The Darling Anabranch Adaptive Management Monitoring Plan

Condition Monitoring 2011

Prepared by Deborah Bogenhuber and Danielle Linklater for the

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Cover Images: [clockwise from top left] monitoring understorey vegetation in a flooded channel, site 12; recently dried floodrunner with lignum, site 1; junction of the Old Darling Anabranch and Redbank Creek near site 4; Common Joyweed *Alternanthera nodiflora* at site 8.
Photographers: D. Bogenhuber and D. Linklater, MDFRC, October/November 2011.

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Contents

Executive summary

This report details the second year of condition monitoring undertaken along the Great Darling Anabranch system from September to November 2011 as part of the *Darling Anabranch Adaptive Management Monitoring Program* (DAAMMP).

The Darling Anabranch system experienced higher than average rainfall and overbank flows in the year preceding the 2011 survey period, in contrast to the first year of condition monitoring in 2010, which followed a long-dry period. Sections of the Darling Anabranch experienced varying hydrology between 2010 and 2011 depending on the source of flow and the influence of regulation.

TREE CONDITION AND RESPONSE

Three tree species occur in the riparian zone throughout the Darling Anabranch, Black Box *Eucalyptus largiflorens*, River Red Gum *Eucalyptus camaldulensis*, and River Cooba *Acacia stenophylla*. These species are monitored annually as part of the DAAMMP.

Overall tree condition improved between 2010 and 2011 and trees responded to the 2010/11 flood with high reproductive output. These results support findings from other work on the Murray River floodplain that the growth of reproductive material is higher for healthier trees.

Change in tree condition from 2010 to 2011 varied across species, with the largest increase in condition in River Red Gum, and an overall decline in condition for River Cooba. Black Box condition improved slightly in 2011, although most trees remained in moderate condition. Black Box trees can be slow to respond to flooding, due to both individual tree physiology and soil characteristics. We hypothesise that Black Box condition will continue to improve particularly at sites along the Old Darling Anabranch in response to the 2010/11 flood.

River Red Gum trees showed the largest improvement in condition, with nearly half of the trees surveyed considered to be in good or very good condition in 2011. Soil salinity (EM31) surveys suggest flushing of saline groundwater and the presence of freshwater lenses at some sites following flooding, which may account for the improvement in River Red Gum stands. Further improvement in River Red Gum condition can be expected in the short-term under continuing favourable conditions.

The majority of River Cooba trees assessed occurred at sites in the influence of Murray River Lock and Weir 9, 63% of which declined in condition. These sites experienced higher than average water levels for a prolonged period both before and during the 2010/11 flood, and the majority of River Cooba trees surveyed were inundated for an extended period (as much as one year). The decline in condition is probably a response to long-term flood conditions, and condition may continue to decline if a dry period does not occur soon.

Grazing impacts from native and exotic fauna were evident at almost all sites, with the greatest impacts from domestic stock. This is likely to have had a long term impact on the riparian community. The inclusion of additional sites not subject to grazing (e.g. within Nearie Lake Nature Reserve) and/or the establishment of stock exclusion plots at current monitoring sites would allow the impact of grazing on tree condition and recruitment to be quantified.

The interim ecological objective for riparian tree communities along the Darling Anabranch is to maintain sustainable communities in the riparian zone. Data currently collected as part of the DAAMMP indicates that recruitment may not be occurring at a level that could sustain populations of the three riparian tree species in the long term. In order to quantify progress toward meeting this objective however information is required on stand condition and recruitment, which is not currently collected as part of the DAAMMP. This information would lead to more confidence in setting targets for future management of environmental flows through the Darling Anabranch.

NATURAL ORGANIC MATTER

Natural organic matter (NOM) load is an important contributor of dissolved organic carbon and nutrients to streams. Monitoring of NOM for the DAAMMP provides an indication of the potential source of carbon and nutrients for the Darling Anabranch, and estimates its distribution and abundance both temporally and spatially.

Observations following the summer 2010/11 flood were that much of the leaf litter at the monitoring sites had been removed from the riparian zone by flood flows, the flood effectively 're-setting' this component of the floodplain.

NOM loadings were higher for River Red Gum than Black Box, River Cooba loads were highly variable ranging from 72 gm^{-2} to 9411 gm^{-2}. Results of 2011 surveys support 2010 results indicating that NOM loads are highest for trees in good condition, decreasing as trees decline in condition, but also decreasing for trees in very good condition.

The distribution and abundance of particulate NOM throughout the Darling Anabranch in 2011 appears to be have been maintained in the short term, when compared with leaf litter loadings in other floodplain areas of the lower Murray River floodplain. The importance of NOM to the Darling Anabranch ecosystem including the aquatic and terrestrial food webs however is unknown. Further study into the sources of carbon being utilised by the food web within the Darling Anabranch, during different stages of the hydrograph, would provide insight into the role of NOM and its importance in the Darling Anabranch and lower Murray River ecosystem with implications for management of future environmental flows through the system.

