Forestry Corporation of NSW

Koondrook-Perricoota Forest Wetland and Understorey Surveys Autumn 2016

October 2016

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Koondrook-Perricoota Forest Wetland and Understorey Assessments 2016

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Please note: the primary outputs of this project are the understorey and wetland datasets (Microsoft excel format).

Acknowledgements:

The authors wish to thank Linda Broekman of Forestry Corporation of New South Wales for assisting GHD in undertaking the monitoring, providing past data and advice.

Cover photo: Swan Lagoon wetland site, taken on 22 April 2016

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Executive summary

The Forestry Corporation of New South Wales (FC NSW) engaged GHD to conduct the Wetland and Understorey Condition monitoring program at Koondrook-Perricoota (KP) Forest, New South Wales, for 2016. This project is part of the Murray Darling Basin Authority (MDBA) funded *The Living Murray* (TLM) *Program*. The Living Murray is a joint initiative funded by the New South Wales, Victorian, South Australian, Australian Capital Territory and Commonwealth governments, coordinated by the Murray–Darling Basin Authority.

The purpose of the wetland and understorey monitoring program is to survey and report on wetland and understorey condition at permanently established monitoring sites across Koondrook-Perricoota Forest. The 2016 surveys represent the seventh year of data collection for the condition monitoring program (surveys undertaken to date include: 2008, 2010, 2011, 2013, 2014, 2015 and 2016).[1] The autumn 2016 surveys were undertaken in April.

This report presents the findings of the 2016 round of monitoring undertaken at Koondrook-Perricoota Forest and compares wetland (semi-permanent) and understorey condition data across monitoring periods. The results are presented by Water Regime Class (WRC) in order of increasing water requirements: Grey Box (GB) Woodland, Black Box (BB) Woodland, River Red Gum Woodlands with Flood Tolerant (FTU) Understorey, River Red Gum (RRG) Forests with Flood Dependent Understorey (FDU) and permanent/semi-permanent wetlands and waterways.

For the purpose of this report, ecological objectives and targets include objectives outlined in the Environmental Water Management Plan for the Forest (MDBA 2012) and targets set by Australian Ecosystems (AE 2011). A review of the vegetation condition monitoring program was recently undertaken (Wills, Bidwell and Sim 2016), which discusses refinement of these objectives and targets. The outcomes of the review are not discussed in this report, but will be incorporated into future monitoring and reporting.

The 2016 data suggest that the current condition of the Forest is similar to that observed in autumn 2010 before the breaking of the Millennium drought, e.g. relatively low indigenous species richness and low indigenous vegetation cover across all WRCs in 2016 (when compared to monitoring years soon after flooding i.e. 2011 and 2014).

All WRCs had the highest number of species in the terrestrial Plant Functional Groups (PFGs;Tda and Tdr), which are species associated terrestrial environments, and target species richness of PFGs considered characteristic of the respective WRCs were rarely met in any of the understorey WRCs across monitoring years. This result is not surprising given that Koondrook Perricoota Forest is a disturbed environment that has been influenced by long-term reduced flows through reduction in size, duration and frequency of flood events in the Forest. In the absence of large scale floods that inundate the floodplains (particularly Red Gum FDU), it can be expected that targets for characteristic PFGs will not be met and understorey sites will continue to be colonised by species associated with terrestrial dry environments, including introduced flora.

[1] The surveys undertaken in 2008 were limited to three wetland transect sites and have therefore been excluded from the analyses. The monitoring program was expanded in 2010 to include seven wetland transects and 55 understorey sites, and expanded again in 2011 to include 16 wetland transects and 60 understorey sites.

Wetlands scored better than treed WRCs and met the target number of species in some but not all characteristic PFGs. The response to the 2011 floods and 2014 managed flood events was evident with increases in numbers of species in characteristic PFGs and cover following floods, sometimes (but not always) meeting the target number of species and target cover. The response of wetlands to the 2014 managed flood event is addressed in Bidwell and Wills (2015). Recent monitoring data from 2016 indicate the number of species in target PFGs and the percent cover of target PFGs is in decline, and also resemble 2010 data before the breaking of the Millennium drought.

Upon investigation of the data collected to date, we recommend the following:

- Continue to monitor wetland and understorey condition at Koondrook-Perricoota Forest as long-term monitoring will continue to capture variation in floristic composition and responses to wetting and drying cycles at Koondrook-Perricoota Forest. If resources allow, continue to monitor in autumn and spring, regardless of whether flooding occurs;
- Apply and test the outcomes of the Vegetation Condition Monitoring Program Review (Wills, Bidwell and Sim 2016) regarding ecological objectives and targets. The ideal time to do this is during the next round of monitoring, likely to occur in spring 2016.
- Targeted surveys are recommended for threatened species for which suitable habitat is present at Koondrook-Perricoota Forest, as this is currently one of the 'ecological targets' for the Forest. Selected populations of threatened flora should then be included in the monitoring program.

This report is subject to, and must be read in conjunction with, the limitations set out inside of front cover of this report and the assumptions and qualifications contained throughout the Report.

Abbreviations

BB	Black Box
CI	Confidence Interval (usually 95% unless stated otherwise)
DBH	Diameter at Breast Height
EVC	Ecological Vegetation Class
FC NSW	Forestry Corporation of New South Wales
FDU	Flood Dependent Understorey
FTU	Flood Tolerant Understorey
GB	Grey Box
KP	Koondrook-Perricoota Forest
MDBA	Murray-Darling Basin Authority
PFG	Plant Functional Group
RRG	River Red Gum
TLM	*The Living Murray Program*
WRC	Water Regime Class

Definitions

The following terms are used throughout this report and thus definitions are provided below.

Extended Dry Period: Refers to the prolonged period of low rainfall and low flow recorded, often referred to at the recent severe drought, extending over much of south-eastern Australia from 1996 to 2010 approximately.

River Regulation: River regulation is the phase given to the time when the River Murray began to be impacted by weirs along the various reaches. The introduction of weirs then allowed provision for offtakes for irrigation demands and water supply demands, so often River Regulation refers to this conglomerate effect of the weirs and water demands increasing. This period commenced from the 1920s onwards when the first Murray River Weirs were constructed and became operational, leading to the ability to provide continuous storage and flow in the river.

Natural Flow: Refers to the river and creek flow patterns experienced (or predicted/estimated) for river flows prior to river regulation.

Current Flow Conditions: The existing flow conditions experienced in the River Murray system, post regulation and water supply demand requirements. Under Current Flow Conditions there is continuous flow in the River Murray all year round and through droughts, however to achieve this there is dampening of many small to medium flood events along the river as these events supply storage throughout the system and are absorbed within the extensive network of infrastructure and demands. Typical current flow conditions on a floodplain are altered flow event conditions, seen through reduced frequency of flooding, reduced peak flows, reduced duration of flows and typically slightly delayed flooding events on a seasonal basis for small to medium flooding events.

Annual Flooding Cycles: This phrase refers to the typical average trends seen under river regulation on an annual basis, with flows tending to increase in the late winter to spring time (impacted by snow melts and higher rainfall timing) to peak in spring/early summer and recede over mid-Summer to autumn, with lower flows or base flows experienced during early winter. Annual Flooding Cycles could also be referred to as annual wetting and drying cycles. Annual Flooding Cycles also occurred pre-regulation; they tended to be more extreme and the peak in the cycle would typically occur slightly earlier in the season.

Event Based Flooding Cycles: This phrase refers to a flood event occurring and receding in the River Murray, based on a single or series of conjoined events. Typically, the event is caused by high rainfall in the upper catchment causing increased flows in the river to a peak or maximum flow, and then a gradual recession of those flows until they begin to approach a baseflow.

River Baseflow: This phrase refers to the complex system of interactions whereby groundwater movement with slow release and lower river flows combine to form a long term pattern of low flows in a river, well beyond a flood event. This tends to affect rivers and creeks of significant size, however baseflow is something that can eventually cease in a system, particularly an unregulated system. River Murray baseflow is now a controlled low-flow volume through the regulated river system and varies along the river, impacted not only by groundwater and receded flooding events but also by passing flow requirements, flow distribution through the system and environmental water flows.

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1. Introduction

1.1 Project context

This Project is part of the Murray Darling Basin Authority (MDBA) funded *The Living Murray* (TLM) *Program*. Wetland and understorey condition assessments are part of the broader Icon Site Condition Monitoring Program for Koondrook-Perricoota Forest, which includes Stand and Tree Condition Monitoring (described in Forbes and Wills 2016a).

The purpose of the program is to survey and report on wetland and understorey condition at permanently established monitoring sites across Koondrook-Perricoota Forest. The purpose of the program is to also monitor temporal change in floristic composition and health, and to investigate progress toward ecological objectives and targets for the Forest (those related to vegetation condition). Monitoring includes monitoring understorey vegetation condition and eucalypt condition at understorey and wetland sites.

The most recent surveys were undertaken in autumn 2016, and this survey represents the seventh year of data collection for the condition monitoring program (surveys undertaken to date include: 2008, 2010, 2011, 2013, 2014, 2015 and 2016).[2]

This report presents the findings of the 2016 autumn monitoring undertaken at Koondrook-Perricoota Forest and compares wetland and understorey condition data across monitoring rounds (2010 to 2016).

The analysis includes comparing results between monitoring years for each Water Regime Class (WRC), and also between WRCs in order of increasing water requirements: Grey Box Woodland, Black Box Woodland, River Red Gum Woodland with Flood Tolerant Understorey, River Red Gum Forest with Flood Dependent Understorey, and finally wetlands (WRCs are described in Section 1.3.1).

1.2 Survey timing

Up until 2014, the vegetation condition monitoring program was principally undertaken in autumn and therefore the program did not fully capture the diversity of flora present, i.e. additional species are likely to be present in spring or summer. To attempt to address this, more recent monitoring was undertaken in spring as well as autumn (in 2014 and 2015) to capture seasonal variation in species richness and vegetation cover, particularly annual introduced flora that may be present in spring but deceased by autumn. Going forward, this approach was considered important given that future monitoring following a managed flood event (timing of flood likely to be winter-spring) would most likely take place in spring or early summer when floodwaters are receding and vegetation response is expected to peak.

It is understood that autumn is generally an appropriate time to capture changes in floristic diversity following summer floods, because floods would have receded by this time and vegetation response to flood would most likely be evident. By undertaking monitoring in two seasons (e.g. autumn and spring), over time we should gain a better understanding of natural seasonal variation of vegetation composition within the Koondrook-Perricoota Forest.

[22] The surveys undertaken in 2008 were limited to three wetland transect sites, and have therefore been excluded from the analysis. The monitoring program was expanded in 2010 to include seven wetland transects and 55 understorey sites, and expanded again in 2011 to include 16 wetland transects and 60 understorey sites.

1.3 Koondrook-Perricoota Forest

The Koondrook-Perricoota Forest ('the Forest') covers approximately 32,000 ha in southern New South Wales and is part of the second largest River Red Gum Forest in Australia (MDBA 2012; see Figure 4). The Forest is a large mosaic of River Red Gum (*Eucalyptus camaldulensis*), Black Box (*E. largiflorens*) and Grey Box (*E. microcarpa*) communities, interspersed by wetland ecosystems. As a TLM Icon site, Koondrook-Perricoota Forest is recognised for its environmental, social, cultural and economic values.

The Forest forms part of a significant vegetation corridor across south-east Australia, providing refuge for many regionally and internationally significant species (Forestry Corporation of NSW, 2012). The ecological significance of the Forest has been recognised, nationally as a Living-Murray Icon site and internationally as a Ramsar wetland. Flooding regime is the primary driver for vegetation distribution and condition within the Forest.

1.3.1 Water Regime Classes

River Red Gum (RRG) is the predominant overstorey species, occupying over 80% of Koondrook–Perricoota Forest (MDBA 2012). It usually forms a pure stand, but does occur with other eucalypt species on less frequently flooded sites. The health of the River Red Gum Forest depends on the frequency, size, duration and timing of flooding, along with antecedent conditions. Black Box communities occur in areas prone to lower frequency, and shorter duration flooding. The Forest also supports extensive areas of Grey Box Woodland, some of which would have been flooded regularly under natural conditions (almost every year).

The following five WRCs are included in the condition monitoring program at Koondrook-Perricoota Forest, in order of decreasing water requirements:

- **Permanent/semi-permanent wetlands and waterways** (i.e. wetland transects). Wetlands require the most frequent flooding and benefit from more prolonged flooding and the persistence of water in pools and depressions (MDBA 2012);
- **River Red Gum Forests with flood dependent understorey**. River Red Gum Forest requires regular inundation to promote the flood dependent understorey (macrophytes) (MDBA 2012);
- **River Red Gum Woodlands with flood tolerant understorey**. River Red Gum Woodlands require less frequent flooding than the RRG Forests because the understorey is not flood dependent (MDBA 2012);
- **Black Box Woodland** (Box Woodlands require little watering; MDBA 2012); and
- **Grey Box Woodland** (proposed to have the lowest water requirements but this varies across the Forest). The lower 200 ha of Grey Box Woodland is inundated by flows of 35,000 ML/d. Under natural conditions these flows would have occurred almost every year with an average duration of more than two months (Ecological Associates 2011). At flows of 60,000 ML/d, 474 ha is inundated and would have experienced inundation events twice in ten years with average durations of less than two weeks. This suggests that some areas of Grey Box may be more tolerant of flooding than others.

The position of the five Water Regime Classes in the landscape is illustrated in Figure 1, along with the ideal flood regime for each WRC. Note that this is a very broad indication of vegetation associations, geomorphic setting and natural flood regime. As over 80% of the Forest supports River Red Gum Forests/Woodlands and these vegetation types have higher water requirements than the other woodlands, the majority of established vegetation survey sites are located within the first three WRCs.

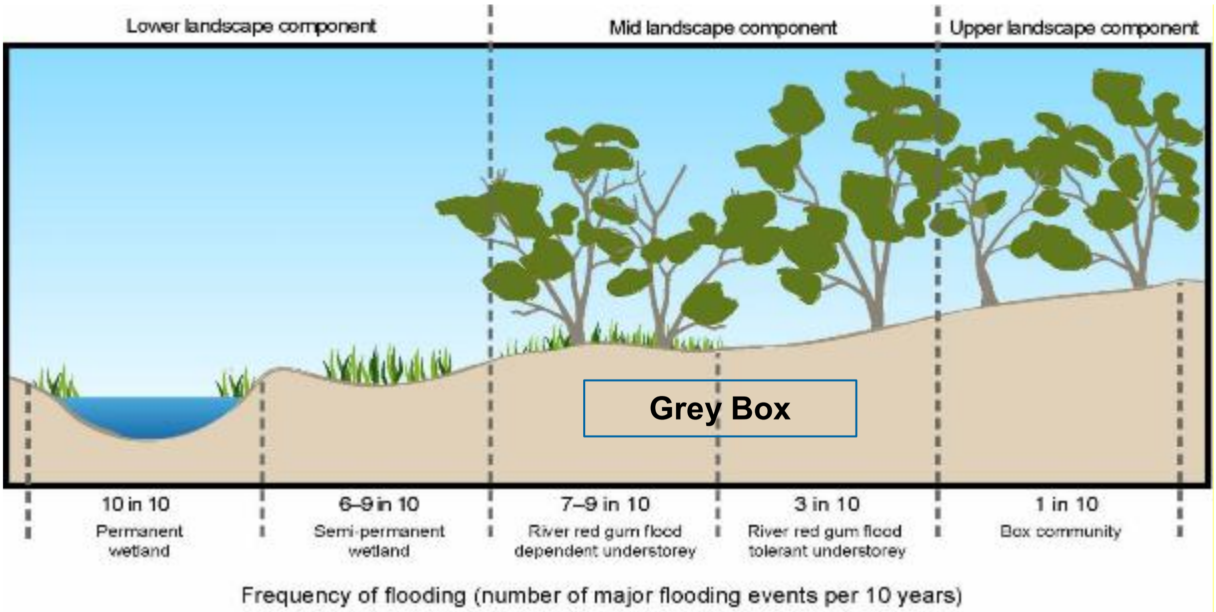


Figure 1 Water Regime Classes (vegetation associations) and ideal flood regime at Koondrook-Perricoota Forest

Source: Ecological Associates (2006) and MDBA (2012)

1.3.2 Floods at Koondrook-Perricoota Forest

The Koondrook-Perricoota Forest receives water in two main ways, the first through local rainfall directly on the Forest (Figure 2) and the second through flood events from the Murray River and upstream catchments spilling into the local floodplain and distributing down the extended anabranch system of the River Murray, formed through the Burrumbury Creek, Myloc Creek, Barber Creek and Cow Creek systems. While rainfall provides some minor watering needs, the Koondrook-Perricoota Forest system was formed on the basis of the main flow contribution through floodplain flows from the River Murray. Flooding is the dominant watering mechanism and provides the vast majority of watering needs of the Forest.

The Koondrook-Perricoota Forest has experienced reduced flooding conditions as a result of River Murray regulation (with the implied increases in irrigation and water supply demand), along with the more recent extended dry period; Millennium drought (between 1997 to 2010). During the Millennium drought, there was little if any flooding experienced in the Forest. While the implications of the river regulation have been a long term impact, the Millennium drought was severe and exacerbated the situation.

The Koondrook-Perricoota Forest system is heavily dependent on flood flows from the Murray River to provide the majority of the watering regime requirements for the floodplain complex. Traditionally this flow has been made available through overbank flows downstream of Torrumbarry Weir when the weir is experiencing high flow events.

Figure 3 shows the flow data from the Torrumbarry Weir (downstream location) recorded from 1996 to 2016, including average monthly flows and monthly maximum and minimum flows, showing the variance in flows along the river. The significant flow events are readily visible.

Under unmanaged conditions, flood water first enters the Forest at Swan Lagoon when the River Murray is experiencing a flow around or exceeding 18,000 ML/d (MDBA 2012, EA 2011 and Dan Hutton, FC NSW, pers. comm.). As flows increase to around 20,000 ML/d multiple additional floodrunners commence to flow, such as Horseshoe Lagoon, Dead River Lagoon, Black Gate Creek, Penny Royal and the upper and lower Thule.

Widespread Forest flooding occurs at River Murray flows in excess of 35,000 ML/d for a sustained duration. Short durations will unlikely provide sufficient volume to result in widespread flooding.

The period of extended dry from 1997 to 2010 is obvious in Figure 3 (low flow conditions measured), with an exceptional flood event in September 2000 noted. Average flow from 1974 to 2013 were noted to be approximately 10,000 ML/day (MDBA, 2013), and flows downstream of Torrumbarry Weir were significantly reduced below average (between 3,800 – 6,800 ML/day for much of 2001 to September 2010).

The period of extended dry was eventually broken during a seven-month period (commencing in September 2010) of significant rainfall that occurred across Australia, resulting in high River Murray flows recorded following September 2010. As a result, in the latter part of 2010 and 2011 flows averaging between 10,000 to 38,000 ML/day above the long term average were noted (peaking at 50,000 ML/day in December 2010/January 2011).

River Murray Flows in 2012 and 2013 trended downwards again. Two floods (smaller than those in experienced in 2010 and 2011) occurred in the Forest in 2012 (August – September) from a maximum flow of 35,700 ML/day noted downstream of Torrumbarry Weir.

No flood events eventuated in the Koondrook-Perricoota Forest from 1993 to 2010, although it is understood that a small volume of environmental flow was made available and directed to Pollack Swamp refuge (MDBA 2012) and localised flooding of inlet areas such as Swan Lagoon received minor flows during that period (GHD 2010).

1.3.3 Timing of monitoring

In interpreting the monitoring data, it is important to consider the data in context of: 1) the Millennium drought; and 2) recent floods (whether they be unmanaged or managed flood events).

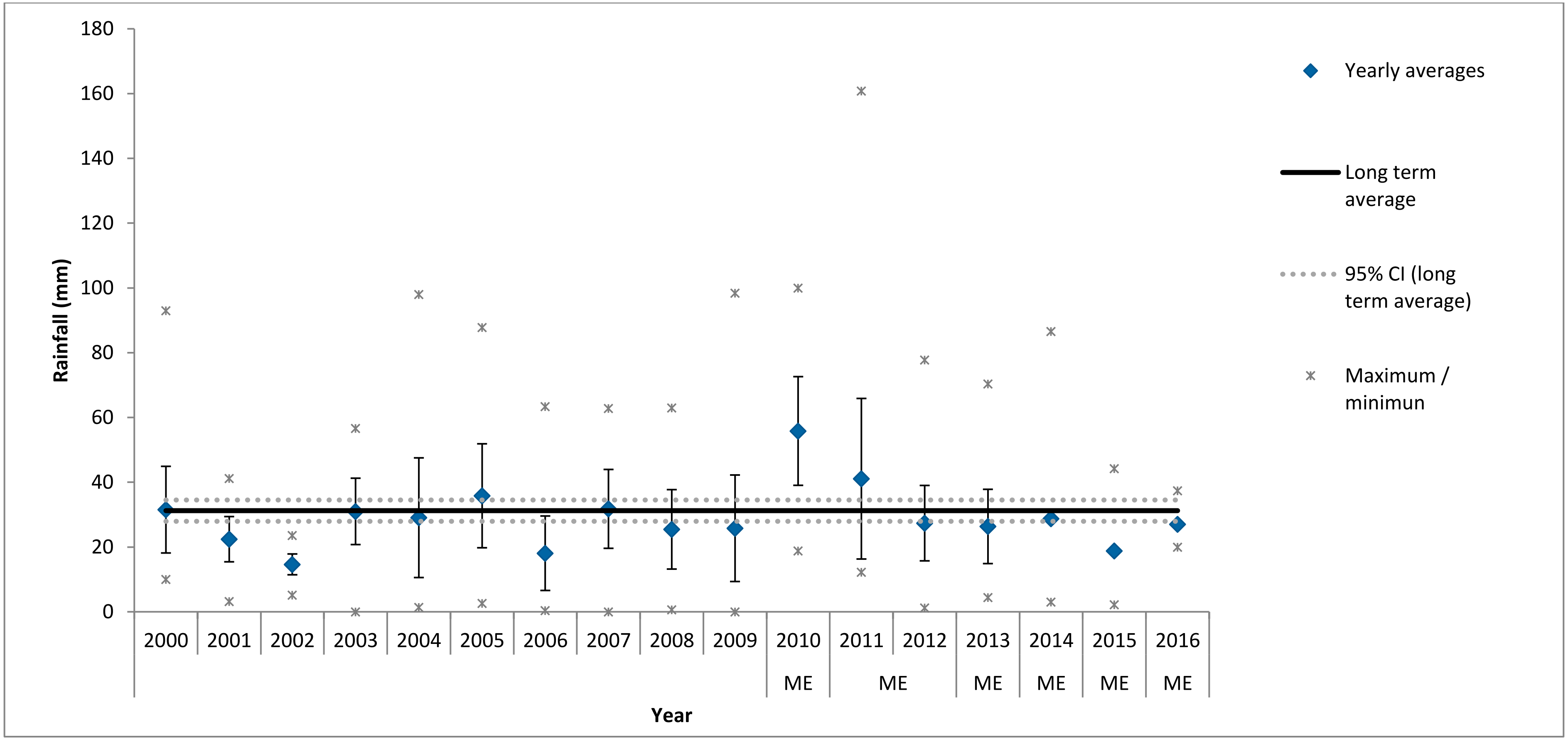
The data collected in autumn 2010 represent the condition of the Forest at the end of the Millennium drought before breaking of the drought in 2011.

Two main flood events occurred within the 2010 and 2016 monitoring period:

- Monitoring in autumn 2011 followed multiple floods, and was undertaken whilst floods were receding or had recently receded at some sites. During this flood event, wetland sites and large areas of the floodplain were flooded;
- Monitoring in spring 2014 and autumn 2015 followed delivery of environmental water to Koondrook-Perricoota Forest. Watering was largely restricted to wetlands and waterways, with very few understorey sites receiving water. Many of the wetlands were in the shallowly inundated, receding phase or deeply inundated, receding phase of the water cycle at the time of monitoring in spring 2014. By autumn 2015, wetlands were typically in the recently receded or drying phase.

See Bidwell and Wills (2015) for details of the 2014 managed flood event and a more detailed discussion of the response of wetland vegetation to the managed flood event.

In 2015, environmental water was delivered to Pollacks Swamp only. A separate report describes the response of vegetation at Pollacks Swamp to the 2015 managed flood event (Forbes and Wills 2016b).



* ME Monitoring Event

Figure 2 Average monthly rainfall (2000-2016) and long term average rainfall (1881-2016) for the nearest operating weather station (Kerang) (BoM 2016)

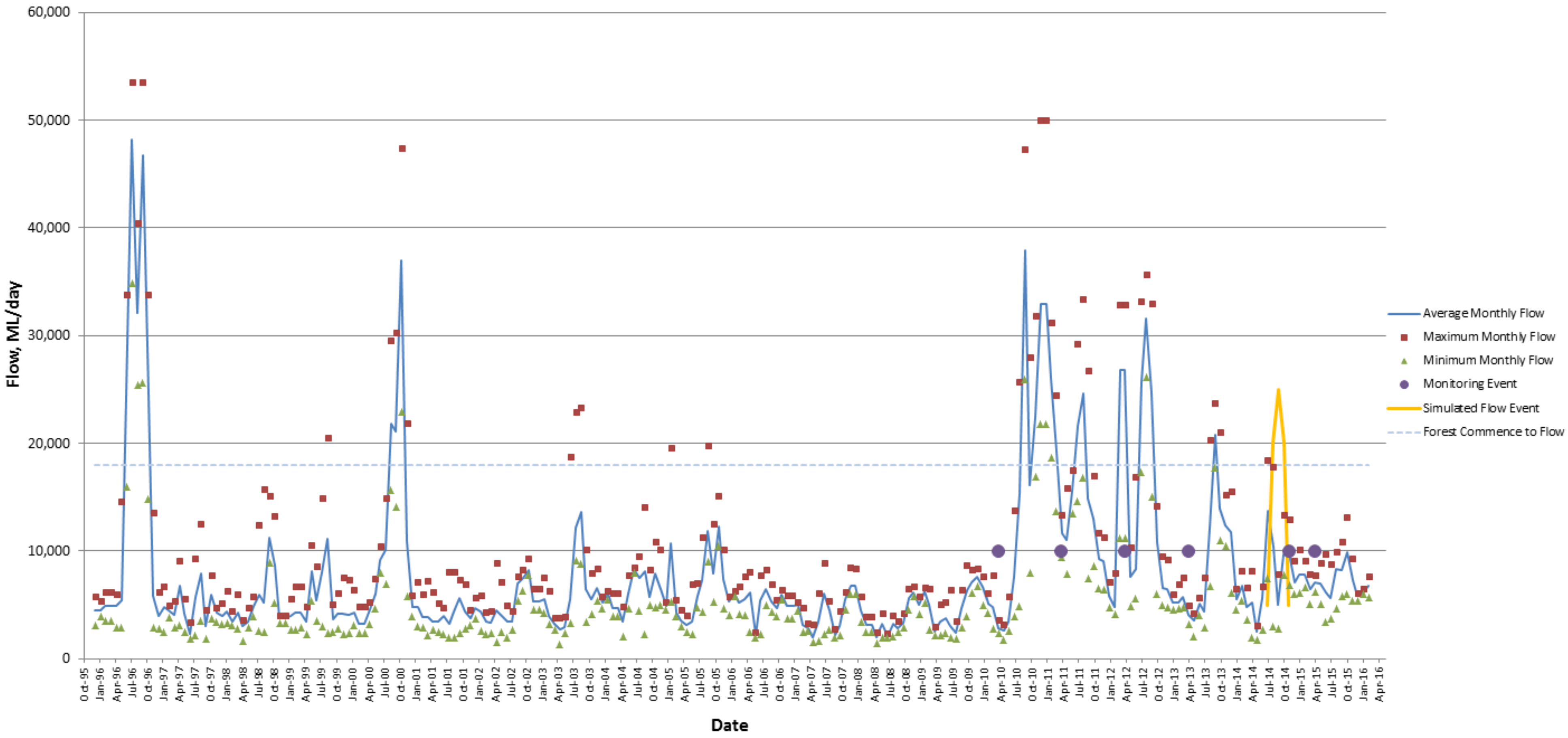


Figure 3 Flow Downstream of Torrumbarry Weir, ML/day (January 1996 to April 2016) (MDBA 2015)

1.4 Ecological objectives for Koondrook-Perricoota Forest

The overarching **ecological objective** for Koondrook-Perricoota Forest wetlands and understorey sites (as outlined in the Environmental Water Management Plan for the Forest; MDBA 2012) is to maintain and restore a mosaic of healthy floodplain communities. This would be indicated by:

- 80% of permanent and semi-permanent wetlands in a healthy condition;
- 30% of River Red Gum Forest in a healthy condition;
- Successful breeding of thousands of colonial waterbirds in at least three years out of 10; and
- Healthy populations of resident native fish in wetlands.

