire ignition
Slashing of fence lines and access tracks	Fence lines and tracks serve as a suitable fire break and access corridor					Tracks and fences provide safe access pathways
Staff trained in fire fighting	Annual training program					Competent and trained staff
Liaison with local Rural Fire Service	Annual meeting with local RFS					Local Bushfire Management Plan includes consideration of BOA fuel loads
Control – patch burns		Review flora monitoring report and relevance of patch burns in context of species density and distribution	Patch burns implemented if deemed warranted Report on patch burn			Use of patch burns defined as a practical and effective technique for enhancing derived grasslands

2.7 Flora and Fauna Monitoring

Regular monitoring of the BOAs will be undertaken to demonstrate whether the objectives of the offset strategy are being achieved. Monitoring will be conducted periodically by suitably skilled and qualified personnel at locations representative of the range of conditions in the BOAs. The monitoring can be separated into three types: Flora, Fauna and Rehabilitation Success.

Baseline surveys of the flora and fauna values within each BOA have been conducted ((Bell, March 2014) and (Forest Fauna Surveys Pty Ltd, 2012)) to enable data to be collected on each specific BOA and enable progress to be monitored appropriately. The baseline surveys have built upon the existing data collected annually as part of the threatened species monitoring. Upper Hunter Strategic Assessment process (in progress) may be able to provide this data, as the fieldwork will be undertaken in the BOA's utilising the BioBanking methodology, which is the methodology outlined below.

BOA's will be monitored to ensure long-term resilience and natural regeneration. Success will be based on the establishment and subsequent development of groundcover, mid-storey and canopy species. Revegetation and rehabilitation techniques will be continually developed and refined over the life of mine through an ongoing process of monitoring on the site and relevant industry experience elsewhere.

Annual reviews will be conducted during operations and post-closure of monitoring data to assess trends and monitoring program effectiveness. The Annual Review will also outline all management actions implemented within each BOA.

Monitoring of BOA monitoring sites and corresponding reference sites will comprise the survey of flora and vertebrates. Monitoring sites within the BOAs will be representative of each vegetation community in each management zone. Data derived from BOA monitoring sites will be compared with analogue sites. In order to provide analogue sites for each vegetation community sampled, reference sites will be established within the Habitat Management Zone of each BOA.

Table 27 and Table 29 present the biodiversity management monitoring completion criteria relating to BOAs as derived from previous monitoring programs. In order to determine progress towards, or achievement of the completion criteria, data from each monitored site will be compared with the benchmark data and trends analysed over the years for each site.

Table 27 Flora Monitoring Performance Criteria and Completion Criteria Per Habitat Management Zone

Habitat Management Zone (Remnant Forest)	Site	Performance Criteria for year 3 (Achievable PC to be updated after each 3 year revision of the BOMP until the benchmark for the target vegetation community is met)						Completion Criteria
		Species Diversity (total) Native (%) Weeds (%)	Canopy Age Basal area (cm^2) Mean DBH (cm)	Stem Density - Canopy (stems/ha) Woody shrubs (stems/ha) *Acacia* stems (stems/ha)	Weed Cover (mean %cover)	Leaf Litter cover (mean %cover)	Bare Ground (mean %cover)	
Bulloak (*Allocasuarina luehamnnii*),	INT01F	30 25 (83.3) 5 (16.7)	2982.17 6.80	5080 0 0	3.7	38.5	5.2	Benchmark for each of the six attributes (Derived from benchmark sites or vegetation database or local / regional benchmarks)
Swamp Oak (*Casuarina glauca*),	INT03F	26 21 (80.8) 5 (19.2)	9009.52 4.23	16600 40 0	0.6	84.0	0.7	Benchmark for each of the six attributes (Derived from benchmark sites or vegetation database or local / regional benchmarks)
Narrow –leaved Ironbark* (*Eucalyptus crebra*)	INT02F INT04F INT08F	35 29 (82.9) 6 (17.1)	4662.39 9.60	2173 1840 0	0.4	38.3	9.6	Benchmark for each of the six attributes (Derived from benchmark sites or vegetation database or local / regional benchmarks)
Spotted Gum	INT05F	55	8550.60	320	1.4	53.0	2.0	Benchmark for each of the six attributes (Derived from

Habitat Management Zone (Remnant Forest)	Site	Performance Criteria for year 3 (Achievable PC to be updated after each 3 year revision of the BOMP until the benchmark for the target vegetation community is met)						Completion Criteria
		Species Diversity (total) Native (%) Weeds (%)	Canopy Age Basal area (cm^2) Mean DBH (cm)	Stem Density - Canopy (stems/ha) Woody shrubs (stems/ha) *Acacia* stems (stems/ha)	Weed Cover (mean %cover)	Leaf Litter cover (mean %cover)	Bare Ground (mean %cover)	
(*Corymbia maculata-Eucalyptus fibrosa*),		50 (90.9) 5 (9.1)	25.46	2640 760				benchmark sites or vegetation database or local / regional benchmarks)
Grey Box (*Eucalyptus moluccana*),	INT06F	38 29 (76.3) 9 (23.7)	8054.99 24.19	480 1920 0	0.5	72.0	5.2	Benchmark for each of the six attributes (Derived from benchmark sites or vegetation database or local / regional benchmarks)
Apple (*Angophora floribunda*).	INT07F	44 34 (77.3) 10 (22.7)	6403.20 10.17	3680 40 0	0.4	82.5	0.5	Benchmark for each of the six attributes (Derived from benchmark sites or vegetation database or local / regional benchmarks)

* data averaged across three replicates.

Table 28 Flora Monitoring Performance Criteria and Completion Criteria Per Habitat Restoration Zone

Habitat Management Zone (Remnant Forest)	Performance Criteria for year 3 (Achievable PC to be updated after each 3 year revision of the BMP until the benchmark for the target vegetation community are achieved as per Table 27)						Completion Criteria
	Species Diversity (total) Native (%) Weeds (%)	Canopy Age Basal area (cm^2) Mean DBH (cm)	Stem Density - Canopy and Woody shrubs (stems/ha)	Weed Cover (mean %cover)	Leaf Litter cover (mean %cover)	Bare Ground (mean %cover)	
Planted Rehabilitation	15 10 (66) 5 (33)	To be defined in Year Y2020	500	15	65	20	Performance criteria to be reviewed Y3, Y5, Y9 with a focus on achieving the benchmarks as defined in Table 27
Derived Grassland/Native Pasture	25 20 (80) 5 (20)		1000	10	80	10	
Cleared Land/Exotic Grassland	25 15 (60) 10 (40)		500	20	70	10	

Table 29 Fauna and Specific Species Monitoring Performance Criteria and Completion Criteria

Specific species	Habitat Management Zone – (Remnant Woodland and Forest)	PC for year 3		Completion Criteria
		Bi-annual seasonal monitoring completed (Y/N)	Monitor and analyse trends in key species indicative of change	
Microbats	All	Yes	Yes	All bi-annual monitoring completed, trends identified and recommendations implemented.
Grey-headed Flying Fox	All	Yes	Yes	
Spotted-tailed Quoll	All	Yes	Yes	
Brush-tailed Phascogale	All	Yes	Yes	
Squirrel Glider	All	Yes	Yes	
Grey-crowned Babbler	All	Yes	Yes	
Specific species	**Habitat Restoration Zone (Planted Rehabilitation, Derived Grassland, Exotic Grassland)**	**PC for year 3**		**Completion Criteria**
		Bi-annual seasonal monitoring completed (Y/N)	**Monitor and analyse of habitat enhancement for key species**	
Microbats	All	Yes	Yes	All bi- annual monitoring completed, trends identified (e.g. reduction in weed density and distribution, increase in habitat, increased areas of preferred vegetation communities) and recommendations implemented.
Grey-headed Flying Fox	All	Yes	Yes	
Spotted-tailed Quoll	All	Yes	Yes	
Brush-tailed Phascogale	All	Yes	Yes	
Squirrel Glider	All	Yes	Yes	
Grey-crowned Babbler	All	Yes	Yes	

2.7.1 Flora

Flora monitoring will be undertaken in remnant and revegetated areas of the BOAs. The flora monitoring program which commenced in 2013 involves detailed quantitative site surveys the methods for which that exceed those noted in the Best Practice Guidelines (NSW Dept Planning & Infrastructure, Jan 2014) for flora monitoring, and also improve on data collection techniques for BioBanking (Eastcoast Flora Survey for Interga Coal Operations Pty Ltd, Feb 2016). Full details are provided in the February 2015 flora monitoring report (Eastcoast Flora Survey for Interga Coal Operations Pty Ltd, Feb 2016) a copy of the relevant sections provided in Appendix A, a summary follows.

- In 2013 permanent monitoring 50m transects-pairs were established in Management Units – Remnant Forest and Grassland;
- At each survey location, two 50m transects ('transect-pairs') were positioned end-to-end across the boundary of selected remnant and grassland areas, so that each transect lay entirely within remnant forest or regenerating grassland;
- Each transect comprised ten quadrats 5x5m in size, positioned along alternative sides of the 50m transect Within each quadrat, data on species diversity, age and structure of the canopy and shrub strata, and canopy frequency and girth is collected. A schematic representation of the transect layout for vegetation monitoring is provided in Figure 7;

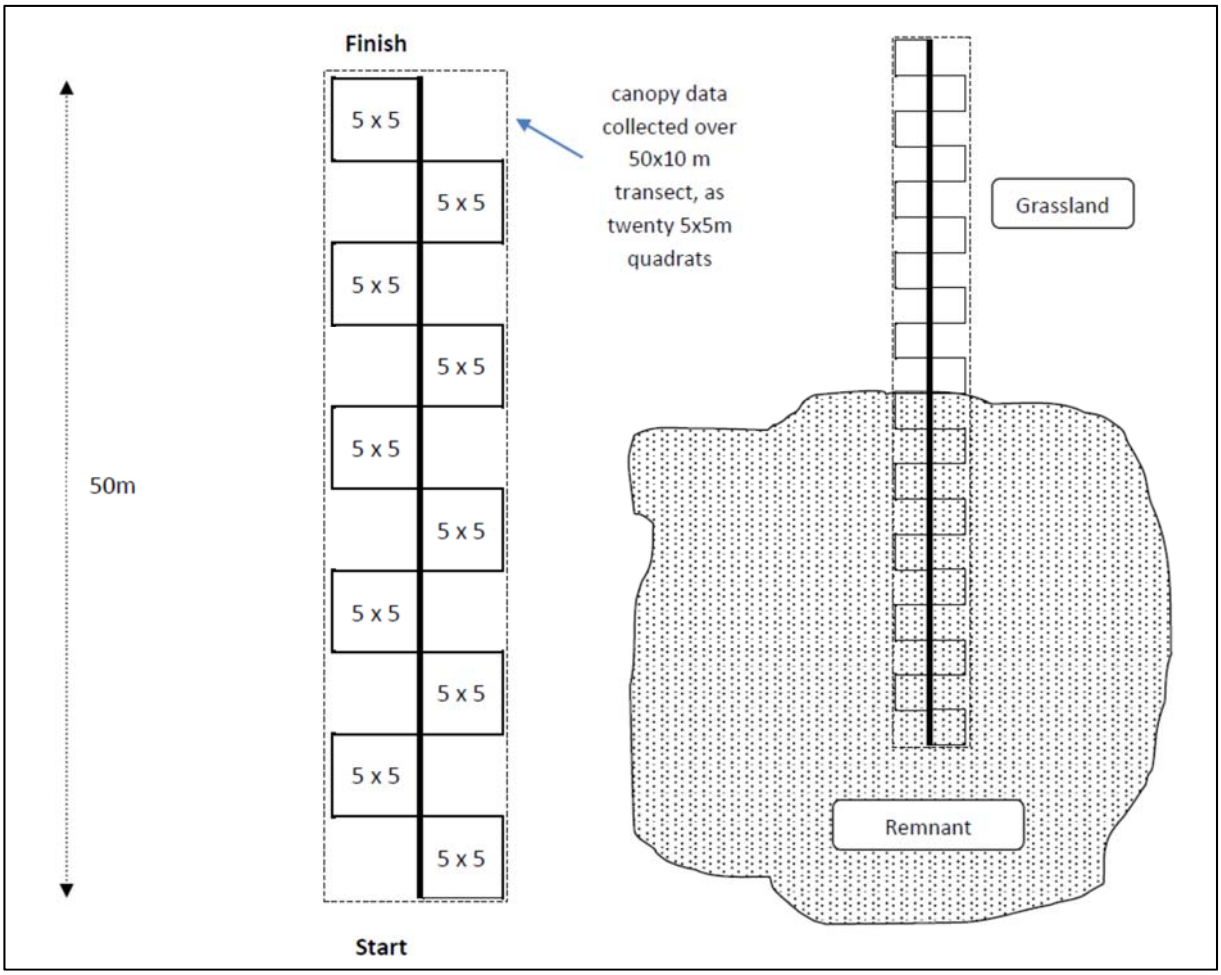

Figure 7 Schematic representation of the transect layout for vegetation monitoring

Ref: Figure 3 (Eastcoast Flora Survey for Interga Coal Operations Pty Ltd, Feb 2016)

- Details are collected on:
  - species composition including weeds – management units;

- species composition including weeds – regenerating grassland;
- canopy composition and structure (undertaken every three years for all 5x5m quadrats per 50m transect), including basal area;
- shrub composition and structure, including shrub diversity, density, *Acacia* species density;
- leaf litter and bare ground;
- quantitative assessment of the success of rehabilitation including germination rates;
- comparison of annual data against previous year's results;
- transect start and end positions are marked by GPS and metal star pickets;
- quadrat corners are marked;
- photographic record of the transect

2.7.2 Fauna

Fauna monitoring will build on surveys currently undertaken and as described in *2015 Fauna Monitoring Report* (Forest Fauna Surveys Pty Ltd, 8 Feb 2016). Monitoring will occur at the same time as flora monitoring (Spring-Summer or as appropriate), and will utilise permanent monitoring locations designated in the plan. The fauna surveys will incorporate the following:

Elements to be Monitored	Monitoring Frequency
Inspection and observation of hollow-bearing trees or nesting boxes for use by Brush-tailed Phascogales and Squirrel Glider or honey-bees;	Bi –annually (2018 and 2020) for the three years of the BMP then every three years.
Diurnal and nocturnal surveys along designated transects for threatened and protected species	
Monitoring of feral animals by use of remote infra-red cameras, presence of impact / damage, sightings and scats	
Comprehensive survey for all fauna groups	

Figure 8 Flora and Fauna Monitoring Sites

N
W
E
S

Glennies Creek

Reedy Creek

Northern BOA

Bridgeman BOA

Falbrook Pit

Stoney Creek

Southern BOA

CHPP

Martin's Creek BOA

Martin's Creek

Blackwall Creek

0

1 km

LEGEND

- Bat Nest Box
- Glider Nest Box
- Possum Nest Box
- Flora Transect - Forest
- Flora Transect - Grassland
- Fauna Transects
- Creek
- Project Area
- Mining Lease Boundary
- Bull Oak Forests of the Central Hunter Valley
- Cleared Land / Exotic Grassland
- Derived Grassland
- Grey Ironbark - Spotted Gum - Grey Box open forest on hills of the Hunter Valley, Sydney Basin
- Planted Rehabiltation
- Swamp Oak Forest - Central Hunter Valley, Sydney Basin

RIXS CREEK PTY LTD

FIGURE 8. FLORA and FAUNA MONITORING SITES

SCALE 1 : 15,000 (A3)

DATE: 7/7/2016

FILE: Integra 5 / BOA Monitoirng Site

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3.0 BOMP Implementation Costs and Conservation Bond

The purpose of this bond is to cover the cost of the management of land required to be set aside as an offset area, should the mine consent holder be unable or unwilling to continue management of the land. This Bond should be calculated generally in accordance with the requirements of the relevant approval condition. The qualification/experience of the personnel to complete the Bond calculation is to be to the satisfaction of the Director-General.

The Conservation Bond value is based on all the activities identified in the approved Biodiversity Offset Management Plan, for a period of three years, being the life of the plan. At the end of the three years, the Conservation Bond value is to be reviewed, with a revised costing provided to the Department of Planning and Infrastructure for review.

A check list and calculation template that includes all of the land management strategies, monitoring and reporting requirements as well as other miscellaneous costs consistent with these best practice guidelines is provided at Appendix B.

In addition to the specific costs identified in this Management Plan, the following expense allowances have been added.

- Monitoring costs if not included in the management plan;
- Mobilisation costs;
- Other miscellaneous cost including council rates, electricity and insurances;
- Project management costs (add 10% to the sub total); and
- Contingency (add 10% to the sub total).

4.0 Reporting and Documentation Requirements

4.1.1 Mining Operations Management System

The ongoing effectiveness and efficiency of the site Mining Operations Management System (MOMS) is monitored as part of the operation's day-to-day management. Feedback from this and other more formal reviews and/ or following special occurrences, form the basis for System improvement and re-design.

In general the MOMS is reviewed and up-dated as follows:

- Every three years; or
- Whenever there is a significant change to relevant legislation; or
- If required to do so by the Regulations; or
- Whenever there is a significant change to the operations; or
- If required (in writing) to do so by a person delegated by a regulatory authority under which the mine operates; or
- Whenever control measures are found to be ineffective either through:
- Changes to the working environment; or
- Changes to operating systems; or
- Subsequent risk assessments; or
- The findings of an audit; or
- Following a fatality or dangerous incident that could reasonably have been expected to result in a fatality; or
- Following an assessment of a related safety alert.

Continual Improvement

Operational activities will be subject to regular review to ensure conformance with commitments made in the MOMS and subordinate plans and strategies.

Document Management

Copies of this document will be managed under the Group Document Management System. This document and other relevant documents are kept on site and are available to all employees.

4.1.2 Annual Review

The Bloomfield Group prepares an Annual Review (AR) as part of the Department of Primary Industries – Mineral Resources' Mining, Rehabilitation and Environmental Management Process framework. This report compiles monitoring results and discusses trends, system changes and responses to any potential issues identified during monitoring. Targets and future initiatives are also identified.

As required by its Development Consent, The Bloomfield Group will undertake an Annual Review of the environmental performance of the Project, which is reported in the AR. This review will include:

- Description of the works that were carried out during the previous calendar year, and the works that are proposed to be carried out over the current calendar year;
- A comprehensive review of the monitoring results of the Project over the previous calendar year, which includes a comparison of these results against the:
    - relevant statutory requirements, limits or performance measures/criteria;
    - monitoring results of previous years; and
    - relevant predictions in the Environmental Assessments;
- Identification of any non-compliance over the previous calendar year, and description of actions which were (or are being) taken to ensure compliance;
- Identification of any trends in the monitoring data over the life of the project;

- Identification of any discrepancies between the predicted and actual impacts of the Project, and analysis of discrepancies;
- Identification of the potential cause of any significant discrepancies; and
- Description of measures which will be implemented over the current calendar year to improve the environmental performance of the project.

Table 30 provides details on the reporting/recording requirements documentation that is to be provided linked to the management strategies as defined in this BMP and which form an integral part of the Rix's Creek Mine MOMS. These reports or records are to be summarised and/or appendixes in the AR.

Table 30 BMP Reporting and Recording – Indicators and Criteria

Indicator	Frequency	Criteria	Document as per RCN MOMS
BOA inspections	Quarterly	At the end of the three years, the Conservation Bond value is to be reviewed, with a revised costing provided to the Department for review	BOA Inspection Protocol
Seed collection	Seasonally	Record all seed collected, species, quantities, dates and areas as per the seed collection protocols	Report from seed merchant to include: - species - amount collected - area collected from - date of collection
Weed control	Annually	Department of Primary Industries – Mineral Resources' Mining, Rehabilitation and Environmental Management Process framework	Annual Review report
	Daily	In accordance with reporting requirements of the *Pesticide Act*.	Weed control field sheet
Vertebrate pest control	Annually	Department of Primary Industries – Mineral Resources' Mining, Rehabilitation and Environmental Management Process framework	Annual Review report
	Daily	In accordance with reporting requirements of the *Pesticide Act*.	Vertebrate pest control field sheet
Flora monitoring	Bi –annually (2018 and 2020) for the three years of the BMP then every three years.	Report that compiles and analyses results of flora monitoring and to compare against performance criteria	Flora monitoring report
Fauna monitoring	Bi –annually (2018 and 2020) for the three years of the BMP then every three years.	Report that compiles and analyses results of fauna monitoring and to compare against performance criteria	Fauna monitoring report

4.2 BMP Review and Process Improvement

The BMP incorporates the requirements of the Project Approval_08_0101 and 08_0102 dated 24 Feb 2016 Schedule 5 Condition 4 that addresses the requirements for then revision of Strategies, Plans and Programs. These requirements follow:

Within 3 months of:

(a) the submission of an annual review under Condition 3 above;

(b) the submission of an incident report under Condition 6 below;

(c) the submission of an audit report under Condition 8 below, or

(d) any modification of the conditions of this approval (unless the conditions require otherwise), the Proponent shall review, and if necessary revise, the strategies, plans, and programs required under this approval to the satisfaction of the Secretary.

Note: This is to ensure the strategies, plans and programs are updated on a regular basis, and incorporate any recommended measures to improve the environmental performance of the projects.

5.0 Bibliography

AECOM on behalf of Rix's Creek Mine. (2015). *Rehabilitation Strategy.*

Bell, S. (March 2014). *2013 Flora Monitoring at Integra Mine Biodiversity Offset Areas, Singleton LGA.* Eastcoast Flora Survey.

Bloomfield Company Ltd. (2011). *Mining Operations (Rix's Creek Mine) – Water Management Plan, Site Water Management Plan Ver 2- 091111 Rix's.*

Bloomfield Group. (Oct 2012). *Land Disturbance Management Procedure.*

Commonwealth of Australia. (n.d.). *Mine Closure and Completion – Leading Practice Sustainable Development Program for the Mining Industry .*

DECC. (2008). *Managing urban stormwater – soils and construction, Volume 2E Mines and Quarries.*

Eastcoast Flora Survey for Interga Coal Operations Pty Ltd. (Feb 2016). *Flora Monitoring at Interga Mine Biodvierity Offset Areas, Singleton LGA- 2015 Results.*

Eddy, D. (2002). *Managing native grassland; a guide to management for conservation, production and landscape protection.* Sydney: WWF Australia.

EMGA Mitchell McLennan - prepared for Integra Coal Operation Pty Limited. (21 September 2012). *Integra Mine Complex Modification 2 Environmental Assessment.*

EMM prepared for Integra Coal Operations Pty Ltd. (May 2014). *Integra Mine Complex Modification 4 - Environmental Assessment.*

Forest Fauna Surveys Pty Ltd. (2012). *Integra Coal North Open Cut Threatened Species Monitoring Report 2012.* Prepared for Integra Coal.

Forest Fauna Surveys Pty Ltd. (8 Feb 2016). *Fauna Monitoring - report to Integra Coal Operations.*

ID, L. (1998). Allocasuarina (Casuarinaceae) invasion of an unburnt coastal woodland at Ocean Grove,. *Allocasuarina (Casuarinaceae) invasion of an unburnt coastal woodland at Ocean Grove,*, 649-656.

Integra Coal Operations (Vale). (2013). *Environmental Management System, Biodiversity Management Plan.* Report prepared by the Environment and Community Advisor for Integra Coal Operations Pty Ltd.

Integra Coal Operations. (11 Oct. 2012). *Stage 2 Non Aboriginal Heritage Management Plan.*

Integra Coal Operations. (4 June 2012). *Aboriginal Heritage Management Plan Integra Open Cut Project.*

Integra Coal Operations Pty Ltd. (14 Nov 2014). *Biodiversity Management Plan.*

Integra Coal Operations Pty Ltd. (4 June 2012). *Rehabilitation Management Plan 2012-2015.*

JP Environmental. (2010). *Erosion and Sediment Control Plan.*

Kerle, J. (July 2005). *Collation and review of stem density data and thinning prescriptions for the vegetation.* Report prepared for Department of Environment and Conservation.

Landcom. (2004). *Managing urban stormwater – soils and construction, Volume 1, 4th edition.*

Nichol, O. (2005). *Development of rehabilitation completion criteria for native ecosystem establishment of minerla mines in the Hunter Valley.* ACARP projectNo C13048.

NSW Dept of Climate and Conservation. (2008b). *Chytrid fungus: Hygiene protocol for the control of disease in frogs .*

NSW Dept of Primary Industries. (2011 - 6th edition). *Noxious and environmental weed control handbook - a guide to weed control in non-crop, aquatic and bushland situations.*

NSW Dept Planning & Infrastructure. (15 Jan 2013). *Integra Mine Modification - Recommendation -Overland Conveyor, Biodiversity Offsets Security and.*

NSW Dept Planning & Infrastructure. (Jan 2014). *Hunter Valley Coal Mines - Best Practice Guidelines for Biodiversity Offset Management Plans .*

NSW Dept Primary Industries. (2010). *Myrtle Rust: Myrtle Rust - Uredo rangelii Prime fact 1017.*

NSW Dept. Planning & Infrastructure. (Jan 2014). *Hunter Valley Coal Mines Best Practice Guidelines for Biodiversity Offset Management Plans.*

NSW Office of Environment & Heritage. (Oct 2012). *The Land and Soil Capability Assessment Scheme - 2nd Approximation.* Sydney.

NSW Office of Environment and Heritage (Scientific Services. (May 2012). *Ecological thinning trial in NSW and Victorian River Red Gum Reserves.*

NSW Office of Environment and Heritage. (n.d.). *http://www.environment.nsw.gov.au/determinations/centralhunterironbarkFD.htm*. Retrieved March 3, 2016

NSW Planning and Assessment Report . (16 Nov 2015). *Integra Mining Complex Biodiversity Offset Strategy Modification.*

Rixs Creek North. (3 Feb 2016). *Waste Management Plan 2016-2018.*

Royal Botanic Ggardens. (2011). *-Phytophthora: Phytophthora dieback – fact sheet .*

The Bloomfield Group - Rixs Creek North. (15 Feb 2016). *Water Management Plan 2016- 2019 Vol 1 - Main Document.*

Appendix A

Flora Monitoring Methodology

Appendix A Flora Monitoring Methodology

To be inserted in final PDF version of the BMP

2016

Flora Monitoring at Integra Mine Biodiversity Offset Areas, Singleton LGA: 2015 Results

February 2016

Report to

Integra Coal Operations Pty Ltd

Stephen A.J. Bell

Eastcoast Flora Survey
PO Box 216
Kotara Fair NSW 2289

Report produced by:

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Cover image: Black Slug Moth caterpillars (*Doratifera casta*) on *Eucalyptus crebra* in INT08F.

Report produced for:

Integra Coal Operations Pty Ltd
VALE Australia
653 Bridgeman Road
Singleton NSW 2333

Project Manager: Chris Quinn (Environment & Community Advisor)

Executive Summary

A third year of flora monitoring has been undertaken across six Biodiversity Offset Areas (BOAs) within the Integra Coal Complex, located 12km north of Singleton in the upper Hunter Valley of New South Wales. These six offset properties (Bridgeman, Martins Creek, Northern, Southern, Supplementary, Western), totaling 574ha, were established to offset land disturbances associated with the Integra Surface Operations. Much of the land comprising the BOAs supports remnant stands of the *Central Hunter Ironbark - Spotted Gum - Grey Box Forest* Endangered Ecological Community, and grasslands derived from it. This report presents the findings of monitoring undertaken during Spring 2015, which have been compared with previous data collected in 2013 and 2014.

Sixteen permanently marked transects of 50m length, incorporating 160 quadrats of 25m^2, were re-sampled as eight 100m *transect-pairs* (2 x 50m transects) within six key management units (vegetation types): Bulloak (*Allocasuarina luehamnnii*), Ironbark (*Eucalyptus crebra*), Swamp Oak (*Casuarina glauca*), Spotted Gum (*Corymbia maculata - Eucalyptus fibrosa*), Grey Box (*Eucalyptus moluccana*), and Apple (*Angophora floribunda*). Each transect-pair spans a recognizable *Remnant Forest-Grassland* boundary, and has been used to collect quantitative data on species diversity, weed prevalence and distribution, canopy and shrub composition, canopy and shrub structure, and ground cover attributes within both Remnant Forest and Grassland.

Based on transect data, the following key points summarise changes in floristics and structure since the 2013 monitoring period (for detailed metrics see **Table 6** and **Table 7** in Section 5.1):

- overall species diversity has increased across all MUs, although in some this is a result of increased herbaceous and grass weed species;
- basal area of canopy species has varied across all MUs, some increasing and some decreasing. Grassland (Ironbark) and Grassland (Spotted Gum) have shown an increase due to ongoing seedling and sapling growth;
- mean DBH of canopy species has also been variable across MUs, the majority have experienced slight decreases;
- canopy stem density has decreased or remained stable for most MUs, possibly due to mortality of seedlings due to dry conditions. Some Grassland MUs have shown increases where canopy species are beginning to colonise grassland areas after removal of cattle grazing pressure. A single canopy seedling within the Grassland (Grey Box) MU has commenced the grassland recolonization of this MU;
- woody shrub density has shown a decrease across many MUs, and the density of *Acacia* stems has also decreased to 2013 levels in the Spotted Gum MU (the only Forest MU yet to support this genus). *Acacia* has also shown a dramatic increase in Grassland (Ironbark), and a smaller increase in Grassland (Spotted Gum);
- estimated weed cover remained more-or-less stable for all Forest MUs, with the exception of the Grey Box MU which showed a significant increase. Weed cover increased for most Grassland MUs, with others showing a decrease. Nearly all weed species are herbaceous in nature, and would have previously been controlled through grazing by cattle under earlier management;

- estimated leaf litter cover remained stable or experienced slight increases or decreases for all MUs;
- estimated bare ground remained relatively insignificant across most MUs, with the greatest change being reductions in the Bulloak and Ironbark MUs. This is probably in response to increased litter or grass growth.

Management Issues arising from the 2015 monitoring include:

- the few locations noted where Coolatai Grass (*Hyparrhenia hirta)* occurs (within the Martins Creek, Supplementary and Western BOAs) should be continually monitored and controlled prior to its spread throughout the grassland areas of all BOAs. Continued invasion by Coolatai Grass will adversely impact on the EECs conserved within the BOAs.
- eradication of Golden Wreath Wattle (*Acacia saligna*) be undertaken as soon as possible, prior to it becoming established as monospecific stands which will accrue a sizeable seed bank in the soil.
- consideration be given to undertaking an ecological thinning trial of remnant vegetation, in an area where regrowth Ironbark (*Eucalyptus crebra*) is returning at high densities (>2000 stems/ha, well above the 30-40 mature stems/ha that once occurred). This need not cover a large area, and would require appropriate approval from planning authorities, together with a detailed implementation and monitoring plan to document ongoing regeneration. Thinning of the developing canopy, together with a controlled ecological burn, will encourage the return of mid-story vegetation that is lacking in these stands.
- consideration also be given to the trial clearing and burning of areas of Swamp Oak (*Casuarina glauca*) forest, prior to it quickly smothering all regenerating grasslands within the BOAs. This is a Central Hunter Valley-wide problem, and its rapid spread is an ongoing threat to the integrity of all Central Hunter EECs. Replacement of this species with appropriate planting of eucalypt canopy species will be required, together with implementation of an ongoing fire management plan to curtail *Casuarina* growth.
- careful monitoring is also required of Bulloak (*Allocasuarina luehmannii*) stands, as this species too can rapidly colonise open areas in the absence of grazing. Some ecological thinning may be required of these stands in the future.
- in relation to operational methods for the flora monitoring program, it is proposed that canopy structure monitoring be altered to a triannual process, rather than the annual assessments that are currently undertaken. After three years of annual monitoring of canopy structure (2013-2015), sensible interpretation of collected data is limited, and would be more beneficial if monitoring events were spread over longer time periods. As part of this proposed revision, assessment of canopy structure should occur over all twenty 5x5m quadrats per 50m transect (as was done in 2015), rather than the ten assessed in 2013 and 2014. All other monitoring methods should remain the same for annual comparisons.

Table of Contents

1. Background

Integra Coal Operations Pty Ltd (ICO) has approval to mine at the Integra Underground and Integra Open Cut operations at Glennies Creek, approximately 12 km north-west of Singleton. The project was approved by the New South Wales Minister for Planning on 26 November 2010 under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) subject to a number of Project Approval conditions. Key among these was the preparation of a Biodiversity Management Plan (BMP) to detail the implementation, management, risks, performance and completion criteria, monitoring, and roles and responsibilities relating to impacts on biodiversity of the project.

The Biodiversity Management Plan specifies that regular monitoring of designated Biodiversity Offset Areas (BOA) be undertaken to demonstrate that the objectives of the offset strategy are being met (Integra Coal Operations Pty Ltd 2013). Principally, the BOAs are to be monitored to ensure long-term resilience and natural regeneration, with success based on the establishment and subsequent development of groundcover, mid-storey and canopy species. As a minimum, flora monitoring is to incorporate:

- quantitative assessment of the structural composition of vegetation;
- qualitative assessment of habitat quality, including the availability and variety of food sources and shelter;
- quantitative assessment of weed abundance and distribution;
- qualitative assessment of the success of rehabilitation including germination rates;
- comparison of annual data against previous year's results; and
- photographic monitoring of regeneration success.

As no areas of rehabilitated lands are the subject of the current monitoring program, some elements of the above are not applicable.

Monitoring of vegetation within designated BOAs commenced in Spring 2013 (Bell 2014), and was repeated in Spring 2014 (Bell 2015). The third year of monitoring was undertaken in Spring 2015, and this current report summarises the results obtained during that period.

2. Study Area

The offset strategy for the Integra Coal Complex incorporates the establishment and management of six BOAs, all of which are the subject of flora monitoring:

- **Northern BOA** - 117ha between Stony Creek Road, Glennies Creek, Thomas Lane, Bridgman BOA and the Supplementary BOA.
- **Southern BOA** - 38ha between Stony Creek Road and current or former open cut mine areas.
- **Western BOA** - 92ha between Stony Creek and Middle Falbrook Roads, Possum Skin Dam and current or former mines areas.

- **Supplementary BOA** - 33ha between Glennies Creek, Stony Creek Road, Middle Falbrook Road and the Northern BOA.
- **Bridgeman BOA** - 87ha between Thomas Lane, Stony Creek Road, the Northern BOA and adjacent private lands.
- **Martins Creek BOA** - 207ha between Bridgeman Road and lands owned by Integra Coal Operations.

All BOAs are former grazing properties with varying amounts of remnant vegetation and regenerating woodlands. Cunningham (2010) has described and mapped the vegetation communities present within the BOAs, which includes (in decreasing areal extent) Tussock Grassland, Narrow-leaf Ironbark - Spotted Gum - Forest Redgum Woodland, Regenerating Native Woodland/ Shrubland, Swamp Oak Forest, Bull Oak Forest, River Oak Forest, and Disturbed Land. The BMP describes each of these communities in further detail.

Figure 1 shows the location of all six BOAs, lying approximately 10km north of Singleton.

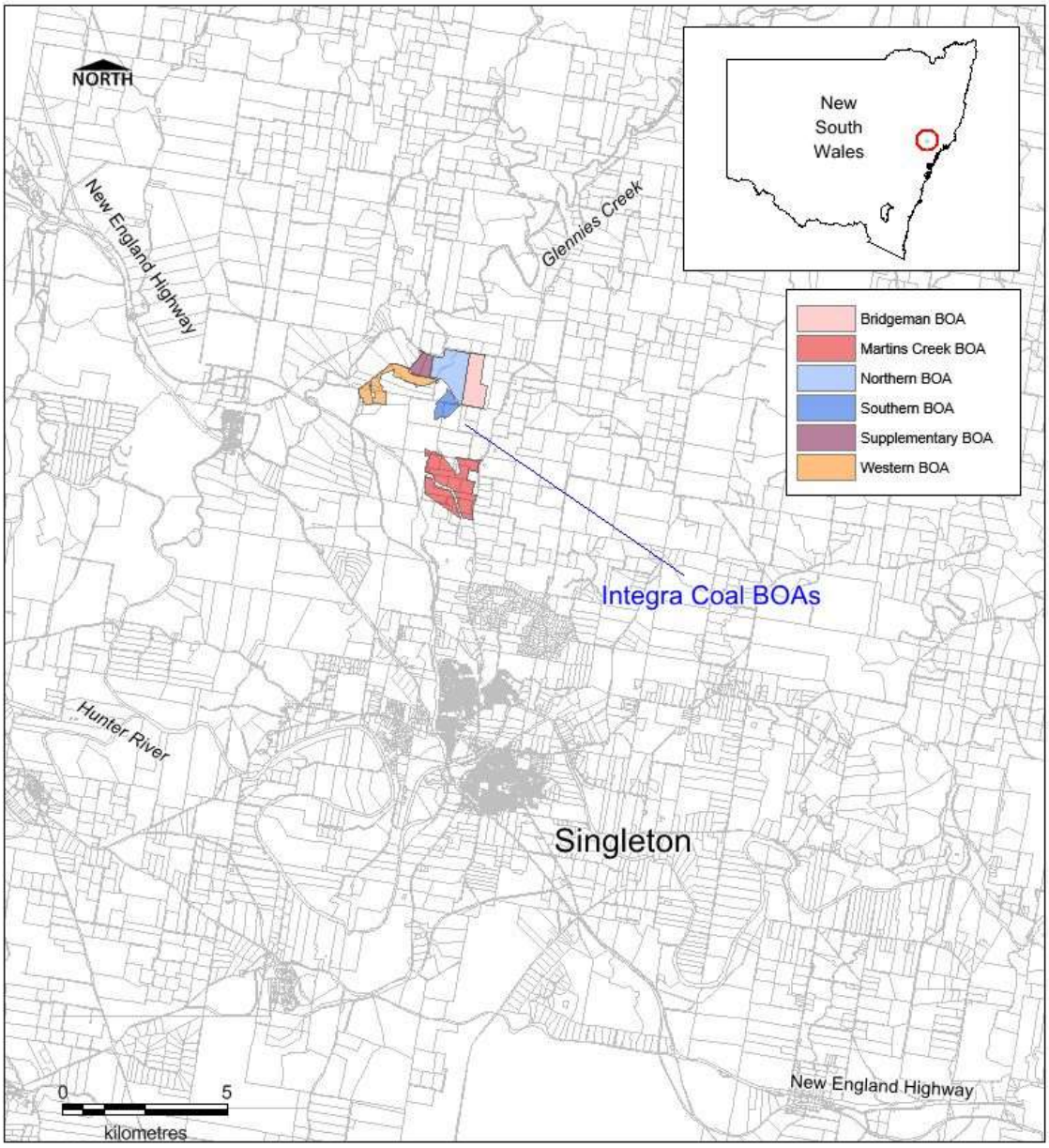


Figure 1 Location of Integral Coal Biodiversity Offset Areas (BOAs).

3. Methods

At the commencement of the 2013 monitoring program, the draft BMP did not specify particular methods for flora monitoring of offset lands. Consequently, those methods adopted for Integra were based on previous experiences of the author at other similar sites in the Hunter Valley. Much of the flora monitoring methods are based on that presented in Bell (2013), which outlines a strategy to improve the quality of data collected and analysed as part of revegetation and offset strategies in the Hunter Valley coal mining industry. By collecting more quantitative data, restoration and regeneration can be assessed scientifically and management issues addressed accordingly.

The six assessment criteria for flora monitoring (listed in the BMP, and reproduced in Section 1 of this report) indicate what information is required from monitoring, but there is little guidance on how that information is to be obtained. The revised final draft BMP now includes specification that monitoring adopt the NSW Governments BioBanking methods as a minimum. The Department of Planning and Infrastructure (2014) released a draft document entitled *Best Practice Guidelines for Biodiversity Offset Management Plans* for the Hunter Valley coal industry. In this document it is stated that "*flora monitoring may include the use of methods such as vegetation structure profiles, full floristic surveys using cover abundance scores (e.g. Braun-Blanquet), Biometric based surveys and photo monitoring*". Clearly, the methods used for the monitoring of vegetation in offset areas have been left to individual mining companies and their consultants to determine.

For the Integra BOAs, the methods established in 2013 target the collection of quantitative baseline data from representative areas to allow rigorous data analysis over coming years. Such methods exceed those noted in the Best Practice Guidelines for flora monitoring, and also improve on data collection techniques for BioBanking. The same methods are currently employed in monitoring works on Glencore lands elsewhere.