UNDERSTOREY VEGETATION

The understorey vegetation community along the Darling Anabranch responded to the prolonged wet conditions from late 2010 up until the survey period in 2011. There was a large shift in the understorey landscape from one dominated by terrestrial dry species to one dominated by amphibious and terrestrial damp plant species. This reflects the conditions at the time of survey in 2011, with many sites having recently exposed damp sediments, following flood recession. These conditions are required for the germination and recruitment of many common plant species along the Darling Anabranch.

Hydrological differences occurred along the Darling Anabranch, and persisted at the time of monitoring, which resulted in different plant communities being recorded in different parts of the system. Hydrology classes were used to examine understorey plant community responses along the Darling Anabranch in 2011. Sites were grouped into four categories based on recent hydrology (specifically, flood recession characteristics) – natural, regulated stable, regulated variable, and weir pool. Distinct plant communities occurred within the 'natural' hydrology class, compared with other hydrology classes which experienced longer flooding duration and lacked a 'natural' flood recession. In general, 'natural' sites had higher species and functional group diversity, were dominated by terrestrial damp and amphibious species recorded in high abundances and had a lower proportion of exotic species. 'Weir pool' sites, which experienced the least fluctuation in water levels prior to monitoring, recorded lowest abundances and with the exception of the sedge *Cyperus gymnocaulos* were dominated by terrestrial dry species and exotic species. 'Regulated stable' and 'regulated variable' sites were also dominated by terrestrial dry species and exotic species.

In total 168 plant species were recorded from 39 families between September and November 2011, compared with 209 species from 46 families in 2010. In both 2010 and 2011 Chenopodiaceae and Asteraceae were the dominant families in terms of abundance records and number of species. The total number of species and families recorded along the Darling Anabranch in both 2010 and 2011 is 234 and 48 respectively.

The impact of grazing on understorey vegetation, including trampling of vegetation and herbivory, was extremely high at many sites. Much of the grazing impact was from domestic livestock however significant effects were also evident from introduced feral and native species. This undoubtedly influenced the results of vegetation surveys. There was a noticeable increase in domestic stock at monitoring sites in 2011 compared with 2010, presumably due to increased feed availability in the riparian zone after the flood. An analysis of the relationship between grazing regimes and understorey vegetation at monitoring sites along the Darling Anabranch would be beneficial to quantify the effect of stocking rates and regimes on riparian condition.

One of the ecological objectives for understorey vegetation is to limit the extent of recognised weeds as invasive species. There was a slight increase in the proportion of weed species overall in 2011 compared with 2010, however the number of exotic species decreased and there were less than half as many abundance records. The highest number and proportion of exotic species were recorded within the 'regulated variable' hydrology class. Results indicate that during extended dry periods native species are favoured, with exotic species colonising areas following more favourable wet conditions. Hence the drying phase in naturally ephemeral systems such as the Darling Anabranch is extremely important in discouraging the establishment and spread of exotic plant species.

Results from 2011 demonstrate that meeting the ecological objectives of maintaining communities of flood tolerant and flood dependent understorey vegetation along the Darling Anabranch can be achieved with the appropriate water regime. Widespread flooding led to a more than three-fold increase in the abundance of terrestrial damp plant species and almost a seven-fold increase in the abundance of amphibious plant species.

Of interest is the lack of submerged and to some extent amphibious emergent species recorded throughout the Darling Anabranch system, especially compared with wetlands along the Murray River. To our knowledge no literature exists to inform the question: were aquatic vegetation communities in inundated zones ever a major component of the vegetation community along the Darling Anabranch? It would be of interest to investigate this through a combination of historical research, seed bank trials and understorey surveys in more stable backwater habitats.

1. General introduction

For a detailed introduction to the Darling Anabranch Adaptive Management Monitoring Program and the hydrology, ecology and cultural heritage of the Anabranch system refer to Bogenhuber et al (2011).

1.1. Purpose and structure of the report

This report details the second year of condition monitoring undertaken along the Great Darling Anabranch system (hereafter referred to as the Darling Anabranch) from September to November 2011 as part of the *Darling Anabranch Adaptive Management Monitoring Program* (DAAMMP). It includes analysis and interpretation of changes observed since 2010. This work was conducted by The Murray-Darling Freshwater Research Centre (MDFRC) for the NSW Office of Environment and Heritage (OEH) and forms a deliverable for Contract No. 0901427/6092-09-11 LMW01 between OEH and the MDFRC.