The Flood Enhancement Works project is designed to help achieve these ecological objectives (MDBA 2012). The works will enable a range of natural flood events to be mimicked, achieving broad-scale inundation of up to 50% of the Forest, including watering River Red Gum communities and wetlands and promoting colonial waterbird breeding events (MDBA 2012).

More specific ecological objectives and targets have been set for wetlands and understorey sites within Koondrook-Perricoota Forest[3] in AE (2011) for each WRC. Targets include (as cited in AE (2011)):

- Supporting an appropriate cover (>50% of total cover) of Plant Functional Groups that are considered characteristic of the WRC and supports appropriate species richness (2/3 of all species possible) in Plant Functional Groups (PFGs) characteristic of the WRC;
- Supporting > 50% of threatened species previously recorded in state databases and the monitoring program in the Forest;
- Having limited cover of high threat exotic plants (<10% cover);
- Not containing ecological indicator species reflective of inappropriate ecological conditions;
- Maintaining a healthy canopy (crown condition score > 3) (Crome, 2004b); and
- Over the long-term demonstrating adequate tree recruitment and growth.

This monitoring report discusses the findings of 2016 wetland and understorey condition monitoring undertaken at Koondrook-Perricoota Forest, and previous monitoring rounds, with respect to achieving the above ecological objectives and targets.

A review of the vegetation condition monitoring program was recently undertaken (Wills, Bidwell and Sim 2016), which discusses refinement of these objectives and targets. The outcomes of the review are not discussed in this report, but will be incorporated into future monitoring and reporting.

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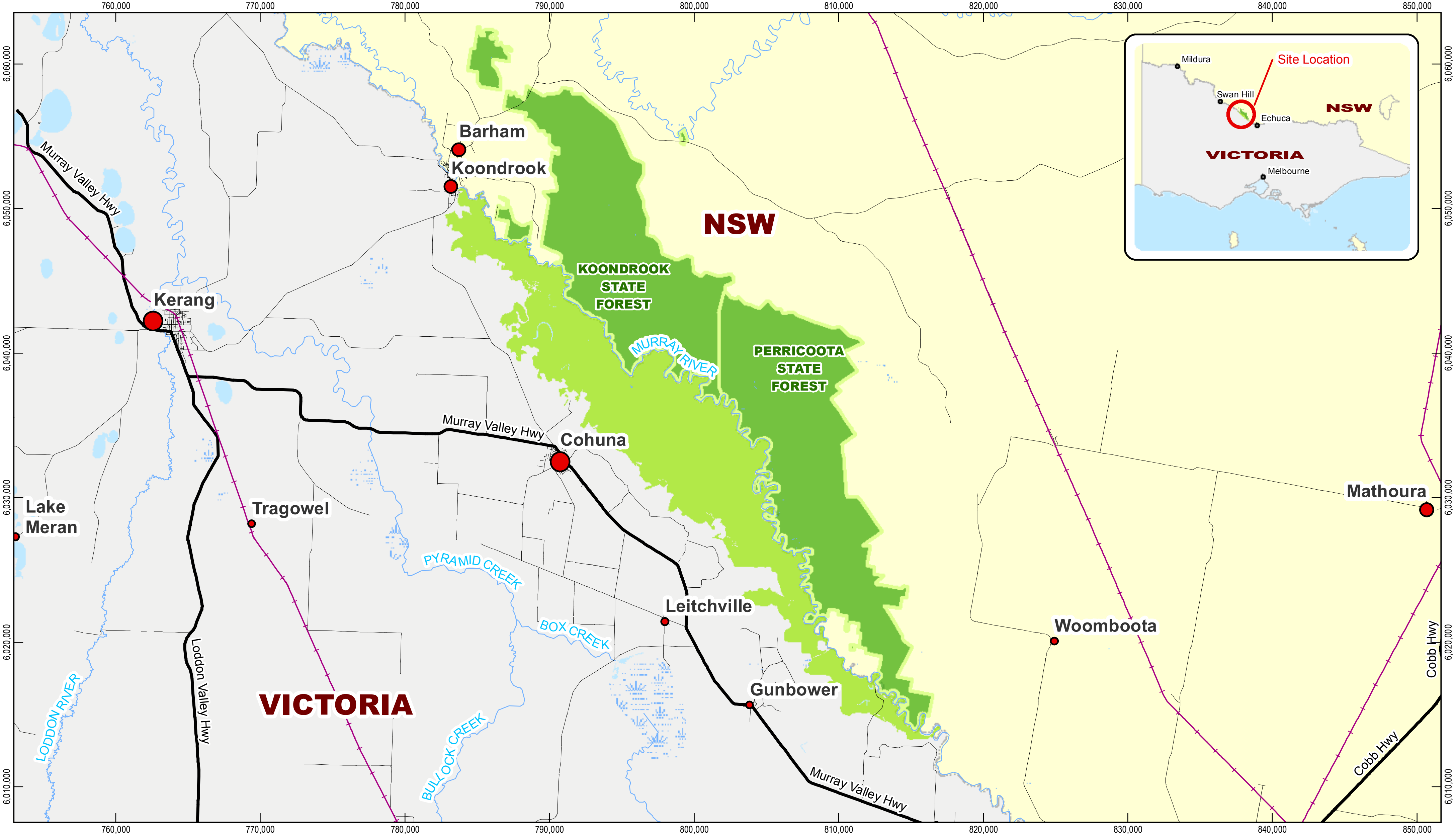
[3] Whilst these targets were originally established for Gunbower State Forest, these targets have routinely been applied to Koondrook –Perricoota in each monitoring period.



Paper Size A4

0 1 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

N

LEGEND

- Rail
- Highway
- Sealed road
- Major water course
- Lake
- Swamp
- Gunbower Forest
- Koondrook-Perricoota Forest
- Towns

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Job Number	31-30222
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Date	03 Jun 2013

Location Map

Figure 4

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180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: DSE, VicMap, 2013; Geoscience Australia, Koondrook and Perricoota State Forest boundaries, 2012. Created by:alovell

2. Methods

2.1 Wetlands and understorey sites

Wetland and understorey condition surveys were undertaken between 4 - 29 April 2016. A total of 76 pre-established sites were assessed in 2016, comprising 16 wetland transects and 60 understorey quadrats. Locations of sites are shown in Figure 5. Surveys were undertaken in accordance with the methods employed in the Koondrook-Perricoota Forest monitoring since 2008 (Table 1) and in Gunbower Forest in Victoria since 2005, following the methods developed by Crome (2004a; 2004b) and later revised by Australian Ecosystems in 2008.[4]

Table 1 provides a summary of the number of transects/quadrats included in each WRC (and proportion of monitoring program), extent (ha) of each WRC at Koondrook-Perricoota Forest, and the density of monitoring plots within each WRC.

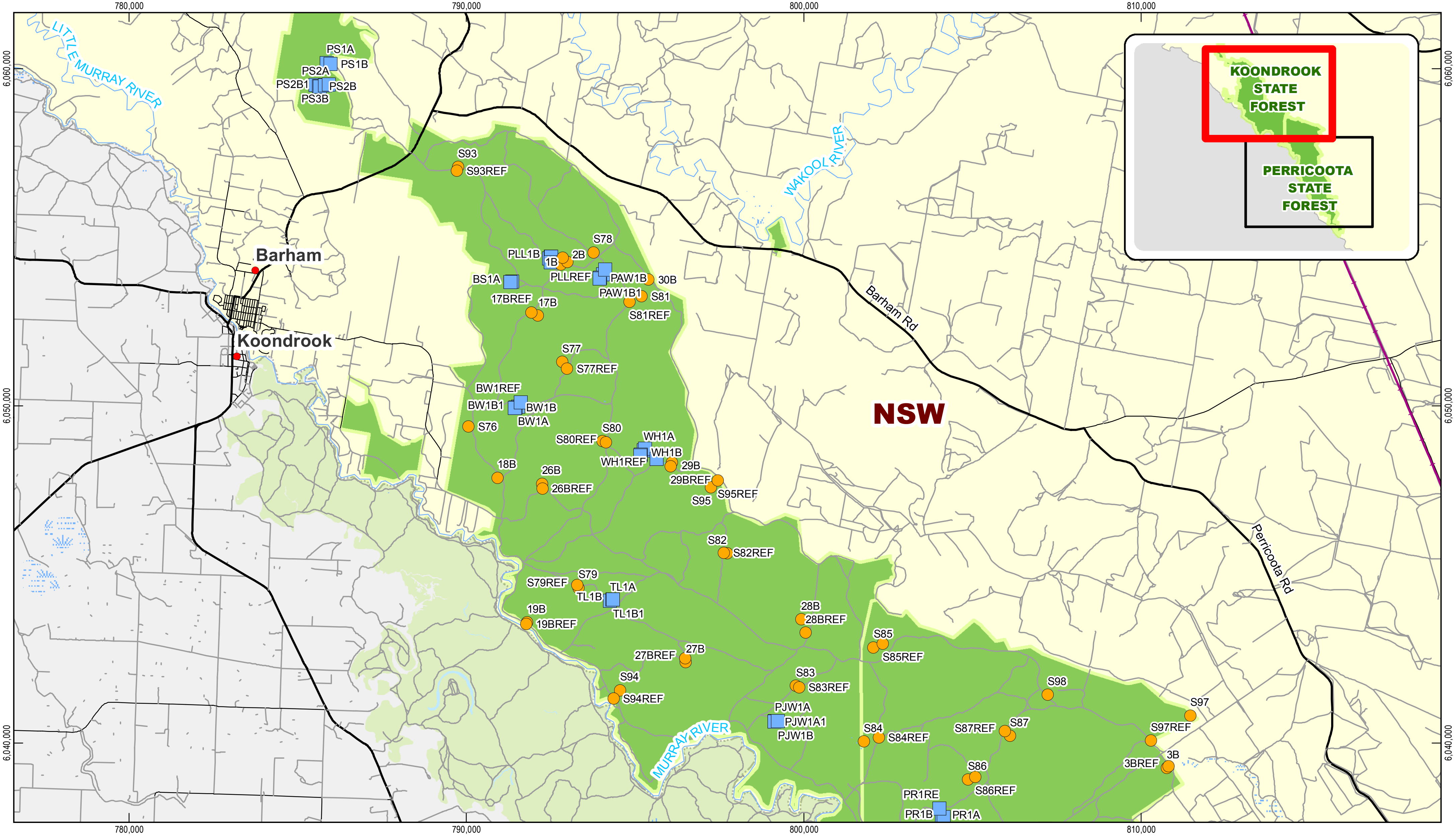
Section 2.1.1 summarises the methods used at wetland transects and Section 2.1.2 summarises the methods used at understorey quadrat sites.

[4] The rapid condition assessment component of the program was excluded from 2014 onwards because it was considered too subjective and qualitative.

Table 1 Number of assessments conducted in Koondrook-Perricoota Forest since monitoring commenced in 2008

Survey method	Area	2008 Spring	2010 Autumn	2011 Autumn	2013 Autumn	2014 Autumn	2014 Spring	2015 Autumn	2016 Spring	2016 Autumn	Density of monitoring plots since 2011
Grey Box Woodland	300 Ha		9	13	13	13	13	13	13	13	1 plot per 23 Ha
Black Box Woodland	4,000 Ha		9	9	9	9	9	9	9	9	1 plot per 444 Ha
Red Gum FTU	7,000 Ha		7	7	7	7	7	7	7	7	1 plot per 1000 Ha
Red Gum FDU	19,000 Ha		30	31	31	31	31	31	31	31	1 plot per 612 Ha
Semi-permanent wetlands	1,700 Ha	3	7	16	16	16	16	16	13[5]	16	1 Plot per 106 Ha
Total transects		**3**	**62**	**76**	**76**	**76**	**76**	**76**	**73**	**76**	

[5] Pollacks Swamp transects were assessed in summer 2016 instead of spring 2015 and were presented in a separate report. The data from 2008 were excluded from the data analyses because of limited sample size.



Paper Size A4

0 0.5 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

N

LEGEND

- Wetland site
- Understorey site
- Highway
- Sealed road
- Unsealed road
- Rail
- Major water course
- Lake
- Swamp
- Koondrook-Perricoota Forest

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Revision | 0
Date | 09 Jul 2013

Wetland and Understorey Condition Assessment Sites at Koondrook-Perricoota Forest

Figure 5
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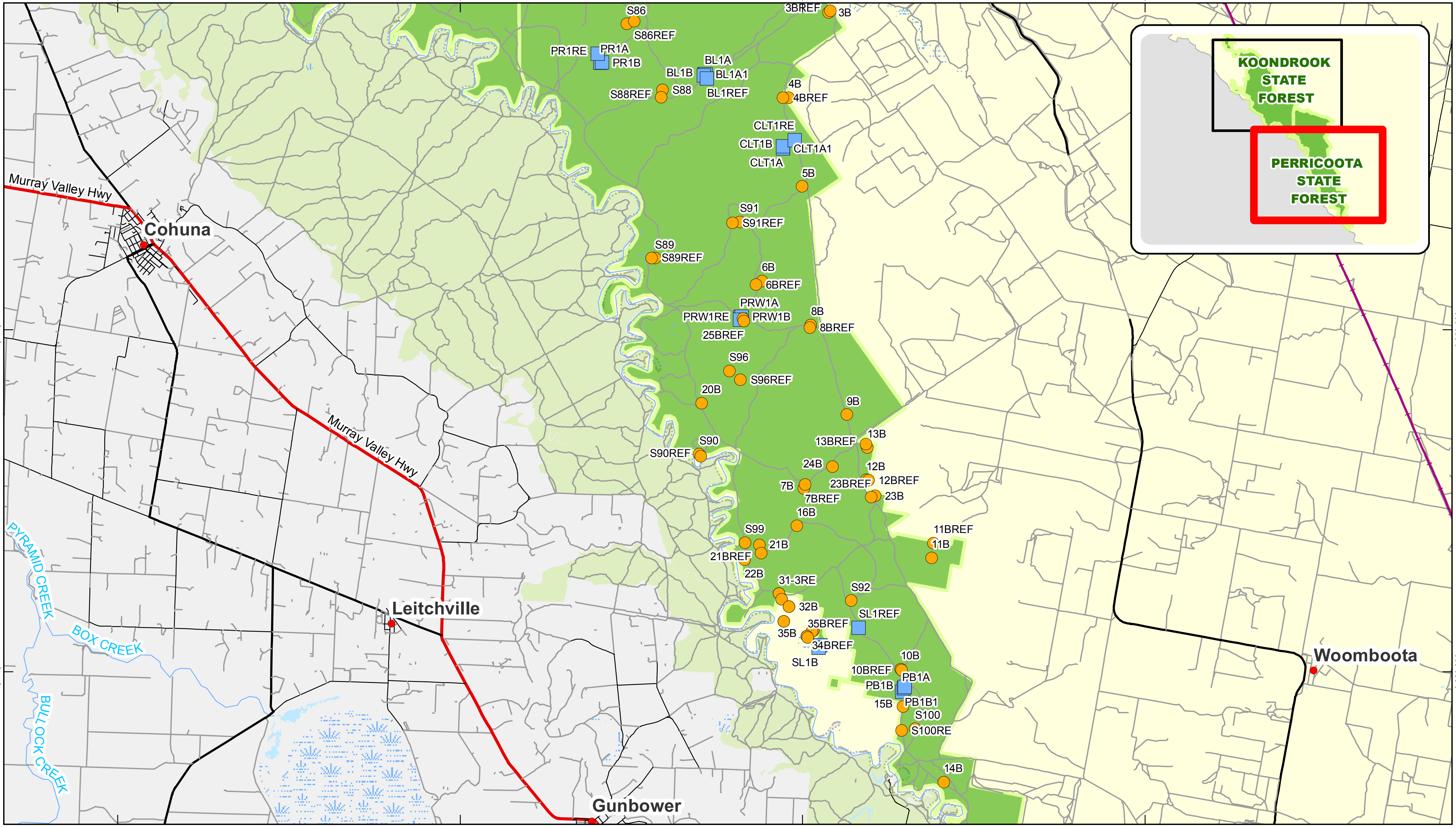
180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: DSE, VicMap, 2013; Geoscience Australia, Koondrook and Perricoota State Forest boundaries, 2012. Created by:cagilbert



Paper Size A4

0 0.5 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

N

LEGEND

- Wetland site
- Understorey site
- Highway
- Sealed road
- Unsealed road
- Rail
- Major water course
- Lake
- Swamp
- Koondrook-Perricoota Forest

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Wetland and Understorey Condition Assessment Sites at Koondrook-Perricoota Forest

Figure 5
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Data source: DSE, VicMap, 2013; Geoscience Australia, Koondrook and Perricoota State Forest boundaries, 2012. Created by:cagilbert

2.1.1 Semi-permanent wetland transects

Transect establishment

Transects in semi-permanent wetlands were previously established by Australian Ecosystems (2010). The protocols outlined in the Procedures for Wetland Survey techniques (PMA3) in Crome (2004b) and revised by Australian Ecosystems (2008) were used to establish transects at each of the 16 wetland sites. In summary, transects were established across the wetland/lagoon as shown in Figure 6 from Benchmark Tree A to Benchmark Tree B. In some cases, transects extended beyond the Benchmark Trees as shown in Figure 6. Transects vary in length at each wetland, as shown in Table 2.

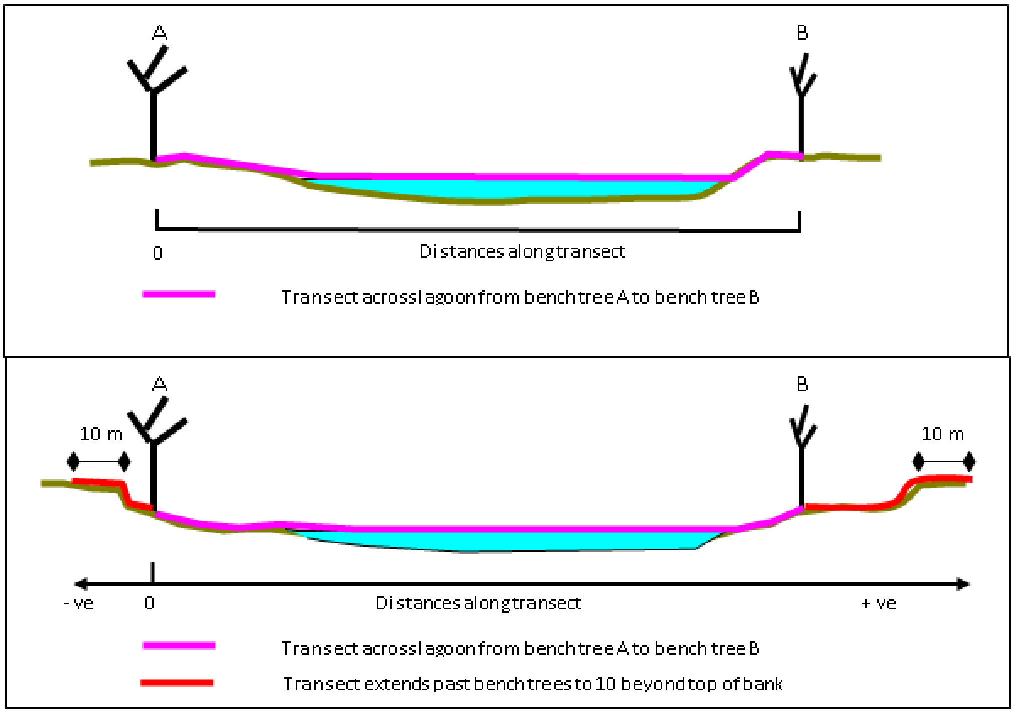

Figure 6 Schematic diagram of a transect across wetland

Blue area is water. Source: Crome (2004b)

Table 2 Wetland transects, names, codes and lengths (metres)

Wetland	Transect Code	Length (m)
Barbers Creek	BC1	49
Belbin Road Lagoon	BL1	65
Bonum Sandhill Wetland	BW1	100
Clarks Lagoon Tributary	CLT1	58
Pressy's Wetland A	PAW1	168
Baldwins	PB1	147
Pressy's Wetland J	PJW1	98
Long Lagoon - KP	PLL1	75
Penny Royal Lagoon	PR1	42
Price Road Wetland	PRW1	36
Pollack Swamp - transect 1	PS1	119
Pollack Swamp - transect 2	PS2	139
Pollack Swamp - transect 3	PS3	119
Swan Lagoon	SL1	94
Twin Lagoon (north)	TL1	100
Waterhole Lagoon	WH1	146

Data collection[6]

Data collected for wetland transects followed the Wetland Survey Protocol (PMA 3; Crome 2004b). Attributes recorded included:

- **Site data** (transect code, collectors, date and general notes such as evidence of fire, grazing, tree falls and logging).
- **Vegetation zones:** Start and end points (metres from the star picket at bench tree A) of the distinct vegetation zones occurring along the transect, and the percent cover of plants one metre either side of the associated section of the transect line (measuring tape) is estimated. Zones are based on distinct changes in plant functional groups. These should be obvious changes in the vegetation, example patches of *Eleocharis acuta* (perennial mudflat flora; PFG ATl, amphibious fluctuation – tolerates low growing) and *Paspalidium jubiflorum* (floodplain flora; PFG ATe, Amphibious fluctuation – tolerates emergent).
- All ground flora within each vegetation zone (species and cover abundance);
- Tree, sapling and seedling attributes as per Table 3 and Table 4 and their position (m) along the transect;
- Water depth to the nearest 10 cm from the water’s edge, recorded every 5 m;
- Percentage cover of exotic and indigenous flora across the transect;
- Vegetation type of the site; and

[6] The rapid assessment of condition was omitted from the program in 2014 because the health indices were considered ill-defined and prone to both linguistic error and operator error. Refer to Hemming and Bidwell (2013) for further details.

- Photographs of each wetland, including six sets of reference photographs:
  - A set of panorama photos of the wetland from bench tree 'A'
  - A single photo straight across the transect, from Bench tree A to B
  - A single photo from Bench tree A to the extension peg A when applicable
  - A set of panorama photos of the wetland from bench tree 'B'
  - A single photo straight across the transect
  - A single photo from Bench tree B to the extension peg B when applicable

Cover abundance scale used in wetland transects and understorey quadrats

1% = Present (i.e. one too few individuals present with less than 1% cover)

2% = More than Present (greater than five individuals), yet not 5% cover

5% = Individuals cover 5% of vegetation zone

> 5% recorded in 5% increments, i.e. 10%, 15% 20%, etc

Table 3 Categories of eucalypt trees and measurements conducted at KP Forest (in accordance with Crome 2004b)

Eucalypt category	Category description	Measurements
Canopy trees (understorey quadrats only)	20 eucalypt trees >3 m in height and >10 cm DBH, located in and around quadrat	Species Crown condition index score
Trees	All eucalypt trees >3 m in height and >10 cm DBH in quadrat/transect	Species DBH Crown condition index score
Other Trees (understorey quadrats only)	All eucalypt trees >3 m in height and <10 cm DBH (at site establishment) in quadrat	Species DBH Crown condition index score
Saplings	All eucalypt saplings 0.25-3 m in height in quadrat/transect	Species Height Crown condition index score
Seedlings	All eucalypt seedlings <0.25 m in quadrat/transect	Species Count

Table 4 Crown Condition Index categories used for assessing condition of trees at KP Forest (in accordance with Crome 2004b)

Crown Condition Index	Description
0 Dead Tree	Dead tree with no original canopy All main branches dead No epicormic growth
1 Unhealthy Tree	Tree with no original canopy Most main branches dead All epicormic growth
2 Unhealthy Tree	Tree with <25% of the original canopy present Some main branches dead (<50% canopy) Predominantly epicormic growth
3 Tree	Tree with 25-50% of the original canopy present Some small dead branches Some epicormic growth (<50% remaining of canopy)
4 Healthy Tree	Tree with 50-75% of the original canopy present Some dead branchlets (<50% of canopy) <10% epicormic growth
5 Healthy Tree	Tree with >75% of the original canopy present May include some dead branchlets and leaves <5% epicormic growth

2.1.2 Understorey quadrats

Quadrat establishment

The understorey surveys are designed to monitor condition of understorey vegetation and eucalypt health. Understorey quadrats were previously established by Australian Ecosystems in and Fire, Flood and Flora in 2011. The protocols outlined in the Programmed Monitoring Activity (PMA) 11.1 (Crome 2004b) and revised by Australian Ecosystems (2008) were used previously to establish understorey quadrats at each of the 60 understorey sites.

In summary, a reference tree is identified at a suitable site and a star picket is placed beside this tree to represent the north-west corner of the quadrat. A 10 m x 10 m quadrat is then marked out using the star picket and the bench tree as the north-west corner and the quadrat is established to the south and east of this star picket.