3.1 Survey Timing & Rainfall

Field work was undertaken primarily during mid November 2015. For grassy woodland and grassland environments, the Spring period is generally accepted as being the most appropriate for detecting maximum species diversity, provided adequate rainfall has been received in the weeks and months prior to survey. For the two months preceding all monitoring events conducted to date (2013-2015), the Singleton district has received below average rainfall (**Figure 2**), with the November-December period being particularly variable. Prior to the 2015 monitoring, the month of August received above average rainfall, however prior to that the Winter was generally dry, similar to 2014. The consequence of this overwhelmingly dry May to November is that the emergence of annual plants, and the flowering of all species (commonly needed for identification), may be affected. A significantly wet April 2015 is evident, however it is unlikely that this period of high soil moisture would have influenced emergence of herbs, forbs and grasses during November.

3.2 Site Selection

Monitoring of vegetation was assessed through the establishment in 2013 of permanent 50m *transect-pairs* (described further below) in Management Units (MUs) ('Remnant Forest' & 'Grassland') within representative areas of vegetation as described by Cunningham (2010). Transect locations were selected following a thorough reconnaissance of BOAs to ascertain the distribution of the main vegetation communities present. The mapping of Cunningham (2010) was used as a guide in this process, but final transect locations were chosen based on consistency of floristic communities, size and proportion of remnant forest stands and their proximity to neighbouring stands, and the likely original composition (parent community) of grassland areas.

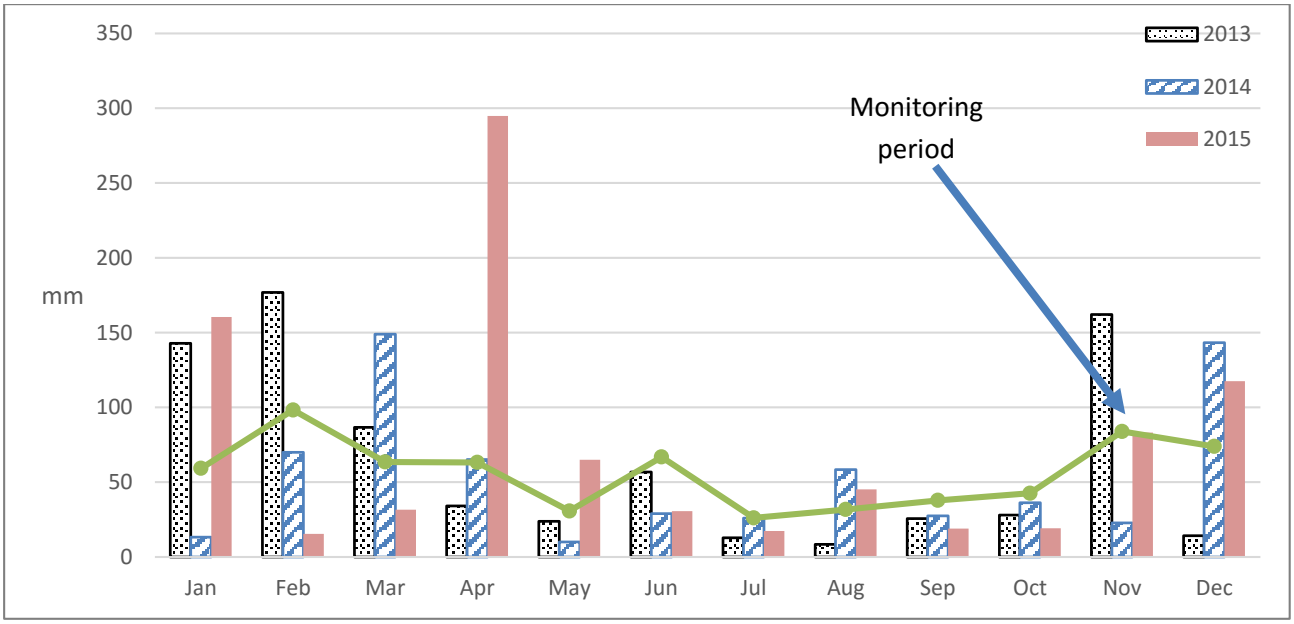


Figure 2 Actual and mean rainfall received for the Singleton Sewerage Treatment Plant, 2013 to 2015 (Bureau of Meteorology 2016).

At each survey location, two 50m transects (‘*transect-pairs’*) were positioned end-to-end across the boundary of selected remnant and grassland areas, so that each transect lay entirely within remnant forest or regenerating grassland. For 2013 and 2014 monitoring, each transect comprised ten quadrats 5x5m in size, positioned along alternative sides of the 50m transect (**Figure 3**). Within each quadrat, data on species diversity, age and structure of the canopy and shrub strata was collected (**Table 1**). In effect, pairs of 50m transects (ie: 100m transects of 20 quadrats) were positioned end-to-end across grassland-remnant boundaries so that regeneration progress (among other attributes) can be tracked over successive monitoring seasons. Each 50m transect collected quantitative data over a 250m^2 area, or 0.025ha; each 100m transect-pair collected the same data over 500m^2 or 0.05ha.

A slight amendment was made during the 2015 monitoring period to capture additional canopy structural data along these transects, as it was recognised that earlier monitoring was collecting only limited amounts of canopy data in some management units. This amendment meant that data on canopy frequency and girth was collected across twenty 5x5m quadrats along each 50m transect (10 either side of the transect, covering 500m^2), rather than the ten previously assessed. This additional data was collected in such a way that comparison could still be made with 2013 and 2014 data, but it is proposed that future monitoring use the extended canopy datasets across 500m^2 (see Section 5.3). It is also proposed that the collection of structural data be undertaken every three years, rather than annually, as effort extended in annual assessments is not reflected in the results obtained. Despite this change in canopy data collection, all other monitoring remained the same.

Eight transect-pairs within regenerating grassland and remnant areas were established in 2013, incorporating 160 quadrats of floristic and structural data (320 quadrats for canopy data from 2015). In total, this equates to detailed quantitative data collection over 4000m^2 or 0.4ha (8000m^2 or 0.8ha for canopy data from 2015). In future, Integra may wish to install additional transect-pairs or individual transects in other representative areas to provide further replication in monitoring.

Table 1 Strategy for monitoring of offset vegetation at Integra.

Activity	Attribute Measured
1. Descriptive	• general description of vegetation • general observations of problem areas or evidence of key or significant species
2. Quadrats (5m x 5m)	• positioned alternately along a 50m transect (**Figure 3**) • count the number & record identity of all species, including grass • count the number of stems of all woody shrubs, recording wattles separately • count the number of stems of all tree species • measure DBH all trees >1.6m high • estimate percentage cover of bare ground & litter; weed species
3. Photography	• photograph transects & quadrats; other areas of interest requiring attention

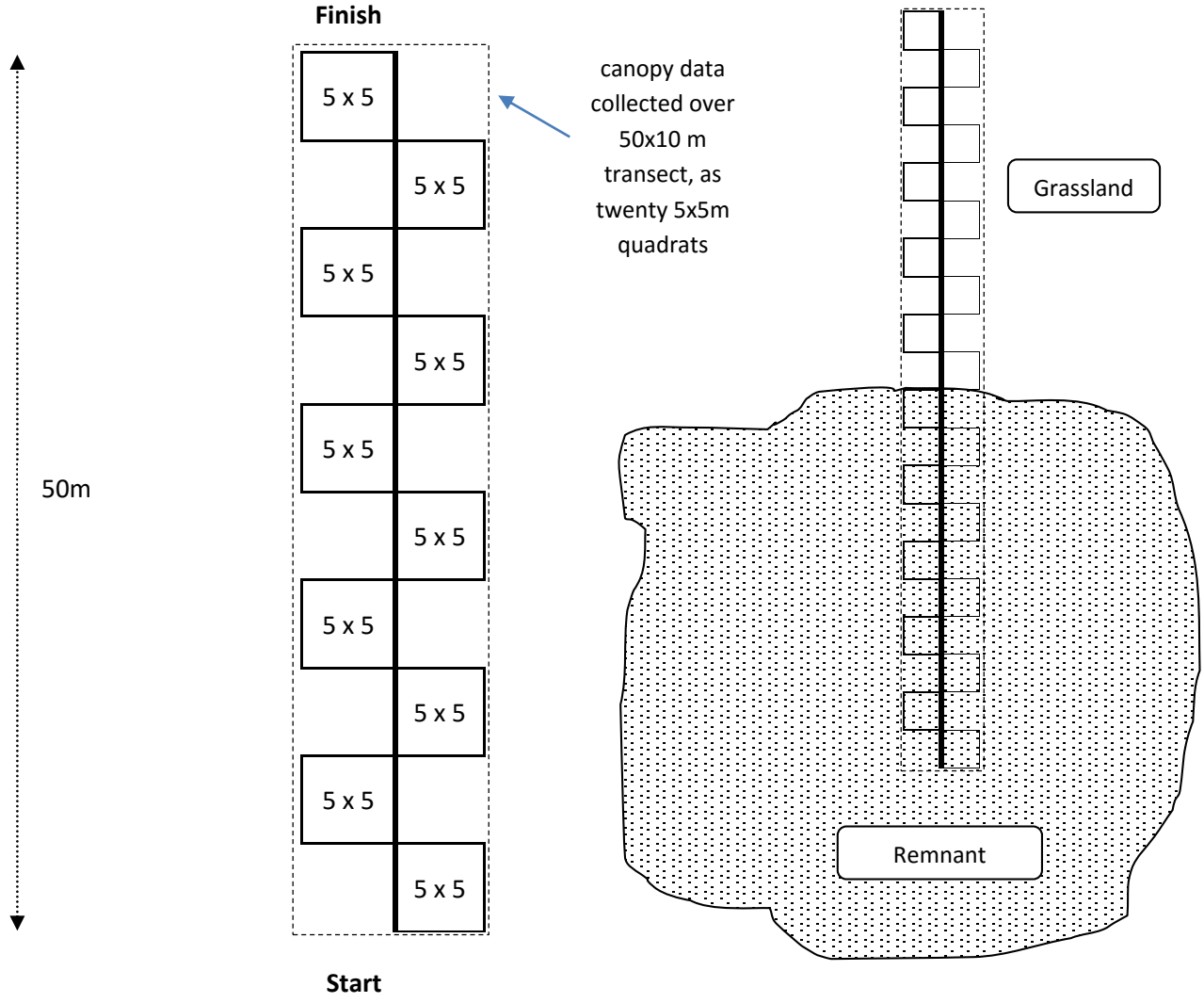


Figure 3 Schematic representation of transact layout for vegetation monitoring (units = m). Single 50m transect (left) and transect-pair (right) arranged end-to-end across a remnant-grassland boundary.

3.3 Species Composition: Management Units

Collectively, the ten 5x5m quadrats comprising each 50m transect allow for the analysis of species diversity over 250m^2 (0.025ha), and between different management units (8 in grassland, 8 in remnant forest). Species-presence data, as collected in each quadrat, was converted to an absolute abundance measure for each 50m transect by tallying the number of quadrats where each species was recorded. On this scale, the maximum abundance value is 10, while the minimum is 1. All sixteen transects were then subjected to multivariate analysis of abundance data using *Primer* (Clarke & Gorley 2005). Non-metric Multi Dimensional Scaling (nMDS) and cluster analysis was run across the sixteen transects to compare grassland and forest sites, including data from 2013 and 2014 for comparative purposes. Both procedures examine attributes of the data and group sites according to similarity, displayed in 2-dimensional space by symbols. Significance testing of returned groups was undertaken using the SIMPROF routine in *Primer*.

3.4 Species Composition: Regenerating Grassland

Analysis of species diversity for each transect-pair (2 x 50m, or 100m) was undertaken through multivariate analysis of species-presence in component quadrats. Using *Primer*, nMDS and cluster analysis was run across the 20 quadrats in each transect-pair to enable comparisons between regenerating grassland and remnant forest. Such analysis also allowed for comparative assessment of those quadrats lying at the interface between forest and grassland, specifically to determine if positive regeneration was occurring.

3.5 Canopy Composition & Structure

The identity and number of all canopy species was recorded for each quadrat, and through mathematical extrapolation used to determine tree densities for both remnant forest and grassland areas. The diametre-at-breast-height (DBH) of all canopy species greater than 1.6m in height within each quadrat was also measured, so that the age structure of existing remnant forest could be established. For multiple-stemmed trees, all stems were measured but only the largest was included in age structure calculations. Canopy specimens less than 1.6m were not measured, but were tallied and included in the lowest age class (0-1cm DBH). In the absence of better quality forests within the BOAs, this data is considered 'baseline' and can be used to compare the progress of regenerating grasslands over subsequent monitoring periods. Note that from 2015 onwards, canopy data was collected across twenty rather than ten quadrats per 50m transect, and the frequency amended to triennially rather than annually (see Section 5.3).

3.6 Shrub Composition & Structure

A count was made of the number of stems of all woody shrubs present in quadrats, and densities calculated for each transect and management unit. It was to be expected that grassland areas would support the lowest density of woody shrub species, given their history of clearing and grazing. Densities of pioneering wattle species (*Acacia*) were also assessed separately, as these species play an important early role in grassland restoration. All shrub densities were compared with data from 2013 and 2014 to monitor changes over time.

3.7 Leaf Litter & Bare Ground

For each quadrat, qualitative assessments were made of the percentage cover of leaf litter and bare ground, and examined collectively by management unit. Comparisons were made with similar data collected in 2013 and 2014.

4. Results

4.1 Management Units

Management Units (MUs) for sampling purposes across all BOAs were established in 2013, based on vegetation mapping available at that time. Some finer resolution of community types was undertaken in 2013 to allow sampling and monitoring of some of the more important floristic combinations (see Bell 2014).

Eight permanent 50m transect-pairs were established in 2013, perpendicular to the interface of grassland and remnant vegetation within the six BOAs. Locations of these eight transect-pairs are shown in **Figure 4** and detailed in **Table 2**, which effectively sampled all of the main vegetation types known from lands within the BOAs. Three transect-pairs (INT02, INT04 & INT08) were positioned within the Narrow-leaf Ironbark - Spotted Gum - Forest Redgum Woodland of Cunningham (2010), which is the most widespread community in the area. In addition, a single transect-pair (INT05) was positioned at the interface of grassland and Red Ironbark-Spotted Gum, and was representative of an unmapped variant of Narrow-leaf Ironbark - Spotted Gum - Forest Redgum Woodland that aligns with the Lower Hunter Spotted Gum-Ironbark Forest EEC (see further discussion in Bell 2014).

Table 2 Location of transects within management units at the Integra BOAs.

Management Unit	Transect No.	Transect Location (MGA, zone 56)	
		Start	Finish
Grassland (Bulloak)	INT01G	327060 6404294	327088 6404252
Grassland (Ironbark)	INT02G	326643 6403965	326686 6403988
	INT04G	326821 6407413	326781 6407452
	INT08G	324999 6406593	325016 6406546
Grassland (Swamp Oak)	INT03G	327629 6403293	327676 6403314
Grassland (Spotted Gum)	INT05G	326181 6407446	326131 6407444
Grassland (Grey Box)	INT06G	327693 6407947	327740 6407929
Grassland (Apple)	INT07G	327148 6406434	327194 6406417
Bulloak	INT01F	327032 6404332	327061 6404293
Ironbark	INT02F	326597 6403944	326643 6403965
	INT04F	326849 6407380	326815 6407413
	INT08F	324981 6406639	324999 6406593
Swamp Oak	INT03F	327581 6403274	327629 6403295
Spotted Gum	INT05F	326230 6407446	326181 6407446
Grey Box	INT06F	327643 6407965	327693 6407947
Apple	INT07F	327103 6406441	327148 6406434

Other transect-pairs established include one in Swamp Oak Forest (INT03), one in Bulloak Forest (INT01), one in Rough-barked Apple Forest (INT07), and one in Grey Box Forest (INT06). The last two (Rough-barked Apple Forest & Grey Box Forest) were not previously delineated in the available mapping, but were considered worthy of monitoring due to their presence as distinct entities in the Central Hunter. No areas of suitable River Oak Forest could be located within the BOAs.

In terms of landscape management units, three transects were located in an Ironbark MU, one in each of Bulloak, Swamp Oak, Spotted Gum, Grey Box and Apple MUs, and eight in the corresponding Grassland MUs (ie: 3 in Grassland derived from Ironbark, 1 each in Grassland derived from Bulloak, Swamp Oak, Spotted Gum, Grey Box & Apple Grassland: **Table 2**). **Figures 5 to 8** show views of each transect at establishment in 2013, and in 2015. Images of all component quadrats are included in **Appendices A7.1 to A7.16**.

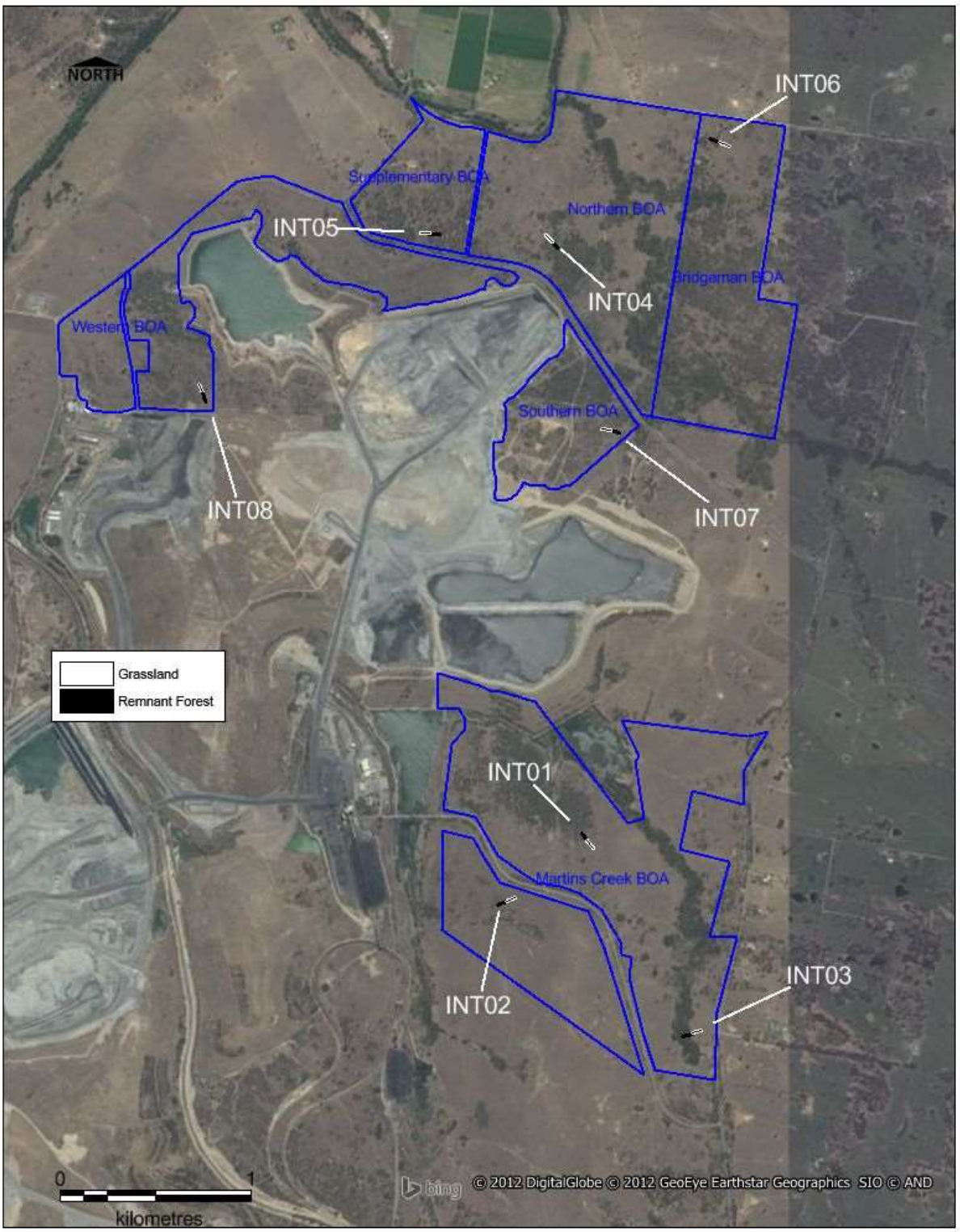


Figure 4 Location of monitoring transect-pairs within the Integra BOAs.

Martins Ck BOA: Bulloak (INT01F) 2013

2015

Martins Ck BOA: Ironbark (INT02F) 2013

2015

Martins Ck BOA: Swamp Oak (INT03F)2013

2015

Northern BOA: Ironbark (INT04F) 2013

2015

Figure 5 Transects (50m) established at Integra BOAs: INT01F - INT04F. Photographed at establishment (2013, left) and in 2015 (right).


Suppl. BOA: Spotted Gum (INT05F) 2013


2015


Bridgeman BOA: Grey Box (INT06F) 2013


2015


Southern BOA: Apple (INT07F) 2013


2015


Western BOA: Ironbark (INT08F) 2013


2015

Figure 6 Transects (50m) established at Integra BOAs: INT05F - INT08F. Photographed at establishment (2013, left) and in 2015 (right).

Martins Ck BOA: Bulloak (INT01G) 2013

2015

Martins Ck BOA: Ironbark (INT02G) 2013

2015

Martins Ck BOA: Swamp Oak (INT03G)2013

2015

Northern BOA: Ironbark (INT04G) 2013

2015

Figure 7 Transects (50m) established at Integra BOAs: INT01G - INT04G. Photographed at establishment (2013, left) and in 2015 (right).


Suppl. BOA: Spotted Gum (INT05G) 2013


2015


Bridgeman BOA: Grey Box (INT06G) 2013


2015


Southern BOA: Apple (INT07G) 2013


2015


Western BOA: Ironbark (INT08G) 2013


2015

Figure 8 Transects (50m) established at Integra BOAs: INT05G - INT08G. Photographed at establishment (2013, left) and in 2015 (right).

Transect start and end positions were recorded by GPS and marked in the field by metal star pickets (see **Figures 5-8**). Quadrat corners were marked by in-ground metal pegs and galvanized washers with flagging tape (**Figure 9**). These can be relocated in subsequent years through use of a small metal detector as necessary, and (unlike light-weight posts) have the advantage of avoiding accidental removal by mine staff or contractors, or dislodgement by wildlife.

Figure 9 Method of marking quadrat corners to avoid accidental dislodgement by wildlife.

4.2 Species Composition: Management Units

Non-metric Multi Dimensionsal Scaling (nMDS) and cluster analysis of the sixteen 50m transects, sampled annually over three years, showed consistent grouping for most transects (**Figure 10**). Significant clustering (at $p<0.1\%$, ~60% similarity) of repeatedly sampled transects occurred for all except two of the Ironbark management units (INT02F & INT08G). A more targeted analysis of the three Ironbark transect-pairs (INT02F, INT02G, INT04F, INT04G, INT08F & INT08G) sampled over the three years (**Figure 11**) showed that 2015 data for INT02F was floristically more similar to all three replicates of INT02G, while INT08G sampled in 2013 was distinct from all other Ironbark MU's. Examination of 2013 data for INT08G shows it to be floristically poor (32 species) when compared to both 2014 (48 species) and 2015 (53 species), which may explain this anomaly. Similarly, INT02F supports considerably more species in 2015 (61) than in 2013 (22) or 2014 (38).

Overall, there was a slight increase in the total species composition in 2015 when compared to 2013 and 2014 (**Figure 12**). Part of this increase is attributable to increasing weed presence (see Section 4.4), but much can be explained by the better growing conditions in 2015.

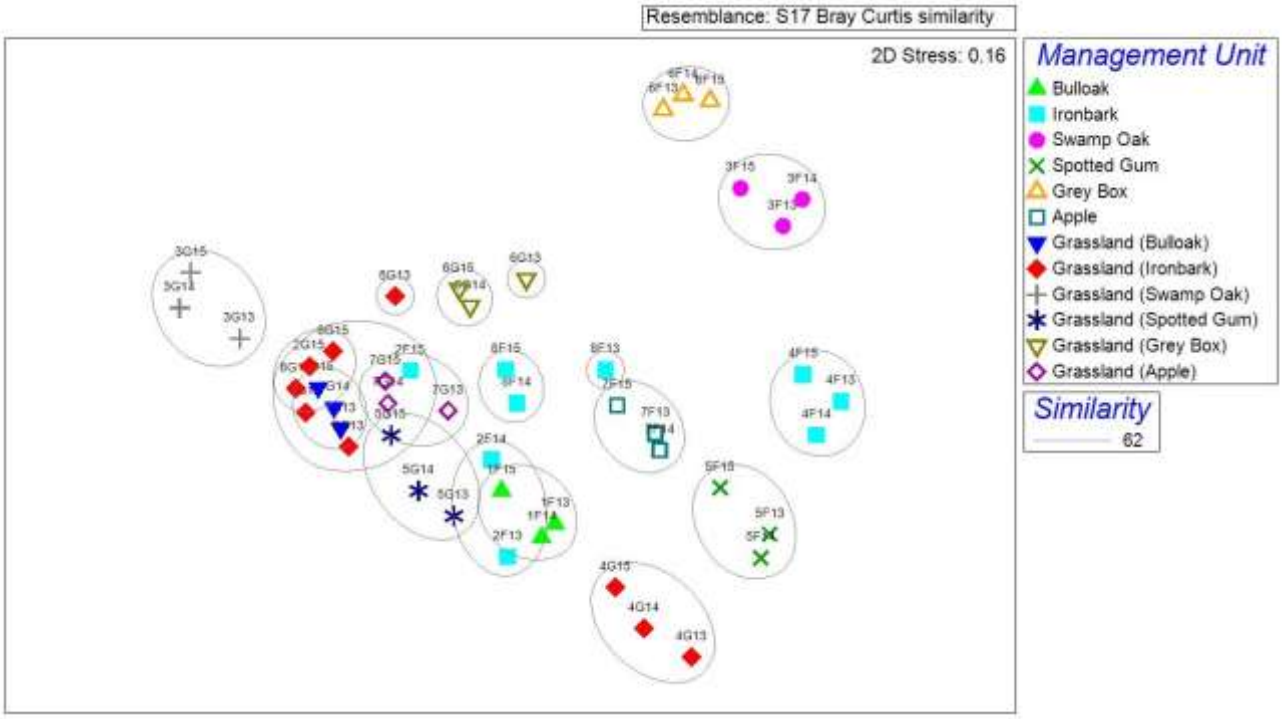


Figure 10 nMDS chart of sixteen transects sampled in 2013, 2014 and 2015 (total sampling events = 48) within grassland and remnant forest management units. Stress = 0.16, p<0.1%. Symbol codes (e.g. 3G14) are transect number (3), management unit (G=grassland) & sampling year (14=2014).

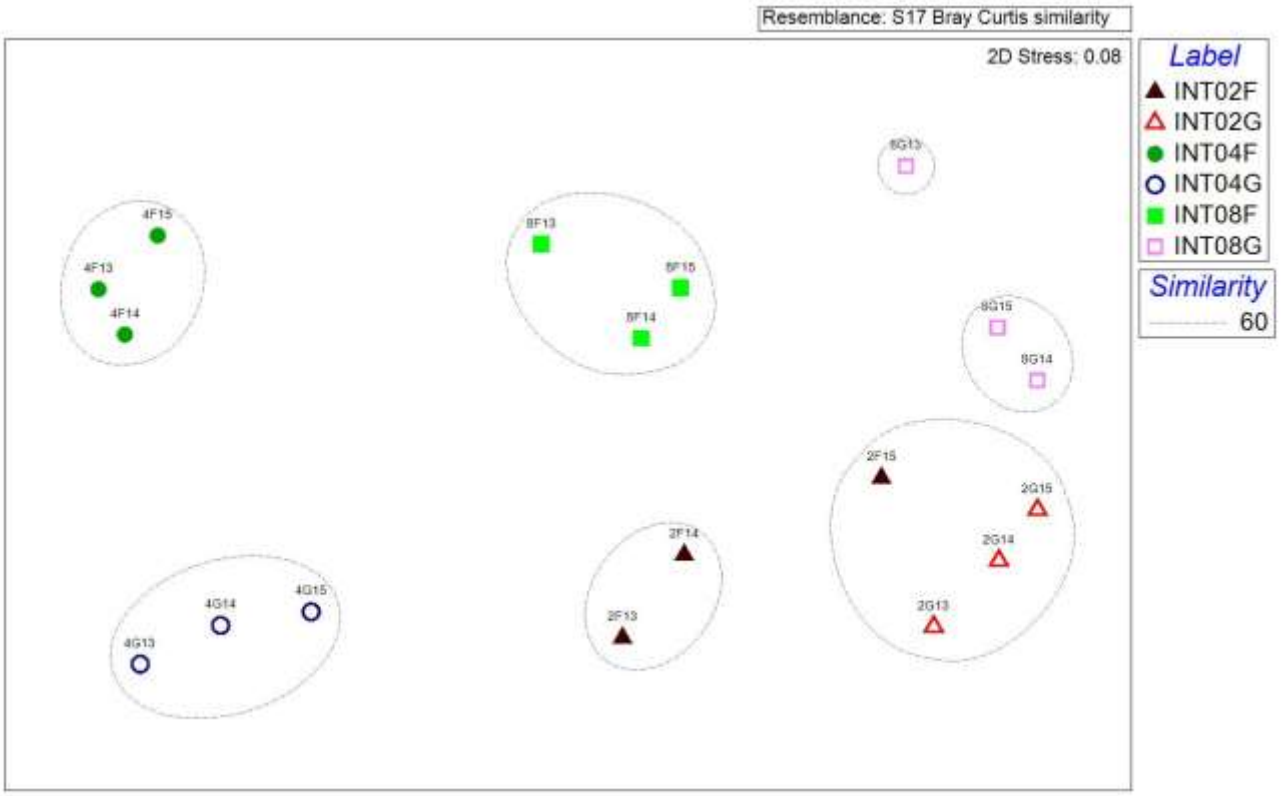


Figure 11 nMDS chart of three transect-pairs sampled in 2013, 2014 and 2015 (total sampling events = 18) within Ironbark grassland and forest management units. Stress = 0.08, p<0.1%. Symbol codes (e.g. 2G14) are transect number (2), management unit (G=grassland) & sampling year (14=2014).

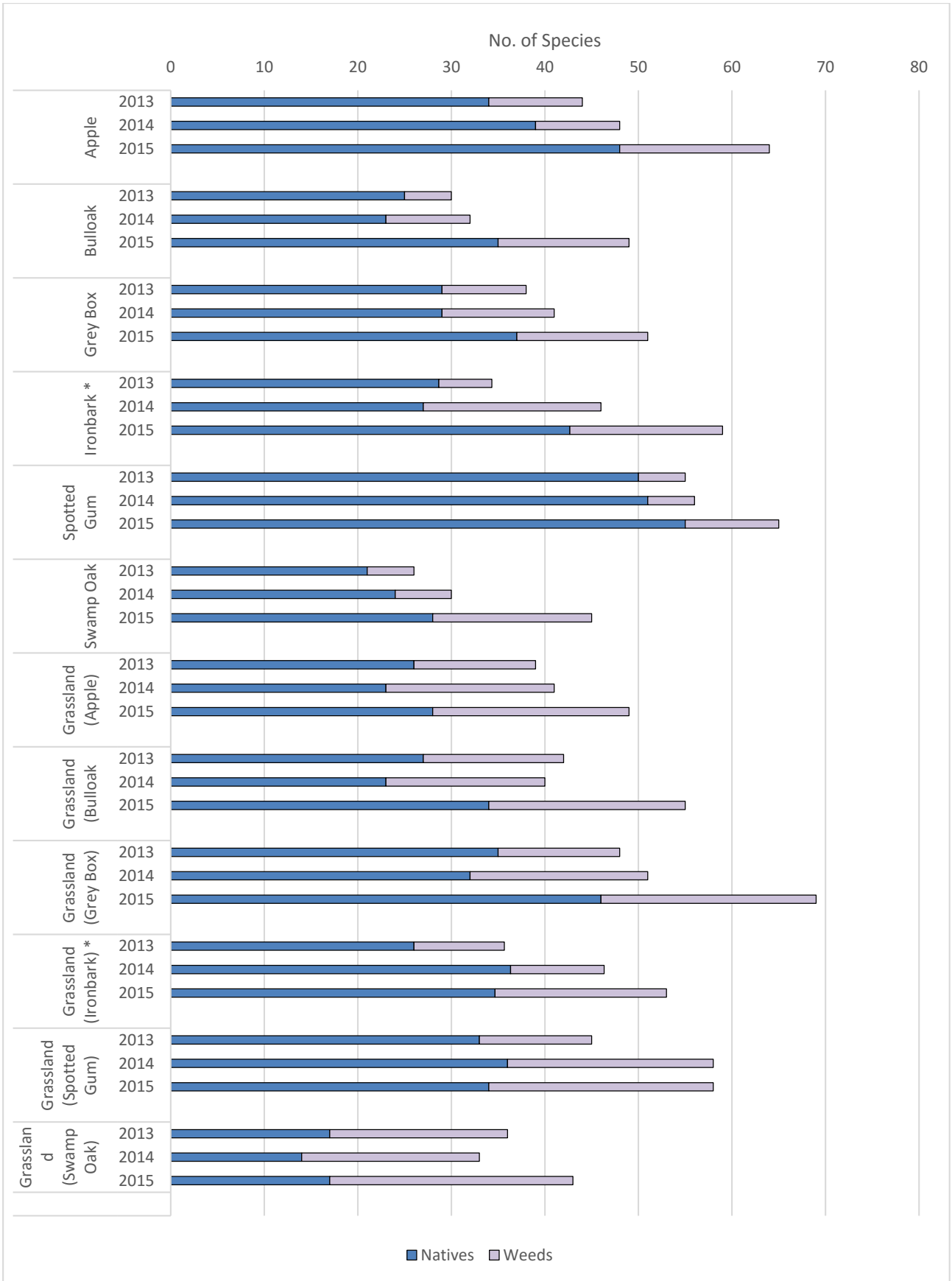


Figure 12 Change in overall species diversity for all management units 2013 to 2015, showing native and weed species. Ironbark units (marked *), figures averaged from three replicate transects.

4.3 Species Composition: Regenerating Grassland

In total, 180 plant species (up from 151 in 2013, and 164 in 2014) were recorded across the 160 sample quadrats in both forest and grassland during 2015 (**Appendix A7.17**), including 53 weed species (36 in 2013, and 48 in 2014). As in previous years, native species diversity was highest in Spotted Gum and lowest in Grassland (Swamp Oak). Weed species were also highest in all Grassland units (18 to 26 species), and minimal in Remnant Forest (10 to 17 species) (**Figure 12**).

Non-metric Multi Dimensional Scaling (nMDS) and cluster analysis of quadrat species-presence data for each 100m transect (50m transect-pairs) revealed clear 'forest' and 'grassland' groups, with quadrats at the interface of these two structural types forming informal (yet significant) associations. It may be expected that these two groups would become progressively closer in 2-dimensional space with continued monitoring in subsequent years, as plant composition changes during regeneration of grassland areas. Using 2015 data, each transect-pair has been examined separately and discussed in the following text. In general, significant splits in the data (at $p<0.001$) have been used to guide interpretation; splits that are not significant have been noted where relevant.

Bulloak-Grassland MU (INT01: Martins Creek BOA) - Four significant groups ($p<0.001$ at 49% similarity) of quadrats are present in this transect-pair (**Figure 13**). This differs from the two groups evident in 2013, and the three in 2014. One group comprises nine quadrats from the Grassland unit (02G-10G); a second comprises quadrats 05F to 10F from the Forest unit (middle to edge of forest remnant) plus 01G on the edge of the Grassland unit; a third group comprises Forest quadrats 01F and 03F (those deeper in the Forest remnant); and a fourth comprises 02F and 04F (also deep in the remnant). The second group of quadrats is here suggesting that quadrat 01G is becoming floristically similar to the bulk of Forest quadrats adjacent to it, but the remaining Grassland quadrats are yet to show this trend. In 2013, there was no indication of this transition.

Ironbark-Grassland MU (INT02: Martins Creek BOA) - One large significant group ($p<0.001$ at 54% similarity) comprising all 20 quadrats suggests that Forest and Grassland units are floristically similar (**Figure 14**). However, two sub clusters are evident (not significant: $p<0.02$) which clearly distinguish Forest and Grassland quadrats. While this split is not significant, the lack of quadrat mixing does indicate that floristic differences between the two sub groups remain. In 2013, 4 of the 10 grassland quadrats (close to the Grassland-Remnant Forest boundary) positioned within the remnant Ironbark forest sub group, but this pattern has not been maintained into 2014 and 2015. Possible reasons for this change may be the dryer seasonal conditions experienced in 2014 and 2015, or potentially the impact on floristic composition of ripping and planting portions of the Grassland transect.

Swamp Oak-Grassland MU (INT03: Martins Creek BOA) - Three significant groups ($p<0.001$ at 33% similarity) of quadrats are present in this transect-pair, with Grassland quadrats remaining distinctly different floristically to Forest quadrats (**Figure 15**). A single quadrat (10F) from the Forest-Grassland interface forms the sole member of the third group, and suggests that this portion of the transect is developing into an ecotonal floristic type. In general, Forest dominated by Swamp Oak shades out many ground layer species, while Grassland is well covered with grasses and forbs, many of them exotic weeds. It will be of interest to see where this quadrat falls in future analyses. In 2013, three significant groups were present for this transect-pair, showing some signs of a transition group between the two, but this pattern was not maintained in 2014.

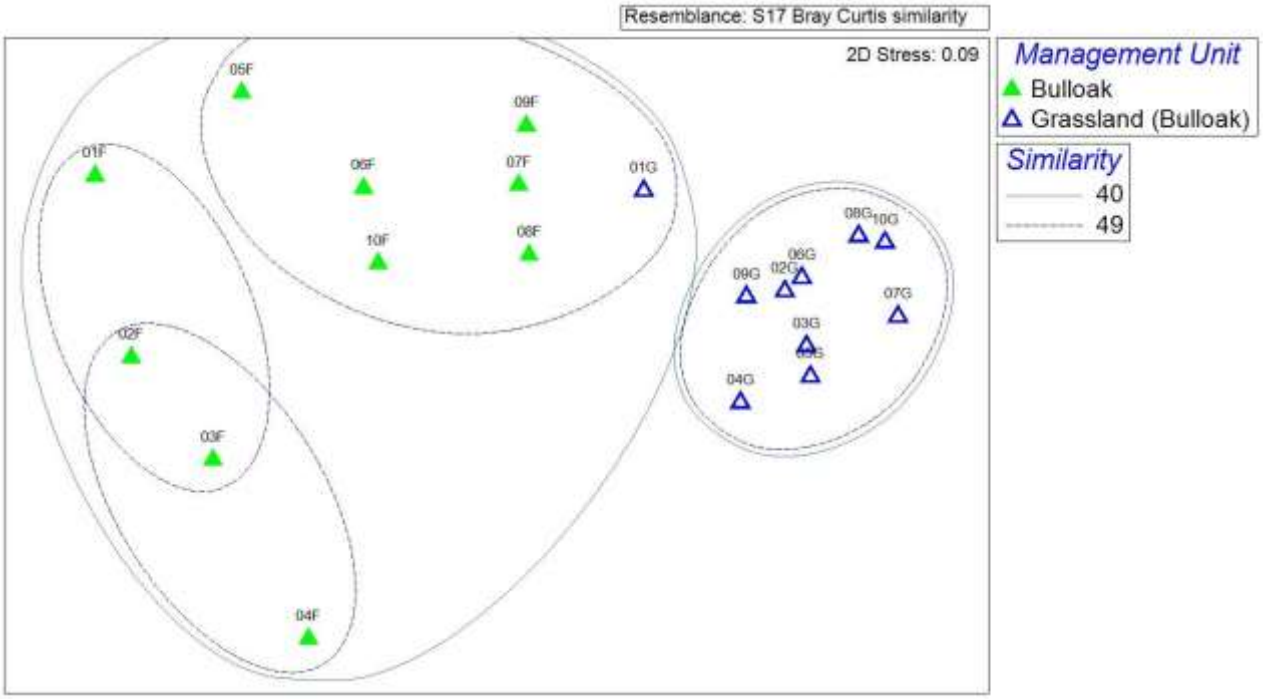


Figure 13 nMDS chart of 20 quadrats comprising transect-pair INT01 (Bulloak-Grassland MU), 2015 data. Stress = 0.09. Unless marked otherwise, ellipses show significant sub-groups (p<0.001) from associated cluster diagram.