This report is structured as follows:

Section 1 – General Introduction (this section)

Section 2 – Tree condition and response

Section 3 – Natural organic matter

Section 4 – Understorey vegetation community

Section 5 – Individual site results (site cards)

Appendices

1.2. Site selection and monitoring components

Sixteen sites were established in 2010 as part of the DAAMMP: one on Tandou Creek, one on Redbank Creek, two on the Old Darling Anabranch, one at the junction of the Old Darling Anabranch and Redbank Creek, and the remaining 11 spread along the Darling Anabranch (Figure 1.1). An additional site (site 1) was established in 2011 on the Old Darling Anabranch, approximately 2 km upstream from site 2 (Figure 1.1). This location was selected because the original site 1 location identified in Campbell and Wallace (2009) was not accessible.

Condition monitoring includes components that are monitored annually or every two or three years. All components and their status as at December 2011 are listed in Table 1.1.

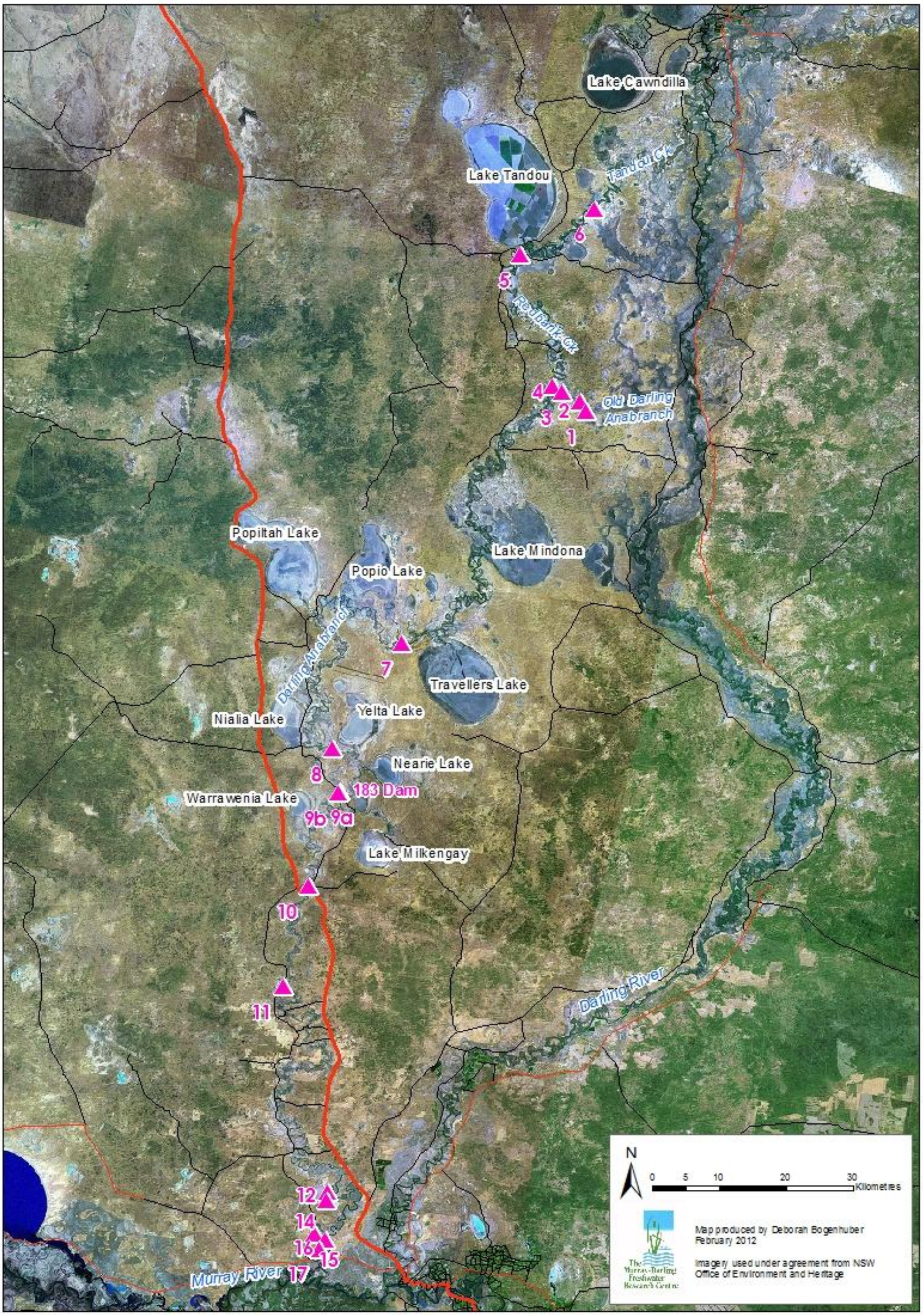

Figure 1.1. The Darling Anabranch system showing monitoring sites 1 to 17 including the Anabranch Lakes.

Table 1.1. Condition monitoring components and their status in 2011.