Sites have been stratified across the five WRCs (see Table 5).

Table 5 Number of sites in each Water Regime Class

Water Regime Class	No. of understorey quadrat sites
Wetlands/waterways	16
River Red Gum with flood dependent understorey	31
River Red Gum with flood tolerant understorey	7
Black Box Woodland	9
Grey Box Woodland	13

Data collection[7]

Data collected at each understorey quadrat followed the Understorey Surveys (PMA11.1) Procedure 2 – Vegetation Sampling (Crome 2004b). Attributes recorded within the 10 x 10 m quadrat included:

- **Site data** (site number, collectors, date and general notes (evidence of fire, grazing, tree falls, logging and other relevant information);
- **Ground flora:** species and cover abundance. Note that species that were present but vegetative material was dead at the time of assessment were recorded but given 0% cover;
- Tree, sapling and seedling attributes as per Table 3 and Table 4;
- Percentage cover of exotic flora and indigenous flora at the site;
- Vegetation type of the site;
- The percent cover of litter, bare ground, open water and course woody debris; and
- Photographs of the site (taken from north-west corner post, facing south, east, and south-east).

In addition, the crown condition of 20 living trees within/surrounding the quadrat was assessed according to the crown condition categories presented in Table 4 and reference photos in Crome (2004b; see Appendix B).

2.2 Plant identification

Flora specimens were identified in the field where possible. If plants could not be positively identified in the field, but had sufficient material to allow positive identification, they were collected and identified under a microscope. Plants were identified using the following resources:

- NSW Flora (RBGS & DT, 2014); and
- Flora of Victoria (RBGM, 2014).

Nomenclature in this report follows the NSW Flora (NSW RBG & DT, 2014).

2.3 Data analysis

2.3.1 Wetlands and understorey sites

For analysis, data were assessed for each of the five Water Regime Classes and are presented in this manner in the results (Section 3).

The aims of the analysis were to:

- Assess the current condition of wetland and understorey sites;
- Compare autumn 2016 data to data collected in previous monitoring rounds (2010, 2011, 2013, 2014 and 2015);
- Identify potential trends in the floristic data and tree condition data; and
- Evaluate progress towards the Icon Site's ecological objectives.

Monitoring sites were grouped by Water Regime Class (WRC) as described in Section 1.3.1.

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[7] The rapid assessment of condition was omitted from the program in 2014 because the health indices were considered ill-defined and prone to both linguistic error and operator error. Refer to Hemming and Bidwell (2013) for further details.

2.3.2 Plant Functional Groups

Each species was assigned a Plant Functional Group (PFG) based on common ecological, morphological and functional responses to inundation (PFGs are described in Table 6). PFGs were assigned to each species using an unpublished master list provided by Casanova et al. (2015)[8], and where new species were identified (i.e. not in the master list) they were assigned a PFG based on habitat requirements as described in RBGM (2014).

Although exotic flora can be ascribed a PFG, only indigenous species were included in the analysis of targets.

For each WRC, certain PFGs are predicted to occur in higher abundance than other PFGs. These are referred to as characteristic PFGs or target PFGs for the particular WRC.

The data for each WRC class were investigated to determine:

- If PFGs characteristic of the WRC were present and whether target numbers of each of these PFGs were achieved; and
- If non characteristic PFGs were present, i.e. species indicative of poor environmental conditions such as lack of flooding.

[8] Casanova et al. (2015). Unpublished master list of Plant Functional Groups. List was developed by experts in workshops.

Table 6 Definitions of Plant Functional Groups used in the data analysis

PFG code	Abbreviation (Brock and Casanova 1997)	Plant Functional Group Name	Description
1	S (Se, Sk or Sr)	Seed/spore born aquatic flora	**Submerged** Adult plants do not survive prolonged exposure of the wetland substrate (drying) and lack perpetuating rootstocks. Seed or spores may persist in soil during dry times.
2	ARp	Rhizomatous aquatic flora	**Amphibious fluctuation – responders floating** Aerial parts of plants survive exposure of the wetland substrate (drying) for sustained periods of time. Plants survive drying by dying back to rootstocks.
3	ARf	Semi-aquatic flora	**Amphibious fluctuation – responders plastic (includes strictly aquatic floaters)** Can actively grow when substrate exposed but still moist, but may die back to rootstocks or seed during sustained dry periods.
	Atw	Perennial	**Amphibious fluctuation tolerator, woody:** Perennial woody species that require water to be present in the root zone but will germinate in shallow water or on a drying profile. Generally restricted to permanently saturated areas.
4a	ATl	Perennial mudflat flora	**Amphibious fluctuation – tolerates low growing** Perennial – maintain same general growth form during brief periods of inundation, but may dieback to rootstocks if unable to develop emergent growth during sustained inundation.
4b	ATl	Annual mudflat flora	**Amphibious fluctuation – tolerates low growing** Annual (or functionally so) – may tolerate very brief periods of shallow flooding during growth phase, but essentially short-lived plants which germinate following flood water recession and produce inundation-tolerant seed during the drying phase.
5	ATe	Floodplain flora	**Amphibious fluctuation – tolerates emergent** Rootstocks tolerate shallow inundation but plant intolerant of sustained total immersion. Recruitment and/or long-term maintenance.
6	Tda	Moisture-dependent	**Terrestrial damp** Rootstocks intolerant of more than superficial inundation, but occurring in areas of good soil moisture conditions which may be influenced by proximity to river and water seepage through soil.
7	Tdr	Terrestrial dry	**Terrestrial dry** Dry-land plants (i.e. flood intolerant and going through life cycles independently of flooding regime).
0	NA	Not-vegetated	Bare ground, litter, logs, water, etc
unknown	NA	Not assigned	Species for which there is insufficient information to assign them a PFG.

Source: AE (2011)

2.3.3 Summary statistics

Where possible, data are presented in line with protocols outlined in *"Guidelines for communicating performance against standards in Forest management*" (Walshe and Wintle, 2006). Where targets have been specified, results are compared against these targets. Due to the skewed distribution of raw data and the presence of outliers, the results present the median value instead of the averages. The median value is where 50% of the data lie above and below. Ninety-five percent confidence intervals were calculated around the median using the formula outlined in Appendix 1 of Walshe and Wintle (2006).

All graphs and calculations were completed in Excel or SPSS (version 23.0).

In most cases, data are presented in box plots: solid black lines represent the median value. Boxes represent the interquartile range where 50% of the data lie; whiskers represent the 95% confidence intervals around the median value, and the circles or asterisks represent outlier values. Larger confidence intervals are indicative of a higher level of variability between sites and / or smaller sample size (Black Box Woodland and Red Gum FTU).

The 95% confidence intervals specify tolerable Type I error rates of 0.05, (in other words less than 5% chance of inferring an effect or impact when there is none), however may have varying Type II error rates (inferring there is no effect when in fact there is insufficient sampling to detect one).

Whilst statistical significance (p-value) has been omitted from this report, where confidence intervals are clearly above or below a threshold or target, then the target has either been met or not. Where confidence intervals overlap targets, this implies there is too much variation in the data and that we cannot be confident of the sites meeting specified targets. Increasing sample sizes, or reducing the level of certainty required (e.g. 80% confidence) may be suitable in such cases.

When comparing two confidence intervals, an overlap by less than 25% indicates statistical significance at the 0.05 level.

2.3.4 Estimates of potential flora

Australian Ecosystems (2011) has previously determined the likelihood of occurrence of rare or threatened flora (based on previous records in government databases such as the Victorian Biodiversity Atlas and NSW Flora Atlas and presence of suitable habitat). Their results were adopted in this report. Three main limitations are acknowledged by AE (2011) in such an approach and are also acknowledged here:

1. Autumn monitoring does not fully capture the species diversity of the Forest, e.g. flora species that occur in spring and summer are not captured. This has subsequently been addressed by undertaking additional monitoring in spring (2014 and 2015).
2. Targeted threatened flora surveys have not been undertaken and thus additional rare or threatened species are likely to occur outside of monitoring plots.
3. Suitable conditions do not exist for all species in all years and the natural flooding cycle is likely to influence the presence or absence of certain species in any given year.

2.4 Limitations

2.4.1 Tree numbering

At many sites, trees are included in three monitoring methods: stand condition, tree condition and understorey condition plots, the tree number for such sites is complex and somewhat confusing. In such cases (where monitoring plots overlap), many trees have numerous tree tags/different numbers.

To address the tree numbering issue during this round of monitoring, careful attention was paid to identify the correct trees to be measured for each method using last year's data and notes on tree tagging. Where tree numbers had faded since the last round of monitoring, numbers were repainted.

2.4.2 Sample size

In the current monitoring sites, River Red Gum Woodland with flood dependent understorey, Wetlands and Grey Box appear to be well represented. Although Grey Box only has 13 quadrats, the extent of Grey Box in the Forest is less than 1% or 300 hectares and therefore has the highest density of sampling. The reason for this sample size is because the Biodiversity Operational Plan identified that Grey Box and Derived Tussock Grassland may be negatively affected by floods. There are only seven and nine understorey condition sites for River Red Gum with flood tolerant understorey and Black Box Woodland respectively, which is equivalent to one quadrat per 1000 hectares, and one quadrat per 444 hectares (see Table 1). Due to a large amount of variation between these sites, many of these sites may have insufficient sampling to be able to confidently detect changes. Furthermore, a sampling size of less than eight will produce confidence intervals that will encompass the lowest and the maximum value, and will therefore be generally uninformative in detecting a change unless large pronounced changes occur.

Nevertheless, River Red Gum Forest and Woodland are the dominant WRC within Koondrook-Perricoota Forest (as described in Section 1.3.1) and are the focus of the environmental watering program (MDBA 2012).

2.4.3 Experimental design

The following potential limitations of the current data sets must be acknowledged when analysing and interpreting the data:

- As transect lengths and transect divisions varied substantially between sites and between years, wetland data do not meet all the requirements of standard statistical tests (AE 2011)

2.4.4 Survey time

Seasons

Up until 2014, the monitoring program was principally undertaken in autumn and therefore the program did not fully capture the diversity of flora present, i.e. additional species are likely to be present in spring or summer. To attempt to address this, more recently monitoring was undertaken in spring as well as autumn (in 2014 and 2015) to capture seasonal variation in species richness and vegetation cover, particularly annual introduced flora that may be present in spring but deceased by autumn. Going forward, this approach was considered important given that future monitoring following a managed flood event (such as the one that occurred in spring 2014) would most likely take place in spring – early summer when vegetation response is expected to peak.

It is understood that autumn is generally an appropriate time to capture changes in floristic diversity following summer floods, because floods would have receded by this time and vegetation response to flood would most likely be evident.

Floods

Surveys in autumn 2013 and 2014 were undertaken at least six months following a flood, whilst surveys in 2011 were undertaken whilst the 2011 flood was receding. In winter-spring of 2014, environmental water was delivered to the Forest during a managed flood event. The flood event was largely limited to wetland sites with very few understorey sites receiving environmental water (refer to Bidwell and Wills, 2015). Surveys in spring 2014 were undertaken whilst the managed flood event was receding. In spring 2015, environmental water was delivered to Pollacks Swamp only (transects PS1, 2 and 3 received water). Spring 2015 monitoring was undertaken at all understorey sites and all wetland sites (except for Pollacks Swamp) to collate additional baseline data on species richness and vegetation cover during spring in the absence of floods. Pollacks Swamp sites were monitored in summer 2016 during the receding, shallowly inundated phase. The Pollack summer 2016 data have been excluded from this report and were presented in a separate report (Forbes and Wills 2016b).

3. Results

3.1 Understorey sites

The most recent monitoring in autumn 2016 indicates that understorey sites within the Forest are generally in poor condition with relatively low indigenous species richness and low indigenous vegetation cover across all WRCs (when compared to previous monitoring years). The data suggest that the condition of the Forest is similar to that observed in autumn 2010 before the breaking of the Millennium drought.

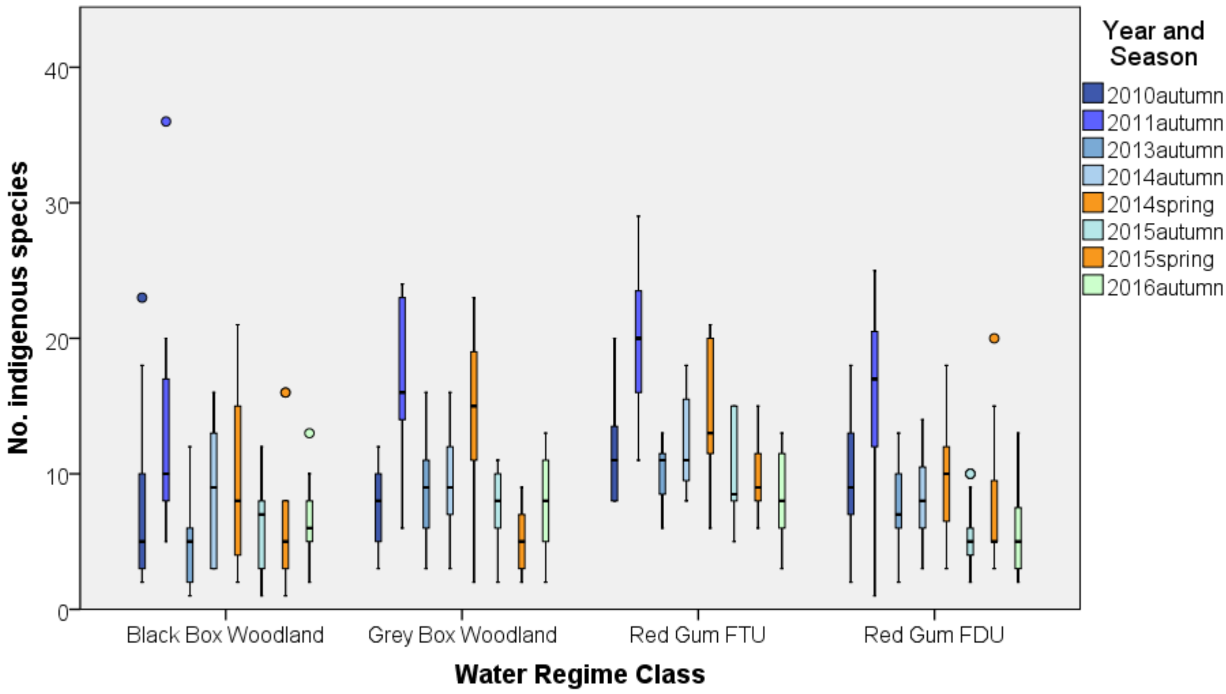
As predicted, there are notable seasonal differences in the vegetation data (between spring and autumn) and in response to flood (i.e. natural flood event in 2011, and managed flood event in spring 2014). Throughout this chapter we will refer to the overall trends able to be observed in the data across all monitoring years, rather than just discussing the current monitoring year in isolation, as differences from one year to the next are not necessarily as significant or informative as looking at trends across larger increments of time.

3.1.1 Indigenous flora – species richness

Figure 7 shows the median number of indigenous flora species encountered across each WRC in each monitoring round. Water Regime Classes are presented in order of increasing water requirements. The most notable trends from the monitoring data to date are:

- Indigenous species richness was higher in 2011 following floods than in most other monitoring rounds. Many of the understorey sites were in the shallow receding or recently receded phase, when monitoring was undertaken in autumn 2011;
- Indigenous species richness was higher in spring 2014 than in autumn monitoring rounds (except for 2011, which followed the 2011 flood event, as noted above);
- Indigenous species richness in spring 2015 was not as high as that recorded in spring of 2014. Notably, spring of 2015 was considered drier across Victoria and New South Wales than typically observed during spring; and
- Indigenous species richness in autumn 2016 appears the lowest since 2010, before the breaking of the Millennium drought, in Red Gum FTU and Red Gum FDU WRCs.

A full list of species recorded at understorey sites across monitoring rounds is provided in Appendix A.



Note: Solid black lines represent the median value. Boxes represent the interquartile range where 50% of the data lie, and whiskers represent the 95% confidence intervals around the median value, and the circles or asterisks represent outlier values.

Figure 7 Median number of indigenous species across Water Regime Classes between monitoring periods (2010 to 2016)

3.1.2 Indigenous flora - vegetation cover

Overall, indigenous vegetation cover has remained relatively stable across monitoring years with the exception of 2011, when following the floods there was a notable increase in the percentage cover of indigenous flora in all WRCs (Figure 8). The data also suggest that cover of indigenous flora is typically higher in spring (with some exceptions) than in autumn in the absence of large floods.

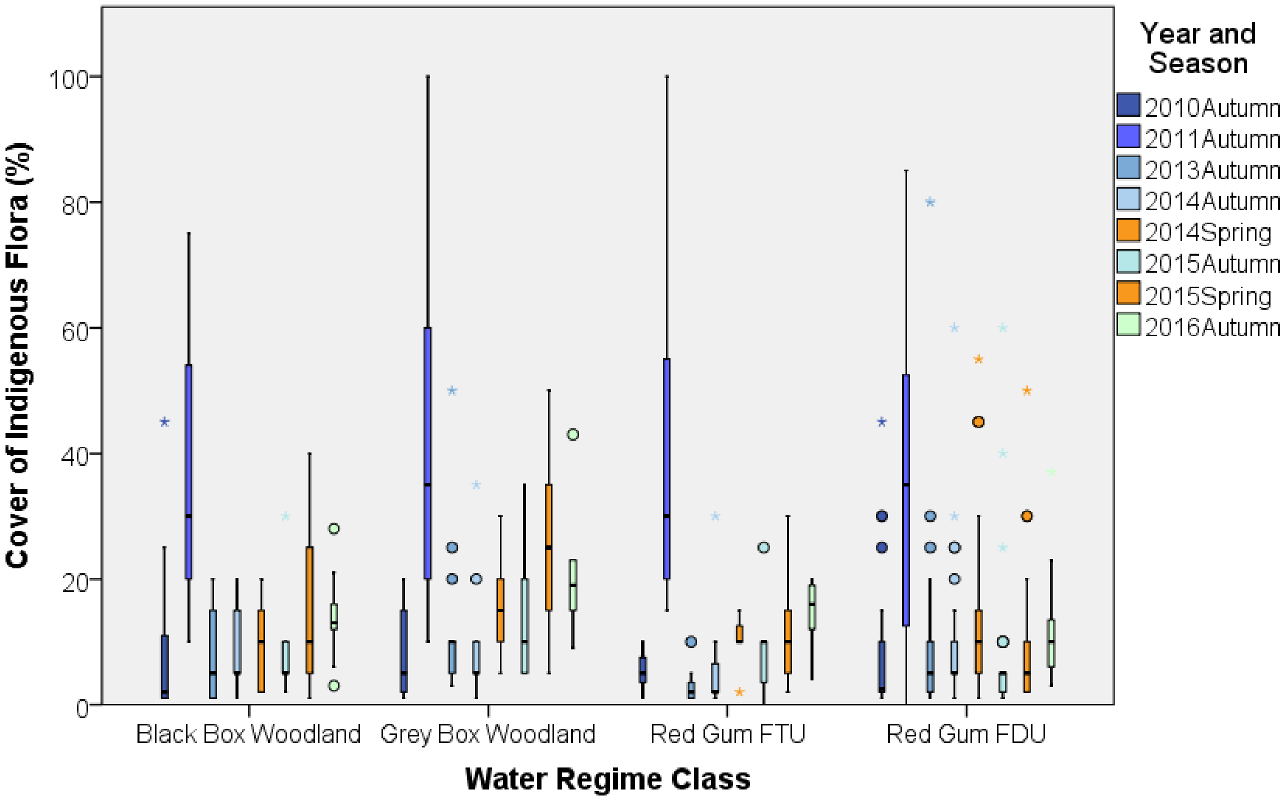


Figure 8 Median percentage cover of indigenous flora species across Water Regime Classes between monitoring periods (2010 to 2016)

3.1.3 Rare and Threatened Species

In previous years, only one threatened species has been recorded within established monitoring sites: *Amphibromus fluitans* (River Swamp Wallaby-grass), a nationally vulnerable species listed under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, and also listed as vulnerable under the NSW *Threatened Species Conservation Act 1996* (TSC Act).

Amphibromus fluitans (River Swamp Wallaby-grass) was not detected in all monitoring rounds, e.g. has not been detected since autumn 2013. Detailed monitoring of this species is recommended. Flowering time is from spring to autumn (November to March). It is possible that this species was not readily detectable at the time of survey in some monitoring rounds, as it was not yet flowering, in which case it would have been recorded as Poaceae sp.[9] It grows mostly in permanent swamps and thus is unlikely to be above-ground in the absence of water or recent inundation.

3.1.4 Weeds – species richness

The number of introduced species was notably higher in spring than in autumn in all WRCs (Figure 9), particularly in spring 2014. The number of introduced species was also notably higher following the 2011 floods than in autumn in all WRCs except for Black Box Woodland (Figure 9). In autumn 2016, the median number of introduced species was similar to other autumn monitoring rounds and lower in some WRCs e.g. Grey Box and Red Gum FDU.

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[9] The flower heads remain almost hidden by the leaf sheaths until the seeds are nearly mature, and even then elongation of the stems is barely sufficient to expose the heads completely (http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10045).

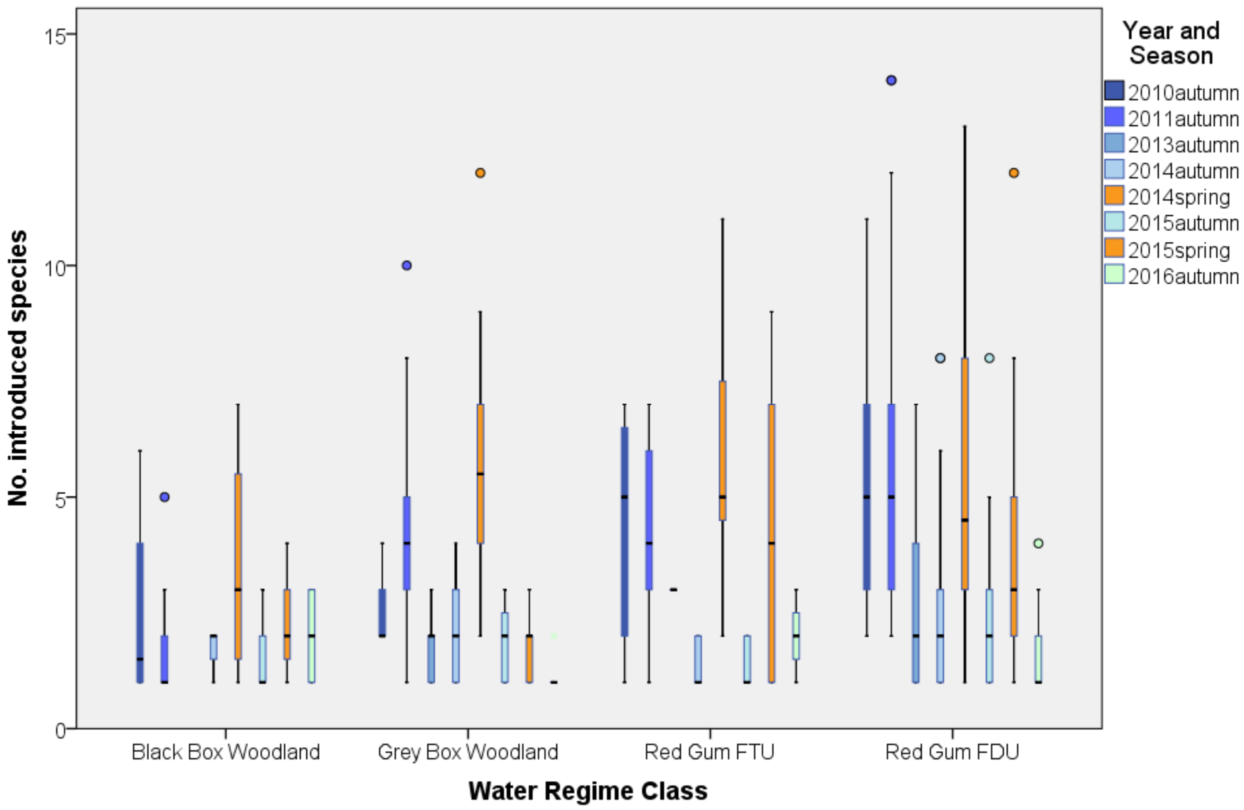
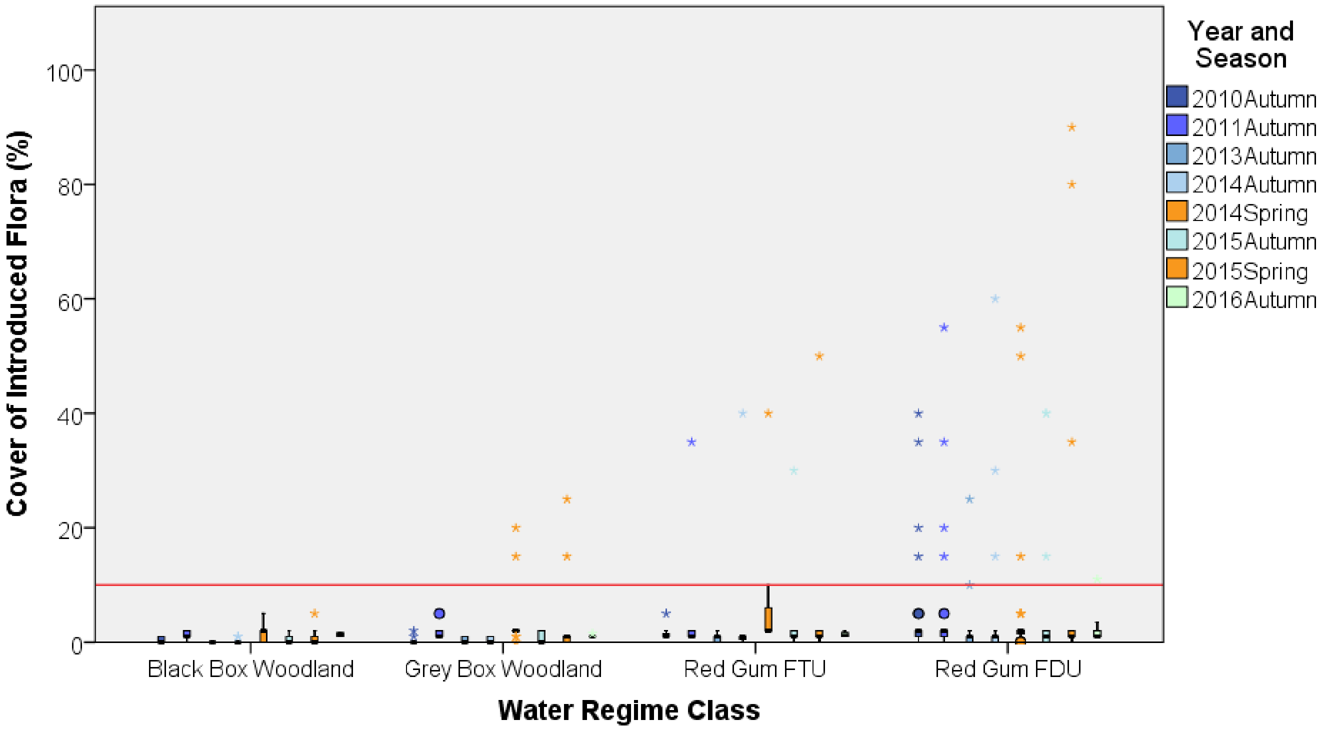


Figure 9 Median number of introduced species across Water Regime Classes between monitoring periods (2010 to 2016)

3.1.5 Weeds – vegetation cover

A target of less than 10% weed cover has been set for all WRCs. Figure 10 shows that this target was met within 100% of Black Box Woodland sites in all monitoring rounds. The median value of weed cover for all other WRCs was also below 10%, indicating that the target threshold was met in the majority of understorey sites. However, some sites sampled exceeded the threshold of 10% (presented as asterisks on Figure 10). The maximum percentage cover of weeds recorded was within Red Gum FDU, where weed cover at one site was 90% cover in spring 2015. Most sites across all monitoring years had very low weed cover, but a small number of sites had substantially higher cover of weeds than 10% (represented by the outliers on the graph).