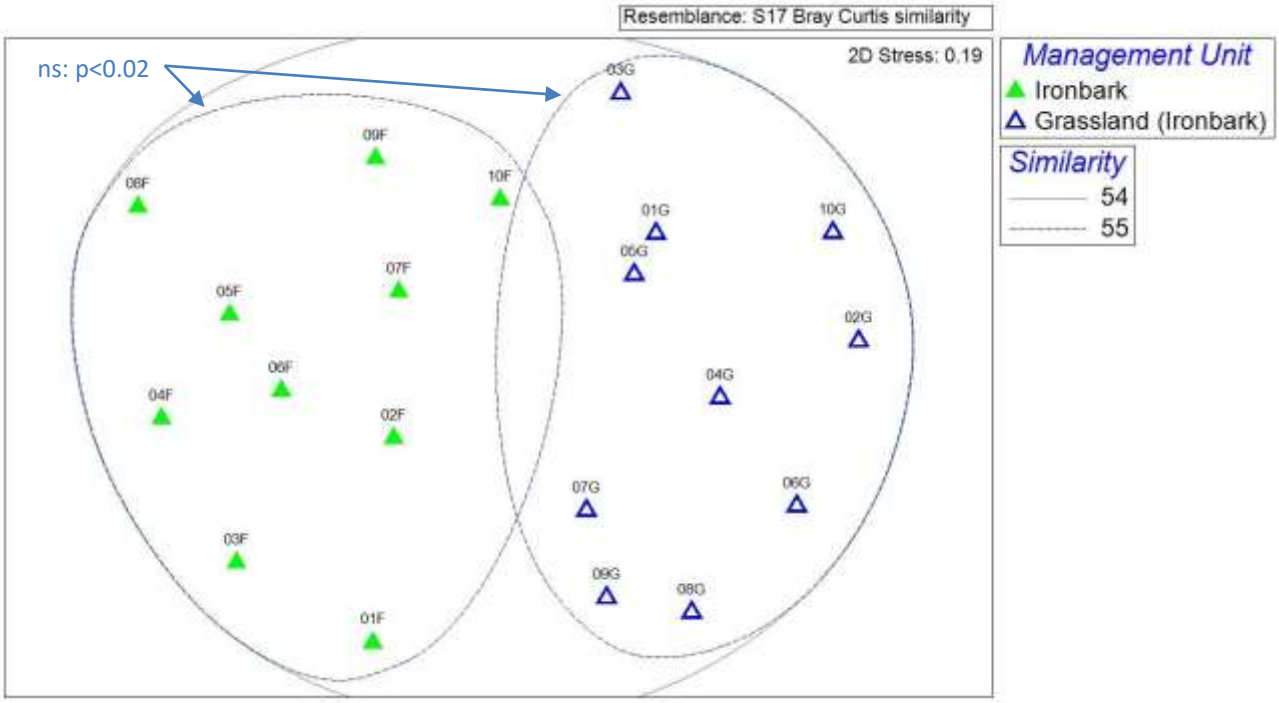


Figure 14 nMDS chart of 20 quadrats comprising transect-pair INT02 (Ironbark-Grassland MU), 2015 data. Stress = 0.19. Unless marked otherwise, ellipses show significant sub-groups (p<0.001) from associated cluster diagram.

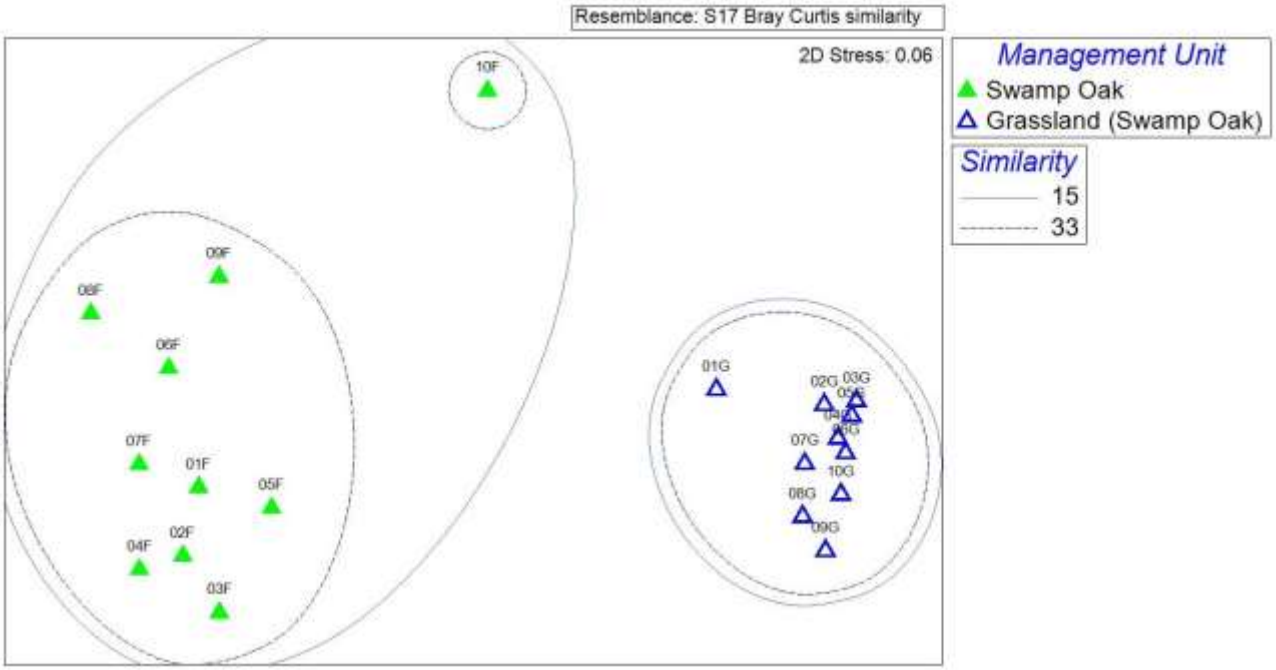


Figure 15 nMDS chart of 20 quadrats comprising transect-pair INT03 (Swamp Oak-Grassland MU), 2015 data. Stress = 0.06. Unless marked otherwise, ellipses show significant sub-groups (p<0.001) from associated cluster diagram.

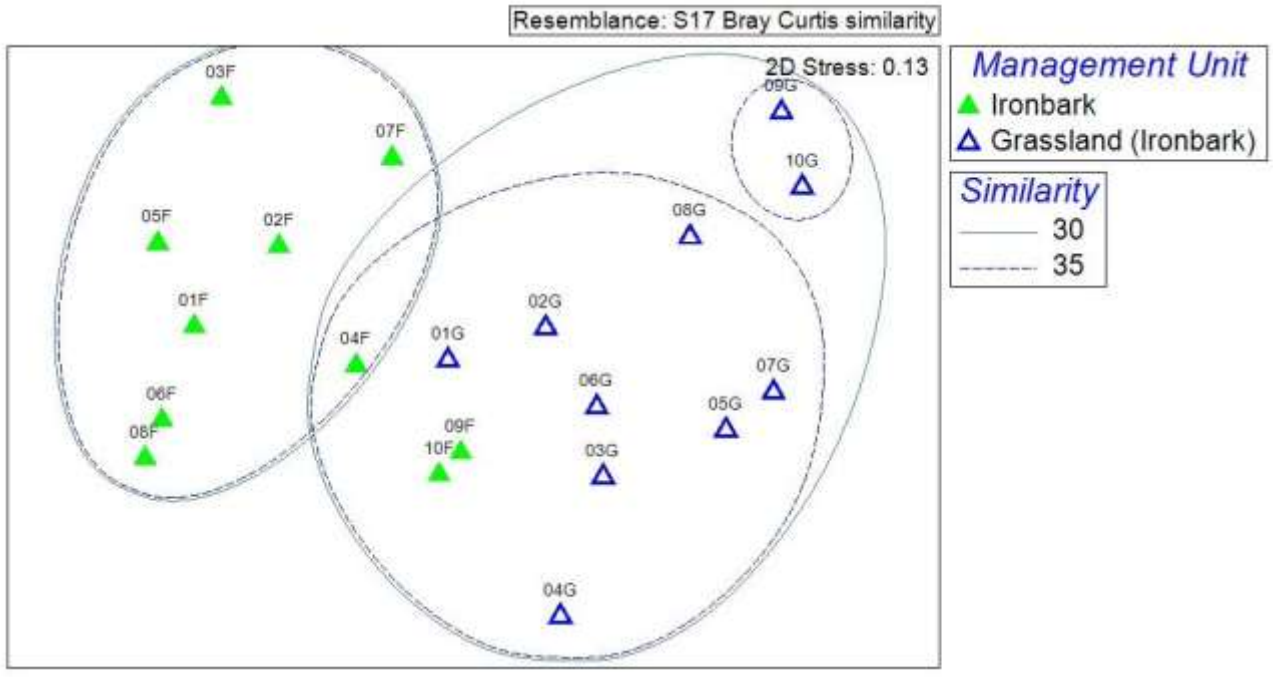


Figure 16 nMDS chart of 20 quadrats comprising transect-pair INT04 (Ironbark-Grassland MU), 2015 data. Stress = 0.13. Unless marked otherwise, ellipses show significant sub-groups (p<0.001) from associated cluster diagram.

Ironbark-Grassland MU (INT04: Northern BOA) - Two significant groups ($p<0.001$ at 29% similarity) of quadrats are present in this transect-pair, which shows consistency with 2013 and 2014 results. However, 2015 data also shows a third significant group ($p<0.001$ at 34% similarity) within the Grassland unit (quadrats 09G & 10G). In one of the main groups, 3 of the 10 Forest quadrats (up from 2 in 2014) are positioned with the 10 Grassland quadrats, while the second group comprises the remaining 7 Forest quadrats (**Figure 16**). The placement of quadrats 04F, 09F and 10F within the Grassland group suggests strong similarities in floristic composition.

Spotted Gum-Grassland MU (INT05: Supplementary BOA) – This transect shows a more complex pattern of floristic relationships, with two levels of significance applicable (**Figure 17**). At the broad level, two significant groups ($p<0.001$ at 26% similarity) of quadrats demarcate 6 of the 10 Grassland quadrats (05G-10G) from all 10 Forest quadrats and the remaining Grassland quadrats (01G-04G). This maintains the pattern established in 2014. For Grassland quadrats close to the forest interface (01G-04G), this suggests a floristic composition more like Forest. A second level of significant division is also apparent in this data ($p<0.001$, 41% similarity), where quadrats 01G-04G and 10F (at the Forest-Grassland interface), separate from all other Forest quadrats. A finer significant split ($p<0.001$, 53% similarity) divides this group into two, with 01G, 02G and 10F showing strong similarity. This may be interpreted as evidence for the beginning of regeneration of those grassland areas towards Forest. Note that a finer split within the remaining Forest quadrats is not significant ($p<0.4$).

Grey Box-Grassland MU (INT06: Bridgeman BOA) - Four significant groups ($P<0.001$ at 48% similarity) of quadrats are present in this transect (**Figure 18**), an increase on the three evident in 2014. In the first major split ($p<00.1$ at 21% similarity), all Forest quadrats (01F-10F) are included with adjacent Grassland quadrats 01G-03G, while Forest quadrats 04G-10G fall in a second sub group. The latter sub group shows a further significant split ($p<0.001$ at 47% similarity) into two: quadrats 04G-06G (middle section of Grassland) and quadrats 07G-10G (end of Grassland). Quadrats 01G-03G significantly ($p<0.001$ at 41% similarity) split away from all Forest quadrats, suggesting that they do not yet approach the floristic composition of Forest. For the transect-pair having the most recent cattle grazing (removed only in early 2014), INT06 continues to display promising results.

Apple-Grassland MU (INT07: Southern BOA) – Grassland quadrats currently fail to show any assimilation with Forest quadrats in this transect-pair, despite more promising results in this regard in 2014 (**Figure 19**). At 34% similarity, a significant split ($p<0.001$) differentiates all 10 Forest quadrats from Grassland quadrats. Within the Grassland quadrats, a further significant split ($p<0.001$ at 54% similarity) demarcates quadrats 01G and 03G from all others, potentially the beginnings of an ecotonal area between the two management units. Four minor splits within the Forest quadrat group are not significant ($p<0.02$).

Ironbark-Grassland MU (INT08: Western BOA) – As in 2014, two significant groups ($P<0.001$ at 43% similarity) of quadrats are present in this transect-pair, comprising 8 of 10 Forest quadrats (01F-08F) in one, and all Grassland quadrats (01G-10G) with Forest quadrats 09F and 10F in the other (**Figure 20**). The presence of 09F and 10F within the Grassland quadrat group supports the progression in floristic composition first noted in 2014, where only 10F was present in the Grassland group. There was no such positioning in 2013.

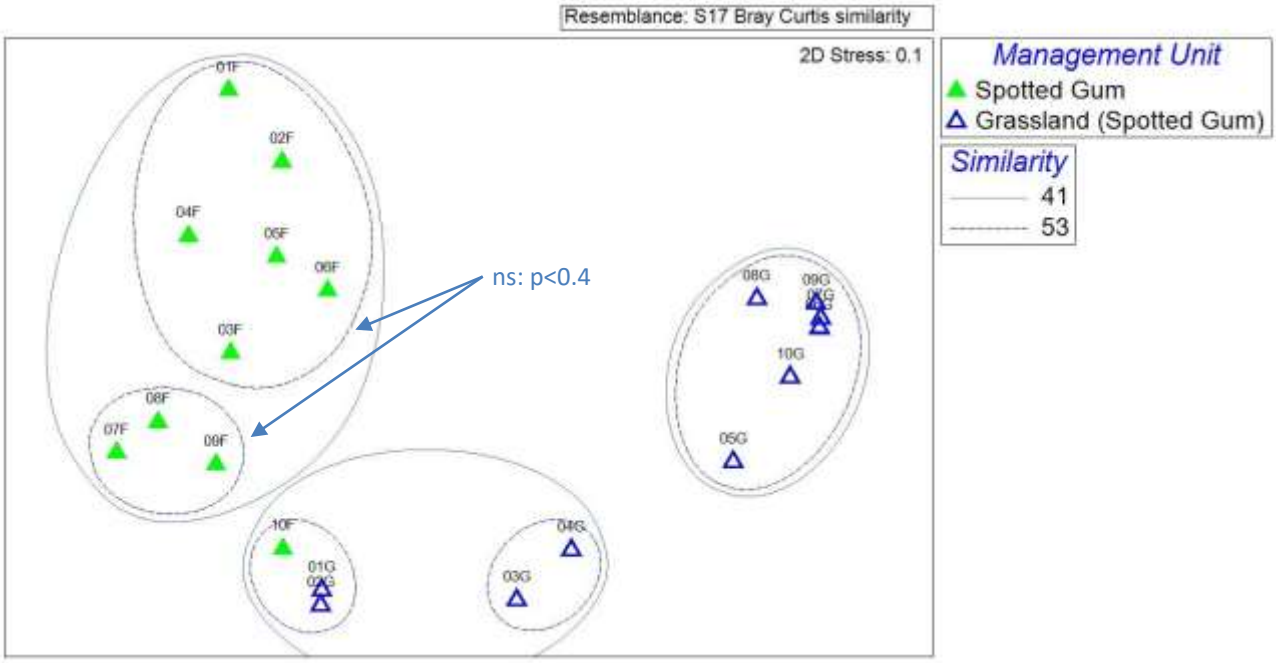


Figure 17 nMDS chart of 20 quadrats comprising transect-pair INT05 (Spotted Gum-Grassland MU), 2015 data. Stress = 0.1. Unless marked otherwise, ellipses show significant sub-groups (p<0.001) from associated cluster diagram.

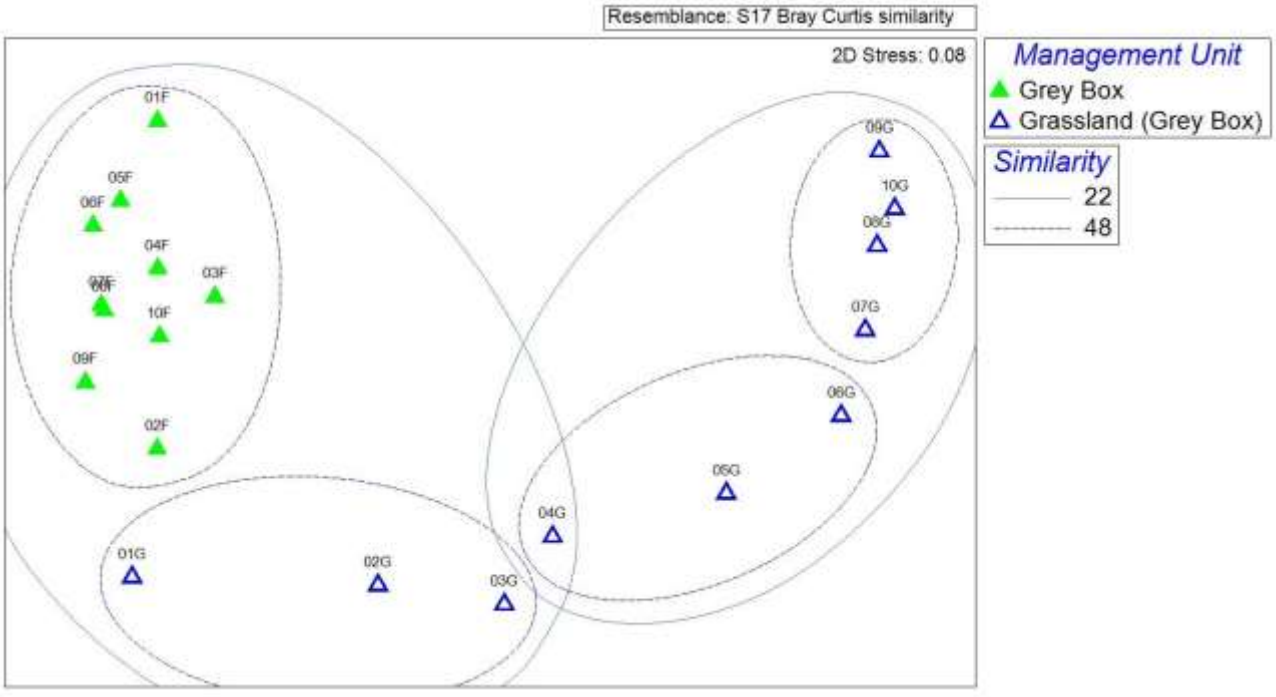


Figure 18 nMDS chart of 20 quadrats comprising transect-pair INT06 (Grey Box-Grassland MU), 2015 data. Stress = 0.08. Unless marked otherwise, ellipses show significant sub-groups (p<0.001) from associated cluster diagram.

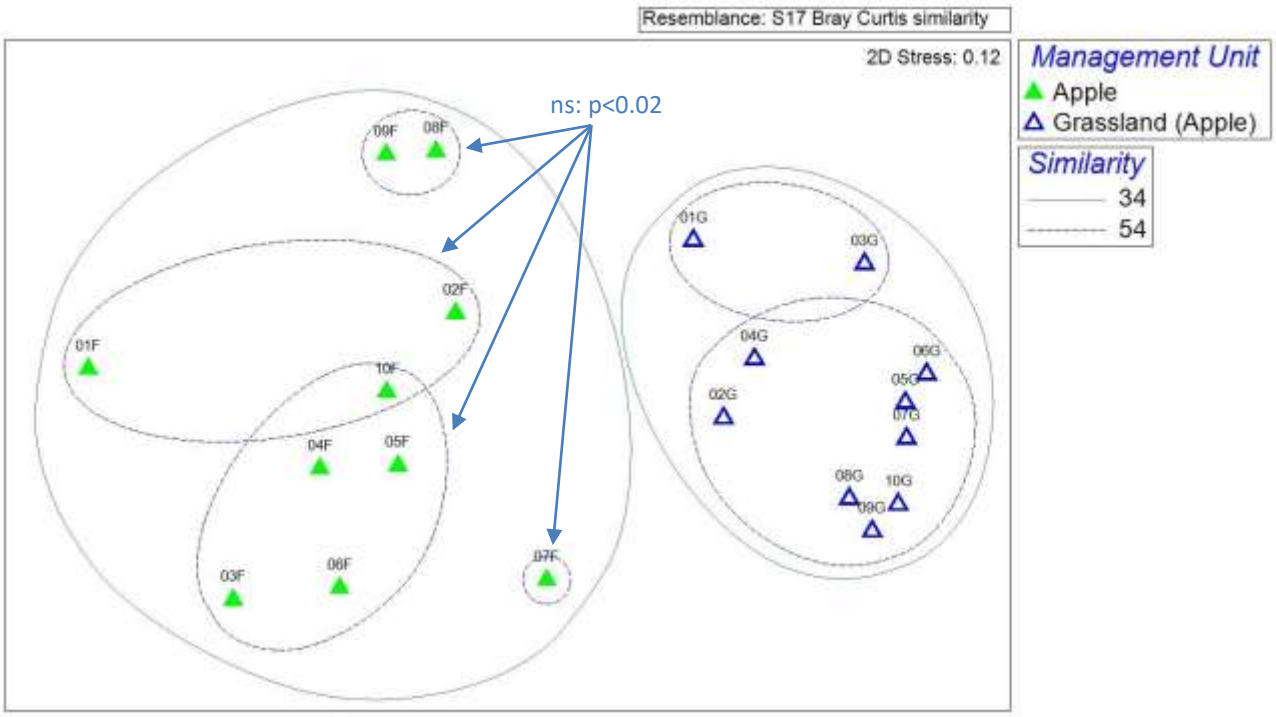


Figure 19 nMDS chart of 20 quadrats comprising transect-pair INT07 (Apple-Grassland MU), 2015 data. Stress = 0.12. Unless marked otherwise, ellipses show significant sub-groups (p<0.001) from associated cluster diagram.

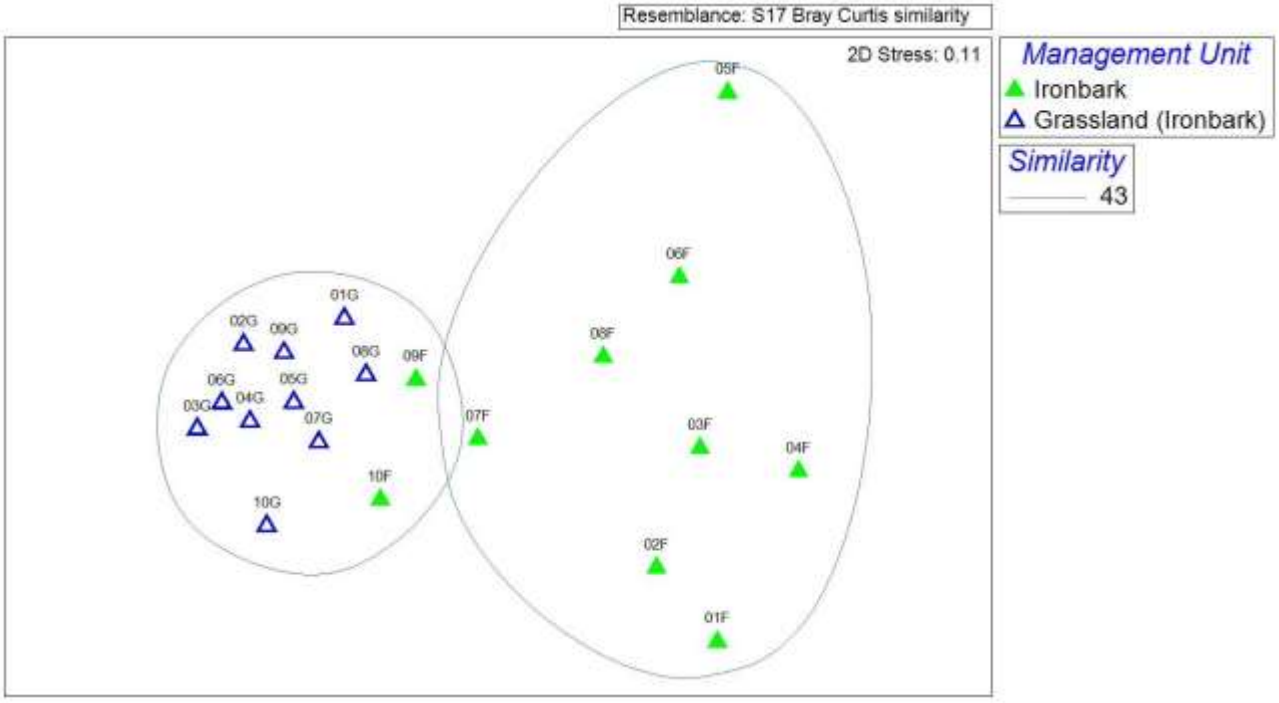


Figure 20 nMDS chart of 20 quadrats comprising transect-pair INT08 (Ironbark-Grassland MU), 2015 data. Stress = 0.11. Unless marked otherwise, ellipses show significant sub-groups (p<0.001) from associated cluster diagram.

4.4 Natives vs Weeds

4.4.1 Weed Abundance

As in previous years, weed species were most prevalent and comprised the highest cover abundance in Grassland, and particularly so in the Grassland (Swamp Oak) MU. **Figure 21** shows the relative proportion of weed species across all units from 2013 to 2015, expressed as mean percentage cover estimates across all quadrats. The majority of weed cover in grassland areas was explainable by the presence of pasture grass species (eg: Carpet Grass, Paspalum), and in some areas the invasive weed Coolatai Grass. It is expected that, over time, the regenerating canopy will gradually shade out most weed species, particularly grass species, and will be observable with future monitoring. There will, however, be a need to carefully monitor the spread of Coolatai Grass and implement controls where necessary (see Section 5.2.1).

Observable changes during the 2015 monitoring include a marked increase in weed abundance in the Grassland (Bulloak) and Grassland (Spotted Gum) MUs, but a significant decrease in the Grassland (Grey Box) MU. The latter drop in weed species abundance may be due to the complete removal of cattle from the Bridgeman Road BOA, and the resurgence of native grass species. The increase in weeds in the Grassland (Spotted Gum) and Grassland (Bulloak) MUs is largely a result of the expansion of Coolatai Grass and Paspalum in those areas. All other MUs showed negligible changes in overall weed abundance.

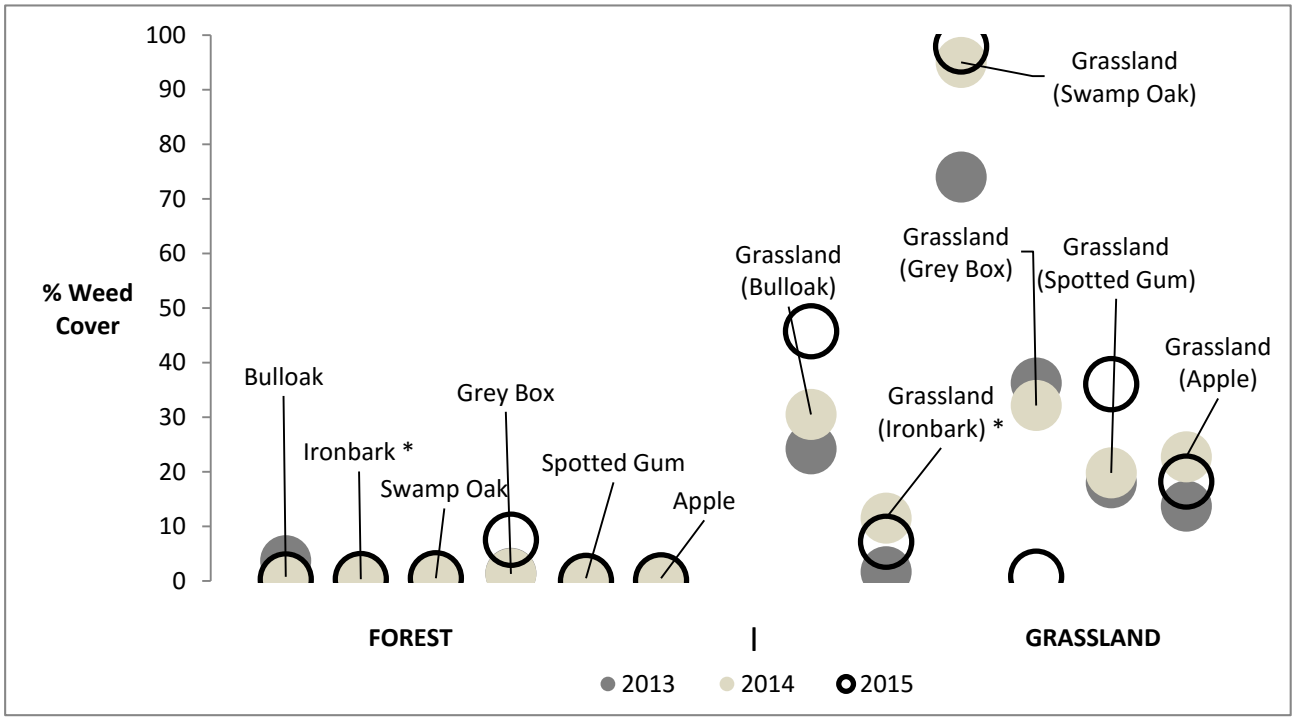


Figure 21 Relative proportion of weed species within management units (2013 to 2015), expressed as estimated % cover averaged over all plots. * n=30 for Ironbark and Grassland (Ironbark) MUs; n=10 for all other MUs.

4.4.2 Native-Weed Transect Profiles

Changes in the proportion of weed and native species continued to be evident across all pairs of 50m transects during 2015 (**Figure 22-29**). Over the three year period monitored to date, most transect pairs have

shown an increase in the presence of weed species. This is particularly evident in the Grassland MUs, but also in some Forest MUs (eg: INT02, **Figure 23**). It is likely that easing of cattle grazing pressure has encouraged the spread of herbaceous weeds, as many of these would have been inadvertently controlled through grazing. Those more problematic weed species, such as Coolatai Grass, requiring active management are discussed elsewhere in this report. Some transect pairs appear less prone to weed invasion: for INT04 (Ironbark) in the Northern BOA, very few weeds species were recorded across the entire 100m transect length in 2013, but in 2014 and 2015 an increasing trend is evident towards the end of the Grassland MU (**Figure 25**).

4.5 Canopy Composition & Structure

4.5.1 Canopy Composition & Density

Seven canopy species were present within sampled quadrats in 2015 (*Allocasuarina luehmannii, Angophora floribunda, Casuarina glauca, Corymbia maculata, Eucalyptus crebra, Eucalyptus fibrosa, Eucalyptus moluccana*). Additional plantings of canopy species (*Corymbia maculata* & *Eucalyptus crebra*) were also evident within INT02G. Given that all BOAs have been previously cleared in the past for cattle grazing, current-day vegetation is regenerating forest from past disturbance events. As a consequence, it can be expected that the density of canopy species is higher than the original woodlands (see Section 5.2.3), but for the purposes of monitoring these densities are now taken as 'baseline'. Based on the 160 sample quadrats examined at Integra from 2013 and 2015, **Figure 30** shows the extrapolated number of stems per hectare for canopy species within sampled management units. Regenerating grasslands clearly fall well short of current-day baselines, but it can be expected that increases will occur for grassland quadrats in subsequent monitoring years. The increases in canopy stem density shown in 2014 have not continued into 2015 for all management units, with most showing a decrease approximating 2013 levels. Part of this may be due to natural mortality of young trees during dry conditions, or detection difficulties as ground vegetation thickens. Three MUs within Grassland (Bulloak, Swamp Oak & Grey Box) have shown increases in canopy stem density during 2015, with the first two of these (Bulloak & Swamp Oak) typical of these highly invasive species.

Since 2013, Grey Box, Swamp Oak and Grassland (Spotted Gum) MUs have shown overall decreases in canopy stem densities over the course of two years, while all others have shown overall increases (**Table 3**). The greatest increase has been in Grassland (Grey Box), where a single seedling resulted in a 100% change (but recorded in the extended 500m^2 area). The next highest, Grassland (Bulloak) and Grassland (Swamp Oak), both showing increases >50%, will require continual monitoring, as regenerating Bulloak and Swamp Oak forests pose a particular threat to endangered grassy woodlands in the Hunter (see later discussion).

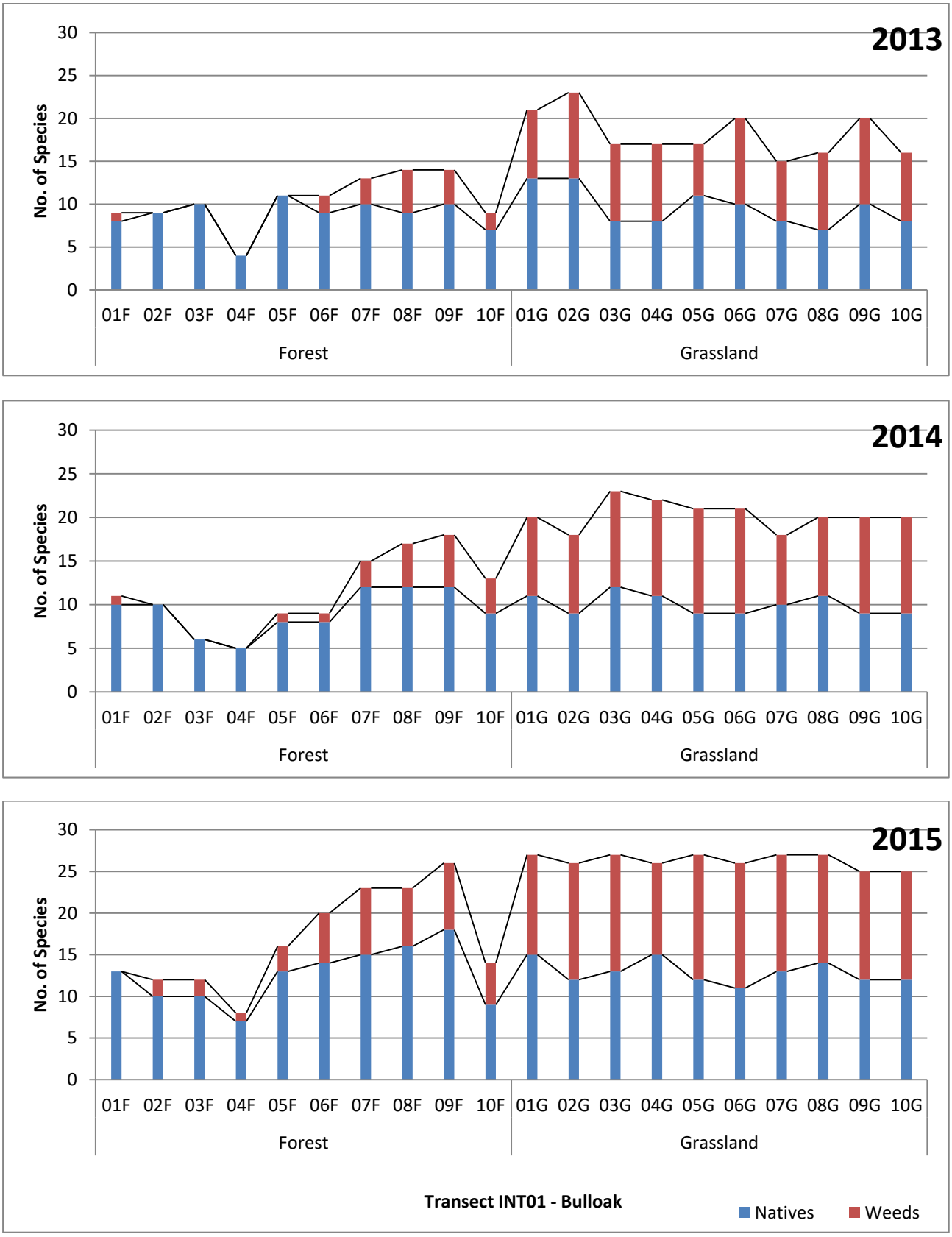


Figure 22 Proportion, number and distribution of native and weed species along transect-pair INT01 (Bulloak-Grassland: Martins Creek BOA) from 2013 to 2015, as represented by presence in 20 offset-contiguous 5 x 5m quadrats. 01F = Forest quadrat; 01G = Grassland quadrat, etc. Total transect length = 100m.

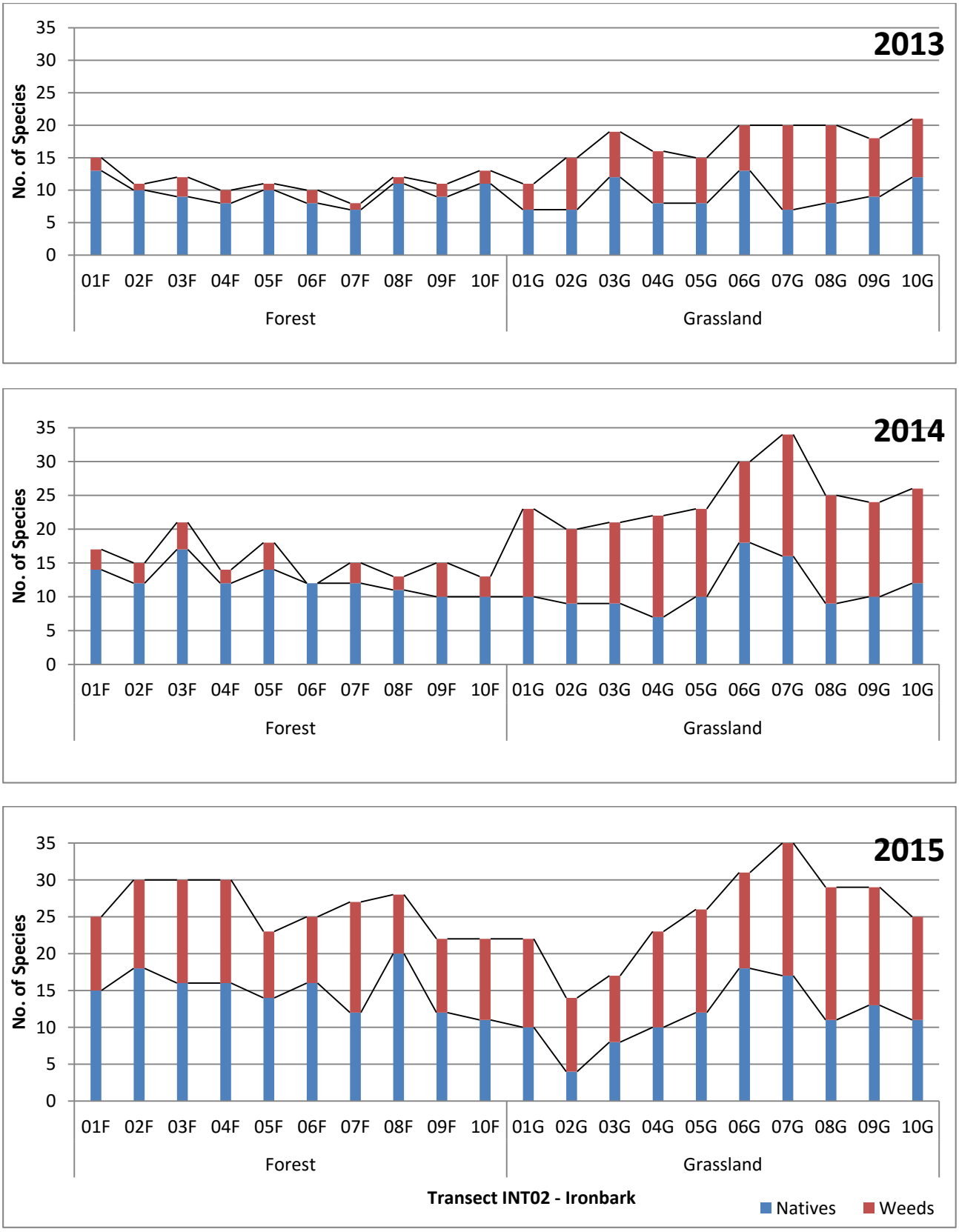


Figure 23 Proportion, number and distribution of native and weed species along transect-pair INT02 (Ironbark-Grassland: Martins Creek BOA) from 2013 to 2015, as represented by presence in 20 offset-contiguous 5 x 5m quadrats. 01F = Forest quadrat; 01G = Grassland quadrat, etc. Total transect length = 100m.