Monitoring component	Status	Detail
Tree condition and response	17 sites assessed, Sep-Oct 2011.	Assessed annually, in 2010 and 2011. Results for 2011 presented in Section 2.
Natural organic matter load	17 sites assessed, Sep-Oct 2011.	Assessed annually, in 2010 and 2011. Results for 2011 presented in Section 3.
Understorey vegetation community	17 sites assessed, Sep-Nov 2011.	Assessed annually, in 2010 and 2011. Results for 2011 presented in Section 4.
Soil salinity (EM31 surveys)	Assessed November 2011.	Surveys to be repeated in 2012.
Lignum health	Assessed at site 1 only (site 1 not assessed in 2010).	Bi-ennial, assessed in 2010; all sites to be surveyed in 2012. Results for site 1 2011 presented in Section 5.1.
Typha distribution	Not assessed.	Bi-ennial, assessed in 2010; all sites to be surveyed in 2012.
Channel geomorphology	Not assessed.	Surveys require the channel to be dry or almost dry – the majority of the channel has retained water throughout 2011, therefore this component will be assessed in 2012 (weather and flow dependent). Subject to ongoing wet conditions, methodology will be reviewed to determine the feasibility of surveying a wet channel.
In-channel regeneration	Not assessed.	Surveys require the channel to be dry or almost dry – the majority of the channel has retained water throughout 2011, therefore this component will be assessed in 2012 (weather and flow dependent). Subject to ongoing wet conditions, methodology will be reviewed to determine the feasibility of surveying a wet channel.

1.3. Hydrology

The Darling Anabranch system experienced higher than average rainfall between March 2010 and February 2011 (Table 1.2), and overbank flows between November 2010 and May 2011 (Figure 1.2). Floodwaters from the Darling River were a result of three extreme rainfall events in the upper catchment during December 2010 and January 2011 and localised rainfall events at Menindee and Wilcannia, upstream of the Menindee Lakes (NOW 2011). Sections of the Darling Anabranch experienced varying hydrology between 2010 and 2011 depending on the source of flow (Lake Cawndilla or the Darling River) and the influence of regulation by Packers Crossing, 183 Dam and Oakbank Dam, and temporary structures across creeks that feed the Anabranch Lakes.

As water filled the Anabranch Lakes in early 2011 (see Figure 1.1), the system was managed primarily for lake bed cropping with the exception of Nearie Lake which is part of a Nature Reserve managed by NSW National Parks and Wildlife Service. Water was prevented from flowing naturally through the Darling Anabranch by partially closing 183 Dam (located downstream of most of the Anabranch Lakes; Figure 1.1) until the lakes were full. 183 Dam was opened fully in November 2011 and discharge increased downstream for a short time.

Table 1.2. Rainfall records for selected stations close to Darling Anabranch monitoring sites. (Data from Bureau of Meteorology web site.)

Station (years of data)	Mean annual rainfall (mm)	Total rainfall March 2010 to February 2011 inclusive (mm)
Menindee Post Office (1876-2011)	244.7	619.2
Wentworth (Willow Point) (1933-2011)	260.2	743 (Feb 2011 highest on record for the month of Feb; 2010 highest annual rainfall on record)
Wentworth (Woodlands) (1919-2011)	260.2	589.2 (December 2010 data missing)
Wentworth Post Office (1868-2011)	287.9	711.4 (Nov 2010 highest on record for the month of Nov)