Due to the small sample size in Red Gum FTU, the confidence intervals are un-informative and encompass the maximum and minimum values recorded.



Note: that red line represents the current target threshold for cover of introduced flora: 10% cover (established by AE 2011).

Figure 10 Median percentage cover of introduced species across Water Regimes Classes between monitoring periods (2010 to 2016)

High threat weed cover

High threat weeds are those declared under the NSW *Noxious Weeds Act 1993*. High threat weeds listed for the Murray Local Control Authority Area recorded within Koondrook-Perricoota Forest in 2016 include:

- *Marrubium vulgare* (Horehound; Class 4)
- *Phyla canescens* (Lippia; Class 4)
- *Rubus fruticosus* (Blackberry, Class 4)

The median percentage cover of high threat weeds did not exceed 10% cover (the health target set for Koondrook-Perricoota Forest) within any WRC in any year (Figure 11).

Black Box Woodland and Red Gum Flood Tolerant Understorey sites contained no high threat weeds in any monitoring round. The maximum value recorded in Grey Box Woodland sites was below 10% (1%). Eight sites within Red Gum FDU contain high threat weeds, and the majority of sites comprise less than 10% cover (1-5%). However, one site (18B) within Red Gum FDU has consistently recorded more than 10% high threat weed cover in all monitoring periods, with maximum cover of 35%. The cover of high threat weeds recorded at 18B in 2016 is less than that recorded in spring 2015.

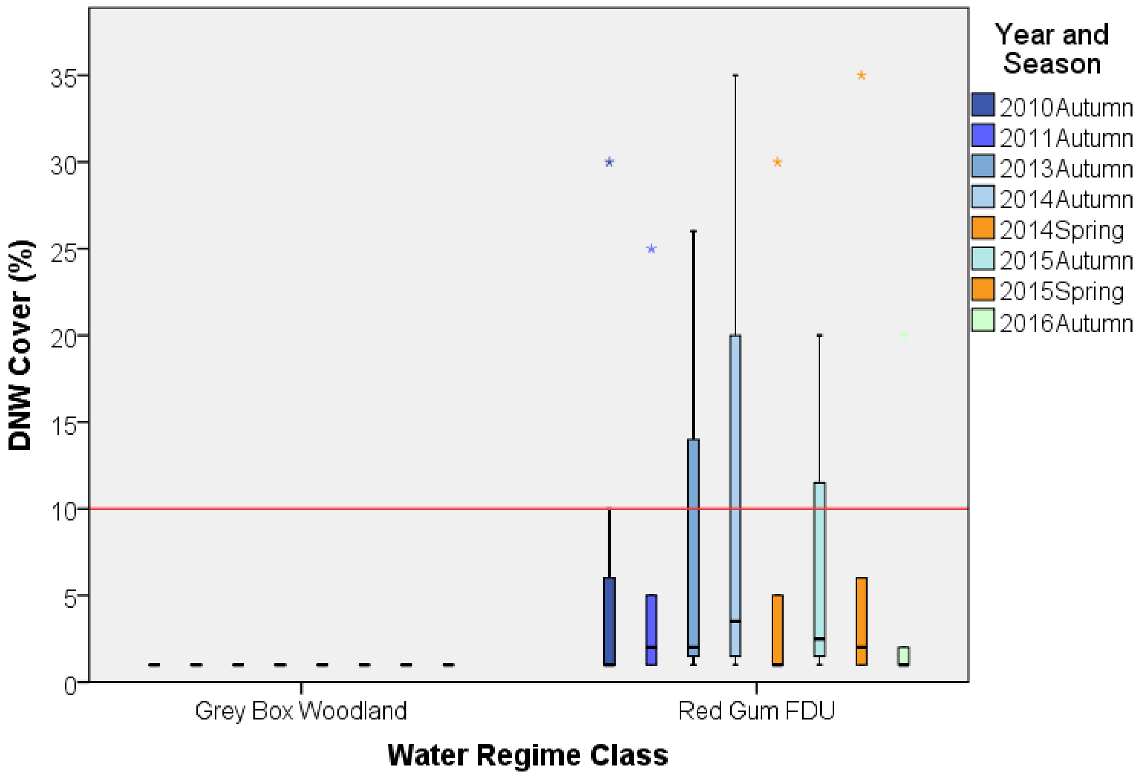


Figure 11 Median percentage cover of high threat Declared Noxious Weeds (DNW) across Water Regimes Classes between monitoring periods (2010 to 2016)*

*Black Box and Red Gum FTU are excluded from the graph because none of these sites had high threat weeds in any monitoring round.

3.1.6 Characteristic Plant Functional Groups

Characteristic Plant Functional Groups (PFGs) were previously determined for each WRC (AE, 2011). Targets for the each PFG were also set, for example:

- Supporting appropriate species richness (2/3 of all species possible); and
- Supporting an appropriate cover (> 50% of total cover is comprised of characteristic PFGs).

These targets have recently been reviewed as part of a FCNSW-funded Condition Monitoring Program Review for Koondrook-Perricoota Forest (Wills, Bidwell and Sim 2016), however will not be discussed here.

Figure 12 and Figure 13 show the **median** number of indigenous species in each PFG across monitoring rounds (2010 to 2015). Each WRC is presented in a separate figure to reduce cluttering of data. 2016 data show very little change has occurred over the past year.

Figure 14 shows the **total** number of indigenous species recorded in each PFG (bars) for each WRC in each year. The total number of predicted species and the target number of species (2/3 of the total predicted number of species) is also overlaid on Figure 14 for PFGs considered characteristic PFGs in the respective WRC. Where the predicted number of species in a PFG is zero, then any species occurring in this PFG is considered uncharacteristic for the respective WRC.

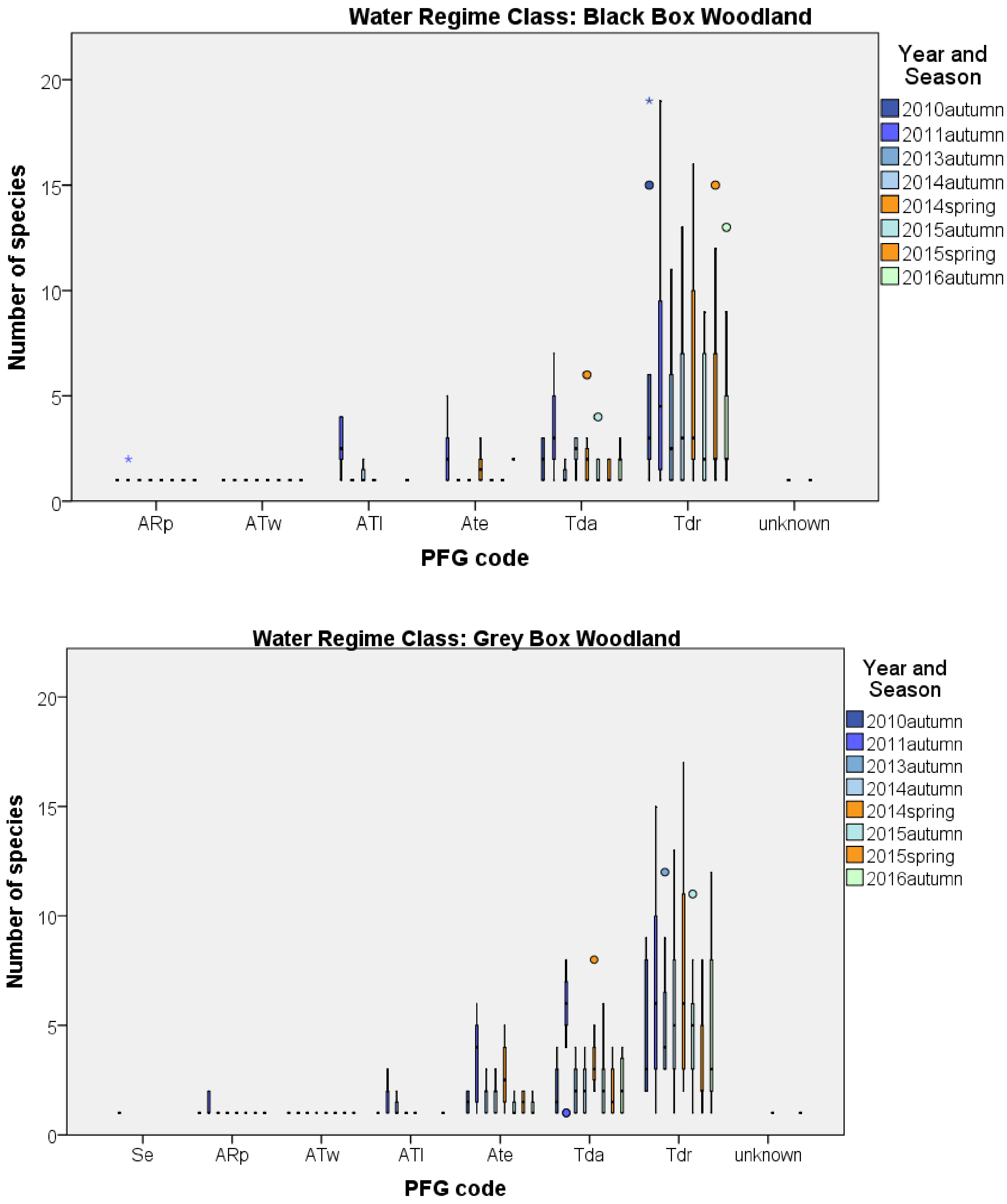
In autumn 2016, target PFG species richness was not met in any WRC, which is consistent with most years in understorey WRCs, except for autumn 2011 and spring 2014 following floods (Figure 14) when some (but not all) of the PFG targets were met, e.g.:

- Terrestrial damp species - Tda (Grey Box, Black Box and Red Gum FDU) in autumn 2011;
- Terrestrial damp species - Tda (Red Gum FTU) in spring 2014; and
- Floodplain flora - Ate (Grey Box) in spring 2014.

The PFG with highest species richness is Tdr (terrestrial dry species) for all WRCs, which are species that are associated with dry environments.

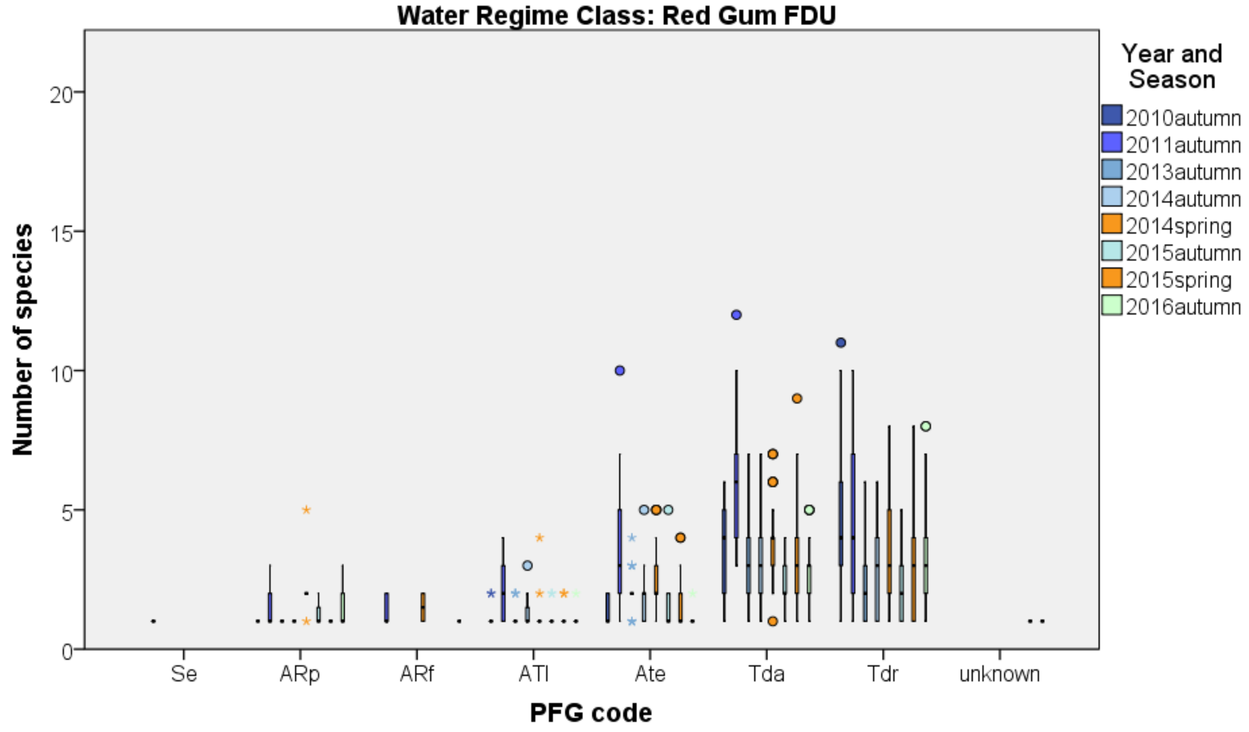
Figure 15 shows the percentage cover of species within target PFG (as a % of total vegetation cover) met for each WRC in each monitoring round. No WRC meets the target for percentage cover of characteristic PFGs (50% of total vegetation cover) in 2016.

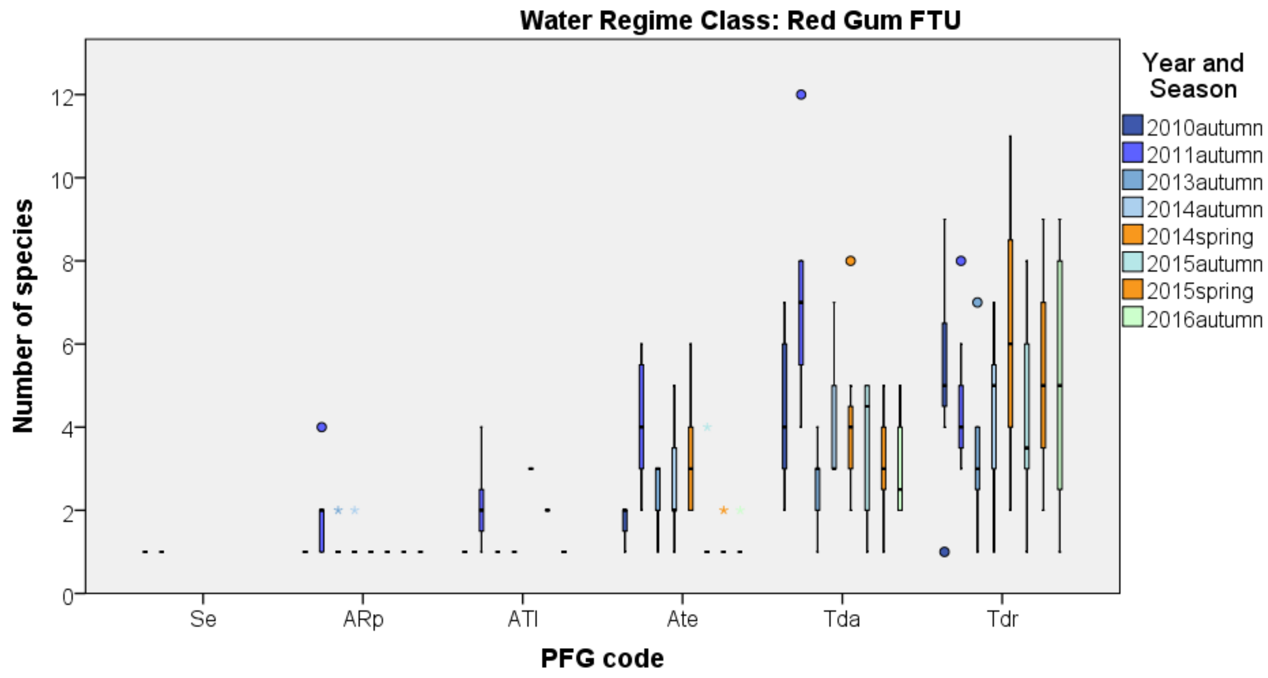
Figure 16 shows the percentage cover of characteristic PFG species recorded in PFGs as a percentage of the total vegetation cover. None of the WRCs show notable changes in the cover of characteristic PFGs between 2015-2016, or since the 2011 floods.



Note: Key to PFG codes: refer to Table 6.

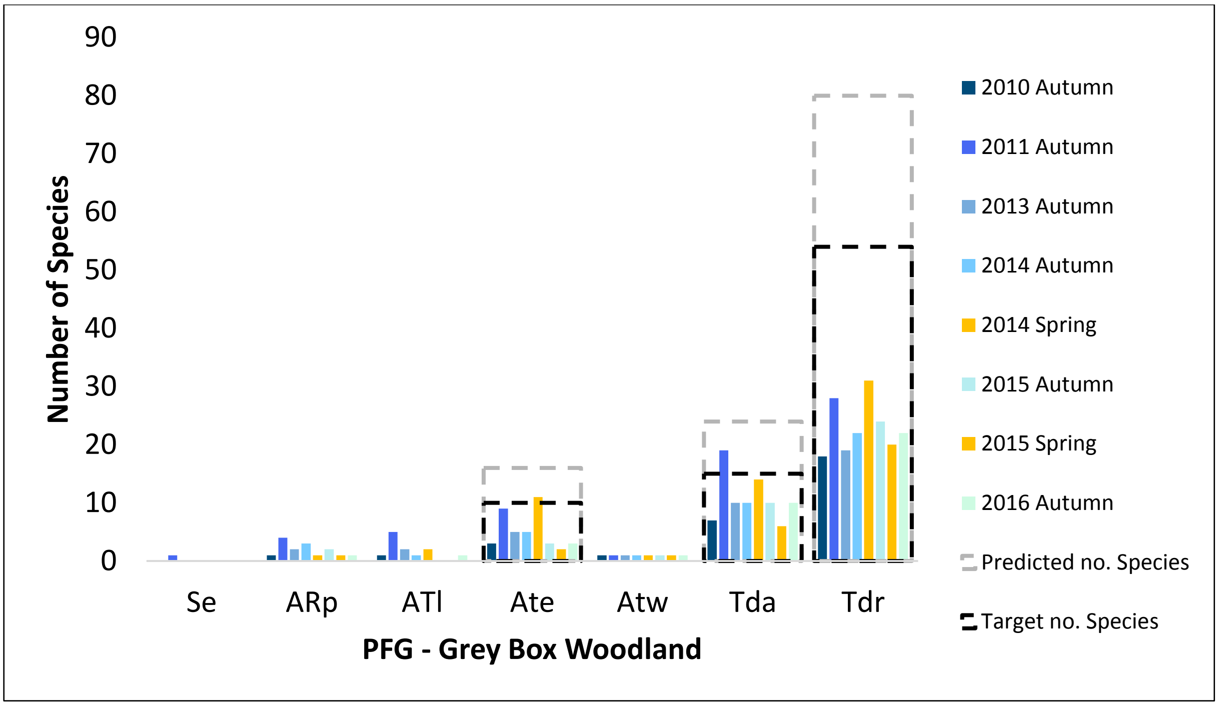
Figure 12 Number of species in each Plant Functional Group across Water Regime Classes between monitoring periods (2010 to 2016) – Black Box and Grey Box Woodlands

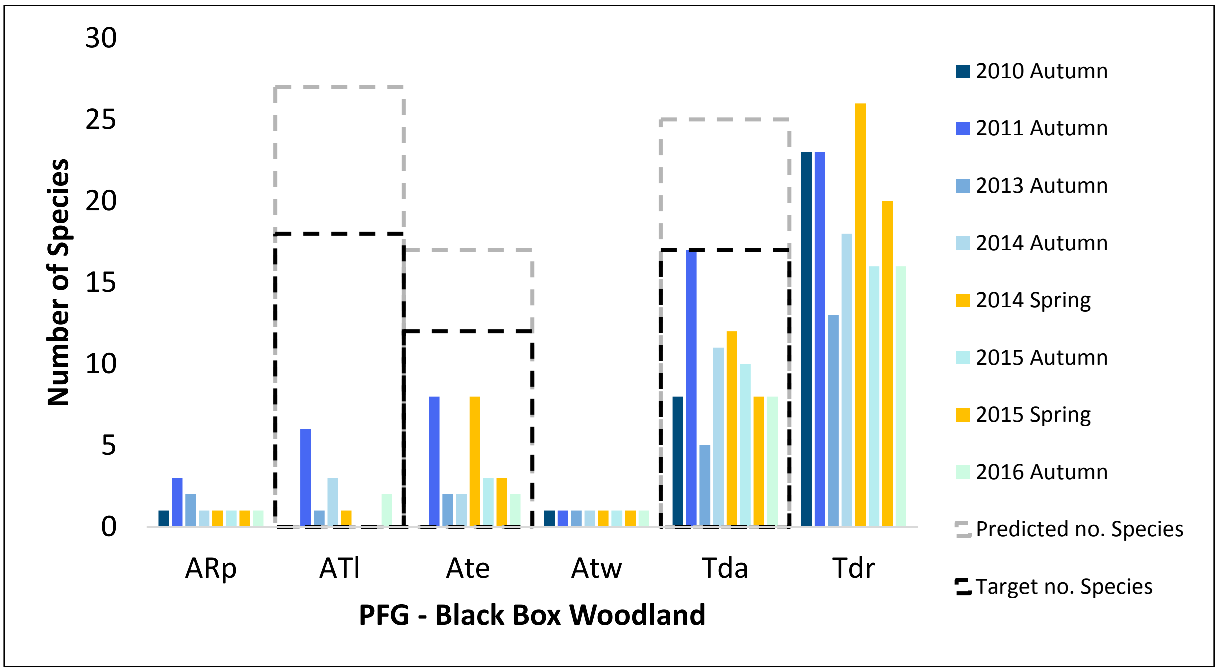


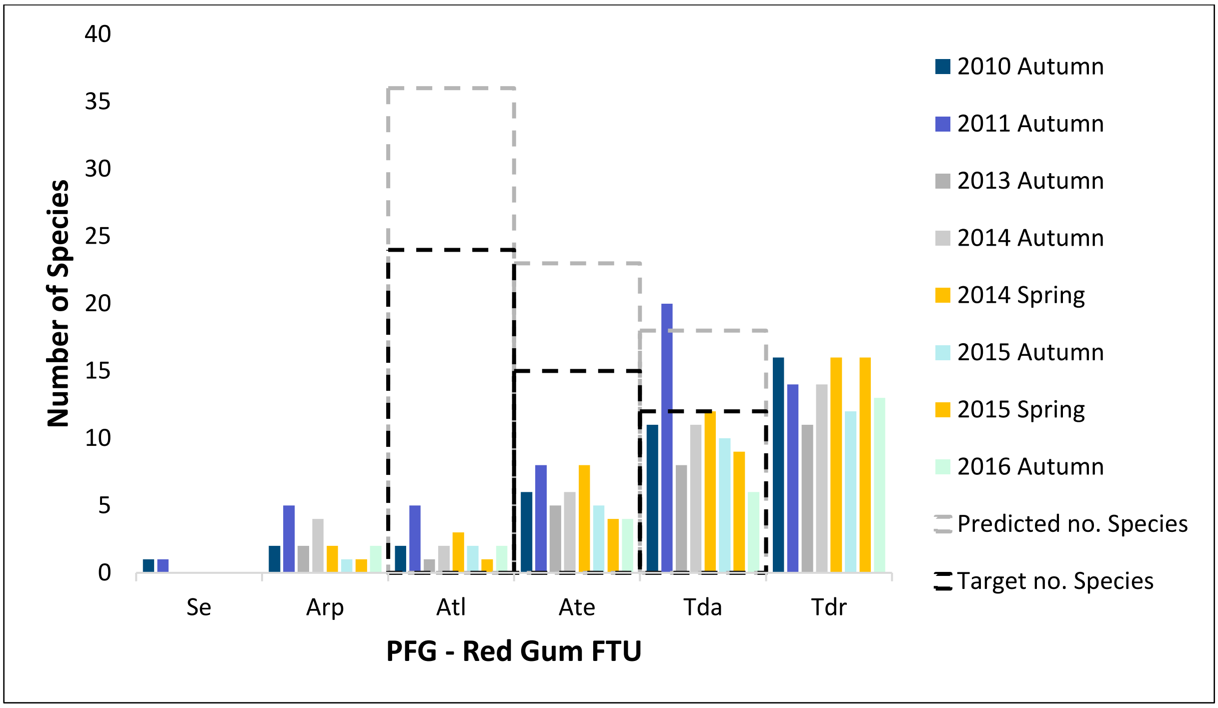


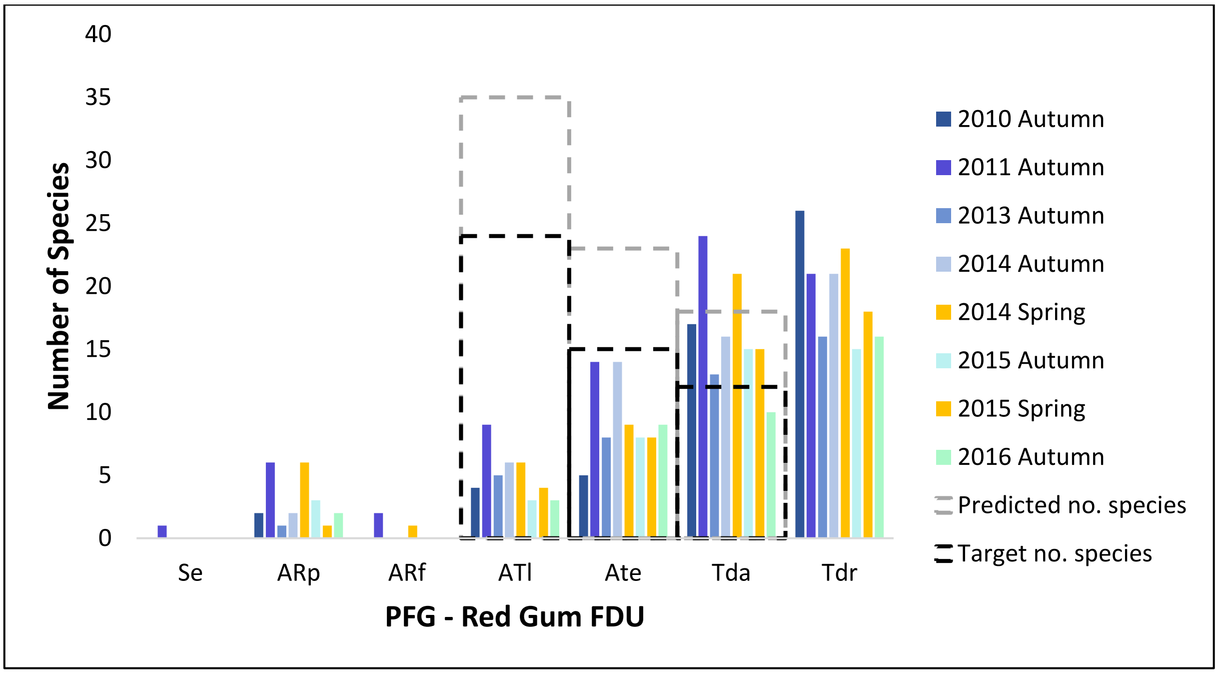
Note: Key to PFG codes: refer to Table 6.