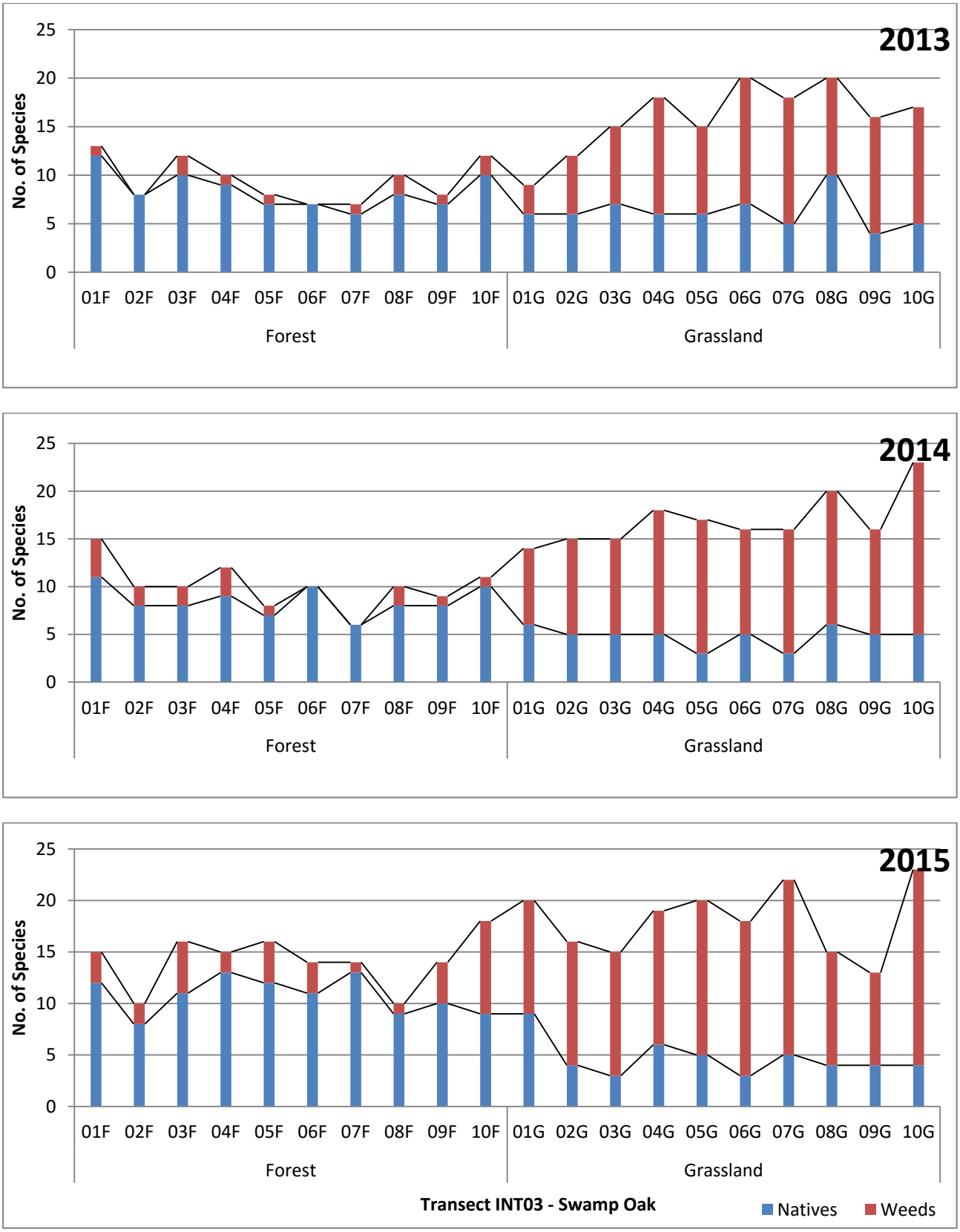


Figure 24 Proportion, number and distribution of native and weed species along transect-pair INT03 (Swamp Oak-Grassland: Martins Creek BOA) from 2013 to 2015, as represented by presence in 20 offset-contiguous 5 x 5m quadrats. 01F = Forest quadrat; 01G = Grassland quadrat, etc. Total transect length = 100m.

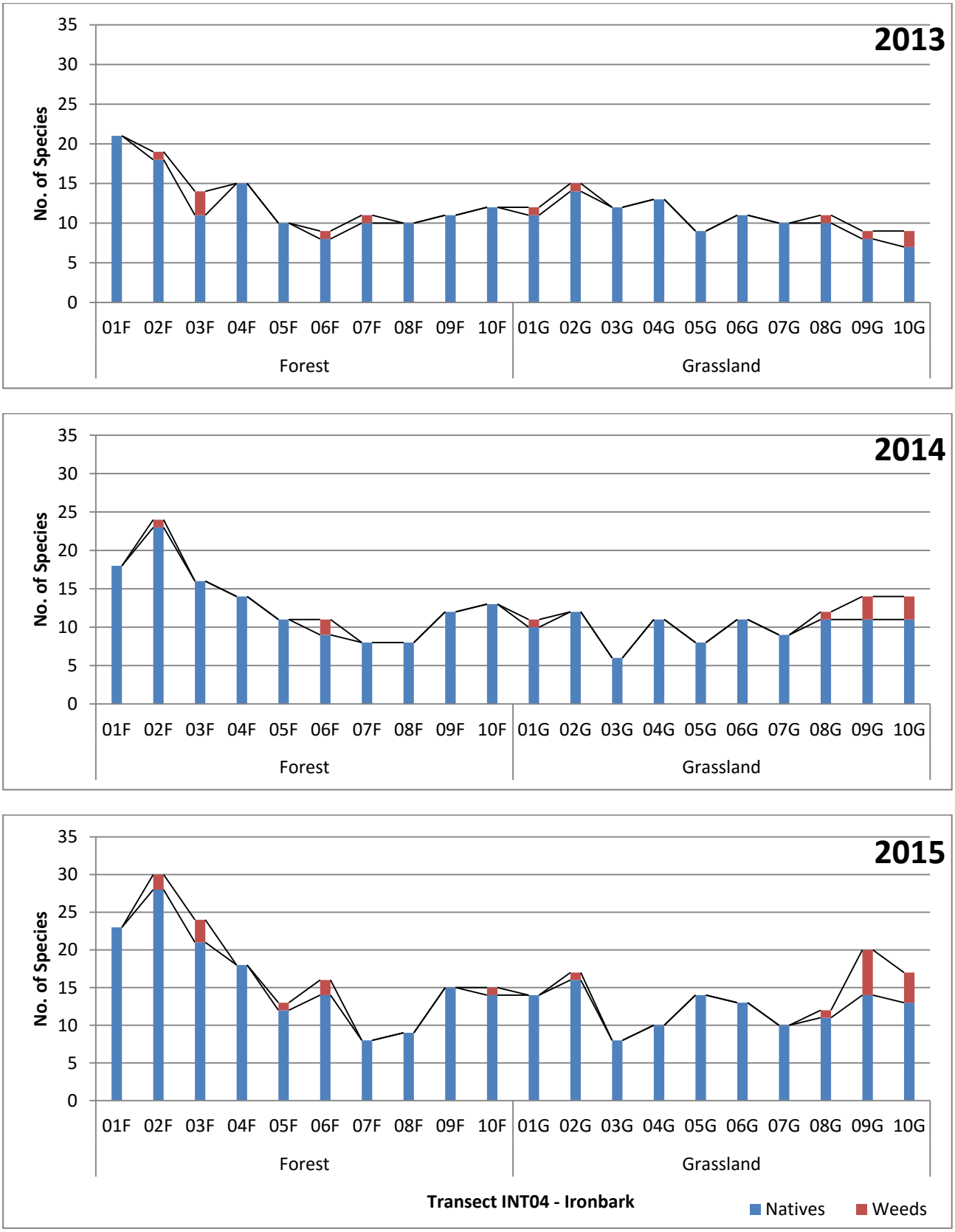


Figure 25 Proportion, number and distribution of native and weed species along transect-pair INT04 (Ironbark-Grassland: Northern BOA) from 2013 to 2015, as represented by presence in 20 offset-contiguous 5 x 5m quadrats. 01F = Forest quadrat; 01G = Grassland quadrat, etc. Total transect length = 100m.

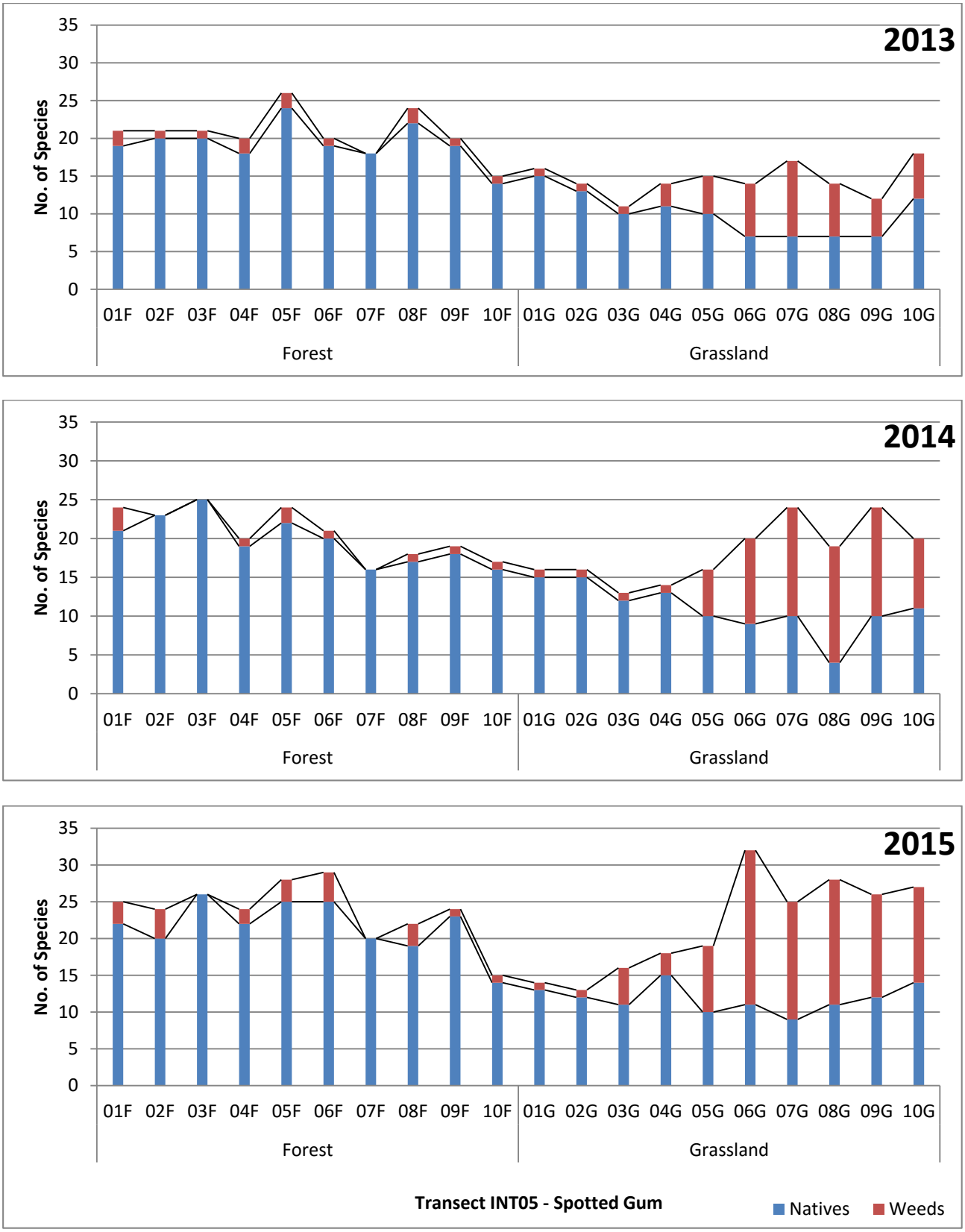


Figure 26 Proportion, number and distribution of native and weed species along transect-pair INT05 (Spotted Gum-Grassland: Supplementary BOA) from 2013 to 2015, as represented by presence in 20 offset-contiguous 5 x 5m quadrats. 01F = Forest quadrat; 01G = Grassland quadrat, etc. Total transect length = 100m.

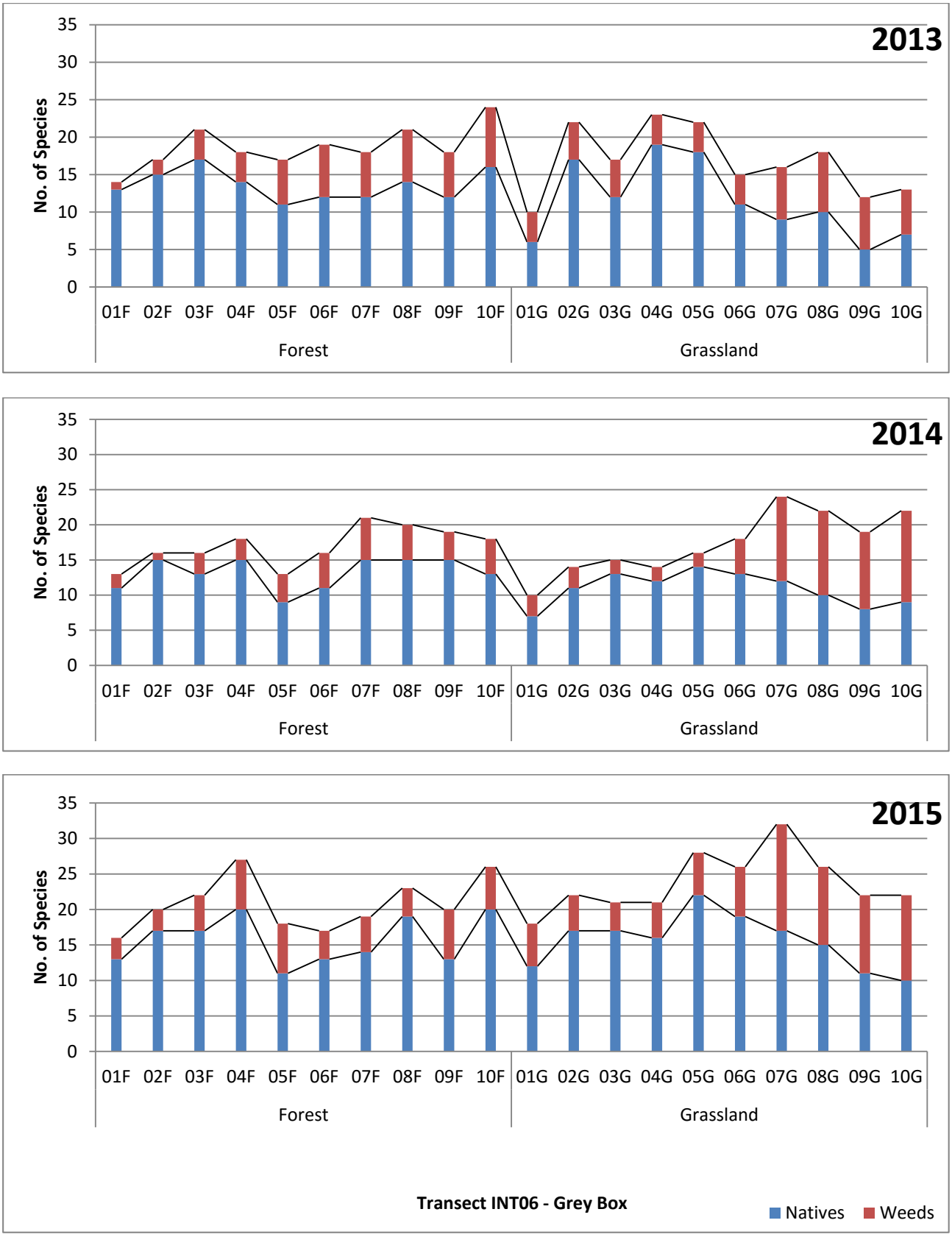


Figure 27 Proportion, number and distribution of native and weed species along transect-pair INT06 (Grey Box-Grassland: Bridgeman BOA) from 2013 to 2015, as represented by presence in 20 offset-contiguous 5 x 5m quadrats. 01F = Forest quadrat; 01G = Grassland quadrat, etc. Total transect length = 100m.

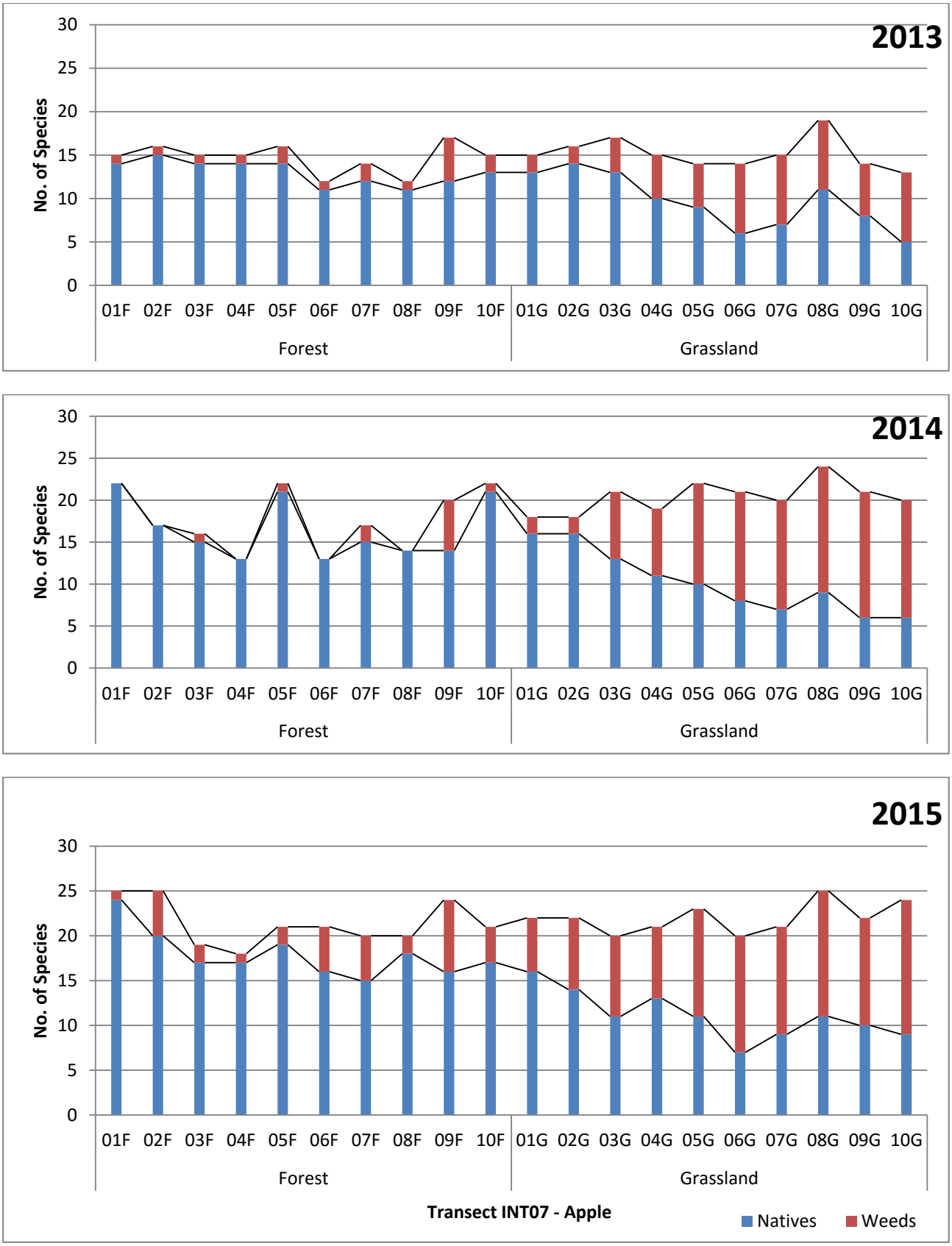


Figure 28 Proportion, number and distribution of native and weed species along transect-pair INT07 (Apple-Grassland: Southern BOA) from 2013 to 2015, as represented by presence in 20 offset-contiguous 5 x 5m quadrats. 01F = Forest quadrat; 01G = Grassland quadrat, etc. Total transect length = 100m.

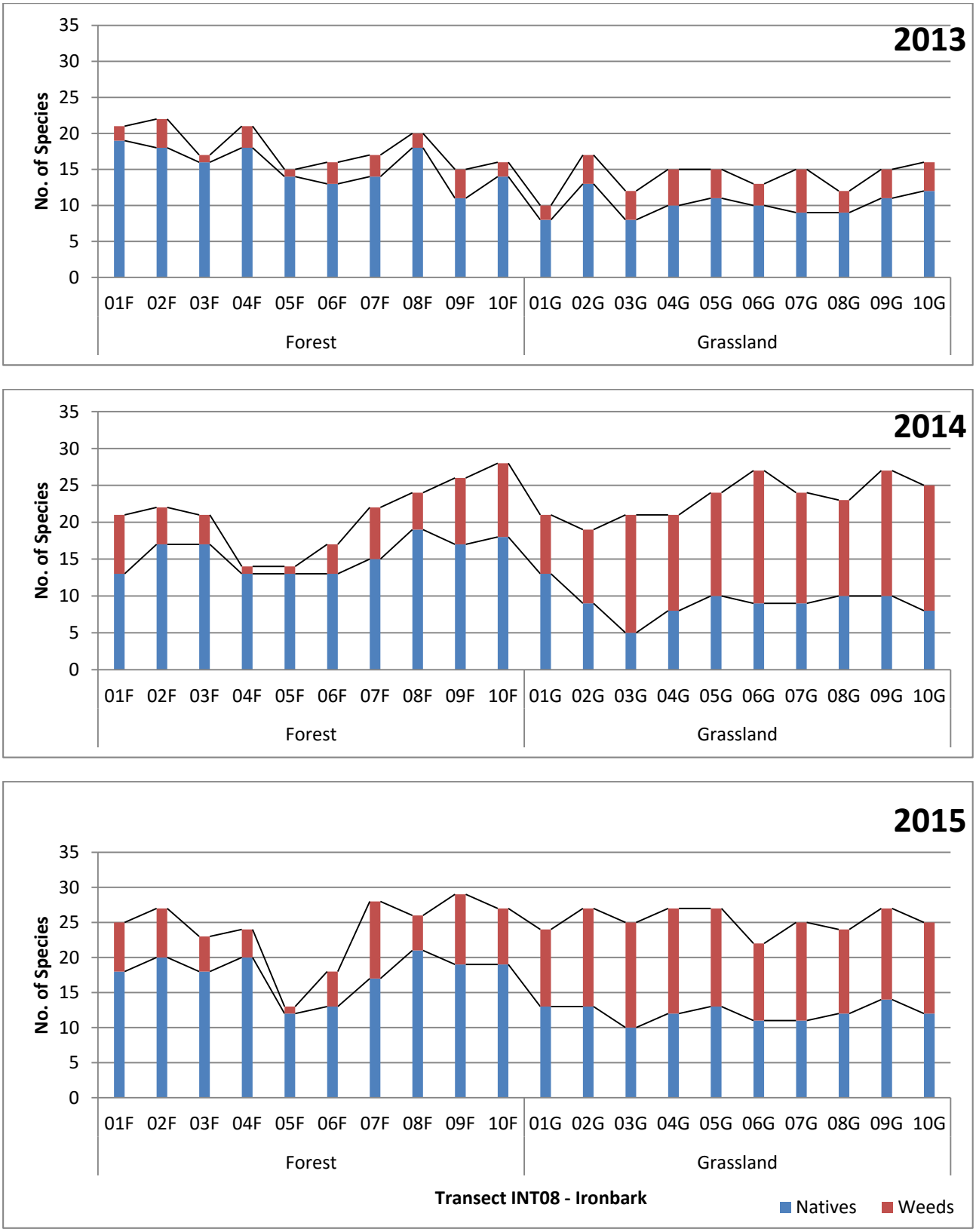


Figure 29 Proportion, number and distribution of native and weed species along transect-pair INT08 (Ironbark-Grassland: Western BOA) from 2013 to 2015, as represented by presence in 20 offset-contiguous 5 x 5m quadrats. 01F = Forest quadrat; 01G = Grassland quadrat, etc. Total transect length = 100m.

Table 3 Percentage change in canopy density for all management units, 2013 to 2015.

Management Unit	Transects	% change from 2013
Bulloak	INT01F	+9.6
Spotted Gum	INT05F	+5.9
Apple	INT07F	+2.7
Ironbark	INT02F, INT04F, INT08F	+0.9
Grey Box	INT06F	-26.3
Swamp Oak	INT03F	-27.5
Grassland (Grey Box)	INT06G	+100.0
Grassland (Bulloak)	INT01G	+56.3
Grassland (Swamp Oak)	INT03G	+54.6
Grassland (Ironbark)	INT02G, INT04G, INT08G	+12.7
Grassland (Apple)	INT07G	+1.3
Grassland (Spotted Gum)	INT05G	-22.2

4.5.2 Canopy Age Structure

Forest vegetation within the Integra BOAs is representative of a regenerating class following previous clearing disturbances. **Figure 31 - 42** illustrate this through age distribution charts for all forest and grassland management units. Data from 2013 onwards are included on these charts, to show how all units are recovering after the cessation of grazing. Note that these charts document data collected from total assessment areas of 250m^2 per transect, between 2013 and 2015. The 2015 assessments extended this data collection to cover 500m^2 per transect, and subsequent assessments will compare results across this larger area (see **Appendix 7.18** for age distribution charts covering the extended areas).

For Bulloak, Ironbark, Swamp Oak and (to a lesser extent) Apple forests, there are clear trends showing regenerating canopy structure, with high numbers of juvenile specimens. These trends, initially identified in 2013, have continued into 2015. This is particularly evident in the invasive Swamp Oak forest (**Figure 33**), where there has been continual recruitment over at least a decade (0-20cm DBH), and a large increase in the 1-5cm DBH class. For Bulloak (**Figure 31**), the dramatic increase in juveniles has continued into 2015. Transects within Spotted Gum (**Figure 34**) and Grey Box (**Figure 35**) were situated within remnant forest that was at least five decades old, possibly older. Age charts for these two MUs show a disjointed distribution of ages, and may reflect a history of periodic disturbance (under-scrubbing, crash grazing) that has removed specific cohorts of regenerating canopy individuals. Neither of these units have shown any significant changes since 2013, although for Spotted Gum there has been a positive transition from the 0-1cm DBH into the 1-5cm DBH class. It is expected that over time, with continuing cattle exclusion, age structure will improve.

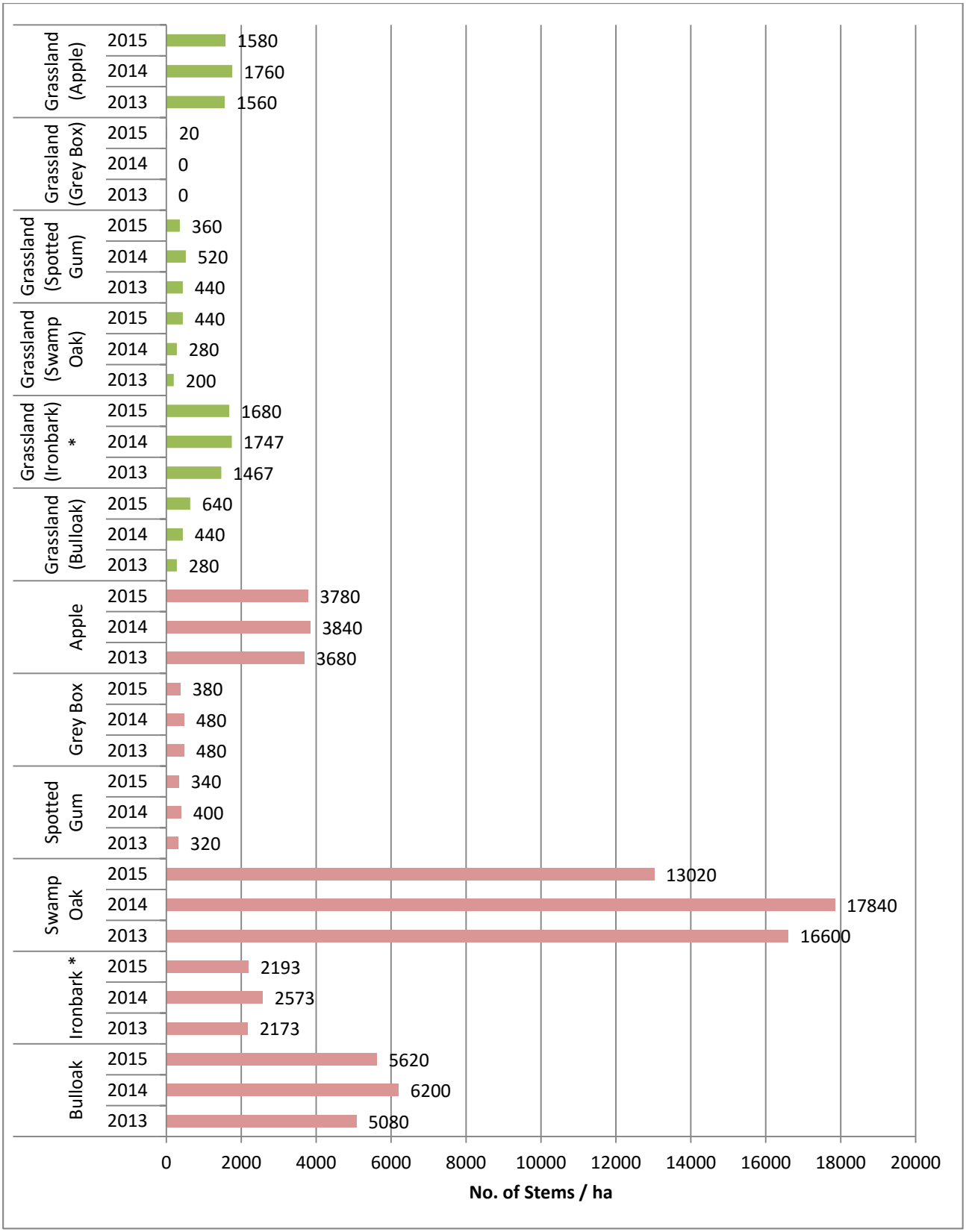


Figure 30 Number of canopy stems per hectare for management units, 2013 to 2015. n=30 for Ironbark and Grassland (Ironbark) MUs; n=10 for all other MUs. NB: 2015 data collected over 500m^2; earlier data over 250m^2.

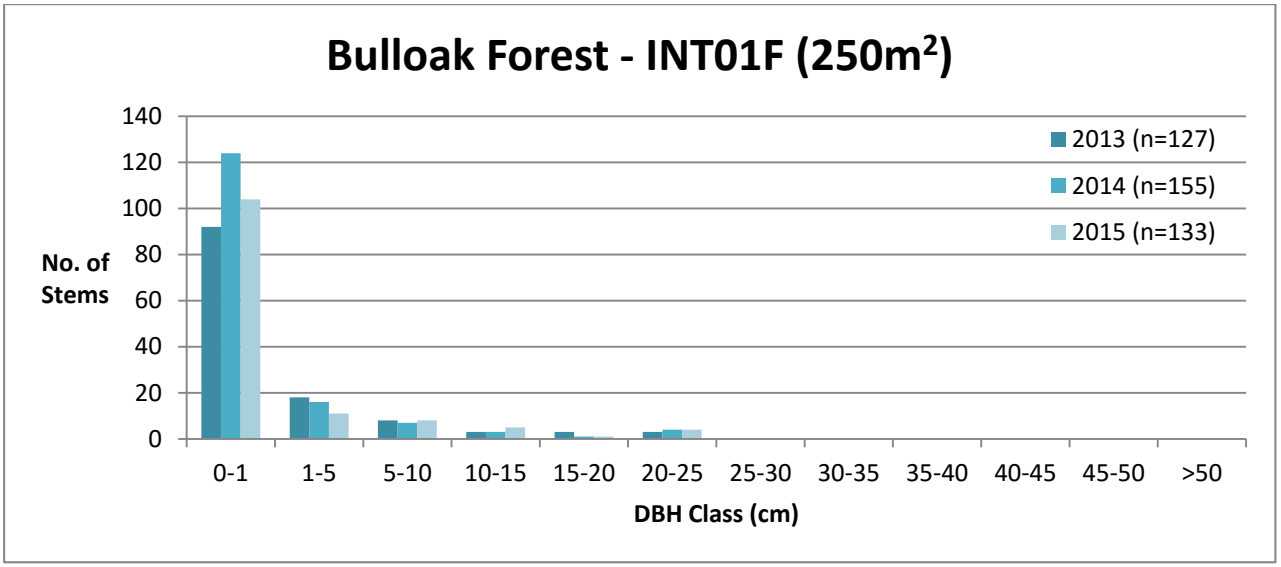


Figure 31 Age class distribution of canopy stems for Bulloak MU, 2013 to 2015.

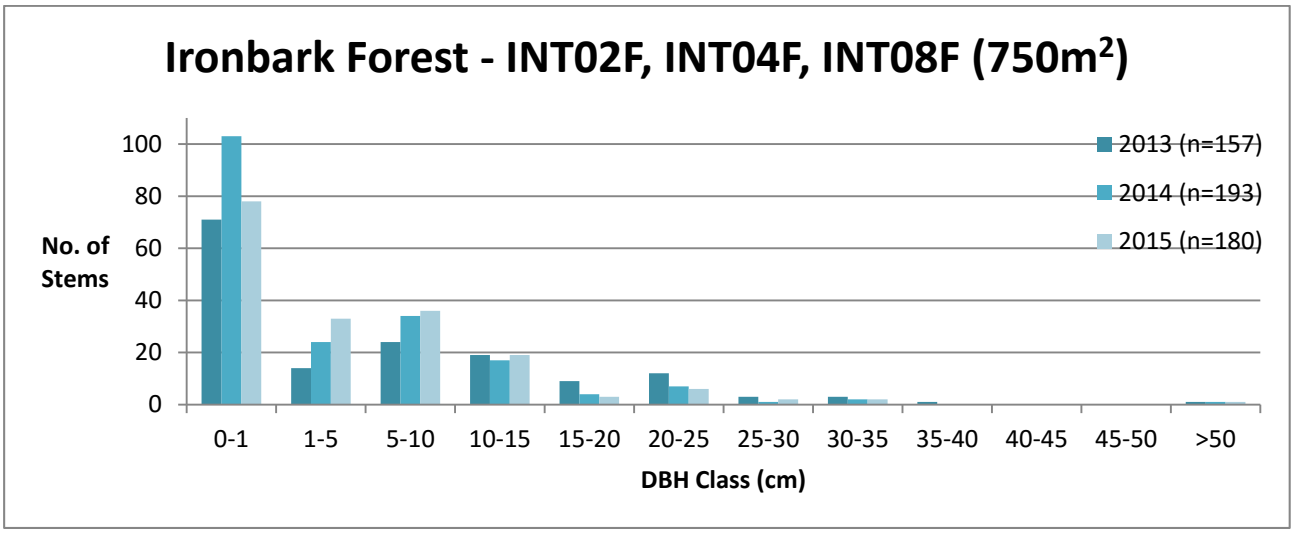


Figure 32 Age class distribution of canopy stems for Ironbark MU, 2013 to 2015.

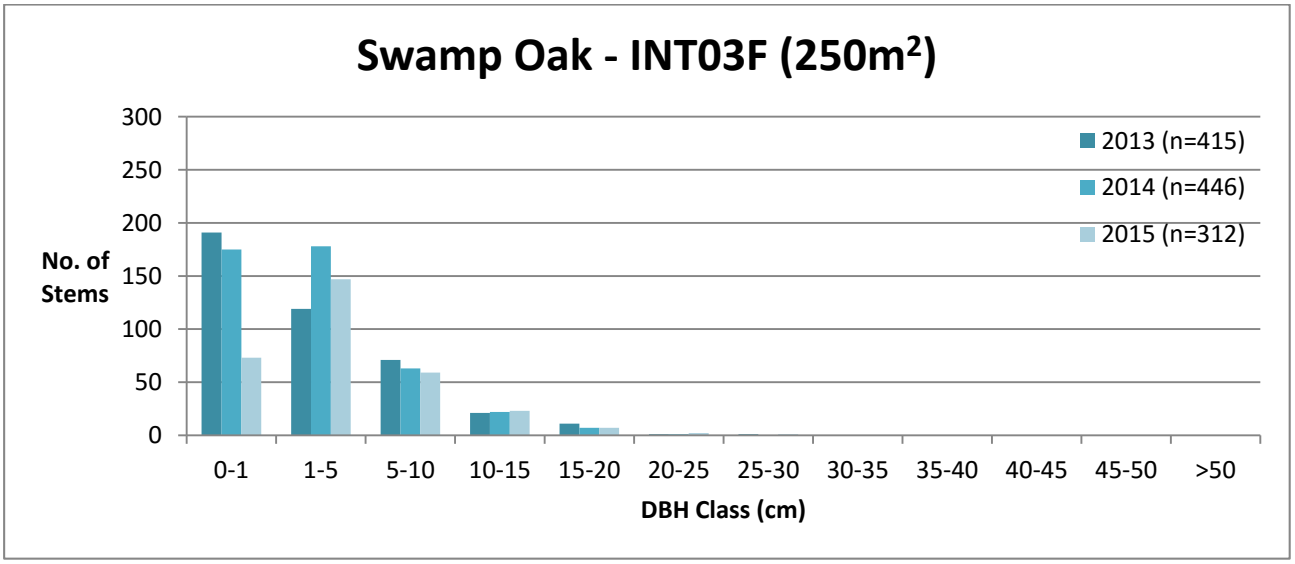


Figure 33 Age class distribution of canopy stems for Swamp Oak MU, 2013 to 2015.

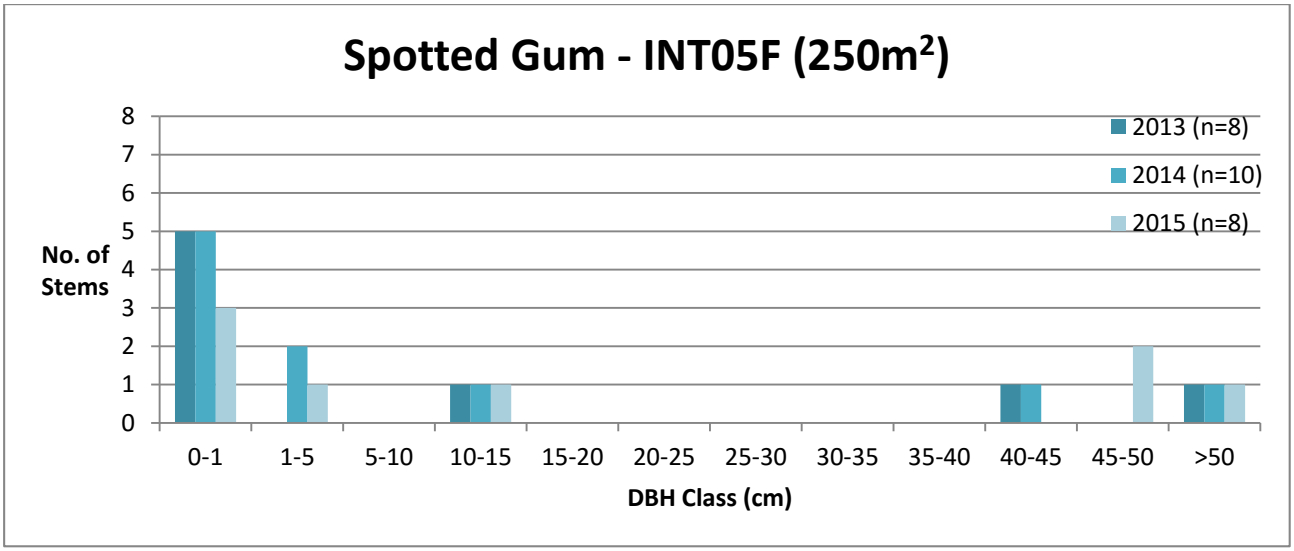


Figure 34 Age class distribution of canopy stems for Spotted Gum MU, 2013 to 2015.