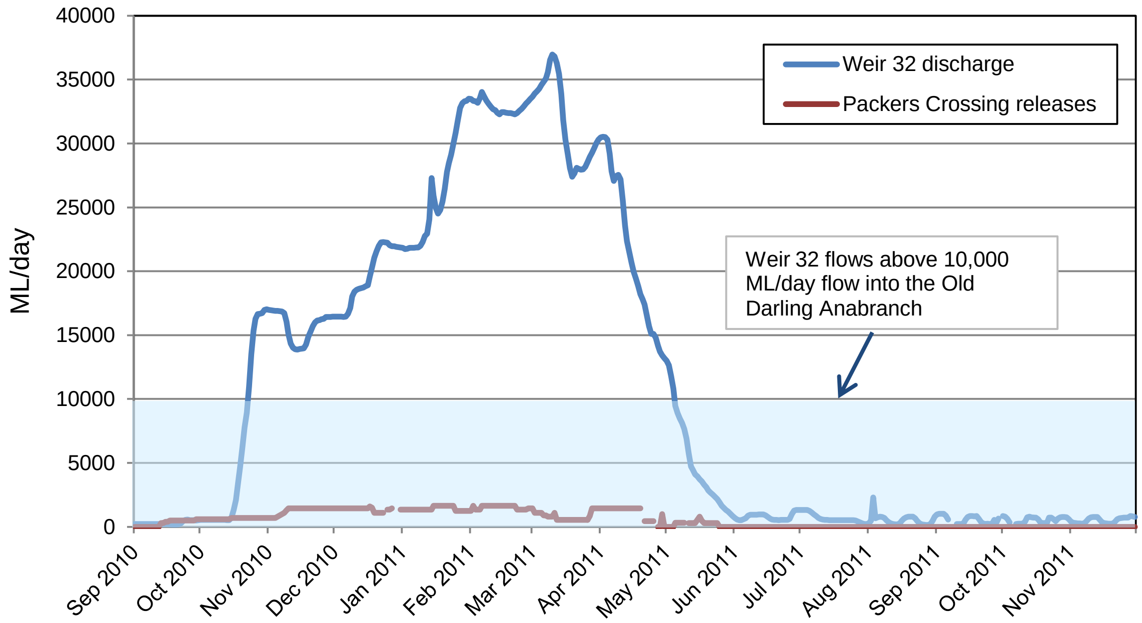

Figure 1.2. Hydrograph of releases from Weir 32 and Packers Crossing, September 2010 to November 2011. (Data courtesy of State Water Corporation.)

A summary of the hydrological status at each site at the time of monitoring is displayed in Table 1.3. During condition monitoring in 2011 all sites retained some standing water, although sites 1 to 5 were almost dry (Table 1.3). In some cases sites were inundated to above the tree line (Table 1.3).

Condition monitoring of the Darling Anabranch channel and riparian zone carried out in 2011 followed extended 'wet' conditions in contrast to the first year of condition monitoring in 2010, which followed a long-dry period. Results are presented in the following sections in the context of the 2010/11 flood.

Table 1.3. Hydrological status of sites 1 to 17 along the Darling Anabranch between September and November 2011.

Site	Date of survey (2011)	Water present	Source of water and timing
1	13 Sep	Shallow pools 0.1 to 0.4 m deep in bottom of channel.	Darling River; ceased flowing into Old Darling Anabranch on approximately May 5, 2011.*
2	13 Sep	Shallow pools to 0.5 m deep in bottom of channel.	Darling River; ceased flowing into Old Darling Anabranch on approximately May 5, 2011.*
3	14 Sep	Shallow pools to 0.5 m deep in bottom of channel.	Darling River; ceased flowing into Old Darling Anabranch on approximately May 5, 2011.*
4	16 Sep	Shallow pools in bottom of channel to 0.1 m deep.	Received flows from Lake Cawndilla (discharged through Packers Crossing, ceased on May 25, 2011) and from the Darling River, September 2010 to May 2011.*
5	4-5 Oct	No standing water, bottom of channel damp.	Received flows from Lake Cawndilla (discharged through Packers Crossing, ceased on May 25, 2011).
6	25 Oct	Inundated to tree-line, stable.	Lake Cawndilla, approximately bank-full since September 2010#.
7	26 Oct	Deep pools (>2 m), stable, inundated to above mid-bank.	Remaining from Packers Crossing releases (from Lake Cawndilla) and/or previous flow from the Darling River, September 2010 to May 2011*; draining from upstream lakes and held back by the partial closure of 183 Dam.
8	27 Oct & 1 Nov	Inundated to tree-line, stable/rising?	Remaining from Packers Crossing releases (from Lake Cawndilla) and/or previous flow from the Darling River, September 2010 to May 2011*; draining from upstream lakes and held back by the partial closure of 183 Dam.
9a	27 Oct	Inundated to above tree-line, stable/rising?	Remaining from Packers Crossing releases (from Lake Cawndilla) and/or previous flow from the Darling River, September 2010 to May 2011*; draining from upstream lakes and held back by the partial closure of 183 Dam.
9b	27 Oct & 1 Nov	Inundated and flowing, falling.	Releases from 183 Dam, draining from upstream lakes.
10	1 & 3 Oct	Inundated to tree-line, stable/rising?	Releases from 183 Dam, draining from upstream lakes.
11	7 Nov	Inundated to tree-line, stable/rising?	Releases from 183 Dam, draining from upstream lakes.
12	2 & 7 Nov	Inundated to mid-bank, falling.	Releases from 183 Dam, draining from upstream lakes.
14	4 Nov	Inundated to above mid-bank, falling.	Releases from 183 Dam, draining from upstream lakes.
15	4 Nov	Inundated to tree-line, falling.	In the influence of Murray River Lock and Weir 9.
16	31 Oct	Inundated to mid-bank, falling.	In the influence of Murray River Lock and Weir 9.
17	28 Oct & 3 Nov	Inundated to mid-bank, falling.	In the influence of Murray River Lock and Weir 9.

*Based upon flow data supplied by State Water Corporation (flows over 10 GL/d past Weir 32 at Menindee enter the Old Darling Anabranch).
#Personal communication with S. Field, Tandou Farm

2. Tree condition and response

"...the presence of trees on the floodplain, are in themselves, the key to their long-term survival."