Figure 13 Number of species in each Plant Functional Group across Water Regime Classes between monitoring periods (2010 to 2016) –Red Gum FDU and Red Gum FTU


90
80
70
60
50
40
30
20
10
0
Number of Species
Se
ARp
ATl
Ate
Atw
Tda
Tdr
PFG - Grey Box Woodland
2010 Autumn
2011 Autumn
2013 Autumn
2014 Autumn
2014 Spring
2015 Autumn
2015 Spring
2016 Autumn
Predicted no. Species
Target no. Species

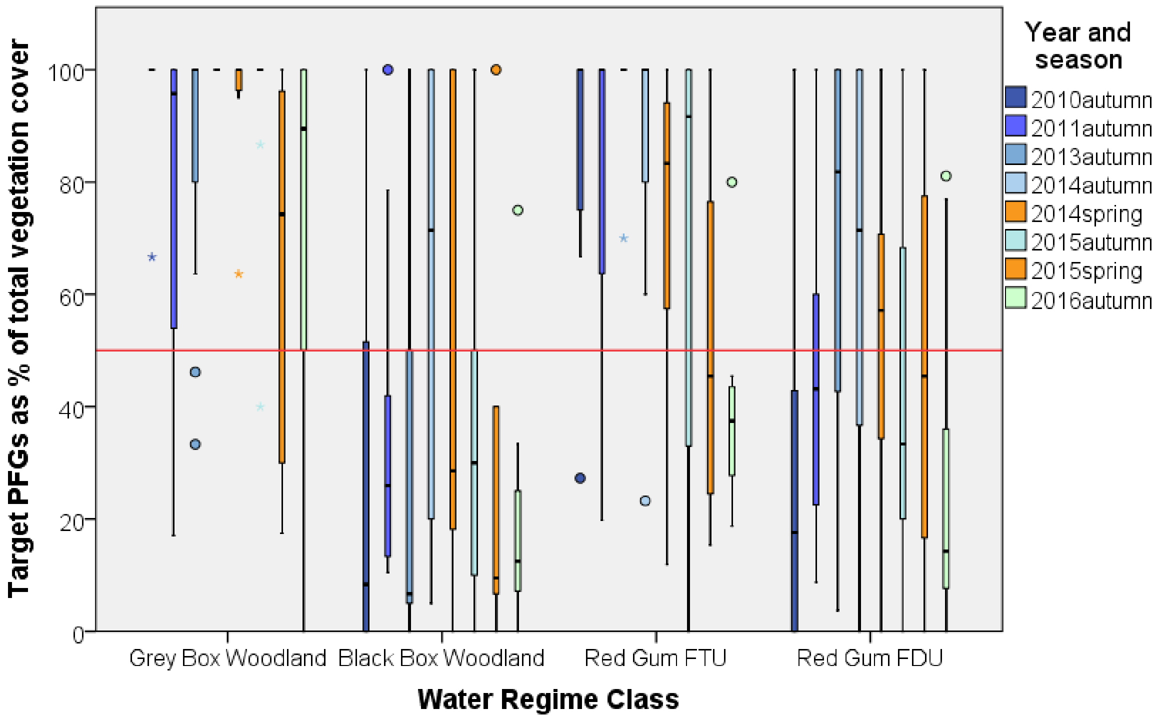

30
25
20
15
10
5
0
Number of Species
ARp
ATl
Ate
Atw
Tda
Tdr
PFG - Black Box Woodland
2010 Autumn
2011 Autumn
2013 Autumn
2014 Autumn
2014 Spring
2015 Autumn
2015 Spring
2016 Autumn
Predicted no. Species
Target no. Species





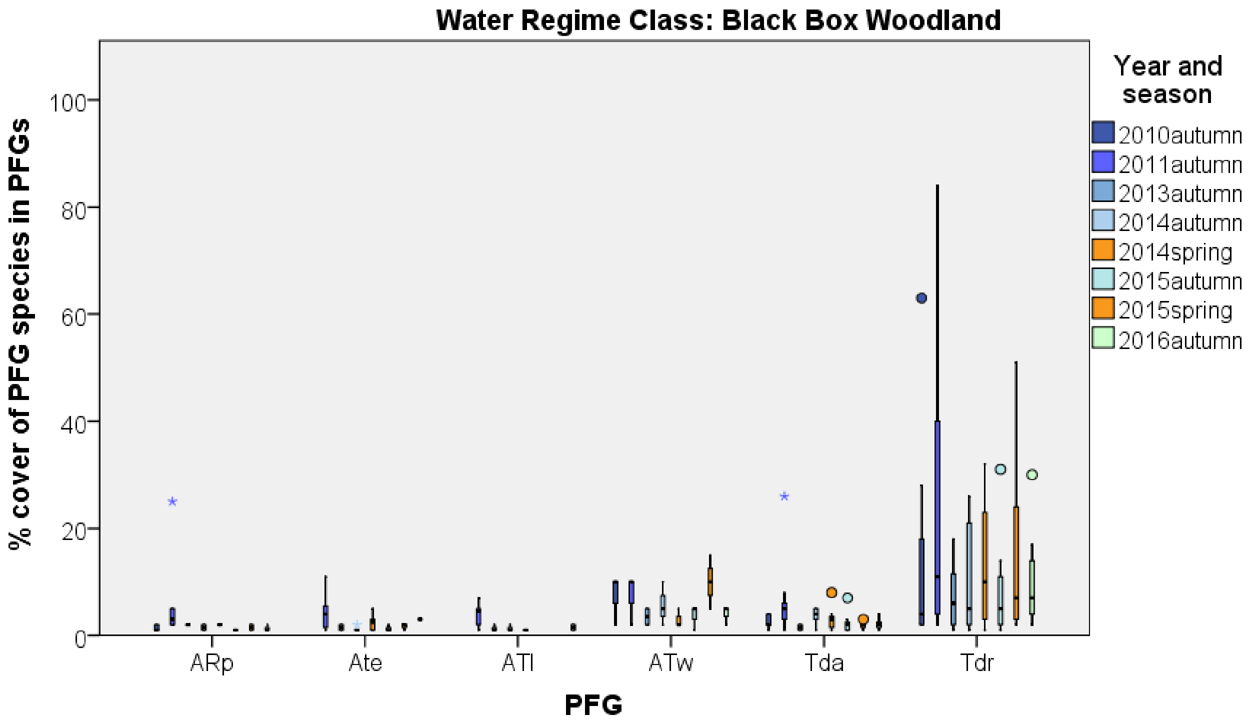
Note: Key to PFG codes: refer to Table 6.

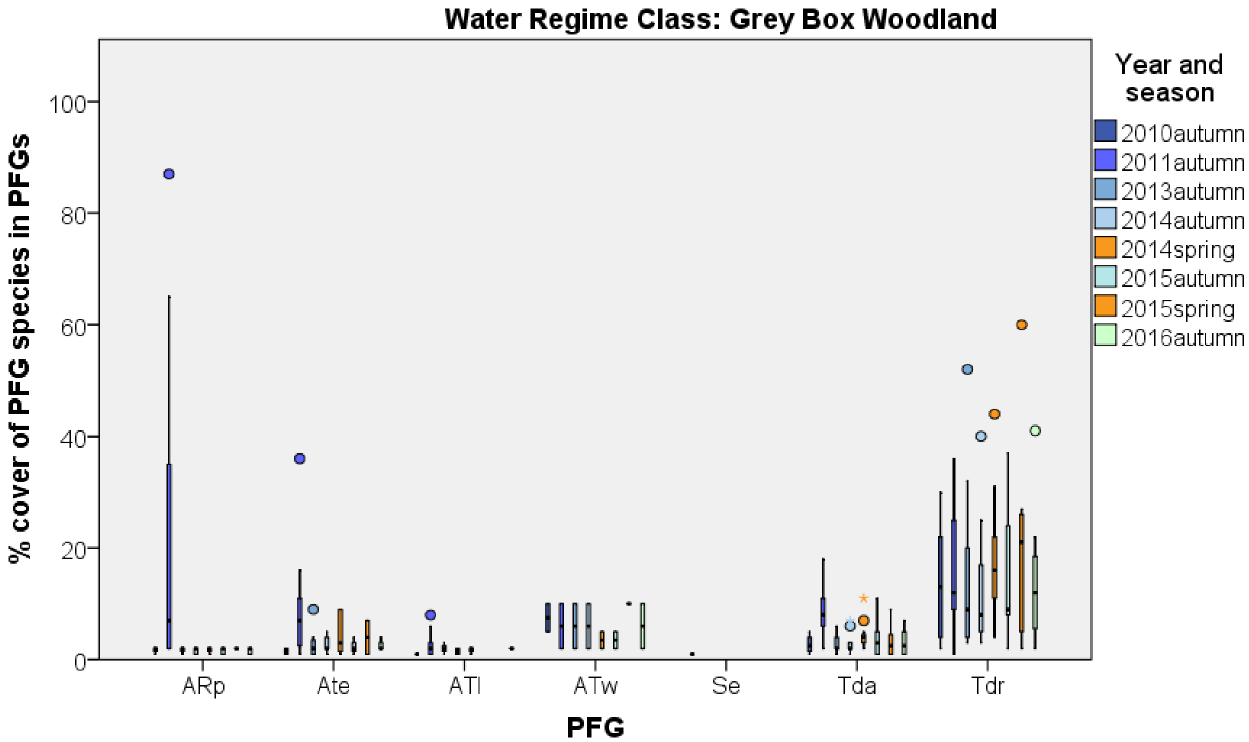
Figure 14 Total Number of indigenous species in target PFGs across individual Water Regime Classes between monitoring periods (2010 to 2016)

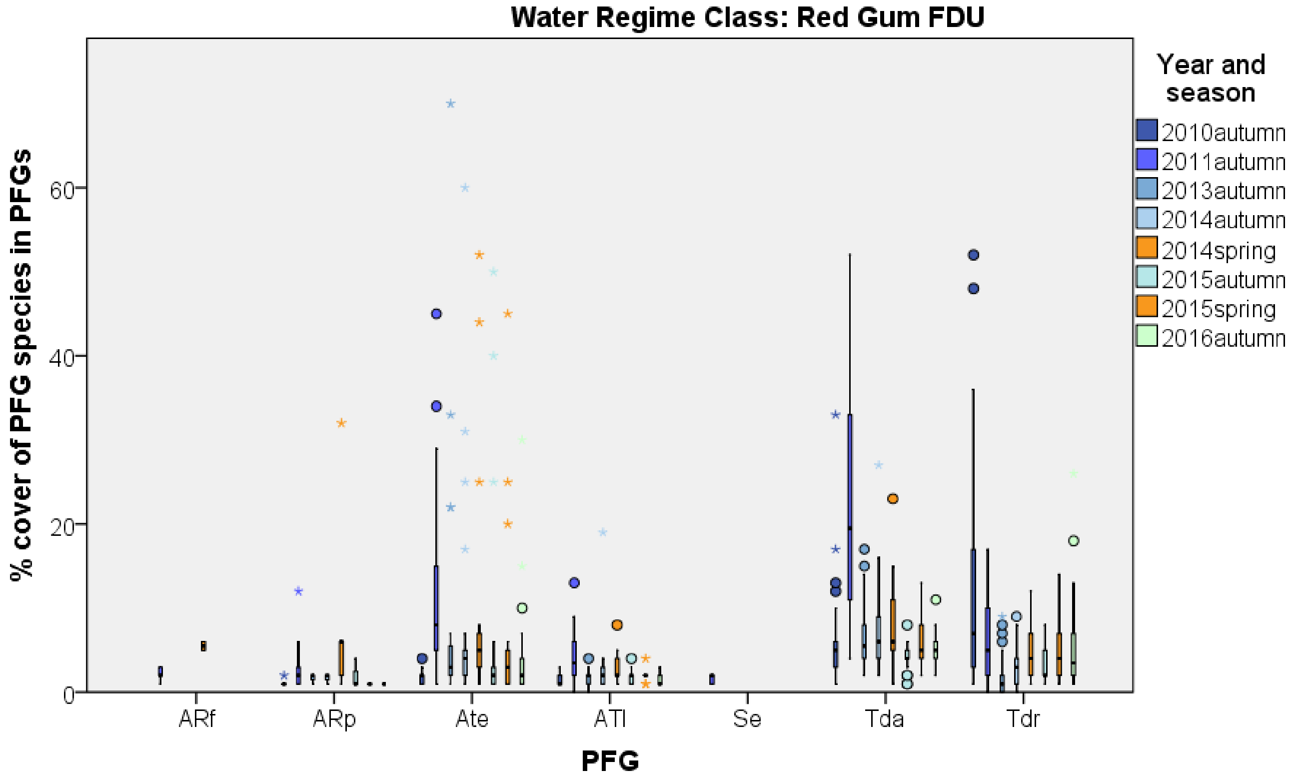


Note: Key to PFG codes: refer to Table 6.

Figure 15 Percentage cover of species in target Plant Functional Groups across Water Regime Classes between monitoring periods (2010 to 2016)


Water Regime Class: Black Box Woodland
% cover of PFG species in PFGs
0
20
40
60
80
100
ARp
Ate
ATl
ATw
Tda
Tdr
PFG
Year and season
2010autumn
2011autumn
2013autumn
2014autumn
2014spring
2015autumn
2015spring
2016autumn


Water Regime Class: Grey Box Woodland
% cover of PFG species in PFGs
0
20
40
60
80
100
ARp
Ate
ATl
ATw
Se
Tda
Tdr
PFG
Year and season
2010autumn
2011autumn
2013autumn
2014autumn
2014spring
2015autumn
2015spring
2016autumn



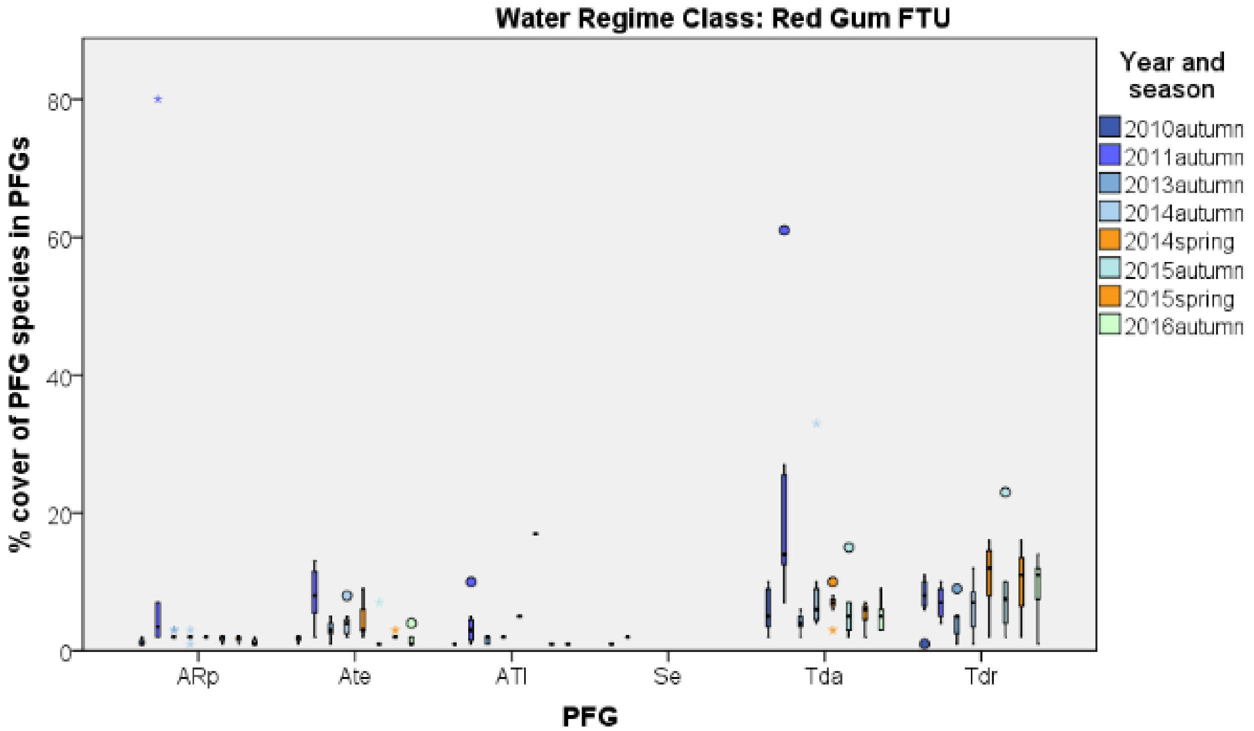


Figure 16 Percentage cover of species in target Plant Functional Groups, as a percentage of total vegetation cover across Water Regime Classes between monitoring periods (2010 to 2016)

3.1.7 Canopy health

Figure 17 depicts the median health of canopy trees in each WRC across monitoring years (black lines). None of the WRCs met the canopy condition index of median score 4 in 2016. Canopy health has declined in Grey Box and Black Box Woodlands since 2010 and 2011 but remained relatively stable in the Red Gum WRCs.

For further details of stand and tree condition at Koondrook-Perricoota Forest (2016) refer to Forbes and Wills (2016), in which monitoring data from 2010 to 2016 for stand and tree condition sites is presented.

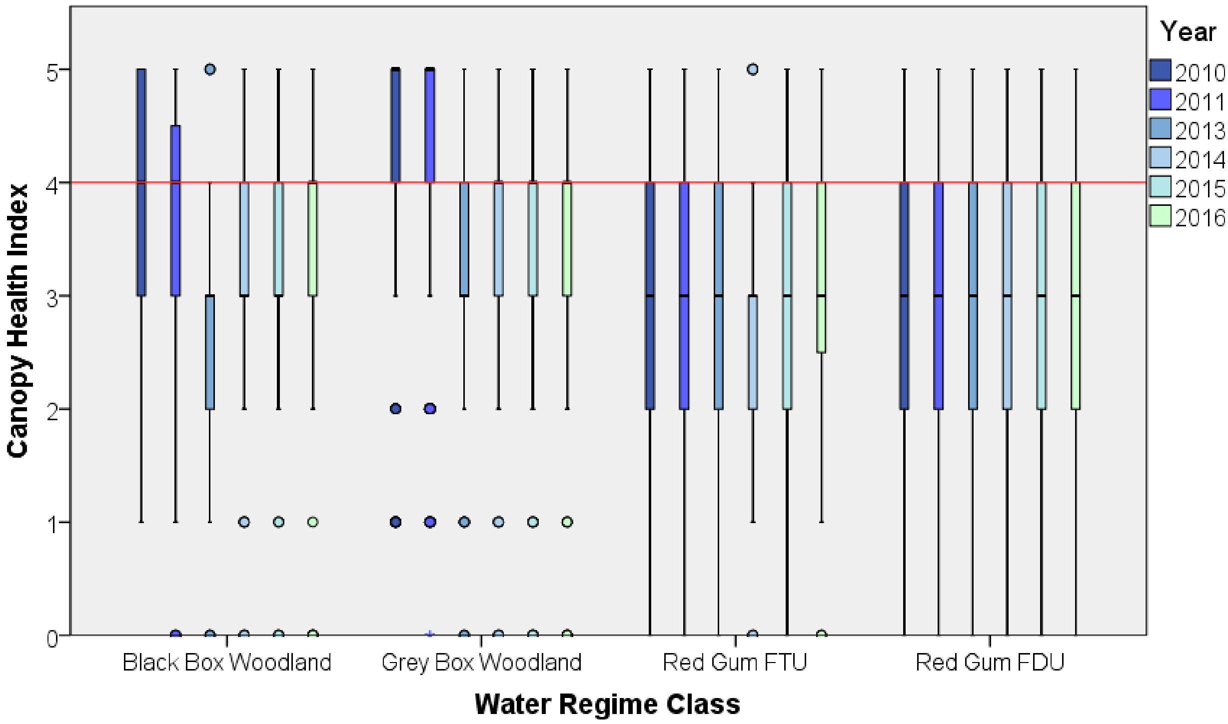


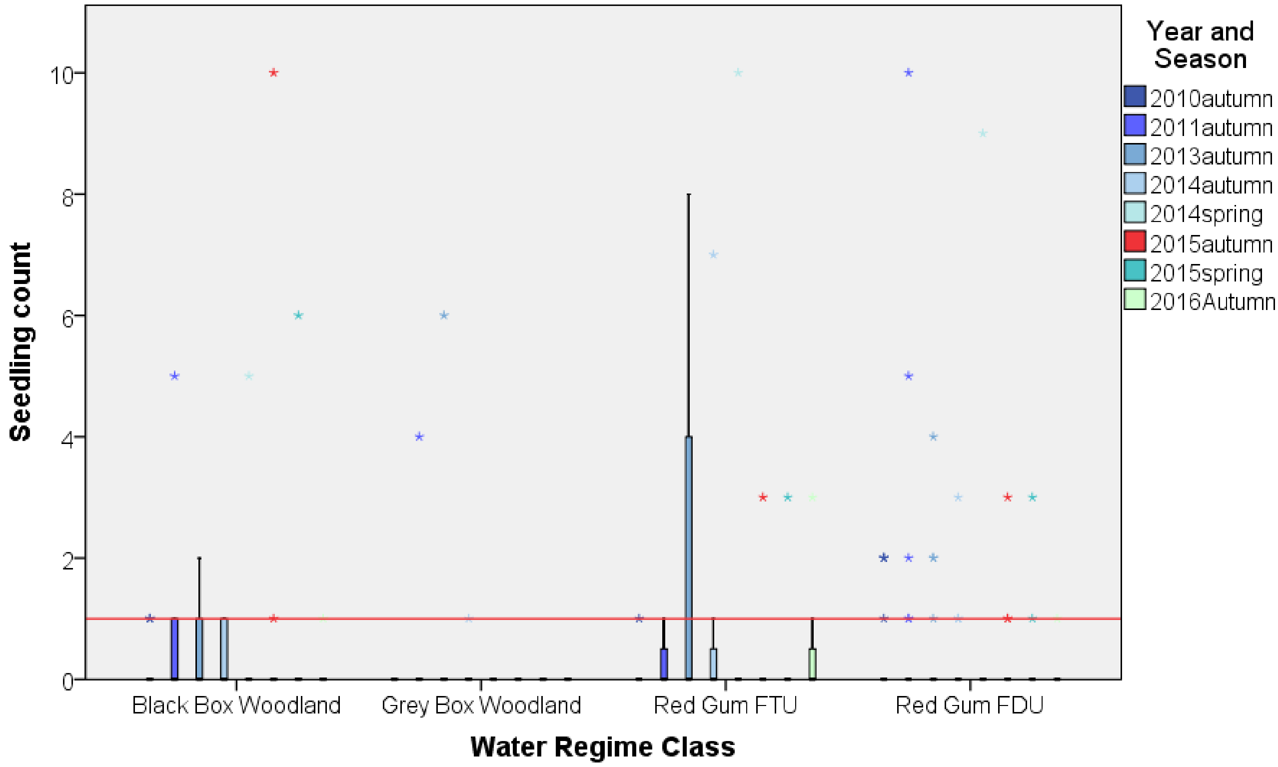
Figure 17 Median canopy health in each Water Regime Class across monitoring years

3.1.8 Recruitment of seedlings and saplings

Figure 18 and Figure 19 depict the median number of eucalypt seedlings and saplings recorded in each WRC between 2010 and 2016 (note that for Figure 18, Red Gum FTU has been shown on a separate graph as sapling counts in this WRC are considerably higher than other WRCs).

A proposed target of one has been arbitrarily set for this analysis; this is equivalent to "at least one seedling and sapling across a minimum of 50% of the sites within each WRC". This target should be modified and should be based on research of healthy levels of recruitment for each WRC.