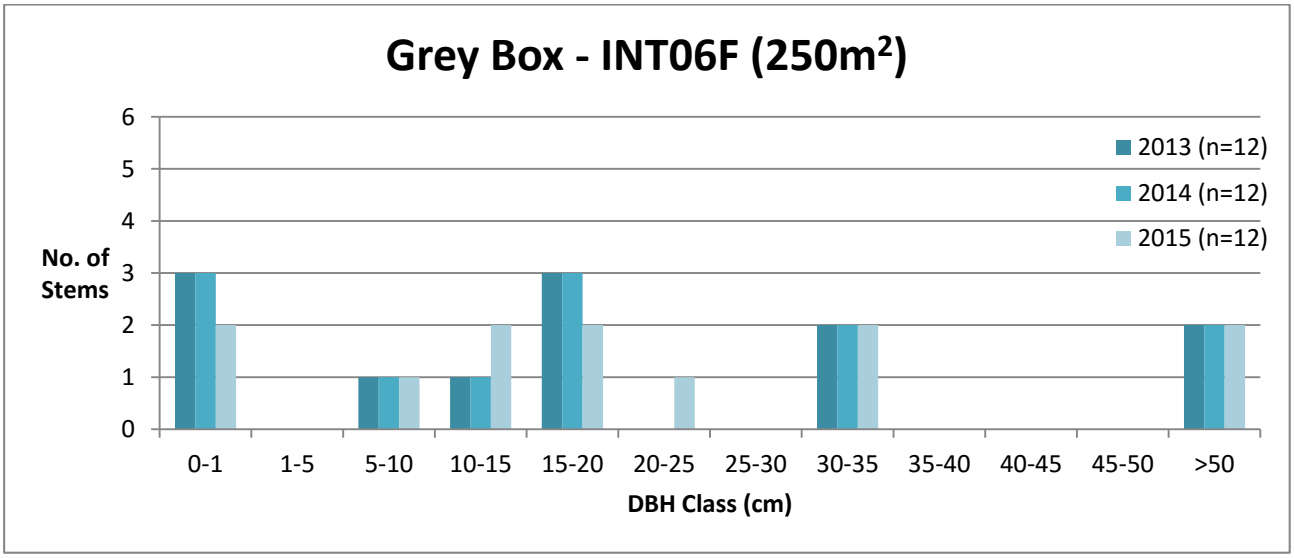


Figure 35 Age class distribution of canopy stems for Grey Box MU, 2013 to 2015.

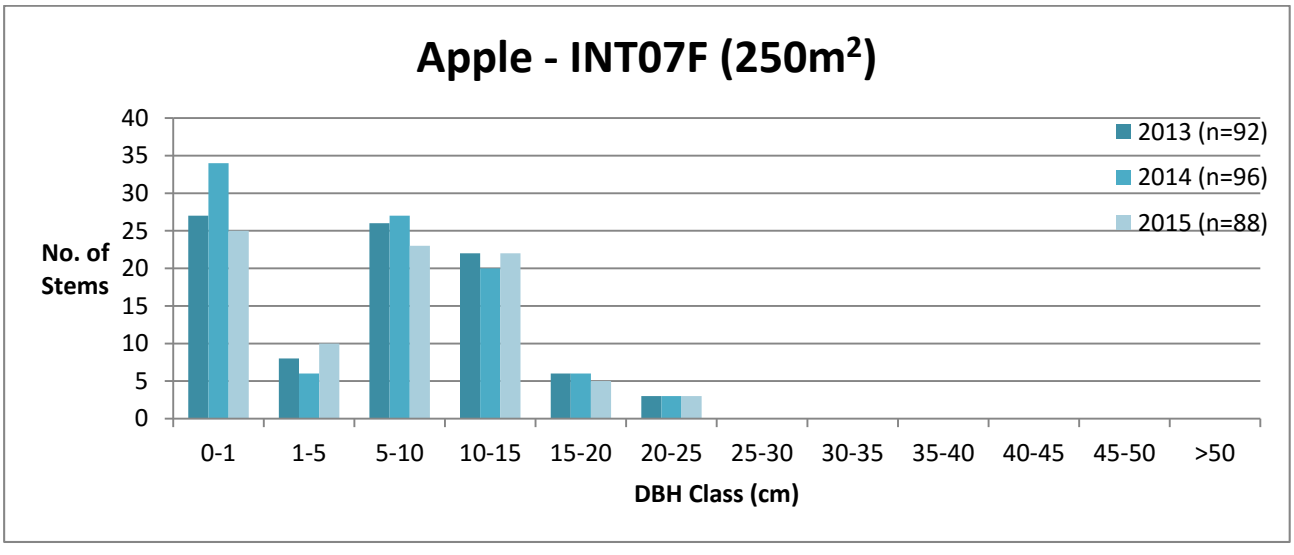


Figure 36 Age class distribution of canopy stems for Apple MU, 2013 to 2015.

The Grassland MUs (**Figures 37 - 42**) display early-stage succession of canopy establishment for all but Grey Box (**Figure 41**). The Bridgeman BOA, where the Grey Box transect is positioned, had late removal of cattle (~early 2014), hence it may be expected that canopy recovery will be delayed. Indeed, canopy assessment over the extended area (500m^2) showed a better developing trend in this lower age class (see **Appendix 7.18**), indicating that recolonization is in process. Transect INT02G in Grassland (Ironbark) had in 2014 been partially ripped and planted with a mix of canopy (*Corymbia maculata, Eucalyptus crebra, Corymbia ?citriodora*) and shrub species (*Acacia decurrens, Acacia ?longifolia, Acacia ?myrtifolia*). These species continue to grow, and will boost return to forest over coming years.

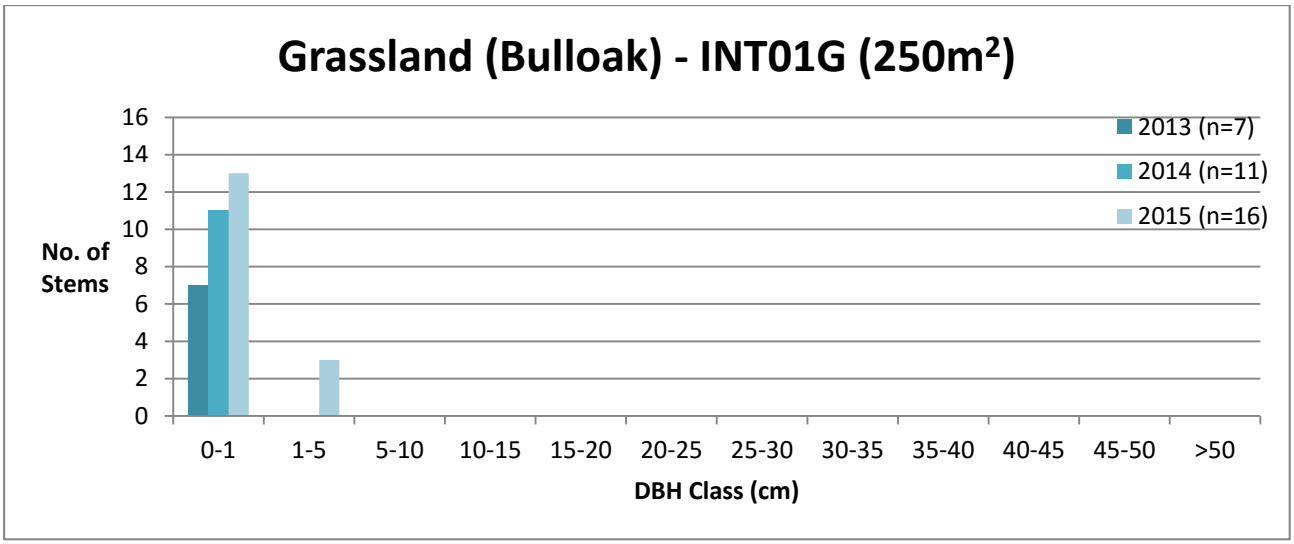


Figure 37 Age class distribution of canopy stems for Grassland (Bulloak) MU, 2013 to 2015.

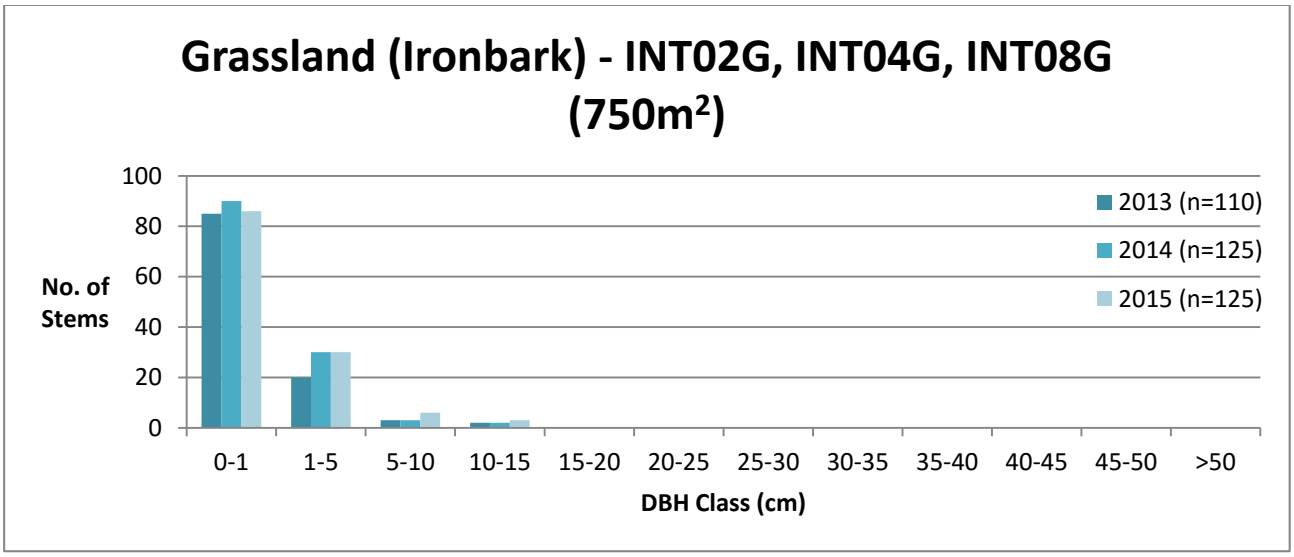


Figure 38 Age class distribution of canopy stems for Grassland (Ironbark) MU, 2013 to 2015.

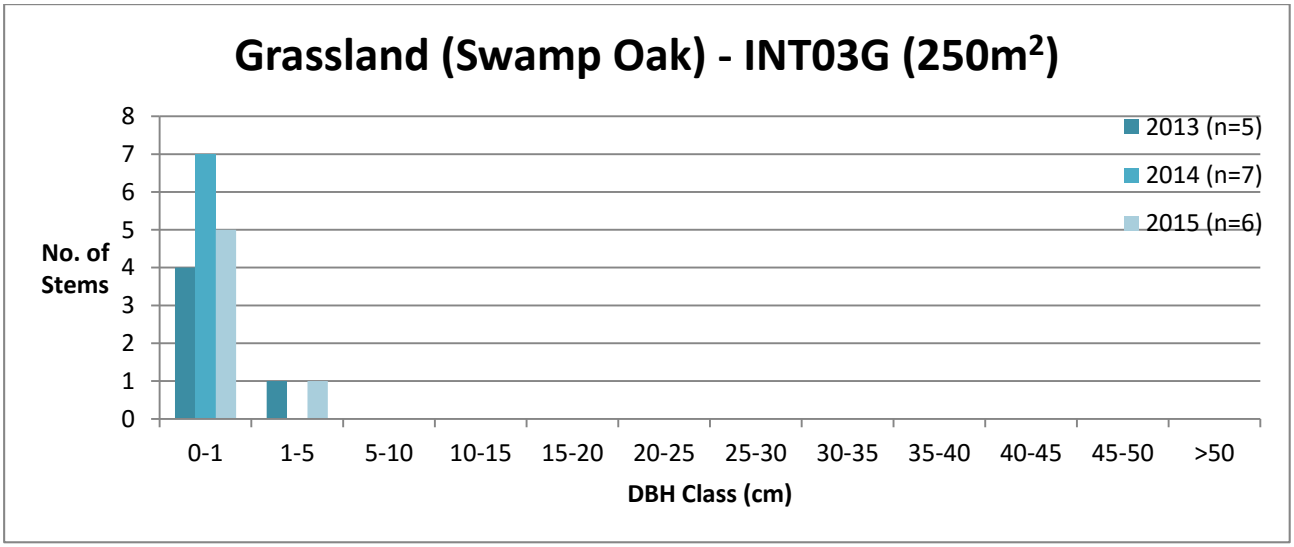


Figure 39 Age class distribution of canopy stems for Grassland (Swamp Oak) MU, 2013 to 2015.

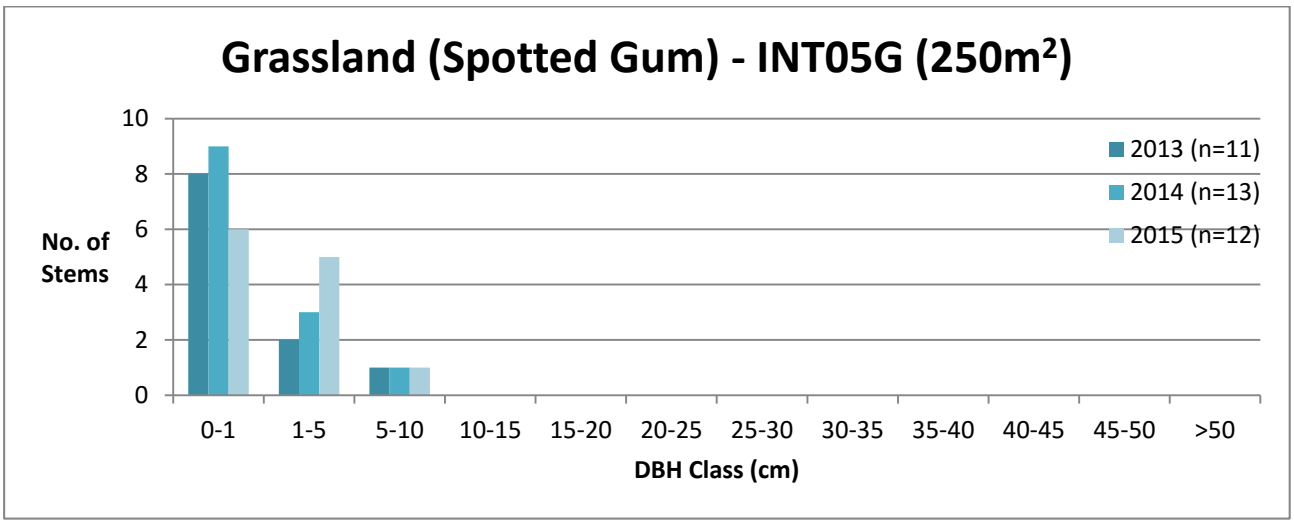


Figure 40 Age class distribution of canopy stems for Grassland (Spotted Gum) MU, 2013 to 2015.

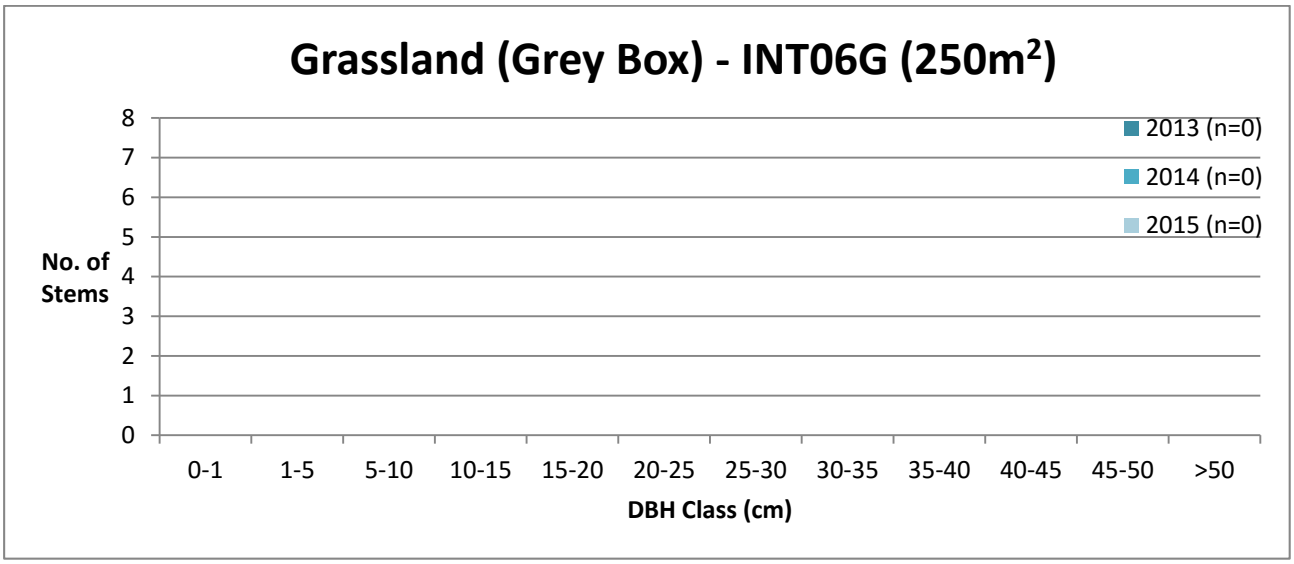


Figure 41 Age class distribution of canopy stems for Grassland (Grey Box) MU, 2013 to 2015.

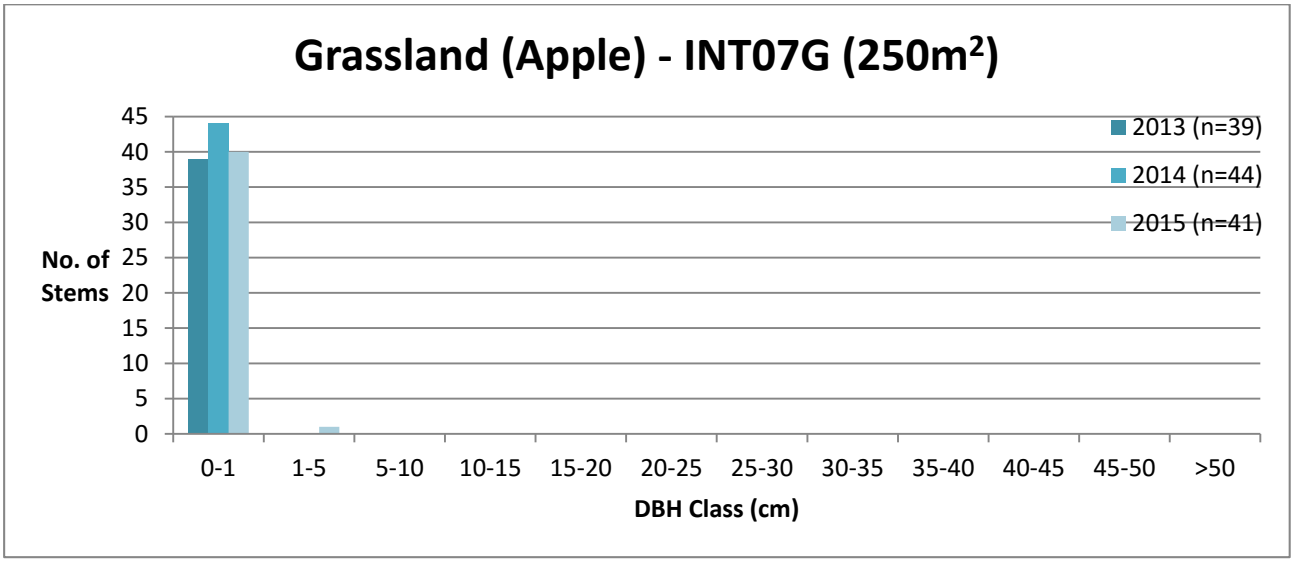


Figure 42 Age class distribution of canopy stems for Grassland (Apple) MU, 2013 to 2015.

4.5.3 Basal Tree Area

Figure 43 (Remnant Forest) and **Figure 44** (Grassland) show the basal tree area (at 2015) and mean Diametre-at-Breast Heights (DBH) for all management units, from 2013 to 2015. For remnant Forest, mean DBH values have changed little since 2013, as is expected over such a short assessment period. As in 2013, mean DBH values are highest in the Spotted Gum and Grey Box MUs (**Figure 43**), reflecting field observations that these two areas support older vegetation than most others. Apple and Ironbark support the next highest mean DBHs, although the latter shows two distinct age classes (not shown in **Figure 43**): transect 04F in the Northern BOA supports an older stand of Remnant Forest than is present in the Martins Creek (transect 02F) or Western (transect 08F) BOAs. Interestingly, Swamp Oak supports the lowest mean DBH but highest basal area, and confirms that this vegetation type has quickly invaded former grazing lands, with few older trees present. Ironbark shows the greatest basal area of all management units, and is comprised largely of many individual trees and saplings at high density (and explaining the low mean DBH).

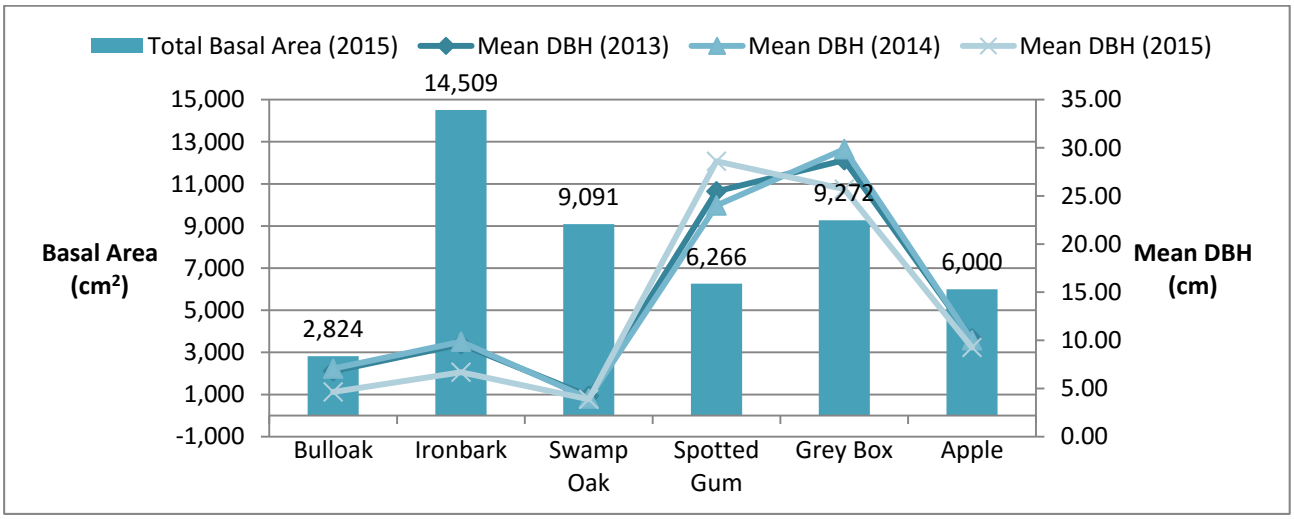


Figure 43 Total basal area (2015) and mean DBH of canopy stems for Remnant Forest MUs (2013 - 2015).

For Grassland MUs (**Figure 44**), the few canopy species present limit useful interpretation of data. However, the high mean DBH and low basal area for Grassland (Ironbark) and Grassland (Spotted Gum) indicate the presence of a few older trees within these management units, contrasting strongly with other MUs, where negligible canopy species were present. One obvious change from 2013 is the decrease in mean DBH for Grassland (Swamp Oak) in 2014, but has begun to increase again in 2015.

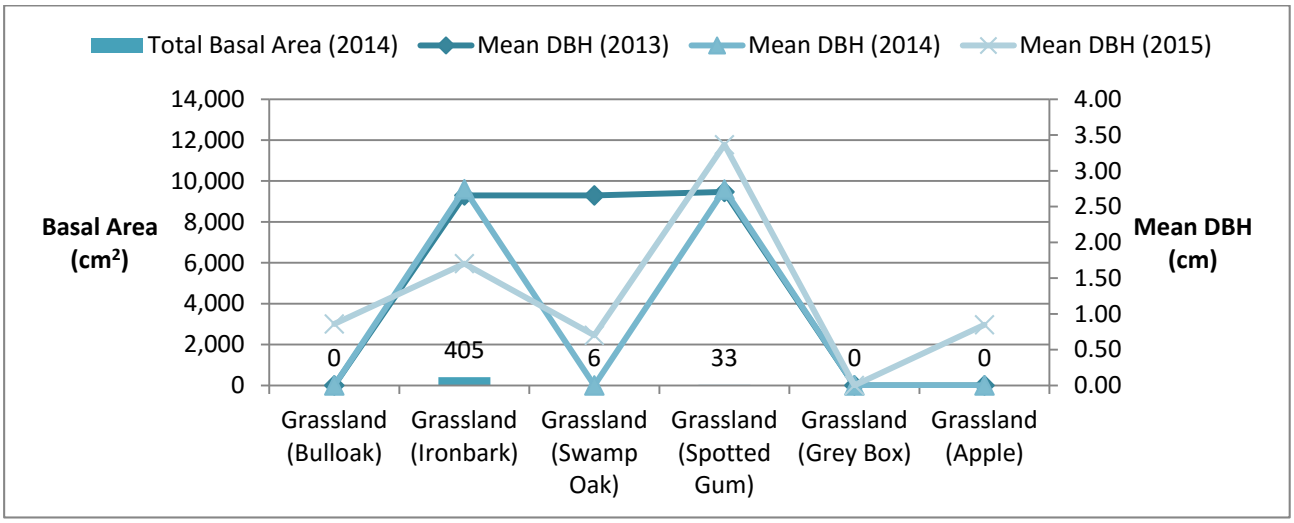


Figure 44 Total basal area (2015) and mean DBH of canopy stems for Grassland MUs (2013 - 2015).

Note that basal area and DBH charts for all MUs across the extended assessment areas (500m^2 per transect) are shown in **Appendix 7.18**, in readiness for future comparisons under the new strategy in coming years.

4.6 Shrub Composition & Structure

4.6.1 Shrub Diversity

In total, twenty-two woody shrub species have been recorded within study transects between 2013 and 2015, including three planted species within one transect, and two weeds (**Figure 45 & 46**). As in 2013, nearly all woody shrubs were recorded within three transect-pairs in 2015: transect INT04 (Ironbark, Northern BOA), transect INT05 (Spotted Gum, Supplementary BOA), and transect INT06 (Grey Box, Bridgeman BOA). This aligns well with other monitoring results (canopy age structure, basal area) that suggested these stands of vegetation were older and supported better structure than other examined stands. The main exception to this was the appearance in 2014 of three planted out shrub species within transect INT02G (Ironbark Grassland, Martins Creek BOA), which have boosted both structure and composition in this area. In general, changes in shrub composition and abundance from 2013 to 2015 reflect natural attrition of seedlings due to dry conditions, and new germinates into the population. A clearer picture of the progress of the shrub layer is likely when assessed at 5-yearly intervals.

Overall, *Maireana microphylla* was the most abundant native shrub species in 2015, followed by *Daviesia ulicifolia*, *Acacia parvipinnula*, and *Pultenaea microphylla*. All other native species occurred less commonly, while the woody weeds *Lycium ferocissimum* and *Olea europea* remained only in Forest units (absent from Grassland units).

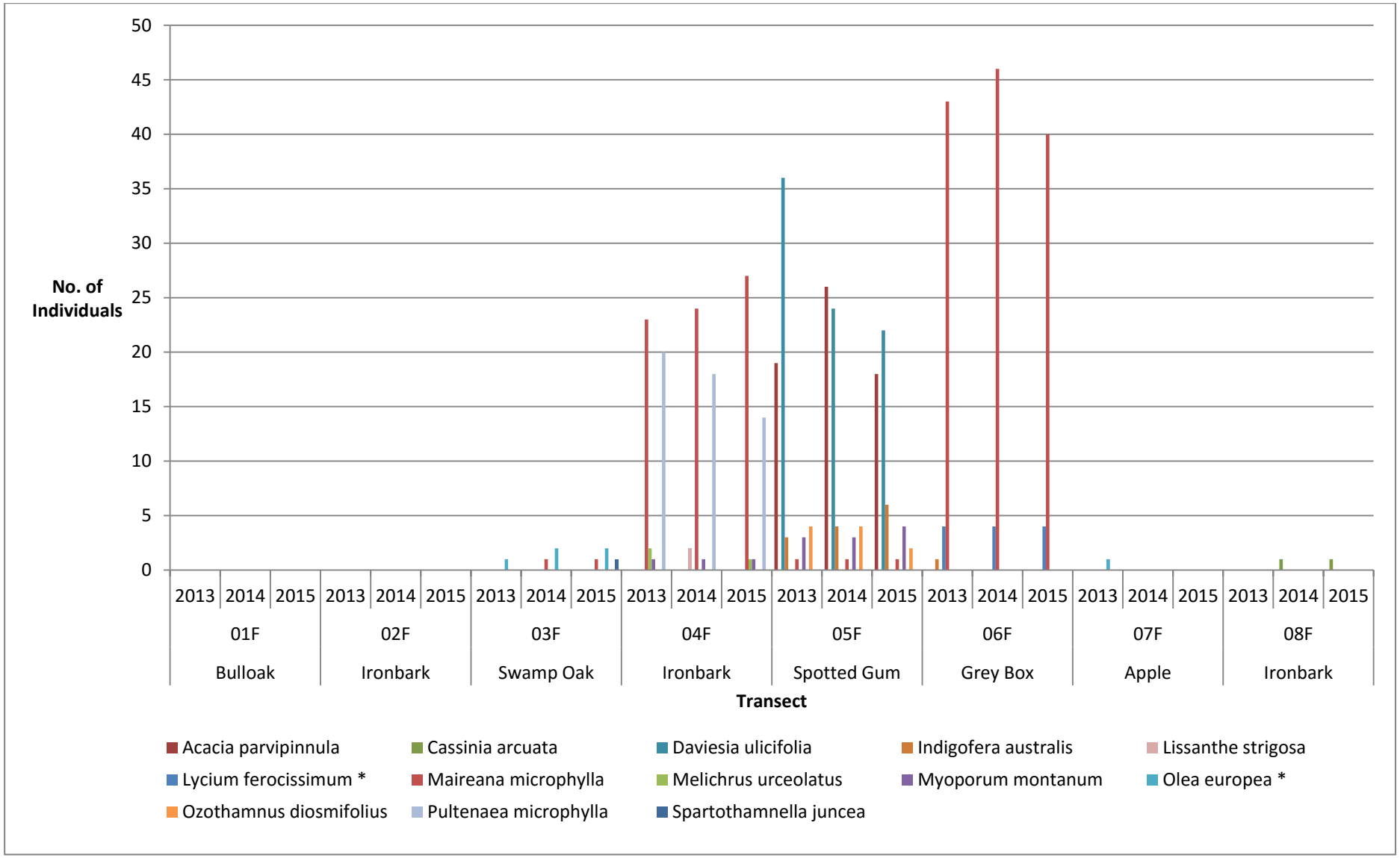


Figure 45 Number of stems of woody shrub species recorded in all Forest transects, 2013 to 2015. * = weed species.

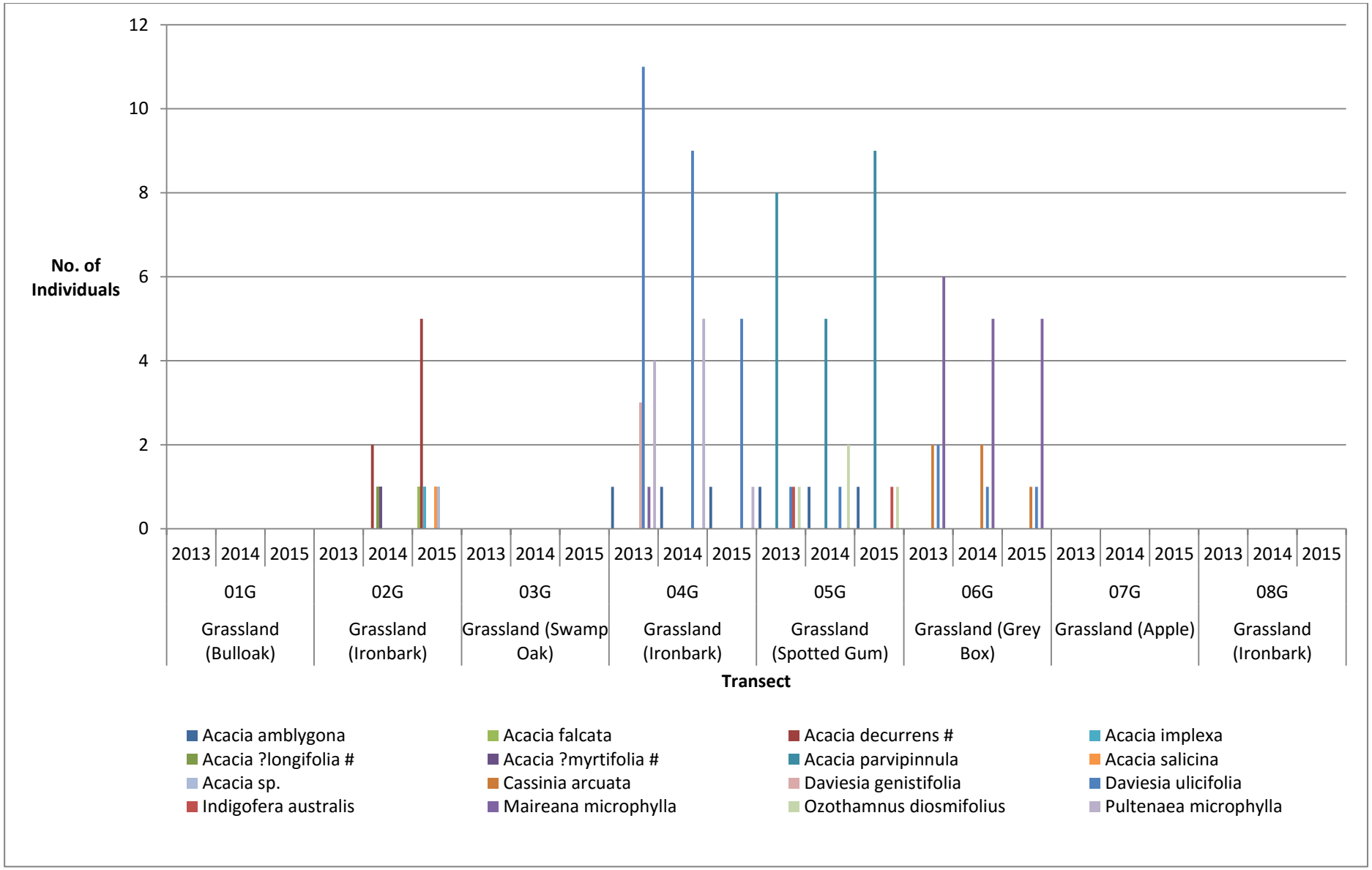


Figure 46 Number of stems of woody shrub species recorded in all Grassland transects, 2013 to 2015. * = weed species; # = planted species.

4.6.2 Shrub Density

Figure 47 and **48** show the average number of woody shrub stems per quadrat in each transect from 2013 to 2015. There is some consistency in the number of woody shrubs in those transects shown to support a shrub layer (transects INT04, INT05 & INT06; Forest & Grassland MUs), but most are showing a decreasing trend. Low standard errors relative to means in Forest transects suggest good shrub representation across all transect quadrats. Conversely, Grassland transects show high standard errors, indicative of inconsistent shrub development. In general, Remnant Forest transects (**Figure 47**) support higher numbers of woody shrub species when compared to Grassland transects (**Figure 48**, a situation which is to be expected initially given past land uses. Remnant Forest transects with little or no shrub layers are of a younger age (see canopy composition in Section 4.5), and are expected to develop an understorey over coming years: this is already becoming evident in INT03F and INT08F. Similarly, Grassland transects will continue to develop shrub layers over time.

Relative to 2013 and 2014 data, there has been a decrease in mean shrub stems for most transects, but it is difficult at this stage to determine reasons for this. Natural attrition due to dry conditions is likely to have reduced the number of very small seedlings over the last 12-24 months.

When examined at the Management Unit level (**Figure 49**, **Table 4**), there has been a decreasing trend in mean shrub stems since 2013, particularly in the Spotted Gum MU. No shrub development has yet been detected in Bulloak, Grassland (Bulloak), Grassland (Swamp Oak) and Grassland (Apple) MUs. With time, it is expected that shrub germination will occur in these units.

The density of shrubs per hectare range from none in Bulloak and three Grassland MUs, to 2120 in Spotted Gum and 1760 in Grey Box (**Table 4**), both down slightly on 2014 results. Compared to 2013 and 2014, results for 2015 show a relatively stable shrub layer across most MUs. A more informed assessment of the development of shrub layers cannot be made until ~5 years of monitoring has been completed, to account for year-to-year seasonal variances.

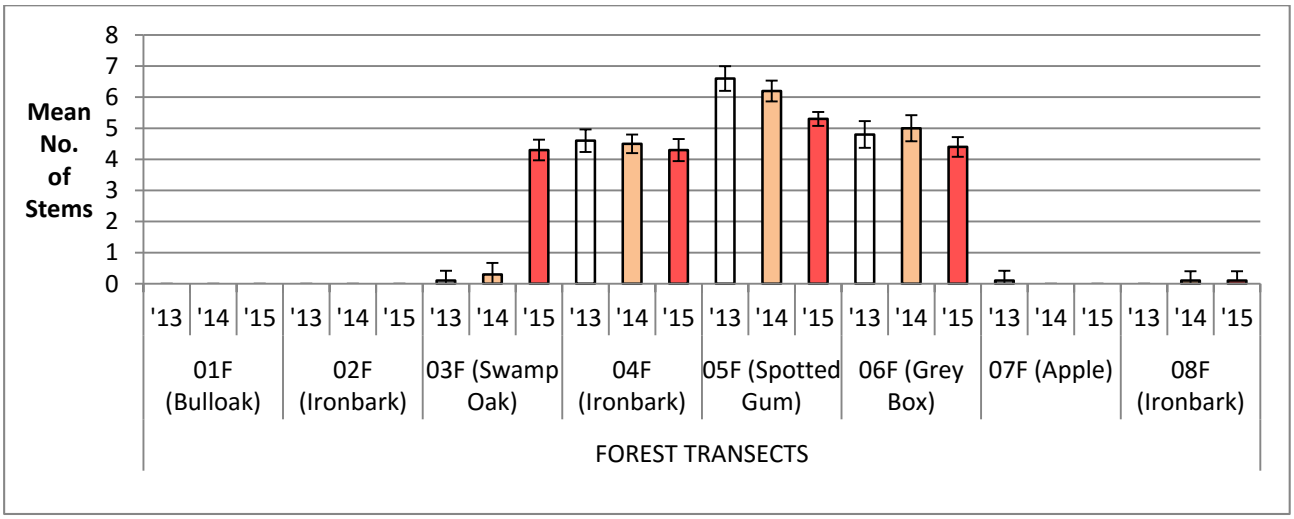


Figure 47 Mean number of woody shrub stems per quadrat (n=10) for each Forest transect (2013 to 2015), with standard error values.

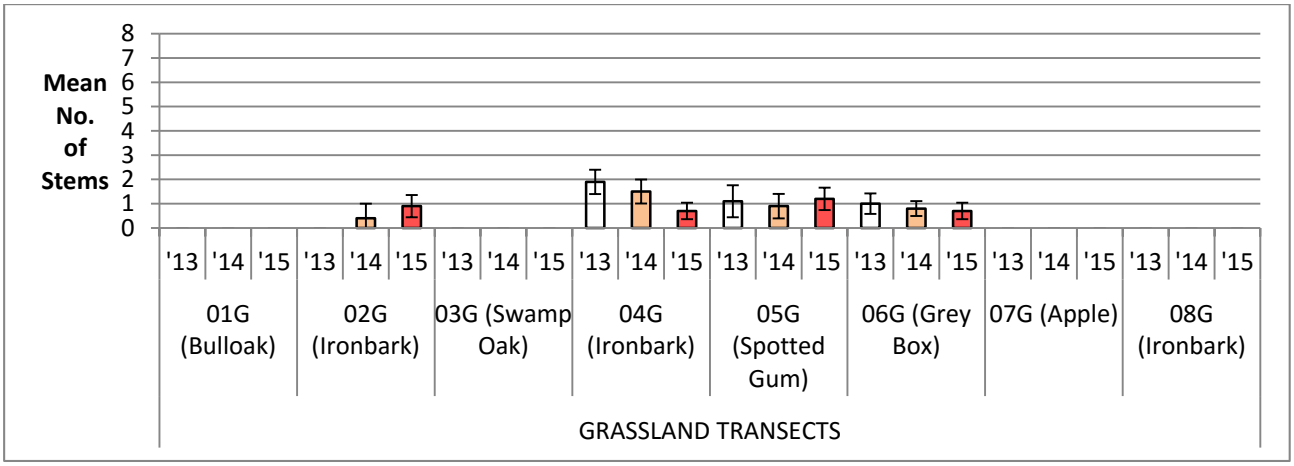


Figure 48 Mean number of woody shrub stems per quadrat (n=10) for each Grassland transect (2013 to 2015), with standard error values.