(Bramley et al 2003)

2.1. Introduction

Trees are important components of riparian zones, providing numerous functions including bank stabilisation, carbon and nutrient inputs via litter fall, habitat, and regulation of water movement through the soil. Three tree species occur in the riparian zone throughout the Darling Anabranch, Black Box *Eucalyptus largiflorens*, River Red Gum *Eucalyptus camaldulensis*, and River Cooba *Acacia stenophylla*. These species are monitored annually as part of the Darling Anabranch Adaptive Management Monitoring Program (DAAMMP). This component of the monitoring program is presented in this section.

Black Box (*Eucalyptus largiflorens*)

Black Box is the dominant tree species along the majority of the Darling Anabranch system, which makes up 72% of trees surveyed in the DAAMMP. Black Box is less tolerant of flooding than River Red Gum, but can withstand longer periods without floods (Roberts and Marston 2000). It is therefore more common at higher elevations on the floodplain.

Black Box is a salt-tolerant species (Doody et al 2009), able to exclude salt through its roots (Streeter et al 1996 referenced in Roberts and Marston 2011), and is found on salt-affected soils along the Darling Anabranch (Figure 2.1). Additional characteristics that allow Black Box to survive in semi-arid floodplain environments are their low oxygen requirements (Akeroyd et al 1998), reducing the risk of waterlogging from floodwaters, and their ability to utilise water opportunistically, favouring sources that require the least amount of energy for uptake (Akeroyd et al 1998).

Ideal hydrological conditions to maintain Black Box health are floods every three to seven years of two to six months duration (Roberts and Marston 2011). The positive effects of a flood on Black Box growth lasts for two years (George 2004) and on a salinised floodplain can last up to 12 years (Slavich et al 1999). This response however is strongly influenced by soil hydraulic properties (Slavich et al 1999, Akeroyd et al 1998). On salinised floodplains such as Chowilla for example, leaching of salts occurs on sandy soils during floods but on heavy clay soils the leaching of salts may not occur (Akeroyd et al 1998). Consequently there may be no response in Black Box trees following flooding (Jolly and Walker 1996).

Recent work has drawn attention to reductions in crown condition and community viability (i.e. insufficient recruitment) of Black Box along the Lower Murray River floodplain (George et al 2005, Lane and Associates 2005, Henderson et al 2010). These have been attributed to reductions in flood frequency (e.g. MDBC 2002) and increases in soil salinity associated with shallower water tables (Slavich et al 1999).

In 2010 86% of the 346 Black Box trees assessed along the Darling Anabranch were considered to be in moderate condition, and a further 11% were in poor or very poor condition. To our knowledge these are the only extensive tree condition surveys that have been carried out along the Darling Anabranch. The only other published data assessing the health of Black Box trees in the Darling Anabranch is at Nearie Lake following the 1990 flood (Lloyd 1992). Adjusting the index scale to compare with that used for surveys on the Darling Anabranch, mean tree health around Nearie Lake was moderate (Lloyd 1992).

This section will present results of 2011 repeat surveys of Black Box trees along the Darling Anabranch and examine their response to the 2010/11 flood.

Figure 2.1. Black Box *Eucalyptus largiflorens* woodland with Pigface *Disphyma crassifolium* understorey on salt-affected soils, near site 8 (Windamingle Station). Photographer: D. Bogenhuber, MDFRC, September 2010.

River Red Gum (*Eucalyptus camaldulensis*)

River Red Gum woodlands dominate the riparian zone of the Darling Anabranch in areas where more permanent water occurs (e.g. deep water holes), and are particularly common at the downstream end in the influence of Murray River Lock and Weir 9. Where present, River Red Gum trees generally occur as a narrow band fringing the channel.

River Red Gum trees utilise groundwater, soil water and surface water (e.g. creeks and rivers), and have been found to use saline groundwater, even when fresh creek water is available (Thorburn et al 1994). River Red Gum communities require flooding to maintain condition (Wen et al 2009). The optimal flooding regime is a flood every two to four years for two to four months duration, with follow-up flooding to enable seedling establishment (Roberts and Marston 2011). Environmental watering or managed flooding has been suggested as a viable way of maintaining River Red Gum populations (Cunningham et al 2011).

The condition of River Red Gums along the Darling Anabranch is known only from the 2010 survey carried out as part of the DAAMMP. Of the 94 River Red Gum trees surveyed, 76% were in moderate condition and 11% were in poor or very poor condition (Bogenhuber and Linklater 2010, unpublished data). It is not known whether these trees have declined in condition as in other parts of the Murray-Darling Basin. For example, along the Victorian Murray River floodplain dieback of River Red Gum forests is estimated to have increased from 45 to 70% between 1990 and 2006 (Cunningham et al 2011). Repeat surveys were carried out along the Darling Anabranch in 2011 following a moderate flood and the response of River Red Gum trees is examined in this section.