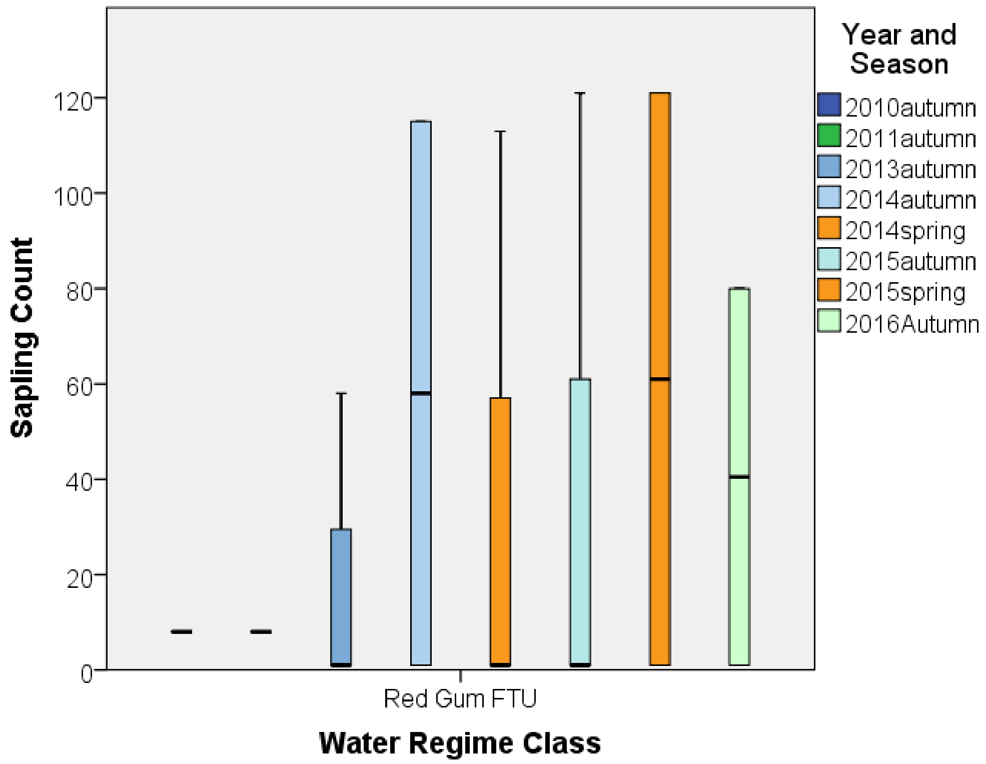
In 2016, recruitment (seedling emergence) was typically low and did not meet the target in the majority of the understorey WRCs (median < 1 seedling per 0.01 ha). Sapling numbers in 2016 appear to have decreased in Red Gum FTU since 2015, but numbers are stable in other WRCs. Site 23B is the only site within the Grey Box Woodland WRC with large sapling numbers (>5 and as high as 48, whereas all other sites have <5) and sapling numbers increased between 2013-15 so much as to become outliers in the data. In 2016 site 23B had 27 seedlings which had decreased 23B's tally enough to become part of the boxplot, hence the appearance of a greatly increased number of seedlings for Grey Box Woodland WRC in 2016.

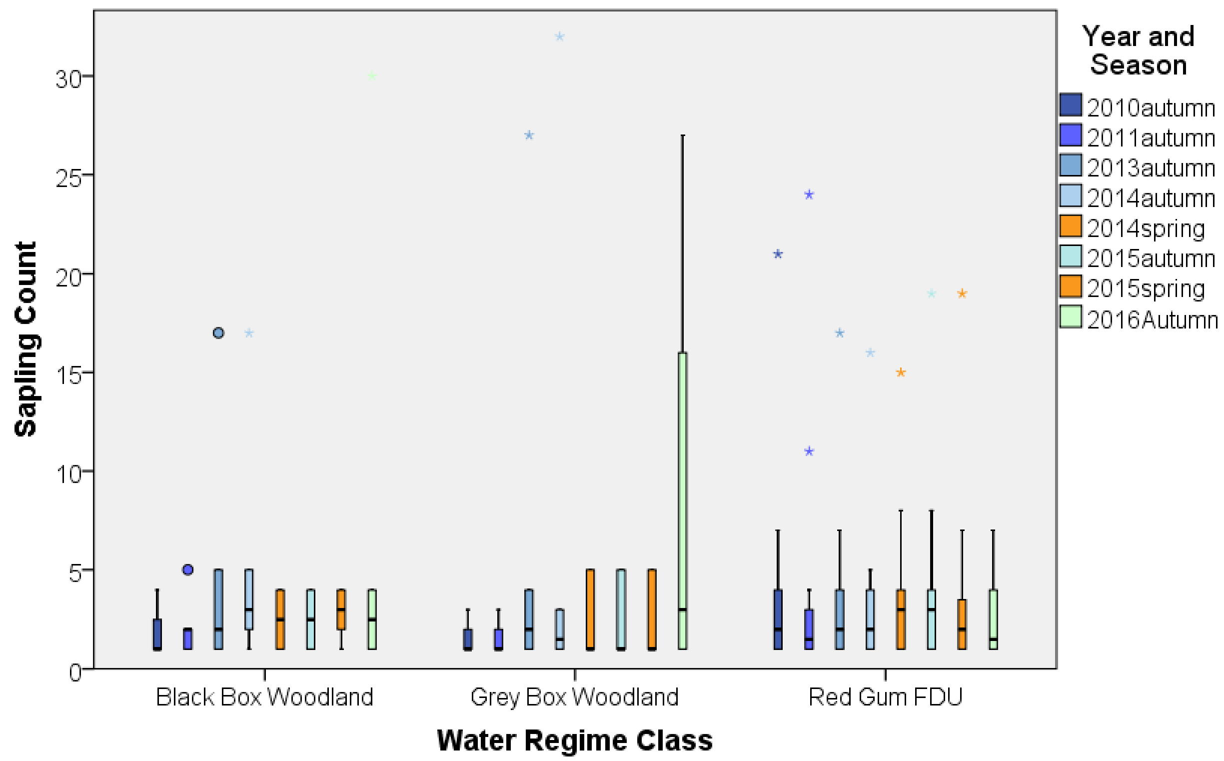


Note: some outliers were excluded from graph[10], e.g. Site S96, which is a Red Gum FTU site, comprised 221 seedlings in 2011.

Figure 18 Median number of seedlings across water regime classes between monitoring periods (2010 to 2016)

[10] Refer to dataset for understorey seedling data.





*Note: some outliers were excluded

Figure 19 Median number of saplings across water regime classes between monitoring periods (2010 to 2016)

3.2 Wetland sites

3.2.1 Indigenous - species richness

The number of indigenous species at wetland sites was higher in flooded years (autumn 2011 and spring 2014) than un-flooded years, noting the higher median number of indigenous species (Figure 20):

- In 2010 when water was delivered to Pollacks Swamp, which represented about half of the sample pool in that monitoring year;
- Following the 2011 flood event (breaking of the Millennium drought); and
- Following the 2014 managed flood event.

Indigenous species richness in 2016 is the lowest recorded since 2013, where a decline following the 2011 floods is observed in the data. Indigenous species richness has also declined since the 2014 floods.

A full list of species recorded at wetlands across monitoring years is provided in Appendix A.

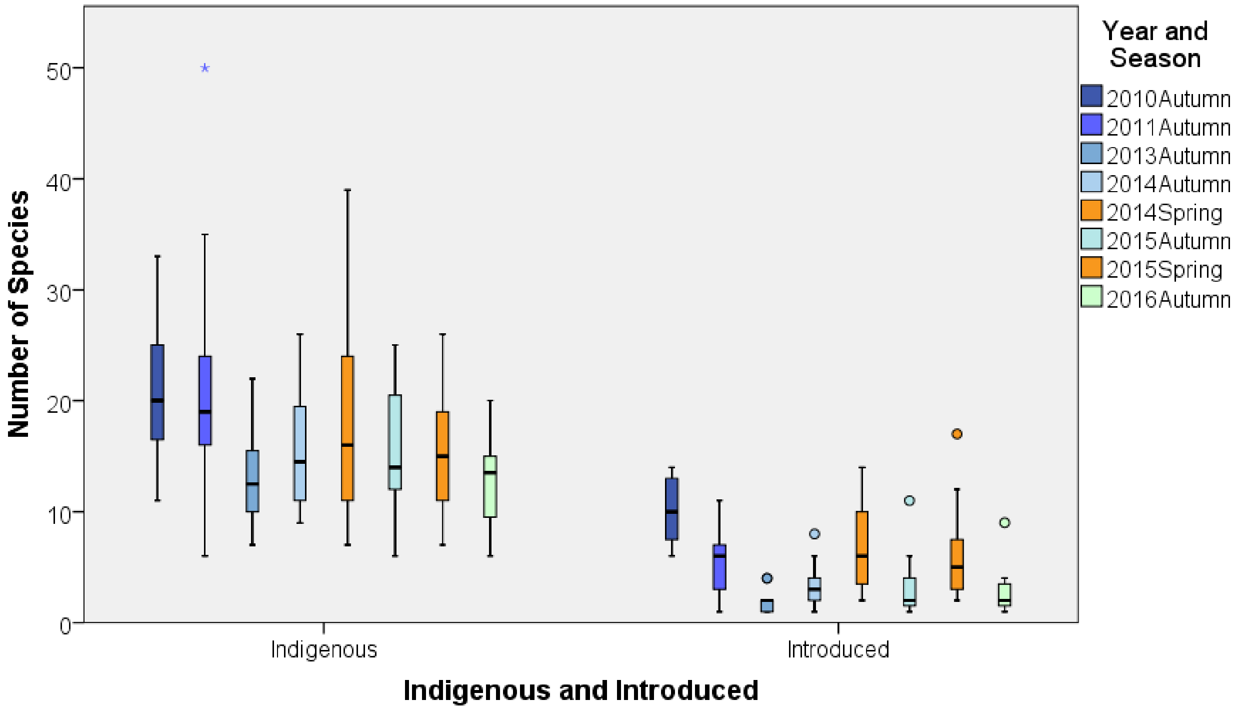


Figure 20 Median number of indigenous and introduced species recorded across wetland transects between monitoring periods (2010 to 2016)

3.2.2 Indigenous - vegetation cover

The highest median percentage cover of indigenous flora in wetlands was recorded in 2010, followed by a decrease in cover in 2011 (Figure 21). Cover of indigenous species has recently decreased (2015-2016), and a trend of decreasing cover appears to have occurred since Autumn 2014. The decrease between 2010-2011 could be attributed to an increase in sample size of wetlands from seven wetlands in 2010 to 16 in 2011 and/or due to floods, which resulted in most wetlands being inundated in 2011, which may have killed many flood-intolerant species.

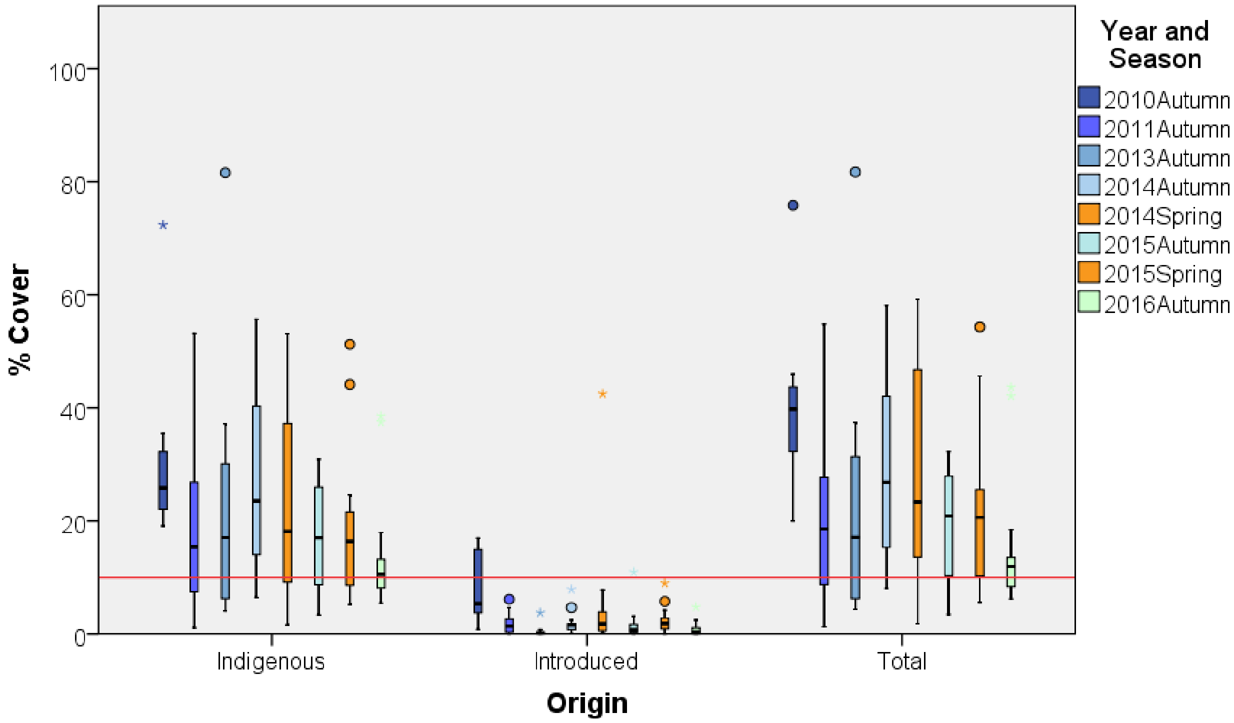


Figure 21 Median % cover of indigenous and introduced species recorded across wetland transects between monitoring periods (2010 to 2016)

3.2.3 Weeds

The number of introduced species was typically higher following the 2011 floods, and following the 2014 managed flood event than in autumn (Figure 20). Notably, the number of introduced species was also typically higher in spring 2015 (in the absence of flood) than in autumn. Many of the weeds observed at wetland sites are annual weeds that typically emerge in winter/spring.

A target of less than 10% weed cover has been set for wetlands. Figure 21 shows that this target was met within the majority of wetland sites in all monitoring rounds, except for autumn 2010, when cover of weeds exceeded the 10% threshold at six out of seven wetland sites.

3.2.4 Characteristic Plant Functional Groups

Target PFGs for wetlands include: aquatic rhizomatous flora (ARp), semi-aquatic flora and aquatic floaters (ARf), mudflat flora (ATl) and floodplain flora (ATe).

Figure 22 shows the **median** number of indigenous species in all PFGs at wetlands across monitoring years. Figure 23 shows the **total** number of indigenous species recorded within each PFG. The total number of predicted species and the target number of species (2/3 of the total predicted number of species) is also overlaid on Figure 23 for PFGs considered characteristic PFGs for wetlands. Where the predicted number of species in a PFG is zero, then any species occurring in this PFG is considered uncharacteristic.

Overall, the target species richness was met in all years for rhizomatous aquatic flora (ARp), for most years for floodplain flora (ATe) groups (not 2016), but not for semi-aquatic flora (ARf) or mudflat flora (ATl), which fell well below the target number in all years, even following floods (2011 flood or 2014 managed flood event) (Figure 23). In 2016, increases in the species richness of terrestrial species was observed. Similar to understorey sites, the wetland sites are dominated by terrestrial species (Tda and Tdr groups).

Figure 24 shows the cover of PFGs across monitoring years, and the cover of characteristic PFGs was close to or above the target at wetland sites (Figure 25) in all monitoring periods. According to the set target, 50% of the total vegetation cover should be comprised of characteristic PFGs. The 2016 results show % cover of characteristic PFGs has decreased since autumn 2015. Notably, wetlands met the 50% cover target of characteristic PFGs in autumn in 2013 and 2015, most likely because of the dominance of mudflat flora (Ate e.g. *Centipeda cunninghammi*; Sneezeweed), as wetlands were typically in the drying phase at this time.

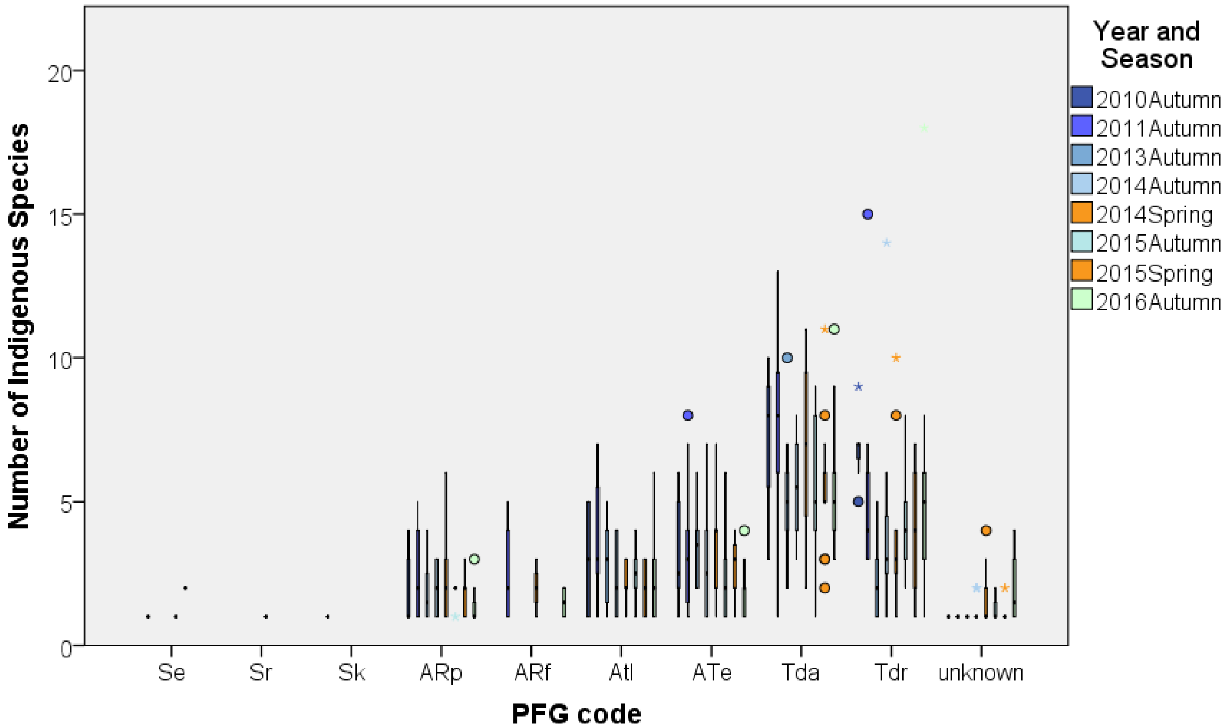


Figure 22 Median number of indigenous species recorded in PFGs across wetland transects between monitoring periods (2010 to 2016)

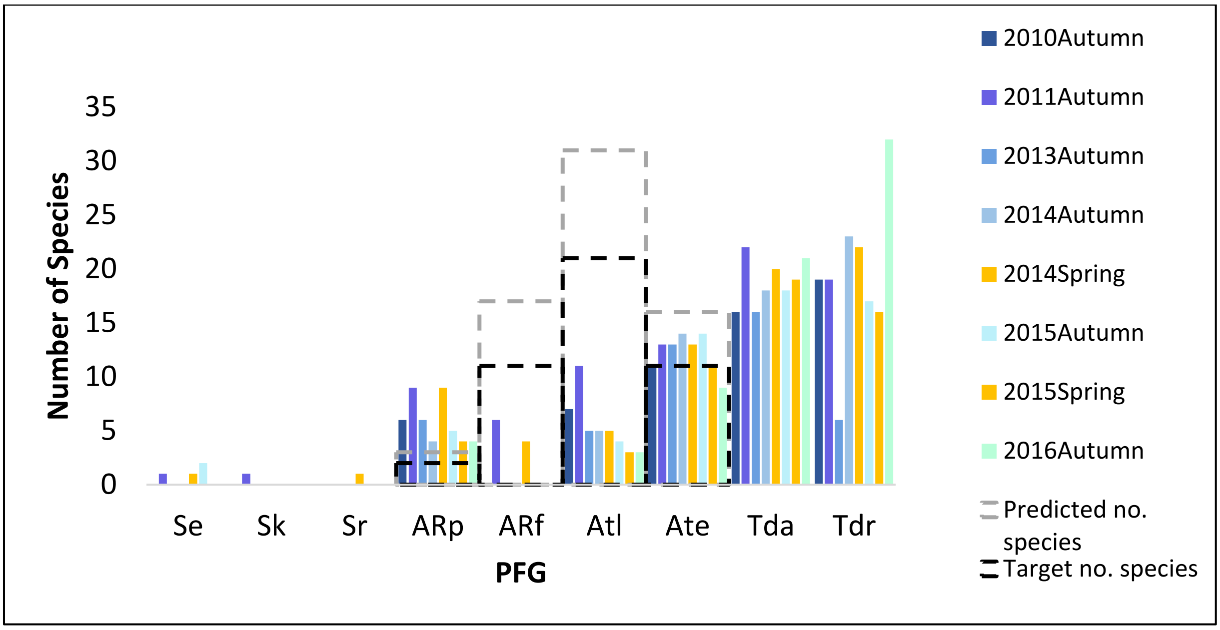


Figure 23 Total number of indigenous species recorded in target PFGs for wetlands between monitoring periods (2010 to 2016)

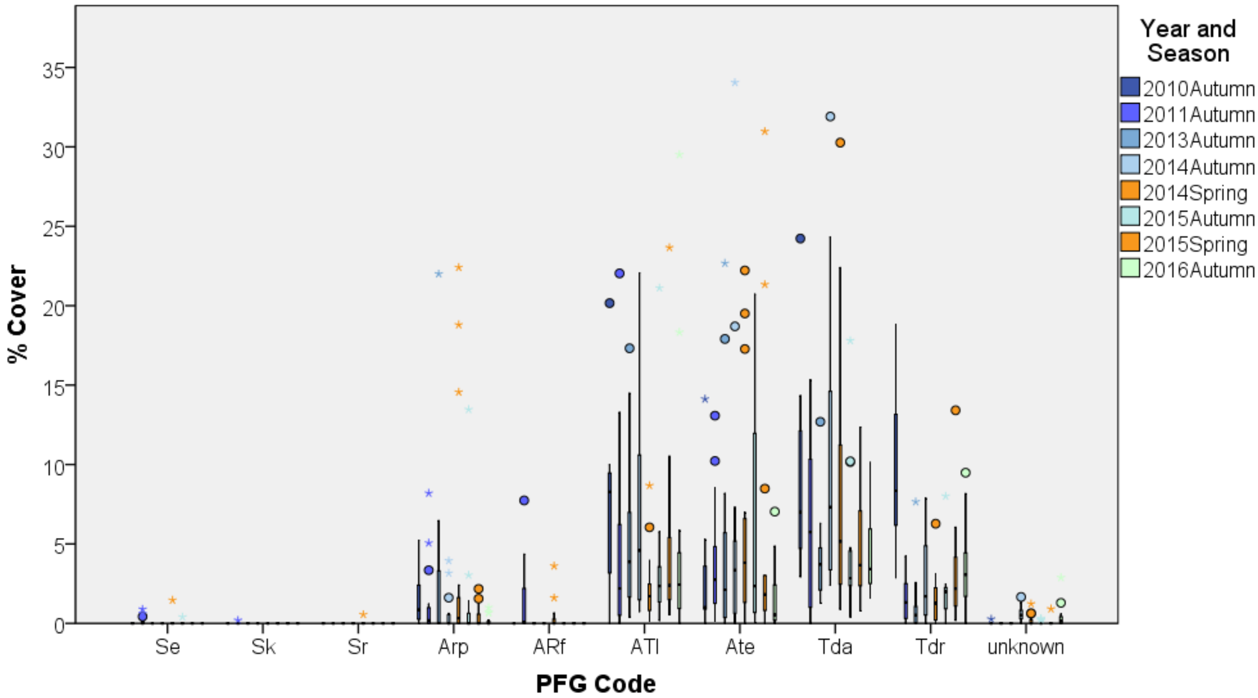


Figure 24 Median percentage cover of PFGs across wetland transects between monitoring periods (2010 to 2016) – indigenous species only

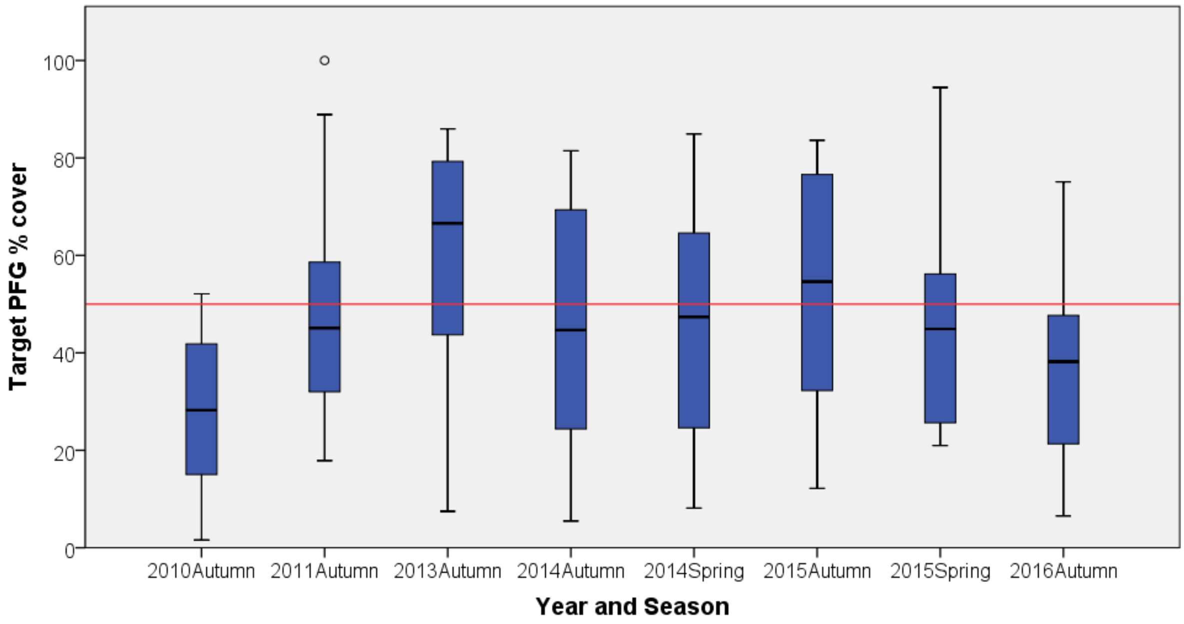


Figure 25 Percentage cover of target PFGs (as a % of total vegetation cover) across wetlands between monitoring periods (2010 to 2016) – indigenous species only

3.2.5 Recruitment of eucalypt seedlings and saplings

Recruitment of eucalypt seedlings appears to have declined between 2010 and 2016 at wetlands. Some of the decline in numbers of seedlings can be explained by the increase in number of saplings, indicating that the seedlings have been recruiting successfully. The median number of saplings has been reasonably stable since Spring 2014.

The 2010 data are somewhat skewed by large numbers of eucalypt seedlings recorded at Swan Lagoon, which receives in-flows more regularly than other wetlands. A band of saplings is present along the northern bank.