Table 4 Number and density of woody shrub stems for all management units, 2013 to 2015. n=30 for Ironbark and Grassland (Ironbark) MUs; n=10 for all other MUs.

Management Unit (Transect)	Stems			Stems/ha*		
	2013	2014	2015	2013	2014	2015
Bulloak (INT01F)	0	0	0	0	0	0
Ironbark (INT02F, INT04F, INT08F)	46	46	44	613	613	587
Swamp Oak (INT03F)	1	3	4	40	120	160
Spotted Gum (INT05F)	66	62	53	2640	2480	2120
Grey Box (INT06F)	48	50	44	1920	2000	1760
Apple (INT07F)	1	0	0	40	0	0
Grassland (Bulloak) (INT01G)	0	0	0	0	0	0
Grassland (Ironbark) (INT02G, INT04G, INT08G)	19	19	16	253	253	213
Grassland (Swamp Oak) (INT03G)	0	0	0	0	0	0
Grassland (Spotted Gum) (INT05G)	11	9	12	440	360	480
Grassland (Grey Box) (INT06G)	10	8	7	400	320	280
Grassland (Apple) (INT07G)	0	0	0	0	0	0

* each transect samples 250m^2

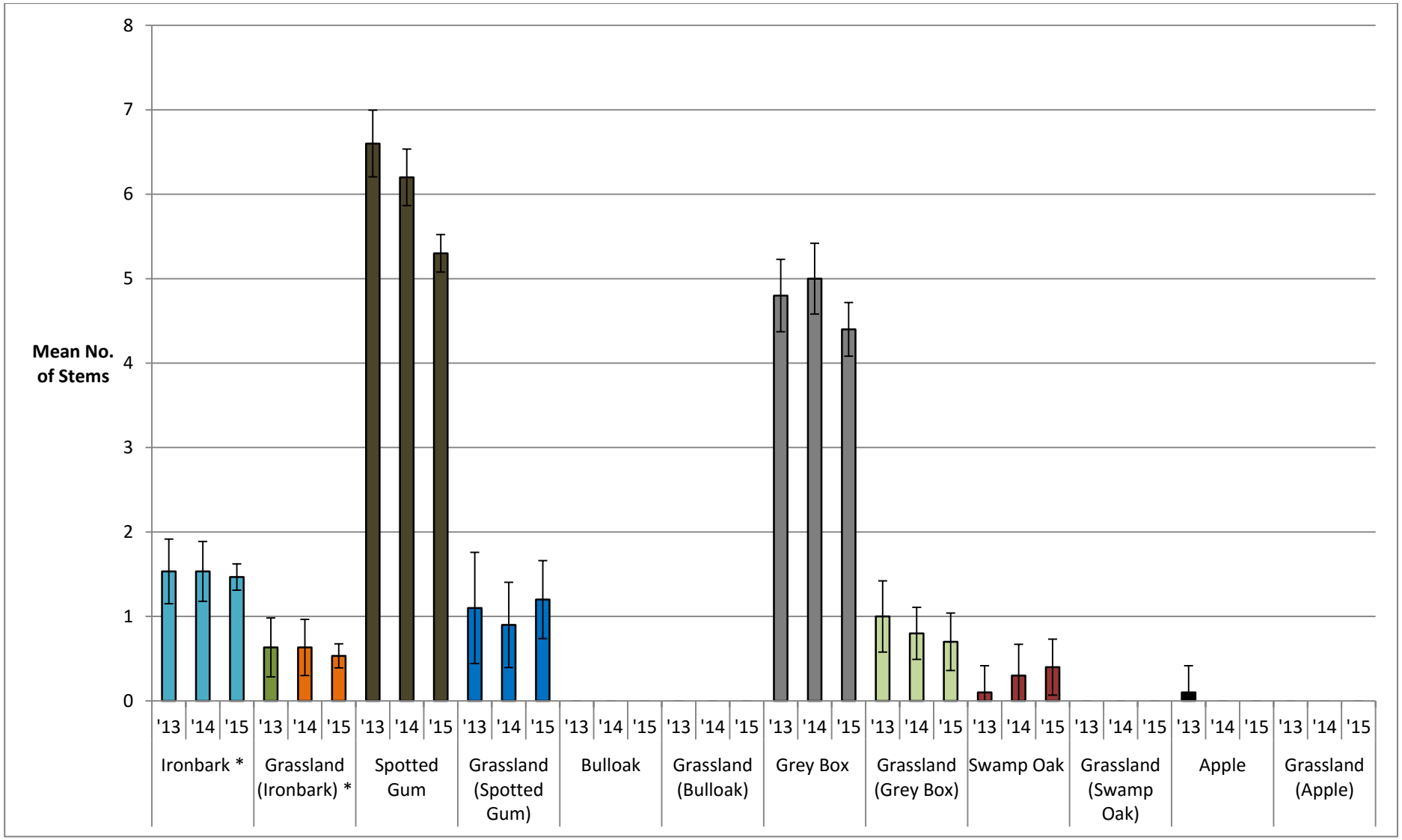


Figure 49 Mean number of woody shrub stems per quadrat for each Management Unit (2013 to 2015), with standard error values. * = pooled data; n=30 for Ironbark and Grassland (Ironbark) MUs; n=10 for all other MUs.

4.6.3 Acacia Density

For *Acacia* species, which are important early colonizers of disturbed ground, few transects supported healthy populations within MUs (**Figure 50 & 51; Table 5**). This may be an impact of prolonged grazing pressure over many decades or an absence of burning (required to scarify seeds) over long periods. Only Spotted Gum (INT05; Supplementary BOA) recorded observable stands of *Acacia* species, both in Remnant Forest (where *Acacia amblygona* was noted for the first time) and Grassland (an increase from both 2013 & 2014 results). Grassland (Ironbark) results have been augmented by the planting of five *Acacia* species in INT02G, and compliment the *Acacia amblygona, Acacia falcata* and *Acacia implexa* naturally occurring there.

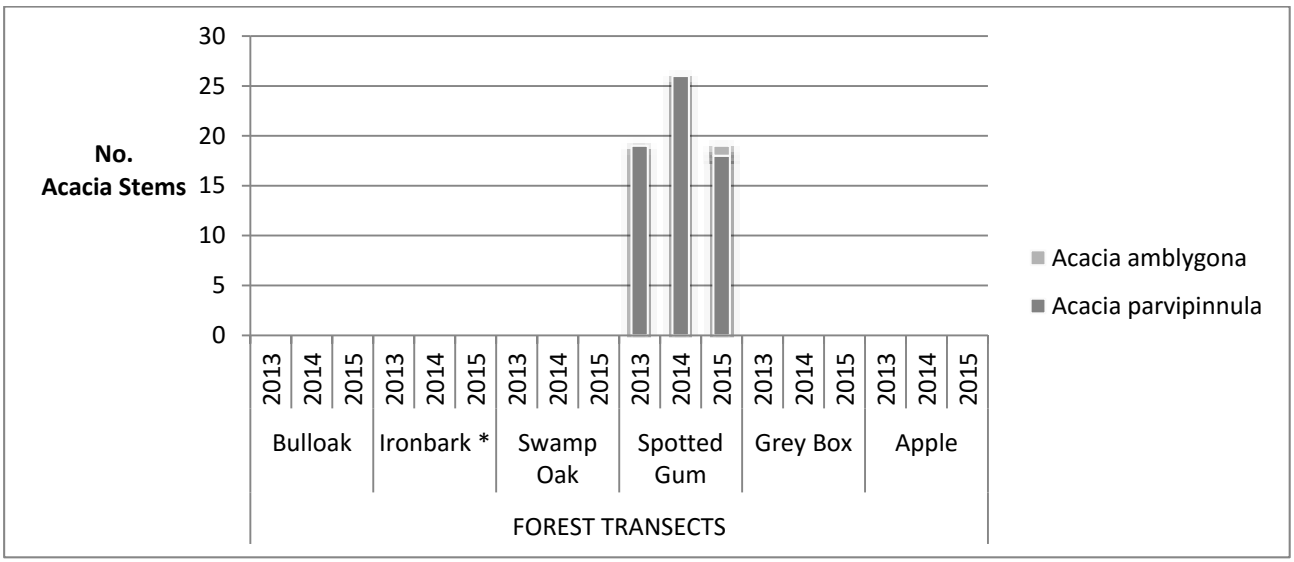


Figure 50 Number of *Acacia* stems recorded for each Forest Management Unit, 2013 to 2015. * = mean values over 3 transects.

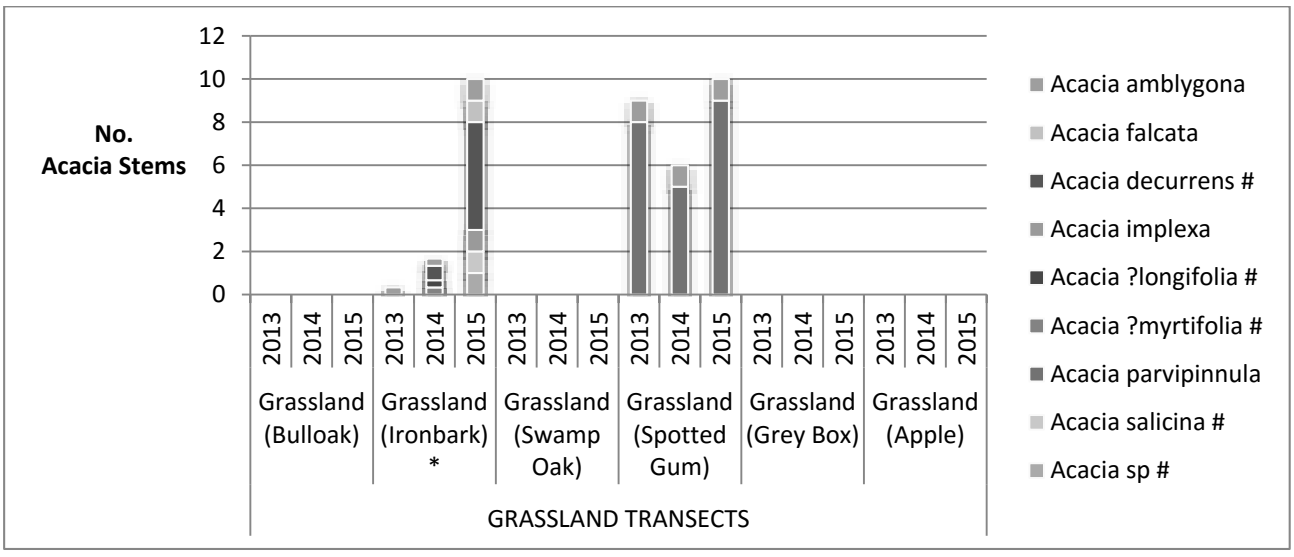


Figure 51 Number of *Acacia* stems recorded for each Grassland Management Unit, 2013 to 2015. * = mean values over 3 transects; # = planted specimens.

Table 5 **Number and density of *Acacia* stems for all management units, 2015. *** n=30 for Ironbark and Grassland (Ironbark) MUs; n=10 for all other MUs; # = planted specimens.

FOREST	**Bulloak**		**Ironbark ***		**Swamp Oak**		**Spotted Gum**		**Grey Box**		**Apple**	
***Acacia* spp**	Stems	Stems/ha	Stems	Stems/ha	Stems	Stems/ha	Stems	Stems/ha	Stems	Stems/ha	Stems	Stems/ha
A. amblygona	0	-	0	-	0	-	0	-	0	-	0	-
A. decurrens #	0	-	0	-	0	-	0	-	0	-	0	-
A. falcata	0	-	0	-	0	-	0	-	0	-	0	-
A. implexa	0	-	0	-	0	-	0	-	0	-	0	-
A. salicina #	0	-	0	-	0	-	0	-	0	-	0	-
A. parvipinnula	0	-	0	-	0	-	18	720	0	-	0	-
A. sp.	0	-	0	-	0	-	0	-	0	-	0	-
Total	0	-	0	-	0	-	18	720	0	-	0	-

GRASSLAND	**Grassland (Bulloak)**		**Grassland (Ironbark)***		**Grassland (Swamp Oak)**		**Grassland (Spotted Gum)**		**Grassland (Grey Box)**		**Grassland (Apple)**	
***Acacia* spp**	Stems	Stems/ha	Stems	Stems/ha	Stems	Stems/ha	Stems	Stems/ha	Stems	Stems/ha	Stems	Stems/ha
A. amblygona	0	-	1	13	0	-	1	40	0	-	0	-
A. decurrens #	0	-	5	67	0	-	0	-	0	-	0	-
A. falcata	0	-	1	13	0	-	0	-	0	-	0	-
A. implexa	0	-	1	13	0	-	0	-	0	-	0	-
A. salicina #	0	-	1	13	0	-	0	-	0	-	0	-
A. parvipinnula	0	-	0	-	0	-	9	360	0	-	0	-
A. sp.	0	-	1	13	0	-	0	-	0	-	0	-
Total	0	-	10	132	0	-	10	400	0	-	0	-

4.7 Leaf Litter & Bare Ground

Percentage cover of leaf litter remained highest in Remnant Forest management units, although in some areas individual Grassland quadrats at the interface with forested areas also showed reasonably high levels. Since 2013, there has been a general reduction in the amount of leaf litter within most MUs, most notably in Swamp Oak, Bulloak and Apple MUs. Spotted Gum and Grey Box MUs showed marginal increases in leaf litter from previous years. **Figure 52** shows the changes in estimated leaf litter for each management unit across all BOAs from 2013 to 2015.

Estimated percentage cover of bare ground has changed little since 2013 across all management units (**Figure 53**).

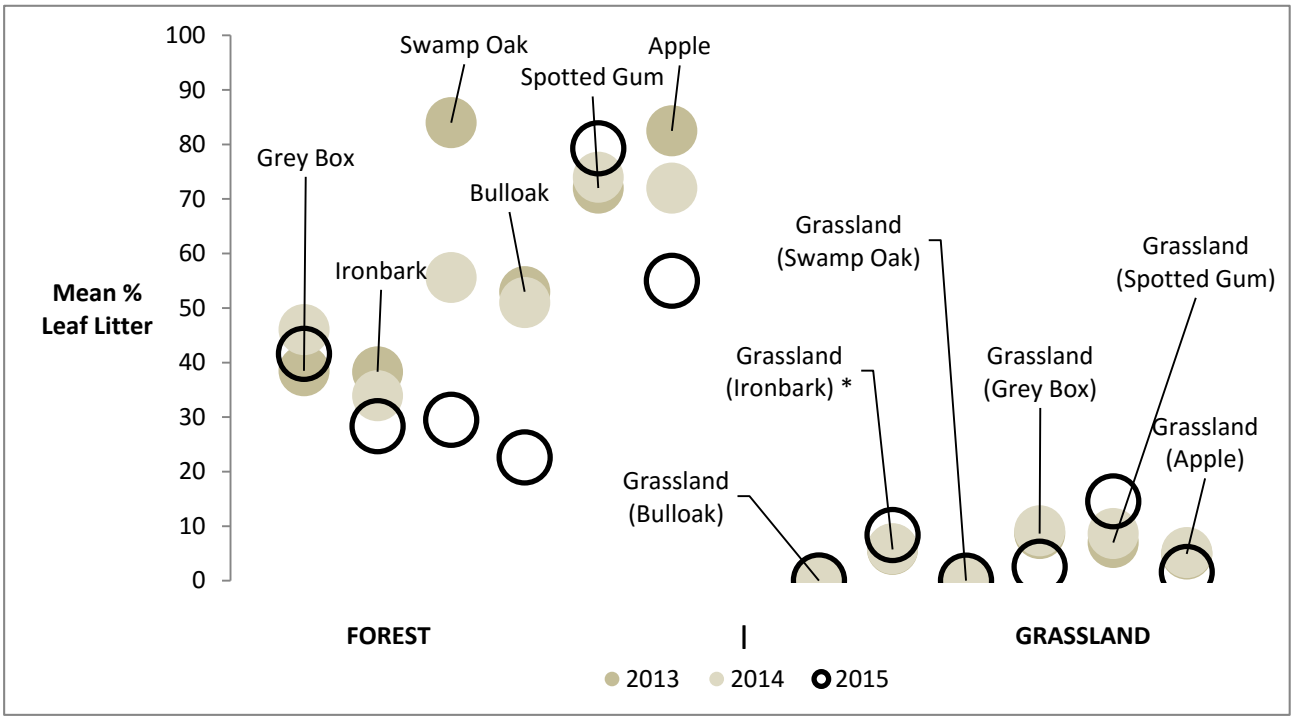


Figure 52 Mean leaf litter within management units (2013 to 2015), expressed as estimated % cover. * n=30 for Ironbark and Grassland (Ironbark) MUs; n=10 for all other MUs.

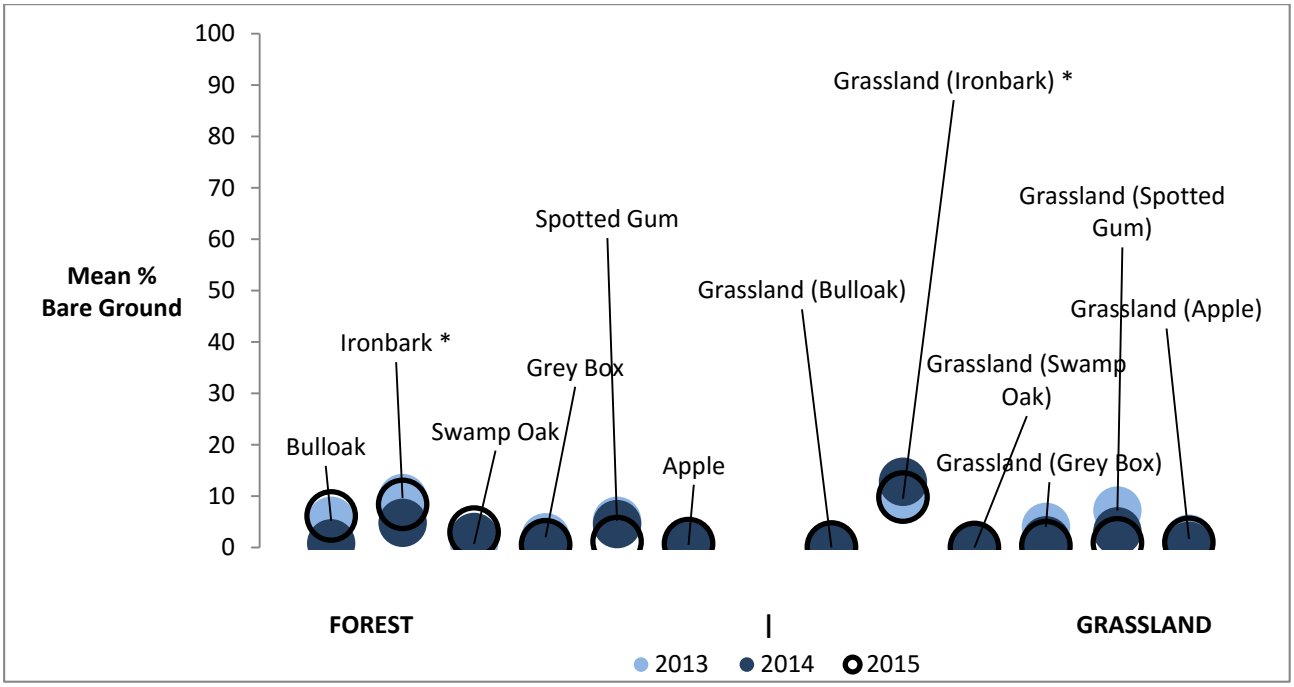


Figure 53 Mean extent of bare ground within management units (2013 to 2015), expressed as estimated % cover. * n=30 for Ironbark and Grassland (Ironbark) MUs; n=10 for all other MUs.

5. Discussion

5.1 Flora Summary

Monitoring of remnant vegetation within six Biodiversity Offset Areas (BOAs) at the Integra Coal Complex has been continued for the 2015 monitoring period. This has been accomplished primarily through the collection and analysis of replicated quantitative data from 16 transects and 160 quadrats (collectively covering 0.4ha) at locations established in 2013. Where applicable, comparisons of newly collected data have been made against 2013 and 2014 results to assist in the assessment of BOA health and regeneration progress.

Beginning in 2015, the collection of canopy structural data has been extended to encompass 500m^2 per transect, doubling the 250m^2 previously assessed in 2013 and 2014. This slight change in methodology was undertaken in recognition of the limited canopy data (stem density, basal area) that could be assessed in some management units. Future monitoring events are planned to adopt this larger assessment area for canopy structure attributes, and will be compared against 2015 data.

Data on species diversity, weed prevalence and distribution, canopy and shrub composition and structure, and ground cover attributes have now been documented and graphed for a third consecutive year, and provide a thorough overview of the progress and health of native vegetation within the six BOAs. By way of summary, **Table 6** and **Table 7** collate the results of all attributes measured across sixteen 50m transects during Spring 2013, 2014 and 2015 at Integra. Remnant Forest MUs (**Table 6**) have been categorized into '*benchmark*' data, while Grassland MUs (**Table 7**) can be considered '*regenerating*'. To demonstrate the progress of regenerating grassland areas back to benchmark forests and woodlands, continued annual comparisons of these attributes will provide tangible evidence of this progression over time, as well as highlighting management issues requiring attention. New and ongoing management issues highlighted from the 2015 monitoring period are discussed in Section 5.2.

Within the Integra Coal Complex, each BOA protects vegetation of differing types and quality, but all are important for regional conservation of threatened habitat:

- **Martins Creek BOA** - the largest of the BOAs, Martins Creek supports extensive areas of regenerating grassland, together with expanding forests of Swamp Oak (*Casuarina glauca*), Bulloak (*Allocasuarina luehmannii*) and Ironbark (*Eucalyptus crebra*). Three transect-pairs (INT01, INT02, INT03) have been established in these three management units and the associated grasslands. Aspects of this BOA form part of the *Central Hunter Ironbark - Spotted Gum - Grey Box Forest* Endangered Ecological Community.

- **Northern BOA** - largely comprised of regenerating grasslands and riparian zones of Swamp Oak (*Casuarina glauca*), together with some areas of Ironbark (*Eucalyptus crebra*). This BOA is under threat from the invasive expansion of Swamp Oak forest, particularly along slopes adjacent to creeklines. A single transect-pair (INT04) has been established in the Ironbark management unit within this BOA. Small areas form part of the *Central Hunter Ironbark - Spotted Gum - Grey Box Forest* Endangered Ecological Community.

Table 6 Summary attributes for 'benchmark' (Forest) management units, based on transect and quadrat data. Data for the Ironbark MU have been averaged across three transects. * = calculated from 500m^2 transects; 250m^2 for 2013 & 2014.

		Category:	*'Benchmark'*					
		Management Unit (Remnant Forest):	**Bulloak**	**Ironbark**	**Swamp Oak**	**Spotted Gum**	**Grey Box**	**Apple**
		Transects:	INT01F	INT02F INT04F INT08F	INT03F	INT05F	INT06F	INT07F
Species diversity	total	(2013)	30	35	26	55	38	44
		(2014)	32	46	30	56	41	48
		(2015)	49	59	45	65	51	64
	native (%)	(2013)	25 (83.3)	29 (82.9)	21 (80.8)	50 (90.9)	29 (76.3)	34 (77.3)
		(2014)	23 (71.9)	36 (78.3)	24 (80.0)	51 (91.1)	29 (70.7)	39 (81.3)
		(2015)	35 (71.4)	43 (72.9)	28(62.2)	55 (84.6)	37 (72.5)	48 (75.0)
	weeds (%)	(2013)	5 (16.7)	6 (17.1)	5 (19.2)	5 (9.1)	9 (23.7)	10 (22.7)
		(2014)	9 (28.1)	10 (21.7)	6 (20.0)	5 (8.9)	12 (29.3)	9 (18.7)
		(2015)	14 (28.6)	16 (27.1)	17 (37.8)	10 (15.4)	14 (27.5)	16 (25.0)
Canopy Age	basal area (cm^2)	(2013)	2982.17	4662.39	9009.52	8550.60	8054.99	6403.20
		(2014)	2641.26	4742.26	8035.26	4171.37	8874.32	6600.55
		(2015)	2823.97	4836.19	9091.17	6265.53	9272.05	5999.66
	mean DBH (cm)	(2013)	6.80	9.60	4.23	25.46	24.19	10.17
		(2014)	7.07	9.86	3.96	24.00	29.85	10.02
		(2015)	4.65	6.68	3.88	28.59	25.70	9.26
Stem Density	Canopy (stems/ha)	(2013)	5080	2173	16600	320	480	3680
		(2014)	6200	2573	17840	400	480	3840
		* (2015)	5620	2193	13020	340	380	3780
	Woody shrubs (stems/ha)	(2013)	0	613	40	2640	1920	40
		(2014)	0	613	120	2480	2000	0
		(2015)	0	587	160	2120	1760	0
	Acacia stems (stems/ha)	(2013)	0	0	0	760	0	0
		(2014)	0	0	0	1040	0	0
		(2015)	0	0	0	760	0	0
Weed cover	(mean % cover)	(2013)	3.7	0.4	0.6	0.5	1.4	0.4
		(2014)	0.8	0.3	0.5	0.5	1.3	0.5
		(2015)	0.3	0.4	0.5	0	7.6	0.1
Leaf litter cover	(mean % cover)	(2013)	38.5	38.3	84.0	72.0	53.0	82.5
		(2014)	46.1	34.0	55.6	74.0	51.0	72.0
		(2015)	41.6	28.3	29.5	79.3	22.6	55.0
Bare ground	(mean % cover)	(2013)	5.2	9.6	0.7	5.2	2.0	0.5
		(2014)	0.8	4.8	2.1	4.6	1.0	0.3
		(2015)	6.2	8.4	3.0	1.2	0.6	0.8

Table 7 **Summary attributes for 'regenerating' (Grassland) management units, based on transect and quadrat data.** Data for the Grassland (Ironbark) MU have been averaged across three transects. * = calculated from 500m^2 transects; 250m^2 for 2013 & 2014.

		Category:	*''Regenerating'*					
		Management Unit (Grassland):	**Bulloak**	**Ironbark**	**Swamp Oak**	**Spotted Gum**	**Grey Box**	**Apple**
		Transects:	INT01F	INT02F INT04F INT08F	INT03F	INT05F	INT06F	INT07F
Species diversity	(total)	(2013)	42	36	36	45	48	39
		(2014)	40	46	33	58	51	41
		(2015)	55	53	43	58	69	49
	native (%)	(2013)	27 (64.3)	26 (72.2)	17 (47.2)	33 (73.3)	35 (72.9)	26 (66.7)
		(2014)	23 (57.5)	27 (58.7)	14 (42.4)	36 (62.1)	32 (62.7)	23 (56.1)
		(2015)	34 (61.8)	35 (65.4)	17 (39.5)	34 (58.6)	46 (66.7)	28 (57.1)
	weeds (%)	(2013)	15 (35.7)	10 (27.8)	19 (52.8)	12 (26.7)	13 (27.1)	13 (33.3)
		(2014)	17 (42.5)	19 (41.3)	19 (57.6)	22 (37.9)	19 (37.3)	18 (43.9)
		(2015)	21 (38.2)	18 (34.6)	26 (60.5)	24 (41.4)	23 (33.3)	21 (42.9)
Canopy Age	basal area (cm^2)	(2013)	0	134.94	6.45	33.26	0	0
		(2014)	0	161.33	0	46.87	0	0
		(2015)	10.90	256.72	2.47	91.04	0	2.07
	mean DBH (cm)	(2013)	0	2.66	2.66	2.71	0	0
		(2014)	0	2.74	0	2.74	0	0
		(2015)	0.86	1.70	0.70	3.36	0	0.85
Stem Density	Canopy (stems/ha)	(2013)	280	1467	200	440	0	1560
		(2014)	440	1747	280	520	0	1760
		* (2015)	640	1680	440	360	20	1580
	Woody shrubs (stems/ha)	(2013)	0	253	0	440	400	0
		(2014)	0	253	0	360	320	0
		(2015)	0	213	0	480	280	0
	Acacia stems (stems/ha)	(2013)	0	4	0	360	0	0
		(2014)	0	22	0	240	0	0
		(2015)	0	400	0	400	0	0
Weed cover	(mean % cover)	(2013)	24.2	1.7	74.0	18.0	36.3	13.7
		(2014)	30.5	11.5	95.0	19.8	32.2	22.8
		(2015)	45.8	7.2	97.9	36.1	0.8	18.2
Leaf litter cover	(mean % cover)	(2013)	0	5.7	0	7.0	8.7	4.9
		(2014)	0	5.9	0	8.7	9.2	5.2
		(2015)	0.1	8.4	0	14.6	2.6	1.6
Bare ground	(mean % cover)	(2013)	0	9.5	0	7.2	4.0	1.7
		(2014)	0.1	12.8	0	3.2	1.4	0.4
		(2015)	0.1	9.8	0	0.9	0.4	1.0

- **Supplementary BOA** - the smallest of the six BOAs, the Supplementary BOA comprises areas of Spotted Gum (*Corymbia maculata*) and Ironbark (*Eucalyptus crebra*) management units, and some regenerating grasslands. A single transect-pair (INT05) has been established in the Spotted Gum unit. Two Endangered Ecological Communities are present in this BOA: *Central Hunter Ironbark - Spotted Gum - Grey Box Forest* and *Lower Hunter Spotted Gum-Ironbark Forest* (see discussion in Bell 2014).

- **Bridgeman BOA** - the Bridgeman BOA supports the most extensive area of native vegetation, however large parts of it now comprise the invasive Swamp Oak (*Casuarina glauca*) unit. In addition, portions of the BOA support Ironbark (*Eucalyptus crebra*), Grey Box (*Eucalyptus moluccana*) and regenerating grassland management units. A single transect-pair (INT06) has been established within the Grey Box management unit. Some portions of this BOA comprise the *Central Hunter Ironbark - Spotted Gum - Grey Box Forest* Endangered Ecological Community.

- **Southern BOA** - the Southern BOA comprises largely remnant forest and woodland of Ironbark (*Eucalyptus crebra*), Bulloak (*Allocasuarina luehmannii*) and Apple (*Angophora floribunda*), with relatively little regenerating grasslands. Within this BOA, a single transect-pair (INT07) has been established in the Apple management unit. Some areas form part of the *Central Hunter Ironbark - Spotted Gum - Grey Box Forest* Endangered Ecological Community.

- **Western BOA** - largely comprised of regenerating grasslands, the Western BOA also supports Ironbark (*Eucalyptus crebra*) and Swamp Oak (*Casuarina glauca*) management units. A single transect-pair (INT08) has been established within the Ironbark unit here, which also forms part of the *Central Hunter Ironbark - Spotted Gum - Grey Box Forest* Endangered Ecological Community.

5.2 Management Issues

5.2.1 Coolatai Grass

Coolatai Grass (*Hyparrhenia hirta)* poses a potentially serious threat to the maintenance and regeneration of derived grassland and woodland ecosystems within the BOAs, including the regeneration of endangered ecological communities. Invasion of native grassy ecosystems by invasive exotic grasses is also a key threatening process on the NSW *Threatened Species Conservation Act 1995*. This species is a rapidly spreading invasive grass originally introduced to Australia from Africa as fodder for domestic stock, but has quickly become problematic in grassy ecosystems. In the Hunter Valley, Coolatai Grass (and the related Jaragua Grass, *Hyparrhenia rufa*) have dramatically spread in recent years, in many cases taking advantage of the de-stocking of grazing lands for conservation offset purposes. Coolatai Grass has the ability to rapidly spread and smother all other ground vegetation, simplifying both structure and floristic composition (Chejara et al. 2010). Changes in ecosystem processes have been previously reported by grasses such as these (eg: Williams & Baruch 2000; McArdle et al. 2004; Chejara et al. 2006; Lindsay & Cunningham 2012), and appropriate control is warranted.

Coolatai Grass appears to have invaded Integra relatively recently, and is persisting in the BOAs. No discussion of its presence or threat was included in the weed management plan prepared for Integra Coal by ENSR Australia (2008). During monitoring surveys in November 2013, Coolatai Grass was observed within the Martins Creek BOA, particularly around the weather station positioned there (possibly a source of introduction). Some plants remain in that location in 2015, although control attempts have been undertaken.

Coolatai Grass was recorded within four monitoring transects in 2015, one less than in 2014. It persists in Grassland transects INT01G (Martins Creek BOA, with abundance value of 3), INT05G (Supplementary BOA, abundance of 3), INT08F (Western BOA, abundance of 1) and INT08G (Western BOA, abundance of 2). No change in abundance values were noted from 2014, indicating that the species has not yet spread beyond those 5 x 5m quadrats. Coolatai Grass was not recorded in transect INT02G, where in 2014 it scored an abundance of 1. Close monitoring and appropriate control of these stands is recommended to limit the further spread of this species throughout the BOAs.

The Co-operative Research Centre for Australian Weed Management (2008) suggest that for small outbreaks of Coolatai Grass (such as is currently present at Integra), manual removal of plants is most effective, preferably before seeding has occurred. For larger infestations, a combination of slashing or burning, followed by herbicide application is recommended. Grazing by cattle is only effective when plants are young, as older plants are relatively unpalatable (Lodge et al. 2006). Further information on the control of this and other weeds species is available at the New South Wales Department of Primary Industries website: http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/profiles/coolatai

5.2.2 Swamp Oak Invasion

Forests dominated by Swamp Oak (*Casuarina glauca*) are widespread in the Hunter Valley, and in recent years there has been some confusion on the conservation significance of this community. In his assessment of the remnant vegetation of the Central Hunter Valley floor, Peake (2006) considered his Central Hunter Swamp Oak Forest to be regionally significant due to its (then) restricted and very highly cleared extent. Earlier, Williams (1993) had treated Swamp Oak forests of the Hunter Valley floor as highly significant and threatened, and worthy of immediate conservation.

However, there is much evidence to suggest that current-day stands of Swamp Oak in the Hunter are highly invasive and not part of the original ecosystems (see discussion in Bell 2014). Elsewhere, there is documented evidence of the impact invading *Casuarina* species can have on eucalypt forests and woodlands. Lunt (1998), for example, describes how a long unburnt reserve in Victoria had been invaded by *Allocasuarina littoralis* over a 25 year period, resulting in the death of eucalypts and densities of *Allocasuarina* as high as 3565 stems/ha. Continued decline of eucalypt heath and dominance by *Allocasuarina* was predicted, unless repeated fire events were introduced. Given that most of the Central Hunter has not experienced regular fire in several decades, this may help explain why Swamp Oak has quickly spread across former grazing lands.

In respect to Integra, there are some important implications stemming from recognition of Swamp Oak as an invasive woody weed. The Biodiversity Management Plan proposes that degraded and regenerating lands be returned to a condition resembling their pre-disturbance state, and includes Swamp Oak Forest as an example. Such an action is strongly discouraged for riparian areas where Swamp Oak becomes a fast-growing invasive tree. As noted above, this vegetation type is not a natural component of the original ecosystems of the Hunter Valley, and successful regeneration of offset areas should not be gauged on the strength of Swamp Oak regeneration. Instead, areas where this species has become established should be regarded as a weed management issue. The high conservation status afforded this community in the BMP is incorrect; Swamp Oak has effectively displaced River Oak Forest from major natural drainage channels throughout much of the Hunter Valley (eg: DECC 2008).

The BMP also includes Swamp Oak in its list of 'typical tree species' to be used in rehabilitation of disturbed areas. For the same reasons noted above, this practice should be discouraged due to the highly invasive nature of this species and its propensity to form dense monospecific stands of vegetation.

5.2.3 Golden Wreath Wattle

As in many other parts of the Hunter Valley, Golden Wreath Wattle (*Acacia saligna*) is present at a number of locations within the Integra BOAs. This species occurs naturally in Western Australia, but is invasive in the eastern States and many other parts of the World (Millar & Byrne 2012; Thompson et. al. 2014), and should be eliminated. *Acacia saligna* has an extensive seed bank where it dominates (Tozer 1998), and successful control will require management over several years.

Muyt (2001) recommends hand-pulling of young plants and saplings, and cut-and-paint or drill-and-fill for older plants. Very old plants rarely reshoot so may be ringbarked or cut with no herbicide application. Fire should be excluded from infested areas unless suitable resources are made available for follow up control of mass germination of soil-stored seed. Lennox et al (2004) have reported some successes with a biological control agent in the control of this species in South Africa, but none is currently available in Australia.

Fortunately, the plants observed within the Integra BOAs have not yet become established as dense thickets, and control should be achievable prior to their spread.

5.2.4 Canopy Thinning

Based on data collected from the 2015 monitoring period, most Forest management units at Integra support canopy densities that far exceed natural values. In decreasing order of density, values obtained are:

- Swamp Oak MU – 16600 stems/ha, or 1 stem/0.6 m^2
- Bulloak MU – 5080 stems/ha, or 1 stem/2.0 m^2
- Apple MU – 3680 stems/ha, or 1 stem/2.7 m^2
- Ironbark MU - 2173 stems/ha, or 1 stem/4.6 m^2
- Grey Box MU - 480 stems/ha, or 1 stem/20.8 m^2
- Spotted Gum MU – 320 stems/ha, or 1 stem/31.3 m^2

Clearly, stem densities as high as 1 per 0.6 m^2 (Swamp Oak) or 1 per 2.0 m^2 (Bulloak) are unsustainable in the long-term, and only the Grey Box and Spotted Gum MUs returned density values that approach what may be considered a natural forest structure. For one other site in the Hunter Valley where this monitoring method has been employed, canopy densities of 1 stem per 4.4 m^2 for Ironbark and 1 stem per 12.5 m^2 for Redgum have been reported (Bell & Murray 2013). All of these values well exceed the ideal goal for Hunter Valley woodlands and forests, which is more in the vicinity of 1 stem per 250-330m^2 (30-40 mature stems per hectare) for Coastal Valley Grasslands (Benson 1999; Kerle 2005). Consequently, there will come a time when some canopy thinning of the developing forests within the BOAs would be desirable, so that the restored woodland more accurately reflects original vegetation patterns. This could perhaps initially be trialed over a smaller area in coming years, and should be fully monitored and documented. Kerle (2005) contains useful background information on this process from throughout eastern Australia, while OEH & Parks Victoria (2012) describe the project design for ecological thinning of River Red Gum reserves which may be used as a model.

5.2.5 Canopy Dieback

During the 2015 monitoring period, some forest areas were suffering from canopy dieback due to heavy infestations with caterpillars of the Four-spotted Cup Moth (*Doratifera quadriguttata*) and the Black Slug Moth (*Doratifera casta*). These were particularly evident in transects dominated by *Eucalyptus crebra* (particularly INT04 & INT08), where numerous caterpillars were clearly visible on leaves (**Figure 54**). Infestations leading to temporary dieback are relatively common in the Hunter Valley, and although under stress individual trees normally recover well from this natural and cyclic event (Collett & Fagg 2010).

Figure 54 Larvae of the Four-spotted Cup Moth (*Doratifera quadriguttata*) and the Black Slug Moth (*Doratifera casta*), on *Eucalyptus crebra* in INT08F.

5.3 Recommendations

Although the primary goal of the flora monitoring program is to collect floristic and structural data that can be used for comparison purposes against ongoing assessments, a number of management issues have become apparent for the maintenance of ecological processes within the six BOAs. Several of these have been previously raised in earlier monitoring reports, but warrant continued consideration:

- the few locations noted where Coolatai Grass (*Hyparrhenia hirta)* occurs (within the Martins Creek, Supplementary and Western BOAs) should be continually monitored and controlled prior to its spread throughout the grassland areas of all BOAs. Continued invasion by Coolatai Grass will adversely impact on the EECs conserved within the BOAs.