River Cooba (*Acacia stenophylla*)

River Cooba is a salt-tolerant species (Marcar et al 2003) that occurs throughout the Anabranch system close to the channel. River Cooba trees generally occur as scattered individuals with Black Box and/or River Red Gum but sometimes in dense mono-specific stands (Figure 2.2a). The hydrological requirements for River Cooba are not as well documented as for River Red Gum and there is little information available on their response to flooding or drought. Roberts and Marston (2011) recommend a water regime of a flood every three to seven years of two to three months duration to maintain condition of River Cooba populations.

Forty River Cooba trees were surveyed as part of the DAAMMP in 2010. Approximately half were considered in moderate or poor condition and stands along the Old Darling Anabranch were observed to have recently died (Figure 2.2b). Flow records show that the Old Darling Anabranch received no inflows for approximately nine years between January 2001 and January/February 2010 (State Water Corporation Menindee flow data). The maximum recommended flood return interval to maintain River Cooba condition is seven years (Roberts and Marston 2011) therefore it is likely that these River Cooba died due to lack of flooding.

In 2011 repeat surveys were carried out along the Darling Anabranch, results are presented in this section and the response of River Cooba trees to the 2010/11 flood is discussed.

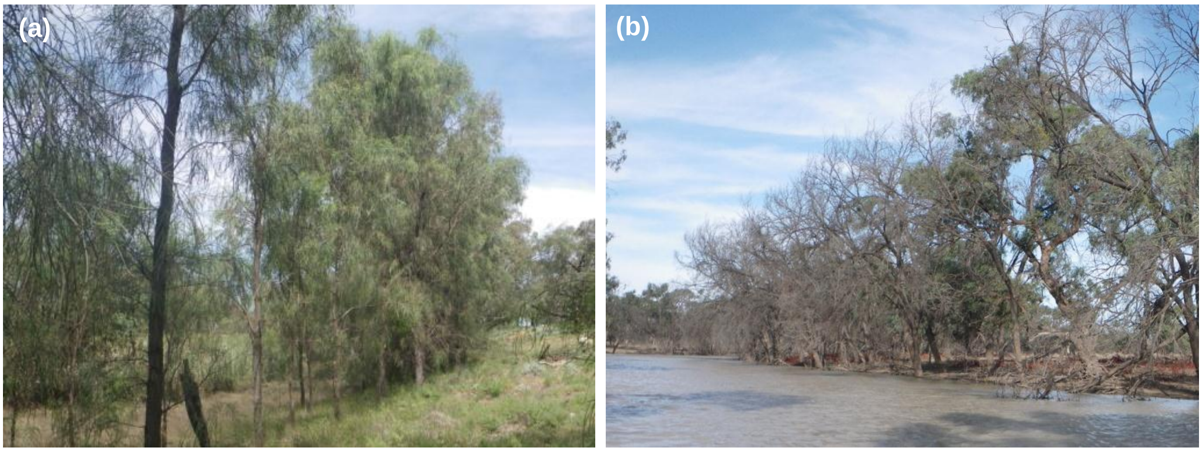

Figure 2.2(a) River Cooba *Acacia stenophylla* stand along the water's edge at site 15, Oakbank Station, October 2010 **(b)** dead River Cooba trees along the Old Darling Anabranch, site 3, January 2012. Photographer: Danielle Linklater, MDFRC.

DAAMMP Ecological objectives

The interim ecological objectives for long-lived woody vegetation (trees) are:

- Maintain sustainable River Red Gum communities within the riparian zone
- Maintain sustainable Black Box communities within the riparian zone
- Maintain sustainable River Cooba communities within the riparian zone

In this section we investigate the response of the three riparian tree species occurring along the Darling Anabranch to the prolonged wet conditions throughout 2011 and discuss progress towards meeting the interim ecological objectives.

2.2. Methods

2.2.1. Site changes

One additional condition monitoring site was established in 2011, site 1, at which tree condition was assessed. A 0.25 hectare tree condition quadrat was established, and thirty trees assessed within the quadrat (28 Black Box and two River Cooba). For location of site 1 and all other sites established in 2010 refer to Figure 1.1 Section 1.

2.2.2. Survey components

Tree condition surveys collected information on the following components:

- Tree information – diameter at breast height, dominance class
- Tree condition assessment – crown extent, crown density, bark condition
- Tree response – new tip growth and epicormic growth, leaf die-off, extent of reproduction, mistletoe load

- Site information – disturbance, insect damage, other biological stressors, presence of seedlings and saplings
- Photo points

Detailed methodology for each of these components are contained within Bogenhuber et al (2011).

2.2.3. Limitations

Visual assessments of tree condition are subjective and may vary between observers and within observers over time. To minimise this variability, observers are trained to carry out these assessments, and assessments are always undertaken by two people, with scores averaged. Where scores are considerably different, they are discussed in the field and adjustments are made where appropriate and mutually agreed. Despite this it should be noted that due to the subjective nature of the assessments a degree of inconsistency is inherent.