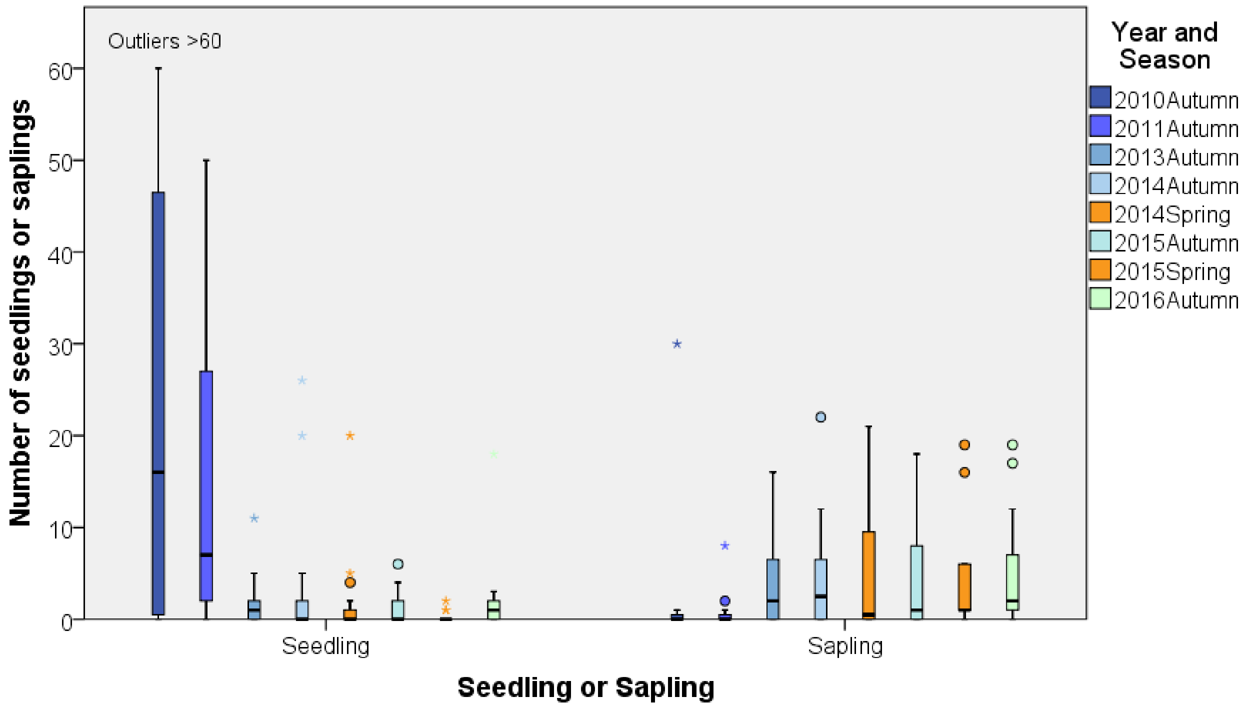


Figure 26 Median number of eucalypt seedlings and saplings recorded across wetland transects between monitoring periods (2010 to 2016)

3.3 Performance against targets for each WRC

Figure 27 shows the performance of each WRC against targets defined in this report and in the AE (2011) report. In 2016, less than or equal to 40% of targets were met in each WRCs, and this is a decrease from the number of targets met in 2015.

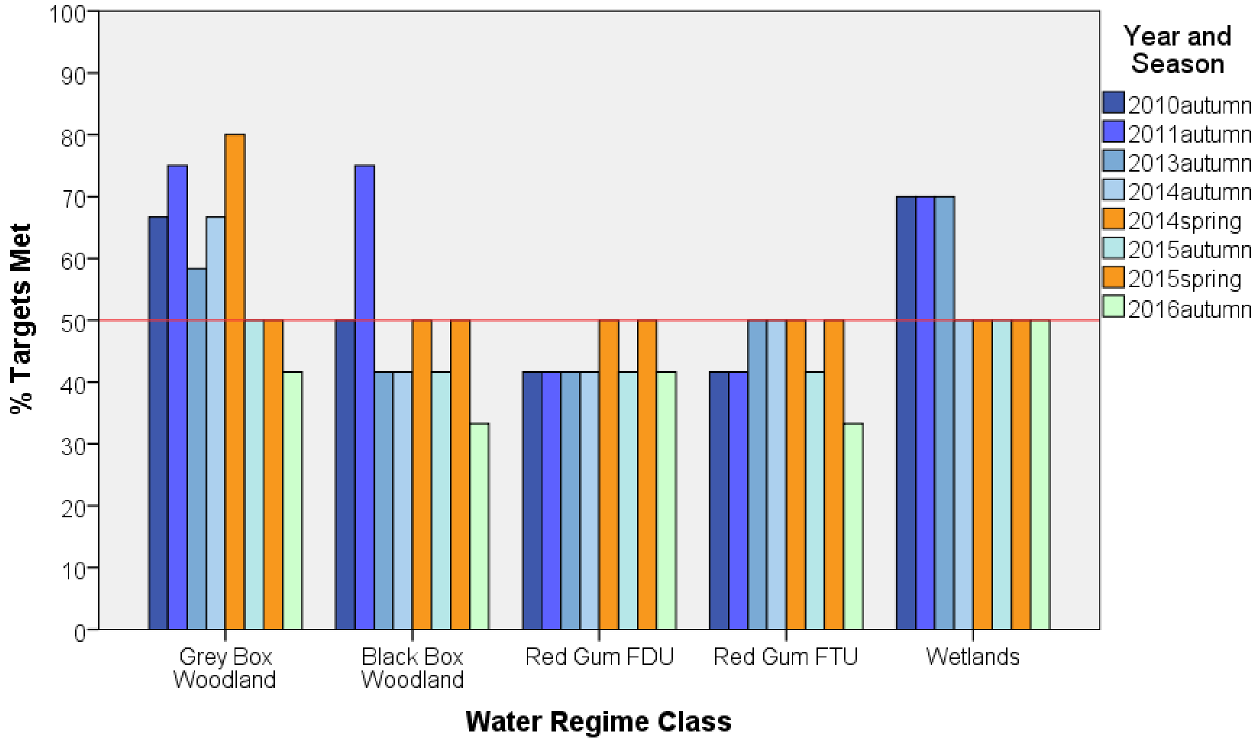


Figure 27 Percentage of targets met in each water regime classes in 2010, 2011, 2013, 2014, 2015 and 2016

4. Discussion

The vegetation condition monitoring dataset for Koondrook Perricoota Forest currently spans seven years, and thus we are now able to identify some clear trends emerging from the data in relation to baseline vegetation condition and response to flood (managed and unmanaged events), as discussed below.

4.1 Understorey sites

Data collected in autumn 2016 suggest that the condition of the Forest is similar to that observed in autumn 2010 before the breaking of the Millennium drought. This is supported by similar low indigenous species richness and vegetation cover in 2016 to that recorded in 2010 in all WRCs. Understorey vegetation responds strongly to flood within the first year following a flood event. This response is somewhat short-lived (<1 year) and species richness and vegetation cover decrease following flood recession, and drying out of floodplain soil. Species contributing to the indigenous species richness data in 2016 largely comprised of terrestrial dry species, which are likely to remain at a site under sustained dry conditions. It is unlikely that indigenous species richness would decrease further, given the persistent nature of these species that are common at monitoring sites throughout the Forest. Indigenous vegetation cover has remained relatively stable between 2013-2016, despite an increase following the 2011 floods. As expected, there are notable vegetation responses to season observed in the data, with higher species richness in spring 2014 and to a lesser extent in spring 2015.

Currently, species associated with terrestrial environments (PFGs Tda and Tdr) are the most prevalent across all WRCs (Figure 12 to Figure 14). The results are consistent with previous monitoring rounds surveyed after recession of floodwaters had occurred (2013, autumn 2014 and 2015). Target species richness of PFGs considered characteristic of the respective WRC were rarely met in any of the understorey WRCs across monitoring years. This is unsurprising given that the Forest is a disturbed environment that has been influenced by long-term reduced flows through reduction in size, duration and frequency of flood events. Grey Box Woodland is the only WRC to meet the 50% target of characteristic PFGs as a percentage of total vegetation cover in more than one year, which is not unexpected as this WRC is associated with relatively drier conditions than the dominant RRG FDU community.

The increase in number of characteristic PFGs following the 2011 floods demonstrates the potential for understorey sites to respond to flood. It suggests a soil-propagule bank persists within the broader floodplain. It is unknown how many years the seedbank can continue to persist and respond to floods when they occur. There may be a critical threshold at which the response of target PFGs will become smaller due to the decline in diversity and abundance of viable propagules within the floodplain (Bidwell and Wills 2015). The last major flood occurred in 2011, and hence the current flood frequency is below the ideal flood frequency for Red Gum FDU (ideal flood frequency is 7-9 in 10 years; Figure 1). In the absence of future large scale floods that inundate the floodplains (particularly Red Gum FDU), it can be expected that targets for PFGs will not be met and understorey sites will continue to be colonised by species associated with terrestrial dry environments, including introduced flora.

The understorey data collected between 2010-2016 indicate a pattern of strong vegetation response to flooding, and then decline within a year afterwards. Species richness and cover may increase or decrease in response to rainfall or season, however do so on a smaller scale than to flooding. Data also indicate that whilst floods create a short lived increase in species richness and cover, it may take multiple, consecutive flood events for compositional changes to be pushed to a new baseline.

4.2 Wetlands

Wetlands met the target number of species in some but not all characteristic PFGs. The response of wetlands to the 2011 floods and 2014 managed flood events was evident with increases in numbers of species in characteristic PFGs and cover following floods, sometimes (but not always) meeting the target number of species and target cover. The delay in vegetation response following the 2011 flood (Figure 20 and Figure 21) was potentially due to sites being surveyed whilst still in the deeply inundated phase. Target cover of characteristic PFGs was met or close to being met in all monitoring periods, however appears to be in decline in the absence of flooding since 2014. Notably, the cover target was met in autumn 2013 and autumn 2015, when wetlands were in the drying phase and dominated by mudflat flora (ATl), such as *Centipeda cunninghammi* (Common Sneezeweed).

The response of wetlands to the 2014 managed flood event is addressed in Bidwell and Wills (2015), in which the results are discussed in context of water cycle phases.

4.3 Canopy condition

Canopy health has declined in Grey Box and Black Box Woodland sites since 2010 and 2011, but has remained relatively stable in the Red Gum WRCs according to the visual assessments undertaken as part of understorey monitoring. None of the WRCs have met the canopy condition target of a median score of 4 since 2011.

The categories for tree health used here are very coarse and it may take a long time to detect improvement between categories. In addition, by the time a decrease in health is detected, it may be difficult to change site conditions and to improve tree health through a managed flood event. For example, the difference between category 3 and category 4 requires an increase in up to 50% of the original canopy (from 25%-50% original canopy in category 3 and 50%-75% original canopy in category 4), and a decrease in epicormic growth by up to 40% (as high as 49% in category 3 to below 9% in Category 4). This coarse scale of measuring tree condition is unlikely to be useful in measuring changes in condition in the short-term, but may be more useful for monitoring long-term changes in canopy health. The concurrent stand and tree condition monitoring (reported separately in Forbes and Wills 2016) should capture changes in stand and tree condition over shorter timeframes.

4.4 Recruitment

Recruitment of saplings and seedlings is varied but typically between 0 and 1 sapling and seedling per site (Figure 18 and Figure 18). Higher recruitment has occurred at wetland sites than understorey sites during the monitoring period. The number of seedlings and saplings has remained relatively stable since 2011 and does not appear to be increasing. It should be noted that the threshold of 1 (per site) was arbitrarily applied and should be revised based on research on recruitment targets for a healthy Forest.

4.5 Defining targets and detecting changes

The majority of the data collected appear to form a reasonable baseline for detecting changes in the Forest in the future as a result of changes to water regimes in the Forest.

Whilst targets have not yet been set for many of the indices measured, the relative stability of variables within each WRC between years (un-flooded years) creates a baseline against which to measure improvement in condition. The recent Vegetation Condition Monitoring Review (Wills, Bidwell and Sim 2016) included development of indices and points of reference for two priority indicators (species richness of characteristic PFGs and tree canopy health). The review highlighted the need to develop additional indices and points of reference for future reporting on vegetation condition. The recent review and the above proposed additional work will assist in streamlining future reporting and assist FC NSW in meeting reporting requirements of the MDBA for TLM sites.

5. Recommendations

Upon investigation of the data collected to date, we recommend the following:

- Continue to monitor wetland and understorey condition at Koondrook-Perricoota Forest as long-term monitoring will continue to capture changes in floristic composition and responses to wetting and drying cycles at Koondrook-Perricoota Forest. If resources allow, continue to monitor in autumn and spring, regardless of whether the Forest is flooded to capture seasonal variation in floristic composition and condition.
- Apply and test the outcomes of the Vegetation Condition Monitoring Program Review (Wills, Bidwell and Sim 2016) regarding ecological objectives and targets. The ideal time to do this is during the next round of monitoring, likely to occur in spring 2016.
- The data collected on tree canopy health as part of the understorey assessments (i.e. 20 understorey trees at each of the 60 understorey sites) is not detecting change within a short-term enough period to be useful for management. We recommend this data is analysed in conjunction with the stand and tree data, which is more likely to be useful in detecting shorter-term changes in tree condition in the Forest.
- Targeted surveys are recommended for threatened species for which suitable habitat is present at Koondrook-Perricoota Forest, as this is currently one of the ‘ecological targets’ for the Forest. Selected populations of threatened flora should then be included in the monitoring program.

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Appendices

Appendix A – Flora lists

Key to table:

1	Number of understorey sites in which species was detected
PFG	Plant Functional Group (refer to Table 6)
EPBC	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
TSC	NSW *Threatened Species Conservation Act 1996*
WONs	Weed of National Significance

Table A1 Flora species recorded at understorey sites 2010 to 2016

Scientific name	PFG	Origin	2014 autumn	2010 autumn	2011 autumn	2013 autumn	2014 spring	2015 autumn	2015 spring	2016 autumn
Acacia acinacea	Tdr	indigenous	2	2	2	2	2	2	2	2
Acacia dealbata	Tdr	indigenous	1	1	1	1	1	1	1	1
Alternanthera denticulata	Tda	indigenous	18	5	41	24	20	12	8	5
Alternanthera sp.	Tda	indigenous						2		
Alternanthera sp. 1 (Plains)	Tda	indigenous	9	7	11	3	12	2	3	18
Amphibromus nervosus	Tda	indigenous		4	21	5	1	1		
Amphibromus sp.	Tda	indigenous								
Amyema miquelii	Tdr	indigenous			1	1				
Anthosache scabra	Tdr	indigenous								
Arthropodium minus	Tdr	indigenous		4	2		3	1	3	
Arthropodium sp.	Tdr	indigenous							1	
Asteraceae sp.	unknown	indigenous	1				1	1	1	
Atriplex semibaccata	Tdr	indigenous	11	21	13	11	9	10	7	10
Austrostipa aristoglumis	Tdr	indigenous					1			
Austrostipa scabra subsp. *falcata*	Tdr	indigenous	3	3	5	2	3		1	
Austrostipa sp.	Tdr	indigenous							1	
Azolla filiculoides	ARf	indigenous			5					
Boerhavia dominii	Tdr	indigenous	1					1		
Brachyscome basaltica var. *gracilis*	Tda	indigenous	10	13	17	9	15	9	5	5
Brachyscome lineariloba	Tdr	indigenous							1	
Calandrinia calyptrata	Tdr	indigenous		1			1		1	1
Calandrinia eremaea	Tdr	indigenous		3			4		2	
Calandrinia sp.	Tdr	indigenous					1		1	
Callitriche sonderi	ATl	indigenous			6		1			
Callitriche sp.	Tdr	indigenous			2		1			
Calocephalus sonderi	Tda	indigenous	2	1	5		3	2	2	
Calotis cuneifolia	Tda	indigenous		1						
Calotis hispidula	Tda	indigenous					1			1
Cardamine moirensis	Ate	indigenous		10	31		13	2	5	1
Carex inversa	Tda	indigenous	12	14	21	8	19	5	12	17
Carex sp.	Ate	indigenous					1	1	1	1
Carex tereticaulis	Ate	indigenous	24	8	23	26	25	18	16	16

Scientific name	PFG	Origin	2014 autumn	2010 autumn	2011 autumn	2013 autumn	2014 spring	2015 autumn	2015 spring	2016 autumn
Cassinia aculeata	Tdr	indigenous		1	1					
Cassinia arcuata	Tdr	indigenous	1							
Centella cordifolia	Tda	indigenous					1			
Centipeda cunninghamii	ATl	indigenous	13	8	43	29	6	9	7	5
Centipeda minima	ATl	indigenous	2		13	1	1	1		
Chamaesyce drummondii	Tdr	indigenous	2	6	8	3	2	2	3	5
Chloris truncata	Tdr	indigenous								
Convolvulus erubescens spp. agg.	Tdr	indigenous	1	1	1	1			1	
Cotula australis	Tdr	indigenous		2	17		13	2	3	1
Craspedia paludicola	Tda	indigenous			1					
Crassula peduncularis	ARp	indigenous					1			
Crassula sieberiana	Tdr	indigenous	5	6	2	2	11	3	3	2
Crassula sp.	ARp	indigenous				1		1		
Cynodon dactylon var. *pulchellus*	Tdr	indigenous	1	8	7	5	3	1	5	5
Cyperus bifax	Ate	indigenous			1					
Cyperus difformis	ATl	indigenous			3					
Cyperus exaltatus	Ate	indigenous	1		3	1	1			
Cyperus gunnii subsp. *gunnii*	Ate	indigenous			1					
Cyperus sp.	Ate	indigenous	1				2	1		
Damasonium minus	ARp	indigenous	1		9		2			
Daucus glochidiatus	Tdr	indigenous	5	5	3		18	10	6	4
Deyeuxia quadriseta	Ate	indigenous	1		1		2			
Dianella admixta	Tdr	indigenous			1		1	1		
Dianella sp. aff. *longifolia* (Riverina)	Tda	indigenous	1	1	1	1	1	1		1
Dysphania glomulifera subsp. *glomulifera*	Tdr	indigenous			1					1
Dysphania pumilio	Tdr	indigenous	2	4	9	3		2		
Echinopogon ovatus	Tda	indigenous						1		
Eclipta platyglossa	Tda	indigenous	2	2	11		6	2	5	
Einadia hastata	Tda	indigenous		3	1	1				
Einadia nutans subsp. *nutans*	Tdr	indigenous	36	43	33	28	36	33	35	38
Elatine gratioloides	ATl	indigenous			3		1			
Eleocharis acuta	Ate	indigenous	9	2	36	3	14		8	9
Eleocharis pusilla	Ate	indigenous	1		6		7			3
Eleocharis sp.	Ate	indigenous	1							2
Elymus scaber var. *scaber*	Tdr	indigenous	1			1	1			
Enchylaena tomentosa var. *tomentosa*	Tdr	indigenous	14	30	12	12	16	18	17	22
Enneapogon nigricans	Tdr	indigenous					1			
Enteropogon acicularis	Tdr	indigenous		1	1					
Epilobium billardierianum	Tda	indigenous			3		3		1	

Scientific name	PFG	Origin	2014 autumn	2010 autumn	2011 autumn	2013 autumn	2014 spring	2015 autumn	2015 spring	2016 autumn
Epilobium hirtigerum	Tda	indigenous			1		1			
Epilobium sp.	Tdr	indigenous					1			
Erodium crinitum	Tda	indigenous		1			2		1	1
Eryngium ovinum	Tda	indigenous	1		1	1				
Euchiton sp.	Tdr	indigenous	1							
Euchiton sphaericus	Tdr	indigenous	6	2	16		4		2	
Eutaxia microphylla var. *diffusa*	Tdr	indigenous	1	1	1	1	1	1	1	1
Exocarpos strictus	Tdr	indigenous	2	2	1	1	2	1	1	1
Geranium sp. 3	Tdr	indigenous	1	1	1	1	1	1	1	1
Glinus lotioides	Tda	indigenous	2							
Glinus oppositifolius	Tdr	indigenous	1							
Gnaphalium polycaulon	Tda	indigenous			11		1			
Goodenia fascicularis	Tda	indigenous		2	1					
Goodenia glauca	Tda	indigenous		3	3					
Goodenia gracilis	Tda	indigenous	1		5		2			
Goodenia pinnatifida	Tdr	indigenous					1			
Goodenia pusilliflora	Tdr	indigenous		2						
Gratiola pumilio	Tda	indigenous					1			
Haloragis aspera	Tda	indigenous			1		1			
Haloragis glauca f. *glauca*	Tda	indigenous	1		1					
Isolepis sp.	ARp	indigenous	1			1				
Juncus amabilis	Ate	indigenous	6		5	6	8	6	3	3
Juncus amabilis	Tda	indigenous	1			1	1	1	1	
Juncus aridicola	Ate	indigenous	1		3	2	1			1
Juncus flavidus	Ate	indigenous	17	3	12	13	15	5	6	4
Juncus gregiflorus	Ate	indigenous	1							
Juncus holoschoenus	Ate	indigenous			1					
Juncus sarophorus	Ate	indigenous					1			1
Juncus sp.	Tda	indigenous			2	1	5	19	16	20
Juncus sp.	Tda	indigenous	1		1	1	1	1	1	
Juncus subsecundus	Tda	indigenous	12		4	15	14	7	8	6
Juncus ustitatus	Ate	indigenous	1							
Lachnagrostis filiformis var. 1	Ate	indigenous	31	4	45	32	29	13	11	4
Lemna disperma	ARf	indigenous			1		1			
Lepidium papillosium	Tda	indigenous							2	
Lobelia concolor	ATl	indigenous	5	8	14	2				1
Ludwigia peploides subsp. *montevidensis*	ARp	indigenous	3		5	3	4	2		
Lythrum hyssopifolia	Tda	indigenous			10		1			
Lythrum salicaria	Ate	indigenous			1					

Scientific name	PFG	Origin	2014 autumn	2010 autumn	2011 autumn	2013 autumn	2014 spring	2015 autumn	2015 spring	2016 autumn
Maireana brevifolia	Tdr	indigenous		1	1	1		1		
Maireana decalvans	Tdr	indigenous	2	4	1	1		1		1
Maireana enchylaenoides	Tdr	indigenous		2	2	1	1	1	1	2
Maireana humillima	Tdr	indigenous		1						
Maireana sp.	Tdr	indigenous					1		1	1
Marsilea costulifera	ARp	indigenous	2	1	9					1
Marsilea drummondii	ARp	indigenous	11	11	19	11	15	10	8	15
Muehlenbeckia florulenta	ATw	indigenous	5	5	5	4	5	5	5	5
Myosurus australis	Tda	indigenous			3		1		4	2
Myriophyllum crispatum	ARp	indigenous	1		9	1	4	1	1	1
Oxalis perennans	Tdr	indigenous	13	15	20	2	18	5	12	12
Oxalis sp.	Tdr	indigenous					1			
Paspalidium jubiflorum	Tda	indigenous	35	34	37	36	35	35	35	35
Persicaria prostrata	ATl	indigenous	2		4	3	3	2	3	3
Pittosporum angustifolium	Tdr	indigenous	2	2	2	2	2	2	2	2
Plantago cunninghamii	Tdr	indigenous	6	3	5	3	5	3	1	2
Plantago drummondii	Tda	indigenous		1						
Plantago turrifera	Tdr	indigenous					2		1	1
Poa labillardierii	Tda	indigenous	1			1	1	2		
Pogonolepis muelleriana	Tda	indigenous					1	1		1
Polygonum plebeium	Tda	indigenous	1							
Potamogeton cheesemanii	ARf	indigenous			1		2			
Pratia concolor	ATl	indigenous					7	1	2	4
Pseudognaphalium luteoalbum	Tdr	indigenous			12	1				1
Pseudoraphis spinescens	ARp	indigenous	2	5	4	2	1			
Ranunculus inundatus	ATl	indigenous			3					
Ranunculus pumilio	Tda	indigenous		3	8					
Ranunculus trilobus	Tda	indigenous			4					
Ranunculus undosus	Ate	indigenous			1					
Rhagodia spinescens	Tdr	indigenous	1	1		1	1	2	1	2
Rhodanthe corymbiflora	Tdr	indigenous					9	1	2	
Rorippa eustylis	Tda	indigenous			2					
Rorippa laciniata	Tda	indigenous		2	1					
Rumex bidens	ARp	indigenous			5		1			
Rumex brownii	Tda	indigenous	18	25	46	23	7	3	3	4
Rumex sp.	Tda	indigenous	1				3	1	2	1
Rytidosperma caespitosum	Tdr	indigenous	1	2	2	2				
Rytidosperma duttonianum	Tdr	indigenous		1			1		1	
Rytidosperma fulva	Tdr	indigenous	1				2			

Scientific name	PFG	Origin	2014 autumn	2010 autumn	2011 autumn	2013 autumn	2014 spring	2015 autumn	2015 spring	2016 autumn
Rytidosperma setaceum	Tdr	indigenous	7	16	11	11	12	7	9	5
Rytidosperma sp.	Tdr	indigenous	1					1		2
Salsola australis	Tdr	indigenous	1	2	1		2	2	1	2
Schoenus apogon	Ate	indigenous	1							
Sclerolaena diacantha	Tdr	indigenous	1	2	1	1	1			
Sclerolaena muricata	Tdr	indigenous	1	2	2	2	2	2	1	2
Senecio cunninghamii var. *cunninghamii*	Tda	indigenous		1						
Senecio quadridentatus	Tdr	indigenous	26	26	33	27	37	28	30	24
Senecio runcinifolius	Tda	indigenous	2	7	14	1	5	2	4	
Senecio sp.	Tda	indigenous	1						1	
Senecio tenuiflorus	Tdr	indigenous	1							
Sida corrugata subsp. *corrugata*	Tdr	indigenous	4	3	4		3	2		3
Sigesbeckia orientalis subsp. *orientalis*	Tda	indigenous			1					
Solanum esuriale	Tdr	indigenous			3				1	
Solenogyne dominii	Tdr	indigenous		1						
Spergularia brevifolia	Tda	indigenous	6	8	5	3	5	5	2	3
Spergularia marina	Tda	indigenous	1	3	1		1	1	1	1
Spergularia sp.	Tda	indigenous					1			
Stellaria angustifolia	Ate	indigenous	3	7	20	5	13	5	5	
Stemodia glabella	ATl	indigenous	2		3					2
Stuartina muelleri	Tdr	indigenous					1			
Teucrium racemosum	Tdr	indigenous		3			1			1
Triglochin multifructa	ATl	indigenous			9					
Triglochin procera	Se	indigenous		1	9					
Triglochin sp.	ATl	indigenous			4					
Triptilodiscus pygmaeus	ATl	indigenous					1			
Vittadinia cuneata var. *cuneata*	Tdr	indigenous	8	7	9	8	10	6	7	4
Vittadinia gracilis	Tdr	indigenous	6	13	4	4	10	6	8	10
Vittadinia sp.	Tdr	indigenous						1	3	
Wahlenbergia fluminalis	Tda	indigenous	24	23	31	8	33	7	23	20
Wahlenbergia luteola	Tdr	indigenous			1	1				1
Wahlenbergia sp.	Tdr	indigenous	1							
Xerochrysum bracteatum	Tdr	indigenous	42	24	38	40	32	19	22	8
Aira elegantissima	Tdr	introduced					1			
Aira sp.	Tdr	introduced					1			
Arctotheca calendula	Tdr	introduced		1	1		2			
Aster subulatus	Tda	introduced	5		9	2	3	2	2	1
Asteraceae spp.	Tdr	introduced					1			
Avena barbata	Tdr	introduced					4	1	1	