- eradication of Golden Wreath Wattle (*Acacia saligna*) be undertaken as soon as possible, prior to it becoming established as monospecific stands which will accrue a sizeable seed bank in the soil.

- consideration be given to undertaking an ecological thinning trial of remnant vegetation, in an area where regrowth Ironbark (*Eucalyptus crebra*) is returning at high densities (>2000 stems/ha, well above the 30-40 mature stems/ha that once occurred). This need not cover a large area, and would require appropriate approval from planning authorities, together with a detailed implementation and monitoring plan to document ongoing regeneration. Thinning of the developing canopy, together with a controlled ecological burn, will encourage the return of mid-story vegetation that is lacking in these stands.

- consideration also be given to the trial clearing and burning of areas of Swamp Oak (*Casuarina glauca*) forest, prior to it quickly smothering all regenerating grasslands within the BOAs. This is a Central Hunter Valley-wide problem, and its rapid spread is an ongoing threat to the integrity of all Central Hunter EECs. Replacement of this species with appropriate planting of eucalypt canopy species will be required, together with implementation of an ongoing fire management plan to curtail *Casuarina* growth.

- careful monitoring is also required of Bulloak (*Allocasuarina luehmannii*) stands, as this species too can rapidly colonise open areas in the absence of grazing. Some ecological thinning may be required of these stands in the future.

- in relation to operational methods for the flora monitoring program, it is proposed that canopy structure monitoring be altered to a triannual process, rather than the annual assessments that are currently undertaken. After three years of annual monitoring of canopy structure (2013-2015), sensible interpretation of collected data is limited, and would be more beneficial if monitoring events were spread over longer time periods. As part of this proposed revision, assessment of canopy structure should occur over all twenty 5x5m quadrats per 50m transect (as was done in 2015), rather than the ten assessed in 2013 and 2014. All other monitoring methods should remain the same for annual comparisons.

6. References

Bell, S.A.J. (2013) *A Strategy for Monitoring Revegetation of Rehabilitation after Coal Mining: Ravensworth Operations, Hunter Valley*. Unpublished Report to Ravensworth Operations. Eastcoast Flora Survey, April 2013.

Bell, S.A.J. (2014) 2013 Flora Monitoring at Integra Mine Biodiversity Offset Areas, Singleton LGA. Unpublished Report to Integra Coal Operations Pty Ltd. March 2014. Eastcoast Flora Survey.

Bell, S.A.J. (2015) Flora Monitoring at Integra Mine Biodiversity Offset Areas, Singleton LGA: 2015 Results. Unpublished Report to Integra Coal Operations Pty Ltd. February 2015. Eastcoast Flora Survey.

Bell, S.A.J. & Murray, M. (2013) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA*. Unpublished Report to Bulga Surface Operations (Glencore). November 2013. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.

Benson, J. (1999) *Setting the Scene: The Native Vegetation of New South Wales*. Native Vegetation Advisory Council of New South Wales, Background paper No 1. 40pp.

Bureau of Meteorology (2016) Climate data from the Australian Government Bureau of Meteorology web site: http://www.bom.gov.au/climate/data/

Clarke, K.R. and Gorley, R.N. (2006). PRIMER v6: User Manual/ Tutorial. PRIMER-E: Plymouth.

Chejara, V.K., Nadolny, C., Kristiansen, P.,Whalley, R.D.B. & Sindel, B.M. (2006) Impacts of *Hyparrhenia hirta* (L.) Stapf (Coolatai grass) on native vegetation in a travelling stock route in northern New South Wales. *In:* C. Preston, J.H. Watts and N.D. Crossman (eds). *15th Australian Weeds Conference Proceedings: managing weeds in a changing climate.* Adelaide, SA, pp. 207–210.

Chejara V.K, Kriticos D.J., Kristiansen P, Sindel B.M, Whalley R.D.B. & Nadolny C. (2010) The current and future potential geographical distribution of *Hyparrhenia hirta. Weed Research* 50: 174–184.

Collett, N.G. & Fagg, P.C. (2010) Insect defoliation of mixed-species eucalypts in East Gippsland. *Australian Forestry* 73(2): 81-90.

Co-operative Research Centre for Australian Weed Management (2008) *Coolatai Grass (*Hyparrhenia hirta*).* http://www.aabr.org.au/images/stories/resources/ManagementGuides/WeedGuides/wmg_coolatai_grass.pdf

Cunningham, G. (2010) *Integra Coal Operations Pty Limited: Opportunities for offset generation within lands between the Integra South Pit and Bridgeman Road, Singleton, NSW*. Geoff Cunningham Natural Resource Consultants Pty Ltd. Unpublished Report to Integra Coal. September 2010.

Department of Environment and Climate Change (2008) *Vegetation of the Cessnock-Kurri Region: Survey, classification and mapping. Cessnock LGA, New South Wales*. Department of Environment & Climate Change (NSW). Sydney. February 2008.

Department of Planning and Infrastructure (2014) *Hunter Valley Coal Mines – Best Practice Guidelines for Biodiversity Offset Management Plans*. Department of Planning and Infrastructure. Unpublished Report prepared by EcoLogical Australia Pty Ltd. February 2014.

ENSR Australia Pty Ltd (2008) *Weed Management Plan: Integra Coal Operations Pty Ltd*. Unpublished Report to Integra Coal. February 2008.

Integra Coal Operations Pty Ltd (2013) *Biodiversity Management Plan*. Issue No. 4. Vale Environmental Management System, Integra Coal Operations Pty Ltd. February 2013.

Kerle, J.A. (2005) *Collation and review of stem density data and thinning prescriptions for the vegetation communities of New South Wales*. Report prepared for Department of Environment and Conservation (NSW), Policy and Science Division. July 2005.

Lennox, C. L., Morris, M. J., Rooi, C. van, Serdani, M., Wood, A. R., Breeÿen, A. den, Markram, J. L., & Samuels, G. (2004) A decade of biological control of *Acacia saligna* in South Africa, using the gall rust fungus, *Uromycladium tepperianum*. *Proceedings of the XI International Symposium on Biological Control of Weeds, Canberra, Australia, 27 April - 2 May, 2003* pp. 574-575. Ed. by Cullen, J. M., Briese, D. T., Kriticos, D. J., Lonsdale, W. M., Morin, L. & Scott, J. K.

Lindsay, E.A. & Cunningham, S.A. (2012) Effects of exotic grass invasion on spatial heterogeneity in the ground-layer of grassy woodlands. *Biological Invasions* 14: 203-213.

Lodge, G.M., McCormick, L H., & Harden, S. (2005) Grazing studies of a *Hyparrhenia hirta* (Coolatai grass) pasture in northern New South Wales. *Australian Journal of Experimental Agriculture* 45: 1603-1611.

Lunt ID (1998) *Allocasuarina* (Casuarinaceae) invasion of an unburnt coastal woodland at Ocean Grove, Victoria: structural changes, 1971-1996. *Australian Journal of Botany* 46: 649-656.

McArdle, S.L., Nadolny, C., & Sindel, B.M. (2004) Invasion of native vegetation by Coolatai Grass *Hyparrhenia hirta*: impacts on native vegetation and management implications. *Pacific Conservation Biology* 10: 49-56.

Millar, M.A. & Byrne, M. (2012) Biogeographic origins and reproductive mode of naturalised populations of *Acacia saligna. Australian Journal of Botany* 60(5): 383-395.

Muyt, A. (2001) *Bush Invaders of South-East Australia: A guide to identification and control of environmental weeds found in South-East Australia*. R.G. and F.J. Richardson, Victoria.

OEH & Parks Victoria (2012) *Ecological thinning trial in NSW and Victorian River Red Gum Reserves. Experimental design and monitoring plan*. NSW Office of Environment and Heritage (Scientific Services Division and Parks & Wildlife) and Parks Victoria. May 2012.

Peake, T.C. (2006) *The Vegetation of the Central Hunter Valley, New South Wales. A report on the findings of the Hunter Remnant Vegetation Project*. Hunter-Central Rivers Catchment Management Authority, Paterson.

Thompson, G. D., Bellstedt, D. U., Richardson, D. M., Wilson, J. R. U., Le Roux, J. J. (2015) A tree well travelled: global genetic structure of the invasive tree *Acacia saligna*. *Journal of Biogeography* 42: 305–314.

Tozer, M.G. (1998) Distribution of the soil seedbank and Influence of fire on seedling emergence in *Acacia saligna* growing on the Central Coast of New South Wales. *Australian Journal of Botany* 46(6): 743-756.

Williams, J.L. (1993) *Casuarina glauca (Swamp Oak): Aspects of its Distribution and Ecology in the Hunter Valley*. Thesis for the Department of Geography, University of Newcastle.

Williams, D.G. & Baruch, Z., (2000) African grass invasion in the Americas: ecosystem consequences and the role of ecophysiology. *Biological Invasions* 2: 123–140.

7. Appendices

A7.1 Transect INT01F - Martins Creek BOA - Quadrat Photographs 2015

INT01F - Quadrat 1

INT01F - Quadrat 2

INT01F - Quadrat 3

INT01F - Quadrat 4

INT01F - Quadrat 5

INT01F - Quadrat 6

INT01F - Quadrat 7

INT01F - Quadrat 8

INT01F - Quadrat 9

INT01F - Quadrat 10

A7.2 Transect INT01G - Martins Creek BOA - Quadrat Photographs 2015

INT01G - Quadrat 1

INT01G - Quadrat 2

INT01G - Quadrat 3

INT01G - Quadrat 4

INT01G - Quadrat 5

INT01G - Quadrat 6

INT01G - Quadrat 7

INT01G - Quadrat 8

INT01G - Quadrat 9

INT01G - Quadrat 10

A7.3 Transect INT02F - Martins Creek BOA - Quadrat Photographs 2015

INT02F - Quadrat 1

INT02F - Quadrat 2

INT02F - Quadrat 3

INT02F - Quadrat 4

INT02F - Quadrat 5

INT02F - Quadrat 6

INT02F - Quadrat 7

INT02F - Quadrat 8

INT02F - Quadrat 9

INT02F - Quadrat 10

A7.4 Transect INT02G - Martins Creek BOA - Quadrat Photographs 2015

INT02G - Quadrat 1

INT02G - Quadrat 2

INT02G - Quadrat 3

INT02G - Quadrat 4

INT02G - Quadrat 5

INT02G - Quadrat 6

INT02G - Quadrat 7

INT02G - Quadrat 8

INT02G - Quadrat 9

INT02G - Quadrat 10

A7.5 Transect INT03F - Martins Creek BOA - Quadrat Photographs 2015

INT03F - Quadrat 1

INT03F - Quadrat 2

INT03F - Quadrat 3

INT03F - Quadrat 4

INT03F - Quadrat 5

INT03F - Quadrat 6

INT03F - Quadrat 7

INT03F - Quadrat 8

INT03F - Quadrat 9

INT03F - Quadrat 10

A7.6 Transect INT03G - Martins Creek BOA - Quadrat Photographs 2015

INT03G - Quadrat 1

INT03G - Quadrat 2

INT03G - Quadrat 3

INT03G - Quadrat 4

INT03G - Quadrat 5

INT03G - Quadrat 6

INT03G - Quadrat 7

INT03G - Quadrat 8

INT03G - Quadrat 9

INT03G - Quadrat 10

A7.7 Transect INT04F - Northern BOA - Quadrat Photographs 2015

INT04F - Quadrat 1

INT04F - Quadrat 2

INT04F - Quadrat 3

INT04F - Quadrat 4

INT04F - Quadrat 5

INT04F - Quadrat 6

INT04F - Quadrat 7

INT04F - Quadrat 8

INT04F - Quadrat 9

INT04F - Quadrat 10

A7.8 Transect INT04G - Northern BOA - Quadrat Photographs 2015

INT04G - Quadrat 1

INT04G - Quadrat 2

INT04G - Quadrat 3

INT04G - Quadrat 4

INT04G - Quadrat 5

INT04G - Quadrat 6

INT04G - Quadrat 7

INT04G - Quadrat 8

INT04G - Quadrat 9

INT04G - Quadrat 10

A7.9 Transect INT05F - Supplementary BOA - Quadrat Photographs 2015

INT05F - Quadrat 1

INT05F - Quadrat 2

INT05F - Quadrat 3

INT05F - Quadrat 4

INT05F - Quadrat 5

INT05F - Quadrat 6

INT05F - Quadrat 7

INT05F - Quadrat 8

INT05F - Quadrat 9

INT05F - Quadrat 10

A7.10 Transect INT05G - Supplementary BOA - Quadrat Photographs 2015

INT05G - Quadrat 1

INT05G - Quadrat 2

INT05G - Quadrat 3

INT05G - Quadrat 4

INT05G - Quadrat 5

INT05G - Quadrat 6

INT05G - Quadrat 7

INT05G - Quadrat 8

INT05G - Quadrat 9

INT05G - Quadrat 10

A7.11 Transect INT06F - Bridgeman BOA - Quadrat Photographs 2015

INT06F - Quadrat 1

INT06F - Quadrat 2

INT06F - Quadrat 3

INT06F - Quadrat 4

INT06F - Quadrat 5

INT06F - Quadrat 6

INT06F - Quadrat 7

INT06F - Quadrat 8

INT06F - Quadrat 9

INT06F - Quadrat 10

A7.12 Transect INT06G - Bridgeman BOA - Quadrat Photographs 2015

INT06G - Quadrat 1

INT06G - Quadrat 2

INT06G - Quadrat 3

INT06G - Quadrat 4

INT06G - Quadrat 5

INT06G - Quadrat 6

INT06G - Quadrat 7

INT06G - Quadrat 8

INT06G - Quadrat 9

INT06G - Quadrat 10

A7.13 Transect INT07F - Southern BOA - Quadrat Photographs 2015

INT07F - Quadrat 1

INT07F - Quadrat 2

INT07F - Quadrat 3

INT07F - Quadrat 4

INT07F - Quadrat 5

INT07F - Quadrat 6

INT07F - Quadrat 7

INT07F - Quadrat 8

INT07F - Quadrat 9

INT07F - Quadrat 10

A7.14 Transect INT07G - Southern BOA - Quadrat Photographs 2015

INT07G - Quadrat 1

INT07G - Quadrat 2

INT07G - Quadrat 3

INT07G - Quadrat 4

INT07G - Quadrat 5

INT07G - Quadrat 6

INT07G - Quadrat 7

INT07G - Quadrat 8

INT07G - Quadrat 9

INT07G - Quadrat 10

A7.15 Transect INT08F - Western BOA - Quadrat Photographs 2015

INT08F - Quadrat 1

INT08F - Quadrat 2

INT08F - Quadrat 3

INT08F - Quadrat 4

INT08F - Quadrat 5

INT08F - Quadrat 6

INT08F - Quadrat 7

INT08F - Quadrat 8

INT08F - Quadrat 9

INT08F - Quadrat 10

A7.16 Transect INT08G - Western BOA - Quadrat Photographs 2015

INT08G - Quadrat 1

INT08G - Quadrat 2

INT08G - Quadrat 3

INT08G - Quadrat 4

INT08G - Quadrat 5

INT08G - Quadrat 6

INT08G - Quadrat 7

INT08G - Quadrat 8

INT08G - Quadrat 9

INT08G - Quadrat 10

A7.17 Flora Species List

Table values are abundance scores between 1 (lowest) and 10 (highest), based on presence in 10 component quadrats per transect, 2015 data. '-' = absent from transect; '*' = weed species; '#' = planted species.

Species	2015_INT01F	2015_INT01G	2015_INT02F	2015_INT02G	2015_INT03F	2015_INT03G	2015_INT04F	2015_INT04G	2015_INT05F	2015_INT05G	2015_INT06F	2015_INT06G	2015_INT07F	2015_INT07G	2015_INT08F	2015_INT08G
Acacia amblygona	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
Acacia decurrens #	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Acacia falcata	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Acacia implexa	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Acacia parvipinnula	-	-	-	-	-	-	-	-	8	4	-	-	-	-	-	-
Acacia salicina #	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Acacia spp. #	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Ajuga australis	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Allocasuarina luehmannii	10	4	2	3	-	-	4	9	1	3	-	-	4	4	2	-
Alternanthera sp. A	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
*Anagallis arvensis **	3	10	7	10	-	10	-	-	2	7	-	1	2	4	5	7
Angophora floribunda	-	-	-	-	-	-	-	-	-	-	-	-	10	5	-	-
Aristida ramosa	10	9	6	1	2	1	3	9	9	10	2	1	9	10	10	10
Aristida vagans	-	-	-	-	-	-	3	3	7	-	-	2	-	-	1	-
Arthropodium sp. B	-	-	-	-	1	-	1	-	4	-	-	-	1	-	-	-
Asperula conferta	-	6	2	1	-	7	-	-	-	-	-	-	2	-	2	6
Austrodanthonia setacea	2	1	-	-	-	-	-	-	-	-	1	1	-	-	-	-
Austrodanthonia tenuior	-	-	4	-	-	-	2	2	4	-	-	-	4	-	7	2
Austrostipa scabra subsp. falcata	2	-	-	-	-	-	-	-	5	-	4	5	3	-	6	-
Austrostipa verticillata	-	-	-	-	5	-	6	-	-	-	10	4	-	-	-	-
*Axonopus fissifolius **	3	1	1	1	-	2	-	-	-	-	-	4	1	6	-	-
*Bidens pilosa **	-	-	1	-	2	-	3	-	4	-	4	-	3	-	-	-
Bossiaea prostrata	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
Bothriochloa decipiens var. decipiens	9	4	9	4	-	-	-	2	-	1	-	3	1	3	4	10
*Briza minor **	-	2	3	9	-	8	-	-	-	6	-	4	-	6	-	3
*Briza subaristata **	-	9	-	10	-	6	-	-	-	1	-	3	-	-	1	5
*Bromus catharticus **	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Brunoniella australis	10	5	5	2	8	-	9	3	7	-	8	3	7	1	8	3
Calocephalus citreus	-	-	-	-	-	-	-	-	-	1	-	-	-	-	9	8
Calotis cuneifolia	-	-	1	-	1	-	1	-	1	-	10	10	2	2	-	-
Calotis lappulacea	-	-	1	-	-	-	2	1	2	1	2	4	5	-	4	1
Carex inversa	1	1	-	3	2	6	7	2	1	-	9	1	2	1	7	-
Cassinia arcuata	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-
Casuarina glauca	-	-	-	-	10	1	-	-	-	-	-	-	-	-	-	-
*Centaurium tenuiflorum **	3	10	10	9	-	1	-	2	-	5	-	4	2	9	6	10
Centella asiatica	-	5	-	-	-	2	-	-	-	-	-	-	-	-	-	-
*Cerastium glomeratum **	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Chamaesyce drummondii	1	-	-	-	1	-	-	2	-	-	2	5	-	-	-	-

Species	2015_INT01F	2015_INT01G	2015_INT02F	2015_INT02G	2015_INT03F	2015_INT03G	2015_INT04F	2015_INT04G	2015_INT05F	2015_INT05G	2015_INT06F	2015_INT06G	2015_INT07F	2015_INT07G	2015_INT08F	2015_INT08G
Cheilanthes sieberi subsp. sieberi	6	10	10	10	6	1	3	5	9	10	-	7	8	10	10	10
Chloris ventricosa	-	1	2	3	1	-	-	-	-	-	2	1	-	-	1	-
Chrysocephalum semipapposum	1	1	10	8	-	-	-	4	2	9	1	7	-	6	5	10
*Cirsium vulgare **	1	1	4	-	1	6	-	-	-	-	-	-	2	-	-	-
Commelina cyanea	-	-	-	-	-	-	7	-	5	1	-	-	-	-	3	-
Convolvulus erubescens	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Conyza bonariensis **	-	9	3	2	2	-	-	-	-	2	1	-	3	2	5	5
Corymbia maculata	-	-	-	2	-	-	-	-	4	5	-	-	-	-	-	-
Crassula sieberiana	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
*Cyclospermum leptophyllum **	-	-	4	3	2	10	-	-	-	4	-	-	-	2	-	5
Cymbopogon refractus	9	10	10	10	1	1	6	7	10	10	-	8	10	10	8	10
*Cynodon dactylon **	2	7	-	-	-	7	-	-	-	4	-	1	-	7	-	7
Cyperus gracilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Daviesia ulicifolia subsp. ulicifolia	-	-	-	-	-	-	-	3	6	-	-	1	-	-	-	-
Desmodium gunnii	-	2	-	-	-	-	2	-	1	-	-	-	1	-	1	-
Desmodium varians	1	-	2	-	-	-	1	-	6	2	-	1	6	-	2	-
Dianella longifolia var. longifolia	3	1	1	-	-	-	1	1	4	1	-	1	2	-	-	-
Dianella revoluta var. revoluta	-	-	-	-	-	-	3	5	4	-	1	2	4	-	-	-
Dichanthium sericeum subsp. sericeum	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichelachne micrantha	2	10	10	10	-	10	1	-	-	6	-	6	1	10	5	9
Dichondra repens	1	4	4	1	7	-	3	-	7	1	9	-	7	3	-	2
Digitaria diffusa	1	-	2	-	-	-	-	-	7	8	2	3	7	1	1	1
Echinopogon caespitosus var. caespitosus	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
Einadia hastata	-	-	-	-	1	-	5	-	1	-	9	3	-	-	1	-
Einadia nutans subsp. linifolia	-	-	-	-	6	-	4	-	1	-	7	1	-	-	1	-
Elymus scaber var. scaber	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Enchylaena tomentosa	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Eragrostis brownii	4	4	-	1	-	-	-	6	-	2	-	6	1	6	2	1
Eragrostis leptostachya	2	-	5	2	-	-	-	1	2	1	-	3	3	-	-	-
Eremophila debilis	-	-	-	-	10	-	9	1	3	-	9	2	2	-	5	-
Eucalyptus crebra	-	-	10	3	-	-	10	5	-	1	-	-	2	-	9	1
Eucalyptus fibrosa	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Eucalyptus moluccana	-	-	-	-	-	-	-	-	-	-	8	-	-	-	1	-
Eucalyptus tereticornis	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Euchiton involucratus	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-
*Facelis retusa **	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Fimbristylis dichotoma	-	1	-	1	-	-	-	-	-	-	-	-	3	6	7	9
*Galenia pubescens **	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-
*Gamochaeta americana **	-	6	8	10	-	-	-	2	1	4	-	8	1	7	5	5
Glossocardia bidens	3	1	1	-	-	-	-	-	2	1	1	-	1	-	-	-
Glycine clandestina	2	4	-	1	-	-	-	-	2	-	1	-	7	-	-	-

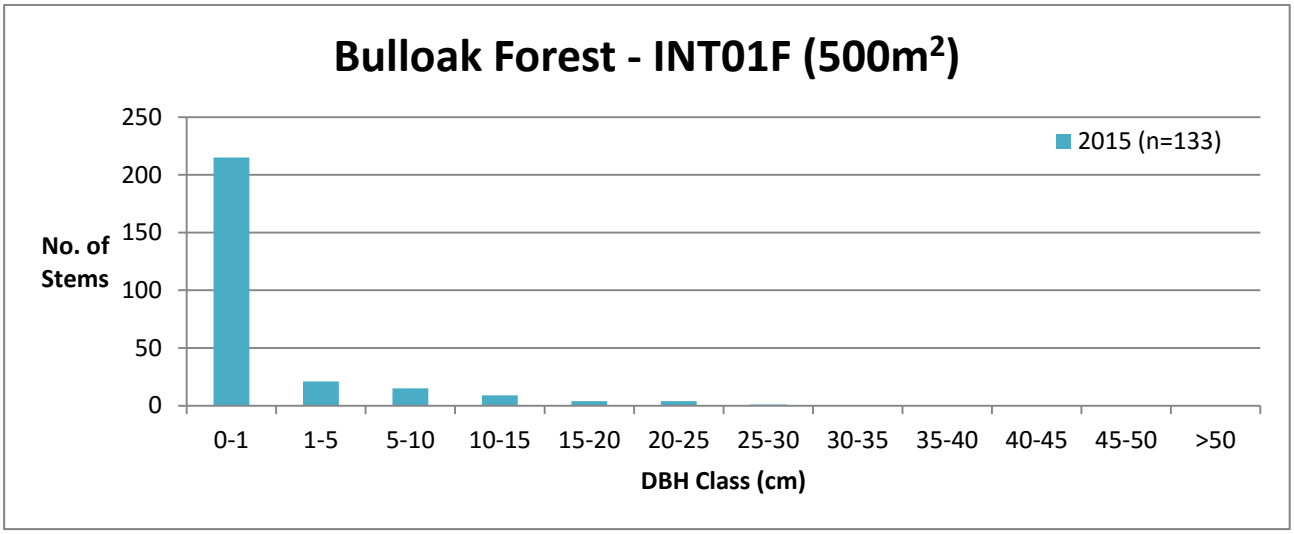
Species	2015_INT01F	2015_INT01G	2015_INT02F	2015_INT02G	2015_INT03F	2015_INT03G	2015_INT04F	2015_INT04G	2015_INT05F	2015_INT05G	2015_INT06F	2015_INT06G	2015_INT07F	2015_INT07G	2015_INT08F	2015_INT08G
Glycine tabacina	10	5	10	4	6	1	4	1	4	6	9	3	8	3	8	3
Gomphocarpus fruticosus *	1	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-
Goodenia hederacea subsp. hederacea	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Goodenia heterophylla subsp. heterophylla	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-
Goodenia pinnatifida	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Haloragis heterophylla	2	2	6	4	-	-	-	-	-	1	-	2	-	3	-	-
Hardenbergia violacea	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Hibbertia diffusa	-	-	-	-	-	-	-	-	8	-	-	-	7	-	-	-
Hyparrhenia hirta *	-	3	-	-	-	-	-	-	-	3	-	-	-	-	1	2
Hypericum gramineum	-	-	-	-	-	1	-	-	-	-	-	2	1	1	-	-
Hypochaeris microcephala var. albiflora *	-	2	4	1	2	6	-	-	-	-	2	1	-	2	4	2
Hypochaeris radicata *	7	10	10	10	4	10	1	2	3	5	4	8	8	10	3	4
Hypoxis hygrometrica var. villosisepala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Indigofera australis	-	-	-	-	-	-	-	-	4	1	-	-	-	-	-	-
Juncus subsecundus	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-
Juncus usitatus	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Lachnagrostis filiformis	-	-	2	-	-	-	-	-	-	4	-	1	-	2	-	-
Lagenophora stipitata	-	-	-	-	5	-	3	-	-	-	-	-	-	-	-	-
Laxmannia gracilis	-	-	-	-	-	-	-	3	-	-	-	-	4	-	1	-
Lepidium africanum *	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Lepidium bonariense *	-	-	-	-	-	-	1	-	-	-	8	3	-	-	-	-
Linaria pelisseriana *	-	-	3	2	-	-	-	-	-	5	-	1	-	1	2	7
Linum marginale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Linum trigynum *	1	10	3	7	1	8	-	-	-	5	-	3	-	4	2	10
Lolium perenne *	-	-	-	-	-	2	-	-	-	2	-	-	-	-	-	-
Lomandra confertifolia subsp. pallida	2	1	2	-	-	-	1	3	-	-	2	7	7	-	-	-
Lomandra filiformis subsp. coriacea	-	-	-	-	-	-	6	9	9	1	-	-	-	-	-	-
Lomandra filiformis subsp. filiformis	-	-	-	-	-	-	6	10	2	-	-	-	-	-	3	-
Lomandra multiflora subsp. multiflora	3	-	-	-	1	-	4	7	8	4	-	5	1	3	4	1
Lycium ferocissimum *	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Maireana enchylaenoides	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-
Maireana microphylla	-	-	-	-	1	-	9	-	1	-	10	3	-	-	-	-
Marsdenia viridiflora subsp. viridiflora	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Melichrus urceolatus	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Melinis repens *	-	-	-	-	-	-	-	-	2	6	-	-	-	-	2	-
Mentha satureioides	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-
Microlaena stipoides var. stipoides	1	-	7	4	10	2	6	4	10	5	10	5	10	9	8	4
Microtis unifolia	2	10	2	4	-	-	-	1	-	4	-	-	-	-	-	1
Murdannia graminea	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Myoporum montanum	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-

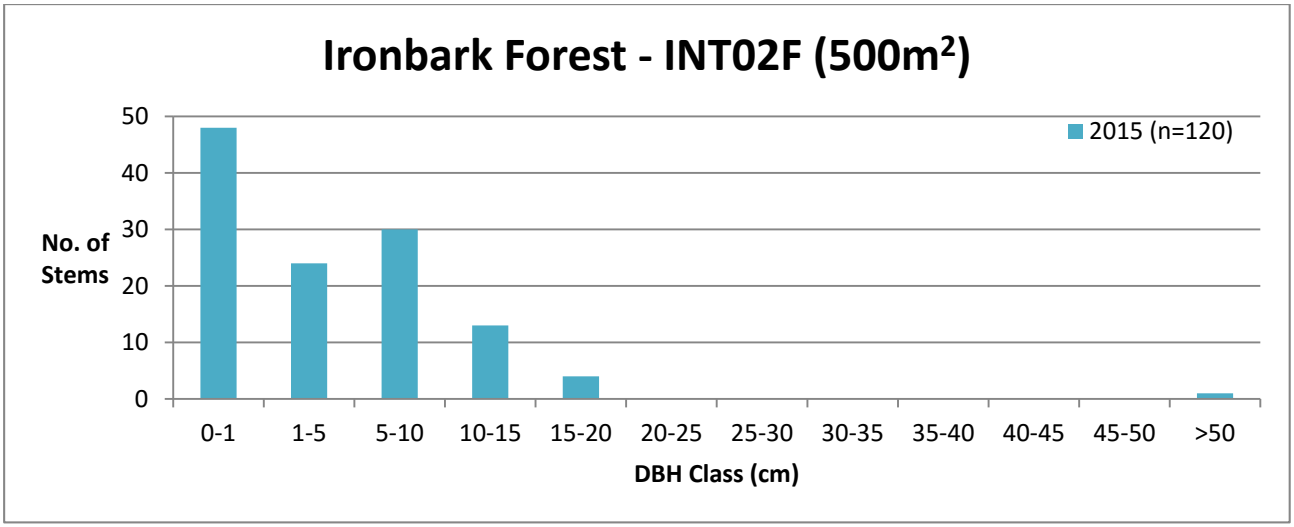
Species	2015_INT01F	2015_INT01G	2015_INT02F	2015_INT02G	2015_INT03F	2015_INT03G	2015_INT04F	2015_INT04G	2015_INT05F	2015_INT05G	2015_INT06F	2015_INT06G	2015_INT07F	2015_INT07G	2015_INT08F	2015_INT08G
*Olea europaea subsp. cuspidata **	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Opercularia diphylla	-	-	-	-	-	-	-	-	6	-	-	-	2	1	-	-
*Opuntia stricta var. stricta **	-	-	-	-	-	-	-	-	1	-	-	-	1	-	5	2
Oxalis perennans	-	2	1	3	4	8	-	-	-	5	3	3	1	3	3	6
Ozothamnus diosmifolius	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-
Panicum effusum	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
*Parentucellia latifolia **	-	4	7	4	-	-	-	-	-	-	-	6	-	6	2	8
*Paronychia brasiliana **	-	-	-	-	-	1	-	-	-	-	7	2	-	-	-	-
Paspalidium distans	7	-	5	-	1	-	4	2	2	1	3	3	2	-	7	1
*Paspalum dilatatum **	5	10	5	10	1	10	-	-	-	6	2	4	2	4	1	10
Pellaea paradoxa	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
*Petrorhagia dubia **	-	-	-	2	-	-	-	-	-	3	-	-	-	-	-	-
Phyllanthus virgatus	2	-	1	-	-	1	-	1	1	-	-	4	1	1	2	2
Pimelea curviflora var. sericea	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
Plantago debilis	-	-	1	-	-	-	1	-	-	-	1	-	-	-	-	-
*Plantago lanceolata **	-	9	4	8	2	10	-	-	1	6	6	4	2	5	5	10
*Plantago myosuros subsp. myosuros **	-	-	1	3	1	1	-	-	-	-	-	1	-	-	-	1
*Poaceae sp. **	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
*Polycarpon tetraphyllum **	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Poranthera microphylla	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Pratia purpurascens	-	-	-	-	4	-	2	-	2	-	2	-	2	-	-	-
Pultenaea microphylla	-	-	-	-	-	-	7	1	-	-	-	-	-	-	-	-
*Richardia stellaris **	5	2	1	2	-	-	-	-	-	-	-	-	-	2	-	6
*Romulea rosea var. australis **	6	10	10	10	-	6	-	2	-	6	-	3	1	7	2	4
Rumex brownii	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Schoenus apogon	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
*Senecio madagascariensis **	3	9	10	10	4	9	3	3	1	8	-	8	3	9	10	9
Senecio quadridentatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
*Setaria parviflora **	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Sida corrugata	-	-	-	-	-	-	-	-	1	-	1	1	-	-	-	-
*Sida rhombifolia **	-	-	-	-	3	-	-	-	5	5	5	1	-	2	-	-
Sida subspicata	-	-	-	-	-	-	-	-	-	-	1	6	-	-	-	-
*Silene gallica var. gallica **	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
*Sisyrinchium sp. A **	-	3	5	2	-	-	-	-	-	-	-	-	-	-	-	-
Solanum cinereum	-	-	-	-	-	-	-	-	-	-	7	2	-	-	-	-
*Solanum nigrum **	-	-	1	-	2	-	-	-	-	-	-	-	1	-	1	1
Solanum prinophyllum	-	-	-	-	8	-	-	-	-	-	2	-	2	-	-	-
Solanum stelligerum	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
*Soliva sessilis **	-	-	1	-	1	-	-	-	-	-	2	-	-	-	-	-
*Sonchus asper subsp. glaucescens **	-	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-
*Sonchus oleraceus **	1	-	-	-	1	-	1	-	1	-	1	-	2	-	-	-
Sorghum leiocladum	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

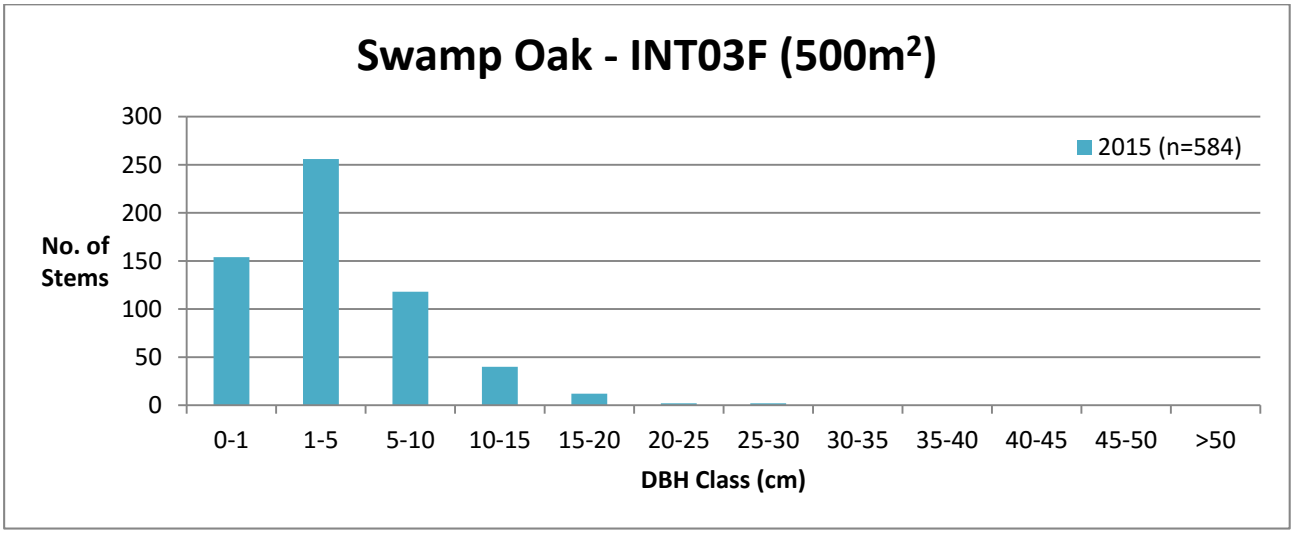
Species	2015_INT01F	2015_INT01G	2015_INT02F	2015_INT02G	2015_INT03F	2015_INT03G	2015_INT04F	2015_INT04G	2015_INT05F	2015_INT05G	2015_INT06F	2015_INT06G	2015_INT07F	2015_INT07G	2015_INT08F	2015_INT08G
Spartothamnella juncea	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Sporobolus creber	1	1	7	3	-	-	1	-	-	-	-	-	1	-	1	1
Stackhousia muricata	8	1	1	3	-	-	-	2	1	-	-	5	-	1	2	-
Taraxacum officinale *	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Templetonia stenophylla	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Themeda australis	1	2	-	-	-	-	-	3	-	-	-	4	-	-	-	-
Tricoryne elatior	2	9	-	2	-	-	-	1	-	-	-	1	-	-	-	-
Trifolium arvense *	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Trifolium campestre *	-	-	-	2	-	4	-	-	-	1	-	-	-	-	-	-
Verbena bonariensis *	1	7	-	-	-	6	-	-	-	3	-	-	-	-	-	-
Verbena rigida var. rigida *	-	-	3	7	-	-	-	1	-	-	-	5	-	5	-	-
Vernonia cinerea var. cinerea	-	-	-	-	-	-	5	1	8	-	-	-	-	-	-	-
Veronica plebeia	-	-	2	-	1	1	2	-	-	-	1	-	-	-	-	-
Vittadinia cuneata var. cuneata	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-
Vittadinia sulcata	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Vulpia muralis *	-	-	-	2	-	3	-	-	-	2	-	6	-	9	3	8
Wahlenbergia communis	2	7	-	2	-	-	-	-	3	-	2	-	3	-	1	1
Wahlenbergia gracilis	1	-	2	2	-	1	-	-	-	4	1	6	2	3	6	2
Zornia dyctiocarpa var. dyctiocarpa	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	2

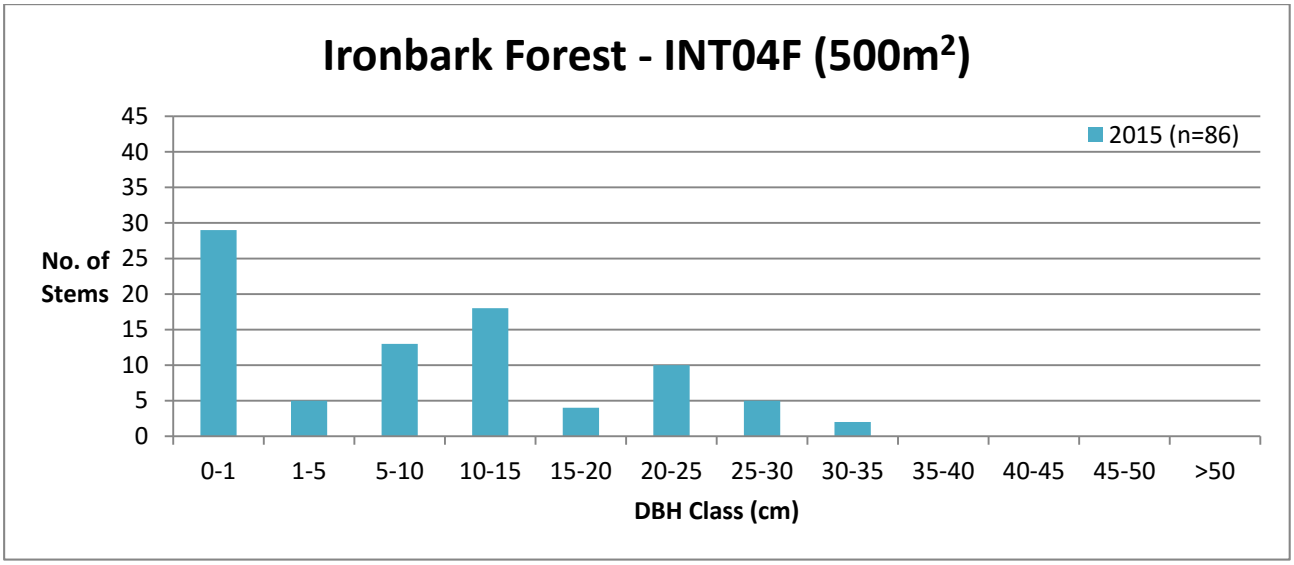
A7.18 Extended Canopy Data

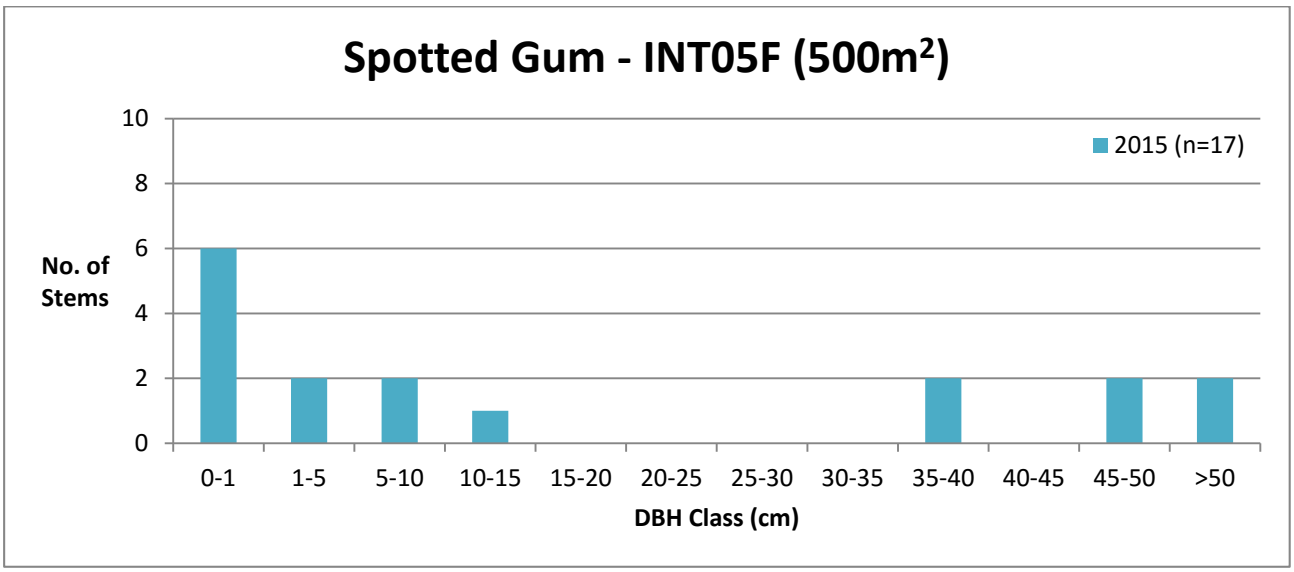
Canopy age distribution and basal area charts are included here for all transects where canopy structural data has been extended across 500m^2 per transect, in preparation for future comparisons.

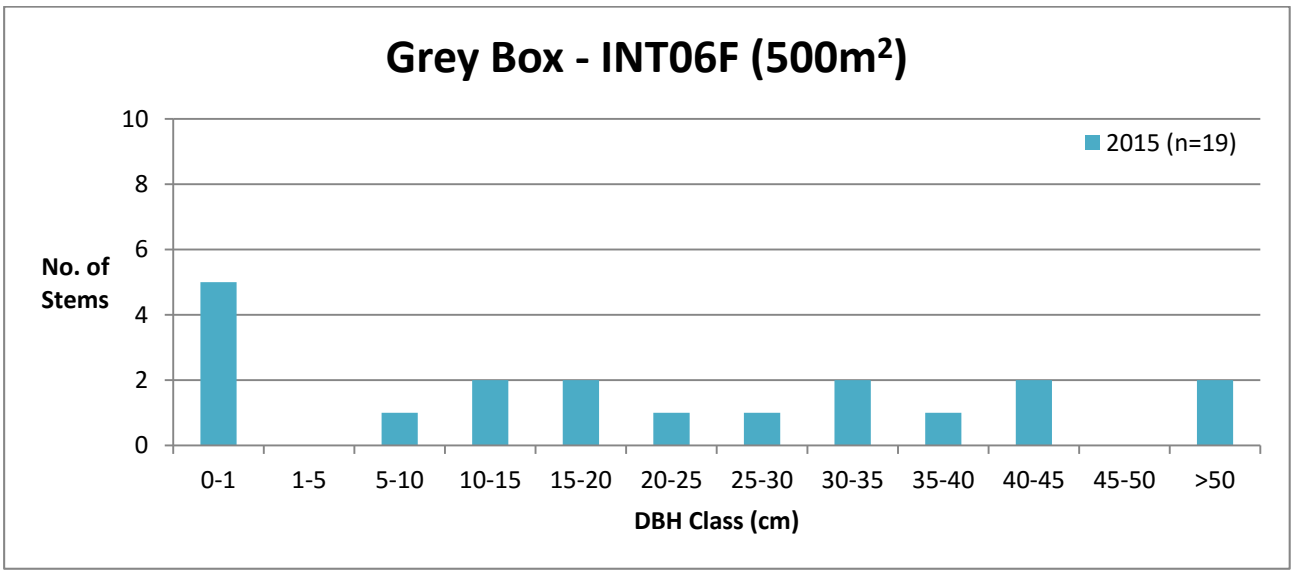


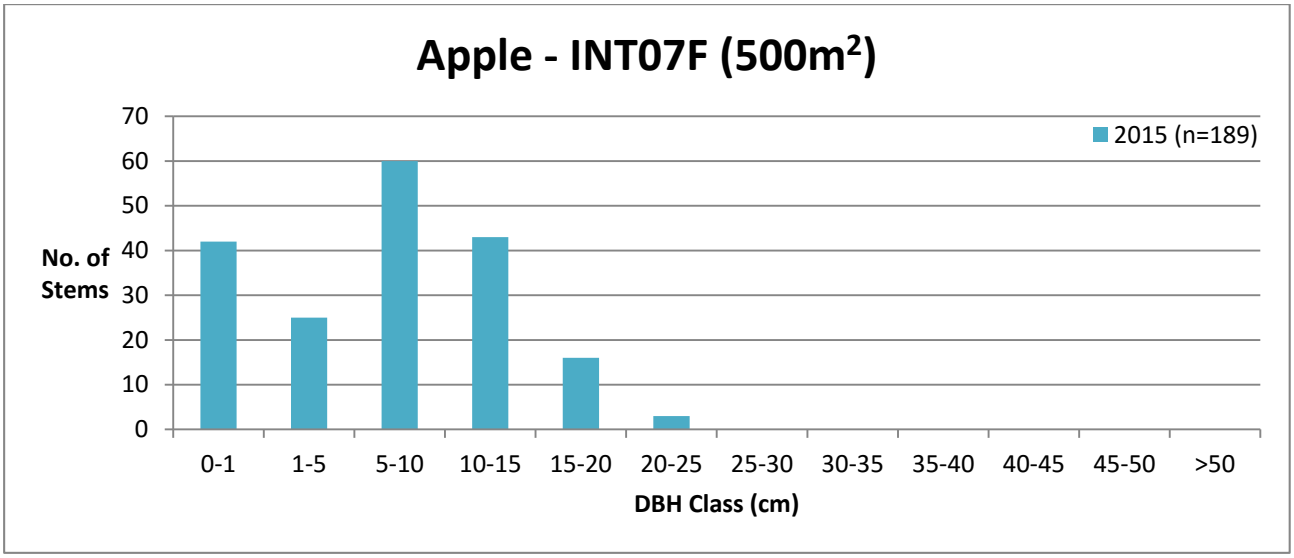


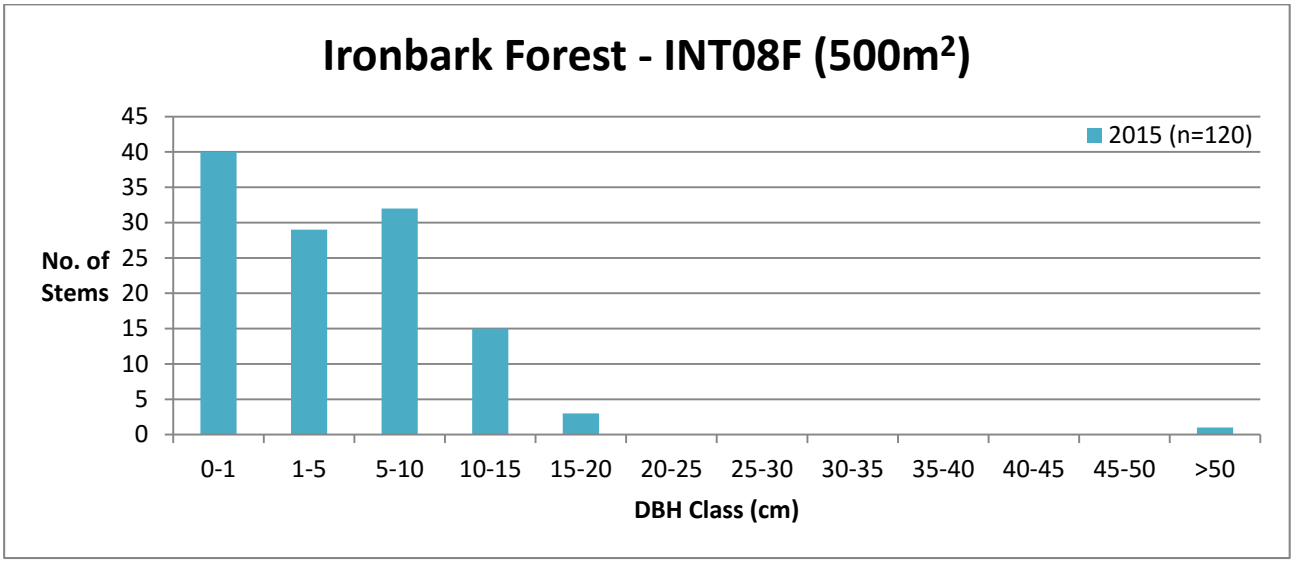


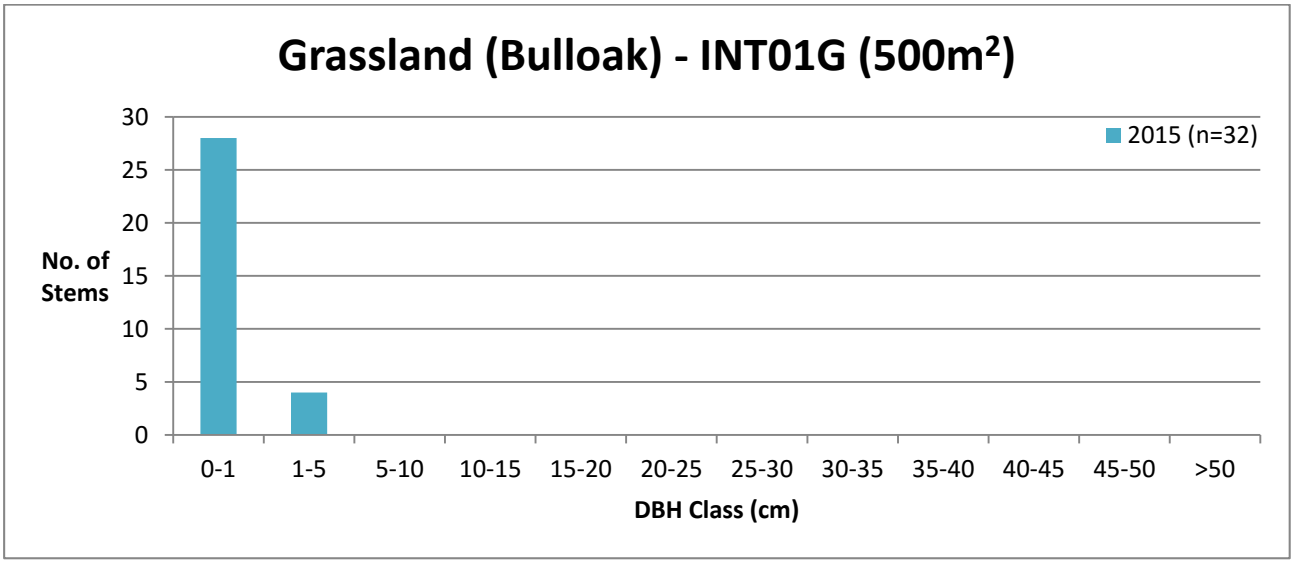

Ironbark Forest - INT04F (500m²)
2015 (n=86)
No. of Stems
45
40
35
30
25
20
15
10
5
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)

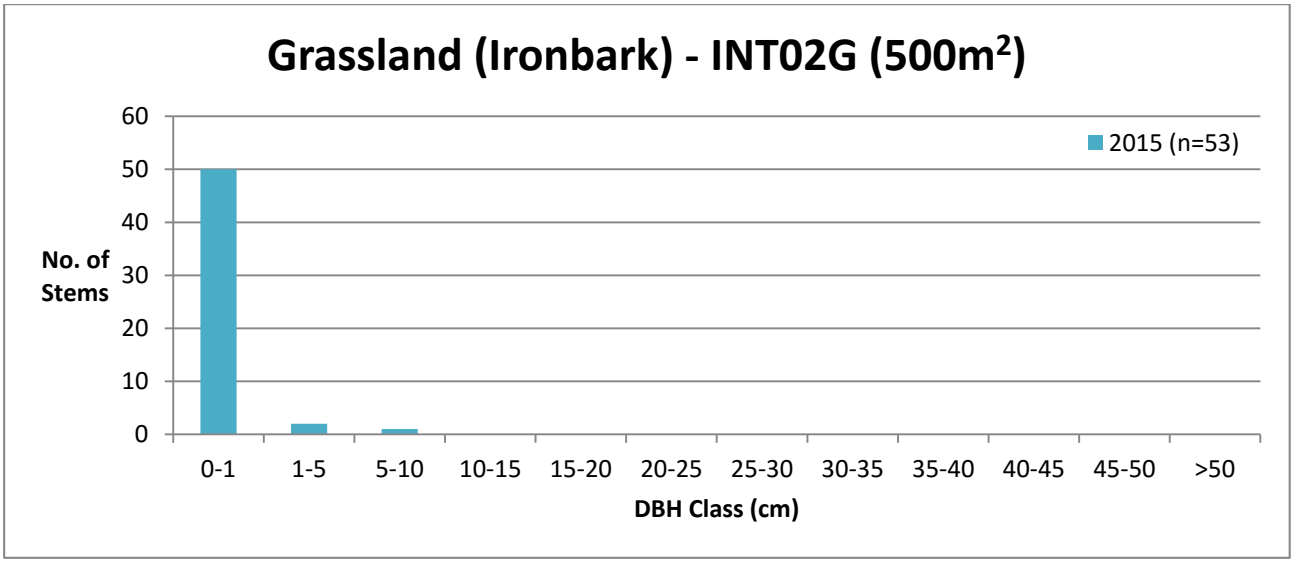

Spotted Gum - INT05F (500m²)
2015 (n=17)
No. of Stems
10
8
6
4
2
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)

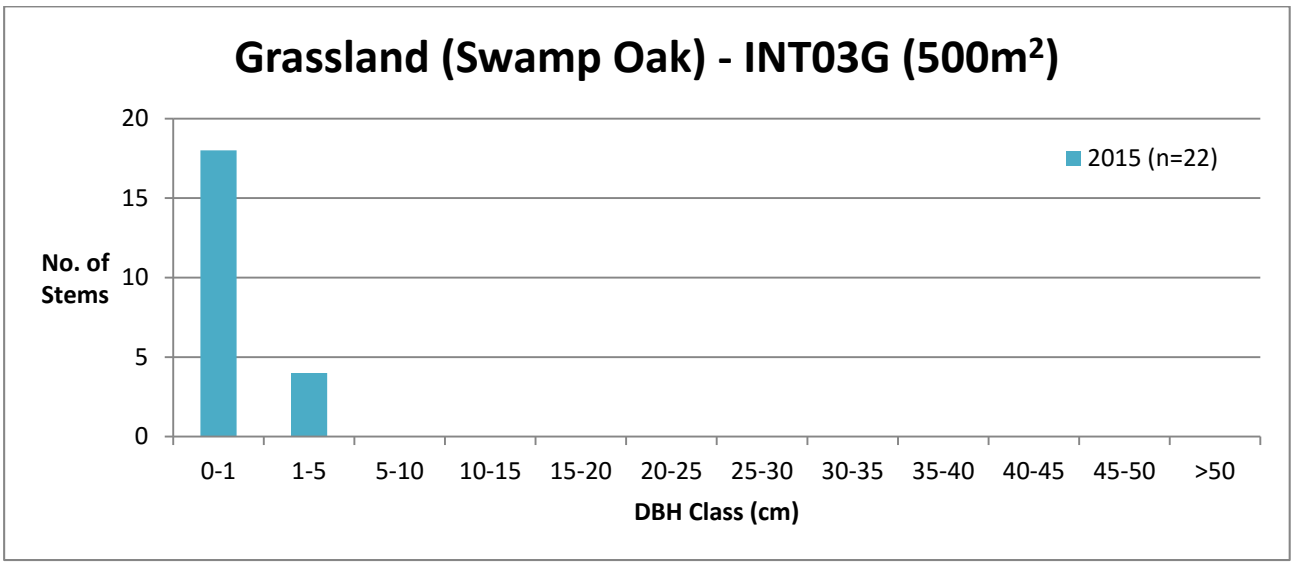

Grey Box - INT06F (500m²)
2015 (n=19)
No. of Stems
10
8
6
4
2
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)

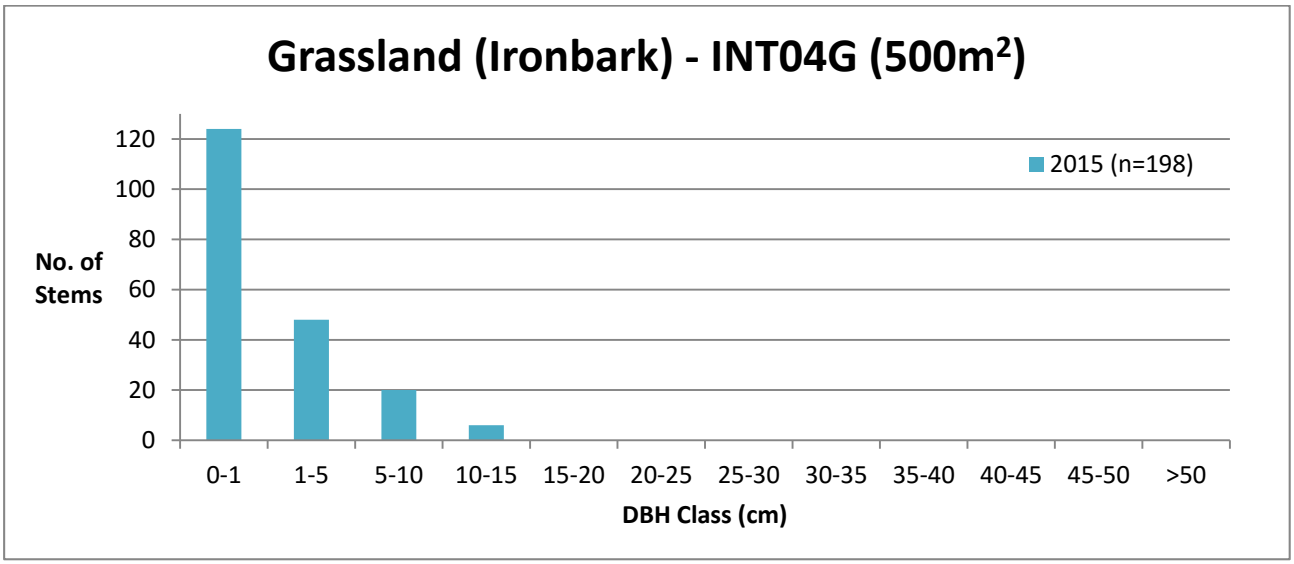

Apple - INT07F (500m²)
2015 (n=189)
No. of Stems
70
60
50
40
30
20
10
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)

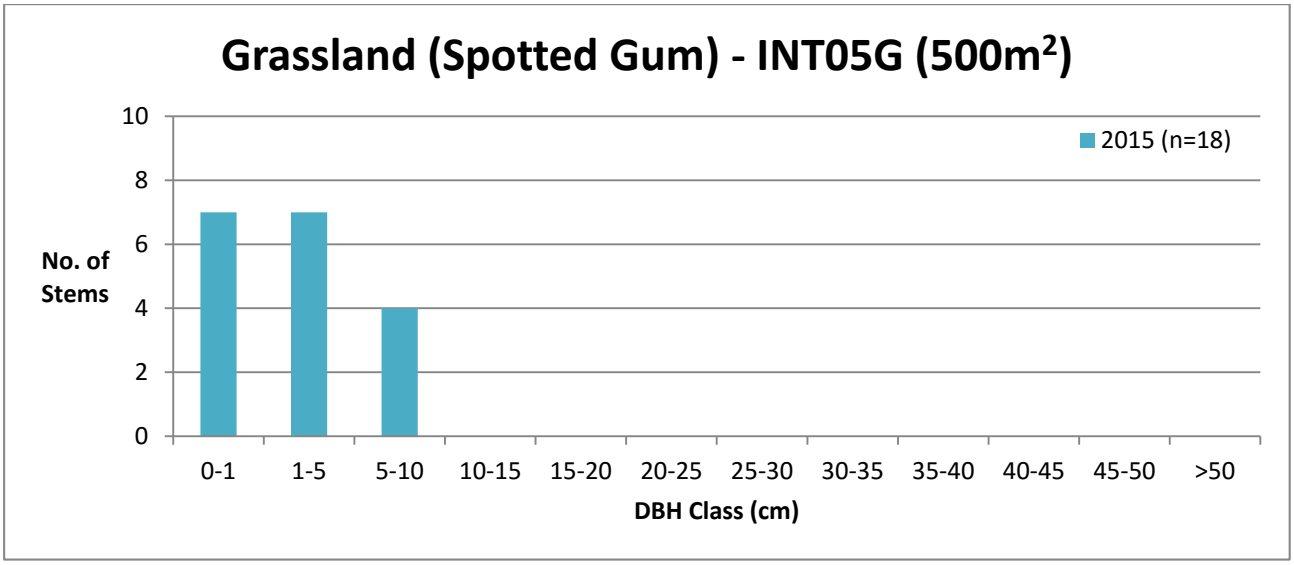

Ironbark Forest - INT08F (500m²)
2015 (n=120)
No. of Stems
45
40
35
30
25
20
15
10
5
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)

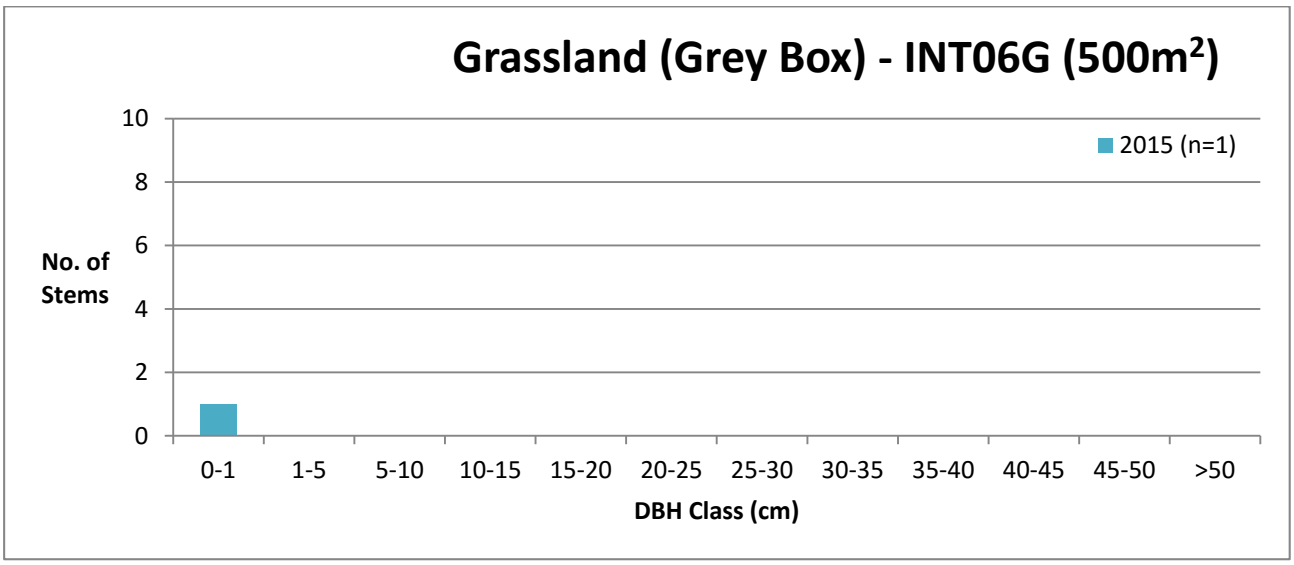

Grassland (Bulloak) - INT01G (500m²)
2015 (n=32)
No. of Stems
30
25
20
15
10
5
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)

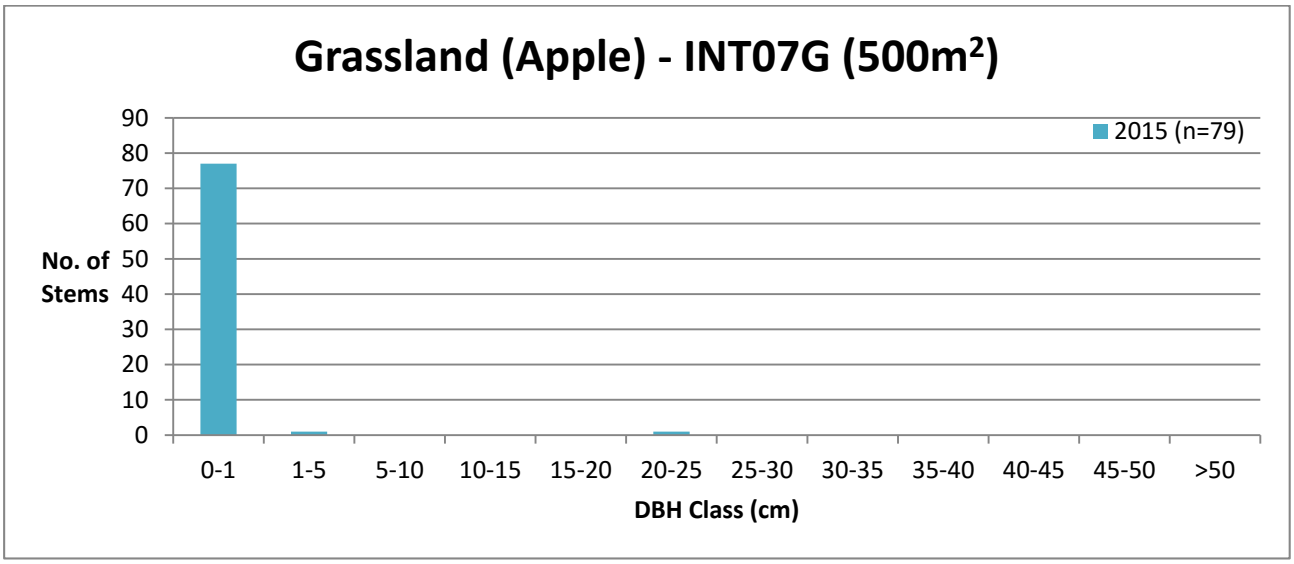

Grassland (Ironbark) - INT02G (500m²)
2015 (n=53)
No. of Stems
60
50
40
30
20
10
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)

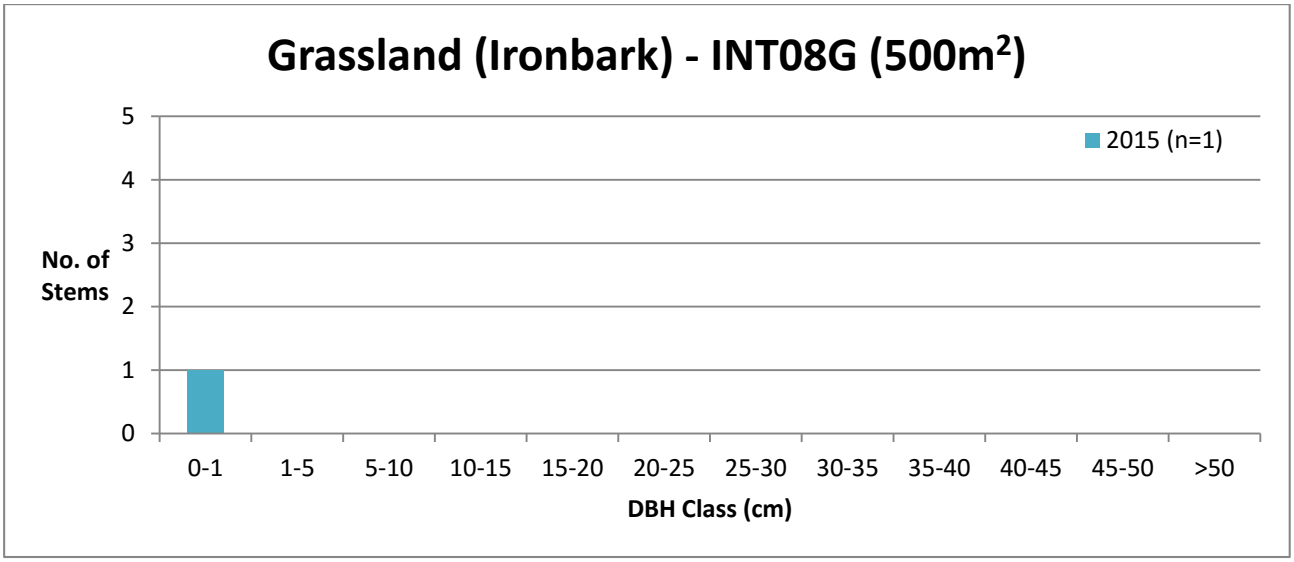

Grassland (Swamp Oak) - INT03G (500m²)
2015 (n=22)
No. of Stems
20
15
10
5
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)

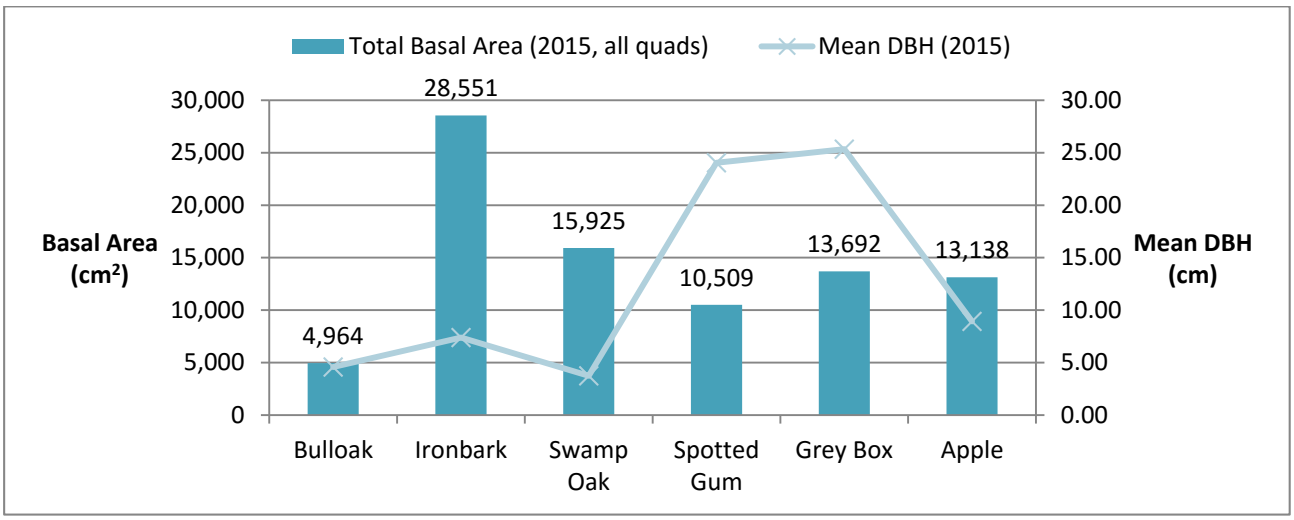

Grassland (Ironbark) - INT04G (500m²)
2015 (n=198)
No. of Stems
120
100
80
60
40
20
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)

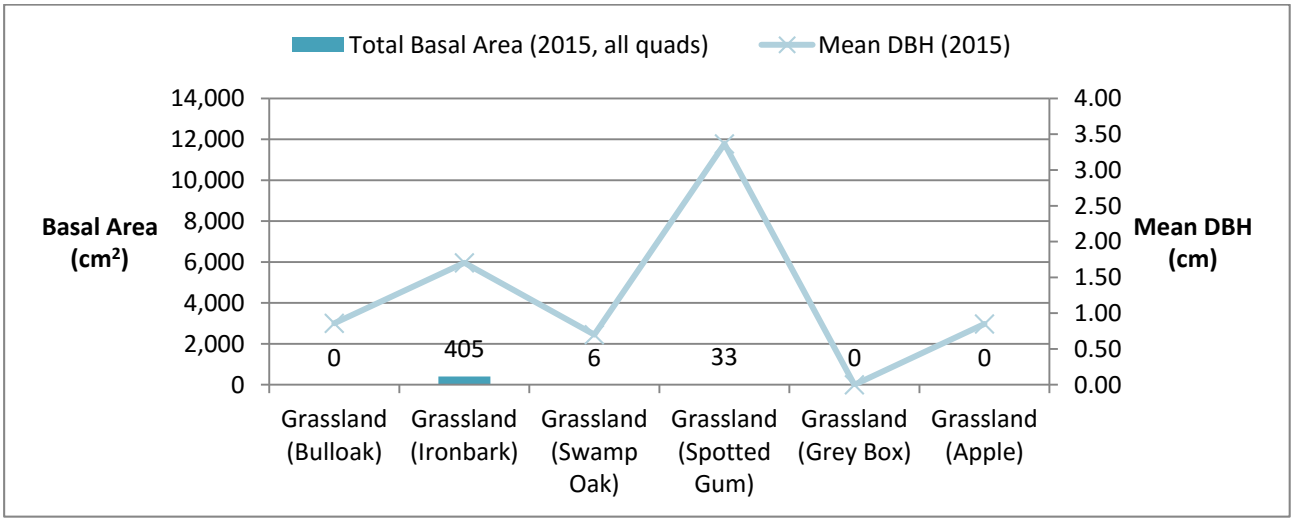

Grassland (Spotted Gum) - INT05G (500m²)
2015 (n=18)
No. of Stems
10
8
6
4
2
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)


Grassland (Grey Box) - INT06G (500m²)
2015 (n=1)
No. of Stems
10
8
6
4
2
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)


Grassland (Apple) - INT07G (500m²)
2015 (n=79)
No. of Stems
90
80
70
60
50
40
30
20
10
0
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)


Grassland (Ironbark) - INT08G (500m²)
No. of Stems
5
4
3
2
1
0
2015 (n=1)
0-1
1-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50
DBH Class (cm)


Total Basal Area (2015, all quads)
Mean DBH (2015)
Basal Area (cm²)
Mean DBH (cm)
30,000
25,000
20,000
15,000
10,000
5,000
0
30.00
25.00
20.00
15.00
10.00
5.00
0.00
4,964
28,551
15,925
10,509
13,692
13,138
Bulloak
Ironbark
Swamp Oak
Spotted Gum
Grey Box
Apple


Total Basal Area (2015, all quads)
Mean DBH (2015)
Basal Area (cm²)
Mean DBH (cm)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
405
6
33
0
0
Grassland (Bulloak)
Grassland (Ironbark)
Grassland (Swamp Oak)
Grassland (Spotted Gum)
Grassland (Grey Box)
Grassland (Apple)

Appendix B

Conservation Bond Cover Note and Cost Calculator

19-Aug-2016
Prepared for – Rixs Creek North Mine – ABN: 76000106972

Appendix B Conservation Bond Cover Sheet and Cost Calculator

Conservation Bond Cover Sheet
Mine/project details

Mine/project name:	Rixs Creek North Mine
Mine/project location:	Singleton – Hunter Valley NSW
Names of conservation areas covered by the bond	Northern BOA Southern BOA Bridgman BOA Martins Creek Apple tree Flat BOA
Operator:	Rixs Creek Mine

Contact details

Contact name:	John Hindmarsh Senior Environmental Officer Rixs Creek North Mine
Contact company:	Ph. 02 6588 8806 Mob – 0427 436 285 Email – jhindmarsh@bloomcoll.com.au Fax 02 6571 1066

:

Conservation bond cost estimate details

Name of the Management Plan the estimate is based on:	Biodiversity Management Plan – Rixs creek North
Period covered by the estimation:	Start date – 1 September 2016 End date – 1 September 2020
Intended date of next review:	1 May 2020
Current bond held by the Department:	$534,000
Total of this conservation bond cost estimate:	$495,927
Details of the land to which the Conservation Bond applies:	See Table below
Please find attached a plan indicating the location of the Biodiversity Offset Areas covered by this Bond, the names of these areas as referred to in the relevant management plan, and the Lot and D.P. numbers.	Refer Fig 1 of the BMP

Supporting documentation

List any documents attached to this submission form	Rixs Creek North Biodiversity Management Plan

Certification

I certify that the information contained in this application is true to the best of my knowledge.

Name:	Signature:
Position/title:	
Date:	

Biodiversity Offset Area	Lot	Deposited Plan
Northern BOA	100	633743
Bridgeman BOA	123	1067863
Southern	100	633743
	2, 10	752450
Martin's Creek BOA	1,2,30,31,43,44,45,73,74,75,76,77,78,81,95,98,136	752455

Conservation Bond Calculation Checklist

Conservation Bond Spreadsheet to be inserted in final PDF version of the BMP

NSW GOVERNMENT | Office of Environment & Heritage

DOC16/422773-1

Mr John Hindmarsh
Senior Environmental Officer
Rix's Creek Pty. Limited
jHindmarsh@bloomcoll.com.au

RE: OEH CONSULTATION – BIODIVERSITY MANAGEMENT PLAN RIXS CREEK NORTH (INTEGRA OPEN CUT) – RIX'S CREEK PTY LIMITED

Thank you for forwarding the Rix's Creek North Biodiversity Management Plan August 2016 for our comment.

The Office of Environment and Heritage (OEH) encourages the development of such plans to ensure that proponents have determined how they will meet their statutory obligations and designated environmental objectives. However, OEH does not approve or endorse these documents as our role is to set environmental objectives for environmental/conservation management, not to be directly involved in the development of strategies to achieve those objectives. In addition due to the short period of time given to review this document OEH was unable to undertake even a cursory review of the current version of the plan. OEH acknowledges Rix's Creek Pty Limited requirement to consult with relevant government agencies and considers that you have consulted with OEH through providing this document.

If you require any further information regarding this matter please contact Ziggy Andersons, Conservation Planning Officer, on 4927 3151.

Yours sincerely

24 AUG 2016

STEVE LEWER
Acting Senior Team Leader Planning, Hunter Central Coast Region
Regional Operations

Locked Bag 1002 Dangar NSW 2309
Level 4/26 Honeysuckle Drive Newcastle NSW 2300
rog.hcc@environment.nsw.gov.au
ABN 30 841 387 271
www.environment.nsw.gov.au

Planning Services
Resource Assessments
Contact: Joel Herbert
Phone: 8289 6614
Email: Joel.herbert@planning.nsw.gov.au

Chris Knight
Environmental Manager
Rix's Creek Mine
PO Box 4
EAST MAITLAND NSW 2323

Dear Mr Chris Knight

Rix's Creek North Project (MP 08_0102)
Biodiversity Management Plan Approval

I refer to your email dated 19 December 2017, seeking approval of the revised Biodiversity Management Plan dated 15 December 2017 (condition 40 of Schedule 3 of MP 08_0102) for the Rix's Creek North Project, which has been prepared in accordance with the mine's project approval.

The Department has reviewed the plan and finds that it meets the satisfaction of the Secretary. Please provide a final version (untracked) of this plan to the Department at your earliest convenience and place a copy on your website.

Should you have any enquiries in relation to this matter, please contact Joel Herbert on the details above.

Yours sincerely,

Howard Reed 22.12.17
Howard Reed
Director
Resource Assessments
as nominee of the Secretary