Scientific name	PFG	Origin	2014 autumn	2010 autumn	2011 autumn	2013 autumn	2014 spring	2015 autumn	2015 spring	2016 autumn
Avena fatua	Tdr	introduced	1							
Avena spp.	Tdr	introduced	2	2	2	1		1		1
Brassica fruticulosa	Tdr	introduced		1						
Brassicaceae spp.	Tdr	introduced	3	2				1	1	
Bromus diandrus	Tdr	introduced	1		3	1	5	2	4	1
Bromus hordaceus	Tdr	introduced					2			
Bromus rubens	Tdr	introduced					3		2	
Bromus sp.	Tdr	introduced						1		
Capsella bursa-pastoris	Tdr	introduced			1					
Centaurea melitensis	Tda	introduced			1		9	3	3	3
Centaurium erythraea	Tda	introduced			1					
Cerastium glomeratum	Tda	introduced		2	2		8		4	
Chondrilla juncea	Tdr	introduced		1	1					
Cirsium vulgare	Tdr	introduced	17	12	36	9	23	14	14	8
Conyza bonariensis	Tdr	introduced	6	2	34	10	3	2		
Cotula bipinnata	Tda	introduced			1					
Cyperus eragrostis	Ate	introduced			5	1				
Dittrichia graveolens	Tdr	introduced					1			
Echium plantagineum	Tdr	introduced	6	10	10		17	11	14	7
Ehrharta erecta var. *erecta*	Tdr	introduced	1	1		1				
Ehrharta longiflora	Tda	introduced	2	1	2	2	6	4	4	1
Ehrharta sp.	Tda	introduced					1	1		
Euphorbia peplus	Tda	introduced							1	
Fumaria bastardii	Tda	introduced	1	6	4		1	1	6	1
Fumaria capreolata	Tda	introduced					3			
Fumaria spp.	Tda	introduced	1		1				1	1
Galium aparine	Tdr	introduced	3	5	9		10	1	4	
Hedypnois cretica	Tdr	introduced					1			
Heliotropium sp.	Tdr	introduced						1		
Helminthotheca echioides	Tdr	introduced		1	3		1			
Hordeum marinum	Tdr	introduced	1	7	2			1	1	1
Hordeum murinum subsp. *glaucum*	Tdr	introduced					5		2	1
Hordeum sp.	Tdr	introduced	1			1	1		2	
Hypochaeris glabra	Tdr	introduced	1	13			1			
Hypochaeris radicata	Tdr	introduced	1	22	10		12	1	6	
Hypochaeris sp.	Tdr	introduced							1	
Lactuca serriola	Tdr	introduced		5	16	1	10	2	3	
Leontodon taraxacoides subsp. *taraxacoides*	Tdr	introduced		1					1	
Lepidium africanum	Tdr	introduced	2	4	2		8	2	2	

Scientific name	PFG	Origin	2014 autumn	2010 autumn	2011 autumn	2013 autumn	2014 spring	2015 autumn	2015 spring	2016 autumn
Lepidium sp.	Tdr	introduced					1			
Lolium rigidum	Tdr	introduced	1	10	13	2	17	1	10	
Lycium ferocissimum	Tdr	introduced		1						
Lysimachia arvense	ATl	introduced	1	1			2		2	
Marrubium vulgare	Tdr	introduced	4	6	4	5	5	4	5	4
Medicago polymorpha	Tdr	introduced		4	4		1	1	3	1
Mesembryanthemum nodiflorum	Tdr	introduced		1			1			
Petrorhagia dubia	Tdr	introduced	1	4	2	1	10		2	
Petrorhagia sp.	Tdr	introduced								
Phalaris minor	Tda	introduced				1	2			
Phalaris paradoxa	Tda	introduced			1	1	2		1	
Phleum praetense	Tdr	introduced					1			
Phyla canescens	ATl	introduced					1			1
Physalis viscosa	Tdr	introduced	1	1	1	1	1	1	1	1
Poaceae spp.	Tdr	introduced	1							
Polygonum aviculare	Tdr	introduced	2		5	1				
Rosa rubiginosa	Tdr	introduced	1	1	1	1				1
Rubus fruticosus spp. *agg.*	Ate	introduced	1	1	1	1	1	2	2	1
Rumex conglomerata	Tda	introduced				1				
Sisymbrium orientale	Tdr	introduced		4	2		5	5	4	2
Solanum nigrum	Tdr	introduced	2	8	9	1	1	1	1	1
Sonchus asper	Tdr	introduced		1	1	1	1		1	
Sonchus oleraceus	Tdr	introduced	2	30	33	1	35	2	16	1
Spergularia media	Tda	introduced					1			
Stellaria media	Tdr	introduced	1	24	21	2	15		2	
Taraxacum sp.	Tdr	introduced		6	1					
Trifolium arvense	Tdr	introduced					3		2	
Trifolium glomeratum	Tdr	introduced			3		13	3	8	
Trifolium sp.	Tdr	introduced	4	4			2			
unknown	Tdr	introduced	13	1	4	5	12	11	8	
Verbascum virgatum	Tdr	introduced		1						
Vicia sp.	Tdr	introduced	1	1	1	1	1		1	
Vulpia bromoides	Tdr	introduced					3			
Vulpia muralis	Tdr	introduced	2				5	3	4	1
Vulpia sp.	Tdr	introduced	1			1	4	1	3	2
Xanthium spinosum	Tdr	introduced	4		4	4				

Key to table:

1	Number of understorey sites in which species was detected
PFG	Plant Functional Group (refer to Table 6)
EPBC	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
TSC	NSW *Threatened Species Conservation Act 1996*
WONs	Weed of National Significance

Table A2 Flora species recorded at wetland sites 2010 to 2016

Scientific name	PFG	Origin	2010 Autumn	2011 Autumn	2013 Autumn	2014 Autumn	2014 Spring	2015 Autumn	2015 Spring	2016 Autumn
Alternanthera denticulata	Tda	indigenous	5	14	15	15	16	15	11	13
Alternanthera sp.	Tda	indigenous						1		2
Alternanthera sp. 1	Tda	indigenous		1			2		1	
Amphibromus fluitans	ARp	indigenous	3	4	4					
Amphibromus nervosus	Tda	indigenous	5	3						
Amphibromus sp.	Tda	indigenous								
Arthropodium minus	Tdr	indigenous		1						
Asteraceae spp.	unknown	indigenous					1	2		
Atriplex semibaccata	Tdr	indigenous	3	2		2	2	4	1	4
Austrostipa scabra	Tdr	indigenous		1		1				
Austrostipa sp.	Tdr	indigenous				1				
Azolla filiculoides	ARf	indigenous		7			2			
Azolla pinnata	ARf	indigenous		4			1			
Brachyscome basaltica var. gracilis	Tda	indigenous		1	2	2	3	3	3	1
Bulbine semibarbata	Tdr	indigenous								
Callitriche sonderi	Atl	indigenous	2	12	6	4		2		
Callitriche sp.	Atl	indigenous	1	4			2			
Callitriche umbonata	Atl	indigenous	1	2						
Calocephalus sonderi	Tda	indigenous					2	2	1	1
Calotis cuneifolia	Tda	indigenous	1							
Calotis sp.	Tdr	indigenous							1	
Cardamine moirensis	ATe	indigenous	2	11	5		6	3	1	
Carex bichenoviana	ATe	indigenous		1						
Carex breviculmis	ATe	indigenous					1			
Carex inversa	Tda	indigenous	1	1	2	2	5	2	3	2
Carex sp.	ATe	indigenous				1	1	2	2	1
Carex tereticaulis	ATe	indigenous		6	8	4	6	5	7	4
Centipeda cunninghamii	Atl	indigenous	4	15	16	14	15	16	12	15
Centipeda minima	Atl	indigenous	2	8	10	10	2	9	6	6
Centipeda sp.	Tda	indigenous			4					2
Ceratophyllum demersum	Sk	indigenous		1						
Chamaesyce drummondii	Tdr	indigenous	3	3	2	3	2	7	7	8

Scientific name	PFG	Origin	2010 Autumn	2011 Autumn	2013 Autumn	2014 Autumn	2014 Spring	2015 Autumn	2015 Spring	2016 Autumn
Chenopodium curvispicatum	Tdr	indigenous						2		
Chloris sp.	Tdr	indigenous	1							
Cotula australis	Tdr	indigenous		4		1	2		1	
Crassula helmsii	ARp	indigenous		1						
Crassula sieberiana	Tdr	indigenous	1							
Cynodon dactylon var. *pulchellus*	Tdr	indigenous	2	2	4	2	2	1	4	3
Cyperaceae spp.	unknown	indigenous				2		1	1	1
Cyperus exaltatus	ATe	indigenous	1	1	4	1	1		1	
Cyperus sp.	ATe	indigenous		1	2	1	3			
Damasonium minus	ARp	indigenous	2	3	2	2	5	3	1	1
Daucus glochidiatus	Tdr	indigenous	2			1	1		1	
Dianella sp. aff. *longifolia* (Riverina)	Tdr	indigenous		1		1				
Dysphania glomulifera subsp. *glomulifera*	Tdr	indigenous	2	1				1		3
Dysphania pumilio	Tdr	indigenous	5	7	8	8	1	7	2	10
Dysphania pumilo	Tdr	indigenous						3		
Eclipta platyglossa	Tda	indigenous		2	1			1	1	
Einadia nutans subsp. *nutans*	Tdr	indigenous	6	6	2	8	7	10	7	8
Elatine gratioloides	Atl	indigenous		4	1					
Eleocharis acuta	ATe	indigenous	1	5		1	5	3	3	2
Eleocharis pusilla	ATe	indigenous		1					1	
Elymus scaber var. *scaber*	Tdr	indigenous				1	1	1		
Enchylaena tomentosa var. *tomentosa*	Tdr	indigenous	1			2		1	2	4
Enteropogon acicularis	Tdr	indigenous		1						
Epilobium billarderium	Tda	indigenous		2					1	
Epilobium sp.	Tda	indigenous					5	2		
Euchiton sphaericus	Tdr	indigenous		1						
Exocarpus strictus	Tdr	indigenous		1	2	1	1	1	1	1
Fimbristylis aestivalis	ARp	indigenous						1		
Glinus lotoides	Tda	indigenous	3	2	10	8	4	9		6
Glinus oppositifolius	Tdr	indigenous						4		
Gnaphalium polycaulon	Tda	indigenous		11	5	5	2	2	3	
Goodenia gracilis	Tda	indigenous		1						
Goodenia sp.	Tdr	indigenous					1			
Haloragis heterophylla	Tda	indigenous		1	2					
Isolepis sp.	ARp	indigenous			1	1	1			
Juncus amabilis	ATe	indigenous		3	2	7	7	5	2	1
Juncus flavidus	ATe	indigenous	3	1	2	2	1	1	1	1
Juncus ingens	ATe	indigenous	2	2	2	2	2	2		2
Juncus sp.	Tda	indigenous		4	9	3	9	11	12	13

Scientific name	PFG	Origin	2010 Autumn	2011 Autumn	2013 Autumn	2014 Autumn	2014 Spring	2015 Autumn	2015 Spring	2016 Autumn
Juncus subsecundus	Tda	indigenous			1	7	10	6	5	4
Lachnagrostis filiformis	ATe	indigenous	3	15	9	6	14	10	11	7
Landoltia punctata	ARf	indigenous		4						
Lemna disperma	ARf	indigenous		2						
Lepidium sp.	Tdr	indigenous					2		2	
Lilaeopsis polyantha	Atl	indigenous	2							
Limosella australis	Atl	indigenous		1						
Lobelia concolor	Atl	indigenous		1		2				
Lobelia pratioides	Atl	indigenous		1						
Ludwigia peploides subsp. *montevidensis*	ARp	indigenous		4	5	6	5	4	4	1
Lythrum hyssopifolia	Tda	indigenous	1	5		2	2	3	1	
Marsilea costulifera	ARp	indigenous	1	2						
Marsilea drummondii	ARp	indigenous		1			1	1		
Marsilea hirsuta	ARp	indigenous	1	1						
Marsilea sp.	ARp	indigenous			1		2			3
Myosurus australis	Tda	indigenous		8			1		4	5
Myriophyllum crispatum	ARp	indigenous		2	2	3	6	2	3	1
Myriophyllum papillosum	ARp	indigenous	1							
Myriophyllum sp.	ARp	indigenous					1		1	
Nitella sp.	Sr	indigenous					1			
Nymphoides crenata	ARf	indigenous					1			
Oxalis perennans	Tdr	indigenous	1	4		3	1		1	2
Oxalis sp.	Tdr	indigenous					2			
Paspalidium jubiflorum	Tda	indigenous	7	14	12	12	14	14	11	14
Persicaria decipiens	ATe	indigenous	1			3		1		
Persicaria hydropiper	ATe	indigenous			3	2				
Persicaria lapathifolia	ATe	indigenous	1		4	6		2	1	
Persicaria prostrata	Atl	indigenous	6	8	10	9	14	13	9	9
Persicaria sp.	ATe	indigenous			2					1
Phragmites australis	ATe	indigenous	1	3	3	3	3	3	2	2
Poaceae spp.	unknown	indigenous				15	3			1
Polygonum plebeium	Tda	indigenous	4		3	1	1	2	4	1
Potamogeton cheesemanii	ARf	indigenous		1			4			
Pratia sp.	unknown	indigenous					1			
Pseudognaphalium luteoalbum	Tdr	indigenous	2	7			1	1	2	
Pseudoraphis spinescens	ARp	indigenous	3	4			2			
Ranunculus inundatus	Atl	indigenous					2			
Ranunculus pumilio	Tda	indigenous	1	7	3					
Ranunculus sceleratus subsp. *sceleratus*	ATe	indigenous	2							

Scientific name	PFG	Origin	2010 Autumn	2011 Autumn	2013 Autumn	2014 Autumn	2014 Spring	2015 Autumn	2015 Spring	2016 Autumn
Ranunculus sessiliflorus subsp. *sessiliflorus*	Tda	indigenous		3						
Ranunculus sp.	unknown	indigenous	1				2			
Rhagodia spinescens	Tdr	indigenous				1	1			1
Rhodanthe corymbiflora	Tdr	indigenous								
Ricciocarpos natans	ARf	indigenous		2						
Rorippa eustylis	Tda	indigenous	3	5			1			
Rorippa laciniata	Tda	indigenous	2			1				
Rorippa sp.	Tda	indigenous				1				
Rumex bidens	ARp	indigenous					2			
Rumex brownii	Tda	indigenous	6	12	9	8	11	5	1	1
Rumex sp.	Tda	indigenous				3	2	3	1	3
Rumex tenax	Tda	indigenous	4			2				1
Rytidosperma caespitosum	Tdr	indigenous		1						
Rytidosperma setaceum	Tdr	indigenous	2	1		1	1		1	1
Rytidosperma sp.	Tdr	indigenous								1
Salsola australis	Tdr	indigenous	1				1	1		1
Sclerolaena muricata	Tdr	indigenous								
Senecio campylocarpus	Tda	indigenous		1						
Senecio quadridentatus	Tdr	indigenous	7	13	8	10	12	10	13	11
Senecio runcinifolius	Tda	indigenous	2	7	2	6	5	2		1
Senecio tenuiflorus	Tdr	indigenous					1			
Sida sp.	Tdr	indigenous				1				
Spergularia brevifolia	Tda	indigenous	1			1	1		2	1
Stellaria angustifolia	ATe	indigenous		1	1	2	4	2		
Stellaria caespitosa	ATe	indigenous	2							
Triglochin multifructa	Atl	indigenous		1						
Triglochin procera	Se	indigenous		6			1	2		
Vittadinia cervicularis	Tdr	indigenous				1				
Vittadinia cuneata var. *cuneata*	Tdr	indigenous	2			1	1	1		1
Vittadinia dissecta var. *hirta*	Tdr	indigenous	1							
Vittadinia gracilis	Tdr	indigenous	2							3
Vittadinia sp.	Tdr	indigenous				1				
Wahlenbergia fluminalis	Tda	indigenous	4	6	3	6	9	8	7	7
Wahlenbergia sp.	Tdr	indigenous				2				
Xerochrysum bracteatum	Tdr	indigenous	4	11		5	11	7	6	4
Zygophyllum sp.	Tdr	indigenous					1			
Alopecurus geniculatus	Tdr	introduced								
Anagallis arvensis	Atl	introduced	1			1			2	
Arctotheca calendula	Tdr	introduced	2				1			

Scientific name	PFG	Origin	2010 Autumn	2011 Autumn	2013 Autumn	2014 Autumn	2014 Spring	2015 Autumn	2015 Spring	2016 Autumn
Aster subulatus	Tda	introduced		2	1	7	3	5	6	
Avena barbata	Tdr	introduced					2		2	
Avena sp.	Tdr	introduced		1		1				
Brassicaceae spp.	Tdr	introduced	2						1	
Bromus hordeaceus subsp. *hordeaceus*	Tdr	introduced	1	2			2			
Bromus rubens	Tdr	introduced					2			
Bromus spp.	Tdr	introduced								1
Capsella bursa-pastoris	Tdr	introduced		1						
Centaurea melitensis	Tda	introduced					4	1	3	1
Cerastium glomeratum	Tda	introduced					3		2	1
Cirsium vulgare	Tdr	introduced	5	9	5	9	14	10	9	4
Conyza bonariensis	Tdr	introduced	1	12	3	10	7	4	4	1
Cotula bipinnata	Tda	introduced		1						
Cucumis myriocarpus subsp. *leptodermis*	Tdr	introduced	1							
Cynosurus echinatus	ATe	introduced					1			
Cyperus eragrostis	ATe	introduced		1						
Echium plantagineum	Tdr	introduced	4	3		3	7	5	6	4
Ehrharta longiflora	Tda	introduced	2				1	1	1	
Fumaria bastardii	Tda	introduced	1			2	3	2	3	1
Fumaria sp.	Tdr	introduced		3		1	2	1		
Galenia pubescens var. *pubescens*	Tdr	introduced						1		
Galium aparine	Tdr	introduced	2	3			1		3	
Heliotropium europaeum	Tdr	introduced	2							
Heliotropium sp.	Tdr	introduced								
Heliotropium supinum	Tda	introduced	1		3					2
Helminthotheca echioides	Tdr	introduced	3	1	1		1	1		1
Hordeum leporinum	Tdr	introduced	2							
Hordeum marinum	Tdr	introduced					1			
Hordeum sp.	Tdr	introduced				1	1	1	2	1
Hypochaeris glabra	Tdr	introduced	5				1			
Hypochaeris radicata	Tdr	introduced	4	2		1	1			
Hypochaeris sp.	Tdr	introduced							1	
Lactuca saligna	Tdr	introduced		1						
Lactuca serriola	Tdr	introduced	1	3			4	2	3	
Leontodon taraxacoides subsp. *taraxacoides*	Tdr	introduced		1			3			
Lepidium africanum	Tdr	introduced					2			
Lolium rigidum	Tdr	introduced	3	2	1		5	1	3	1
Lotus sp.	Tda	introduced								

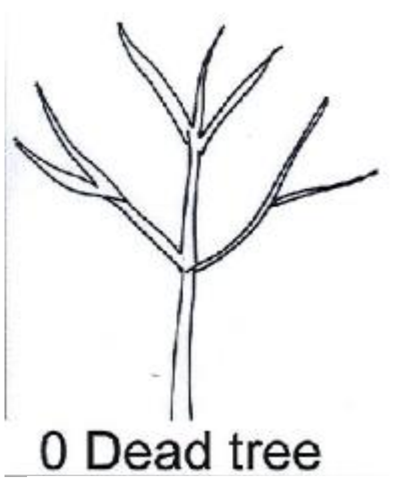
Scientific name	PFG	Origin	2010 Autumn	2011 Autumn	2013 Autumn	2014 Autumn	2014 Spring	2015 Autumn	2015 Spring	2016 Autumn
Malva parviflora	Tdr	introduced	2	1						
Malva sp.	Tdr	introduced				1				
Marrubium vulgare	Tdr	introduced	2	1	1	3	4	4	4	4
Medicago minima	Tdr	introduced					1			
Medicago polymorpha	Tdr	introduced	1		1		3	1	1	1
Petrorhagia dubia	Tdr	introduced	3	1		1	2			
Phalaris minor	Tda	introduced			1					
Phalaris paradoxa	Tda	introduced					1		1	1
Phyla canescens	Atl	introduced	1							
Poa annua	Tda	introduced			1					
Polygonum aviculare	Tdr	introduced	1	1		2				
Scorzonera laciniata	Tdr	introduced								
Silybum marianum	Tdr	introduced				1				
Sisymbrium orientale	Tdr	introduced							1	
Solanum nigrum	Tdr	introduced	3	3	1					
Sonchus asper	Tdr	introduced	1	2			2		1	
Sonchus oleraceus	Tdr	introduced	7	11		4	12	5	8	1
Stellaria media	Tdr	introduced	3	7	1		1		1	
Trifolium angustifolium	Tdr	introduced					1			
Trifolium arvense var. *arvense*	Tdr	introduced	2						1	
Trifolium dubium	Tdr	introduced					2		1	
Trifolium glomeratum	Tdr	introduced				3	4	1	2	4
Trifolium sp.	Tdr	introduced	1	3		2		1		1
Trifolium subterraneum	Tdr	introduced	1							
Trifolium tomentosum var. *tomentosum*	Tdr	introduced								
Verbena officinalis	Tdr	introduced			1					
Verbena supina	Tda	introduced						1		
Vicia hirsuta	Tdr	introduced					1			
Vicia sp.	Tdr	introduced		1					1	
Vulpia bromoides	Tdr	introduced					1			
Vulpia sp.	Tdr	introduced						1	2	1
Xanthium spinosum	Tdr	introduced		1		1				

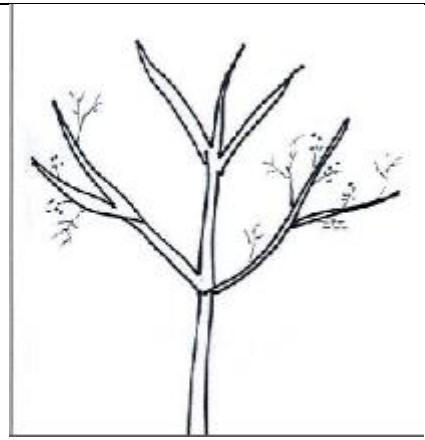
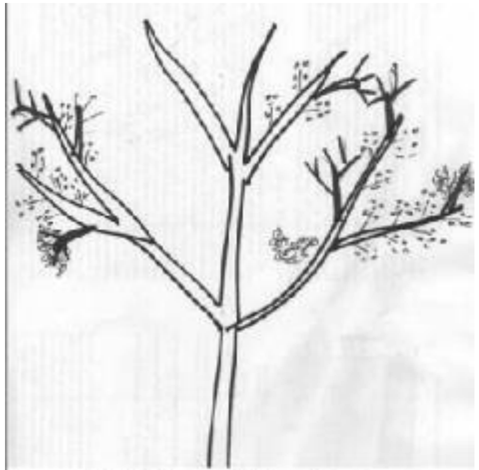
Appendix B – Crown Condition Index

The Procedure follows Holland (2000). Crowns are scored by comparison with the photographs which are reproduced here with permission of Holland.

References

Holland, K (2002). Black Box (*Eucalyptus largiflorens*) tree health and groundwater discharge on the lower River Murray floodplain: linking spatial and temporal scales. Ph. D. thesis, School of Biological Sciences, Flinders University of South Australia.)

	Black Box (*Eucalyptus largiflorens*)	Red Gum (*Eucalyptus camaldulensis*)	
Tree health index = 0 Dead tree with no original canopy All main branches dead No epicormic growth			 0% canopy

Tree health index = 1 Tree with no original canopy Most main branches dead NB Shoots are to be considered as epicormic if they have initiated from the trunk or old stems and are less than 3cm in diameter.			 **1 UnhealthyTree** 0% Original Canopy
Tree health index = 2 Tree with <25% of the original canopy present Some main branches dead (<50% canopy) Predominantly epicormic growth (>50% of remaining canopy) NB Shoots are to be considered as epicormic if they have initiated from the trunk or old stems and are less than 3 cm in diameter.			 2 Unhealthy tree <25% canopy

Tree health index = 3 Tree with 25-50% of the original canopy present. Some small dead branches. Some epicormic growth (<50% of remaining canopy) NB Shoots are to be considered as epicormic if they have initiated from the trunk or old stems and are less than 3 cm in diameter.			 3 Tree (25-50% canopy)

Appendix C – Selection of site photos 2011, 2013, 2014, 2015 and 2016 wetland and understorey sites

Red Gum with Flood Dependent Understorey


S81 Pan SE_2011 autumn


S81 Pan SE_2013 autumn


S81 Pan SE_2014 autumn


S81 Pan SE_2015 autumn


S81 Pan SE_2016 autumn

Red Gum with Flood Tolerant Understorey


S97 Pan SE_2011 autumn


S97 Pan SE_2013 autumn


S97 Pan SE_2014 autumn


S97 Pan SE_2015 autumn


S97 Pan SE_2016 autumn

Black Box Woodland


9B Pan SE_2011 autumn

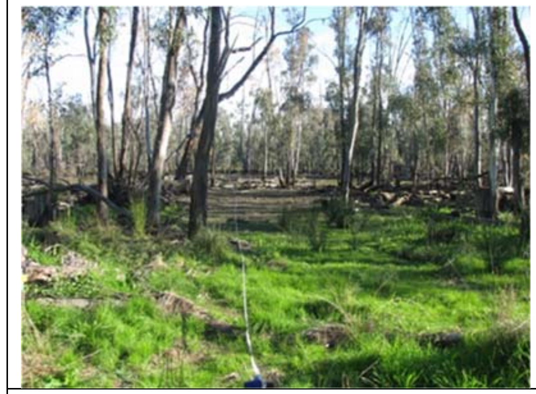

9B Pan SE_2013 autumn


9B Pan SE_2014 autumn


9B Pan SE_2015 autumn


9B Pan SE_2016 autumn

Grey Box Woodland

				
24B Pan SE_2011 autumn	24B Pan SE_2013 autumn	24B Pan SE_2014 autumn	24B Pan SE_2015 autumn	24B Pan SE_2016 autumn
Wetlands				
				
Pressy A Wetland PAW1 to PAW1B 2011	Pressy A Wetland PAW1 to PAW1B 2013	Pressy A Wetland PAW1 to PAW1B 2014 autumn	Pressy A Wetland PAW1 to PAW1B 2015 autumn	Pressy A Wetland PAW1 to PAW1B 2016 autumn

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