2.2.4. Statistical analysis

Visual representations of the data were produced in SigmaPlot and Microsoft Excel MSTM. The software package Primer v6 (Clarke and Gorley 2006) was used to visualise patterns in the condition variables between sites and among years, using Principal Component Analysis (PCA). Site average data was normalised to account for the range in data values and scales, and the assessment matrix included crown extent, crown density, new tip growth, epicormic growth, leaf die-off, reproductive extent, and mistletoe load. Because the variable "bark condition" only applies to River Red Gum it was not included in the multivariate analysis.

Statistical differences in condition among sites and years were analysed by permutational ANOVA (PERMANOVA) utilising the PERMANOVA+ add in (Anderson et al 2008) within Primer v6 (Clarke and Gorley 2006). The factors "site" and "year" were fixed and the analysis was performed using 9999 permutations and unrestricted permutation of raw data. The condition and response data for individual trees was normalised to account for the range in data values and scales and a resemblance matrix created using Euclidean distance. Significant effects were accepted at $P < 0.05$, with *a posteriori* pair-wise comparisons run if the main test was significant. The assessment matrix for the PERMANOVA analysis included crown extent, crown density, new tip growth, epicormic growth, leaf die-off, mistletoe and reproductive extent. As for PCA, because the variable "bark condition" only applies to River Red Gum it was not included in the multivariate analysis.

2.3. Results

2.3.1. Site description and tree information

Five hundred and ten (510) trees were surveyed across 17 sites on the Darling Anabranch system. Black Box is the dominant tree species, River Red Gum and River Cooba are more prevalent at downstream sites (Figure 2.3). Table 2.1 defines how sites were assigned dominant or co-dominant tree species, used within this section for displaying results.

Photo points of tree condition at each site for 2010 and 2011 are contained within Appendix A.

Figure 2.4 displays the mean diameter at breast height (DBH) for trees at each site assessed. Site 17 recorded the largest mean DBH of 1035 mm, and the largest overall DBH (River Red Gum) of 3210 mm.

Disturbance was high across all sites, predominantly from grazing, trampling and flooding. Flooding resulted in some erosion and uprooted trees; sites where riparian trees had been inundated for extended periods of approximately 12 months showed a decline in the condition of inundated trees (mostly saplings or juvenile trees), which had yellowing and dead foliage (Figure 2.5). Grazing impacts were mostly caused by domestic stock and/or goats, rabbits and Black-tailed Native Hens (*Gallinula ventralis*) (Figure 2.6), however grazing by kangaroos and emus also occurred. Minor disturbances included rubbish, insect damage, camping, lopping of tree limbs, wind damage and soil salinity. Presence of seedlings and saplings within tree condition quadrats was generally low, and they were absent altogether from several sites.

Table 2.1. Definitions used for dominant and co-dominant tree species

Category	When 2 species are present:	When 3 species are present:
Dominant	Dominant species ≥ 65% of total trees	Dominant species ≥ 50% of total trees
Co-dominant	Each species ≥ 40% of total trees	Co-dominant species make up ≥ 80% of total trees; and each species is ≥ 40% of total trees

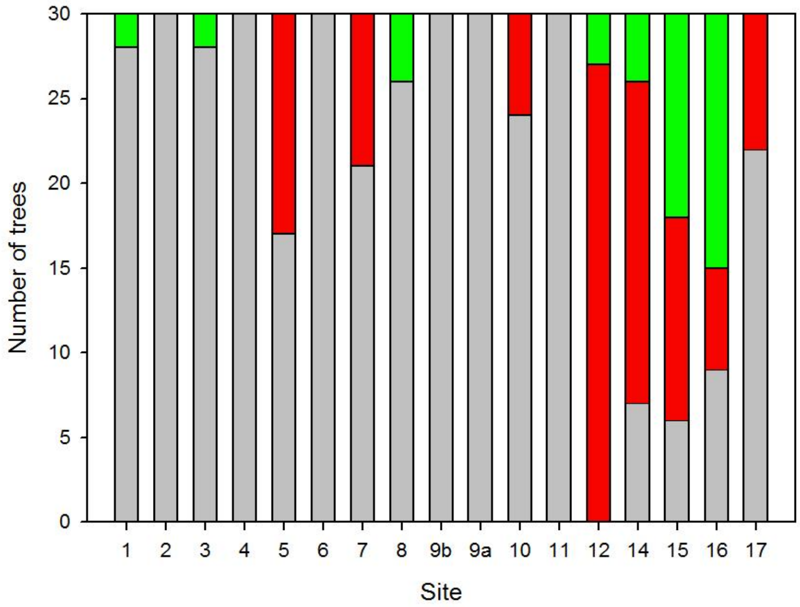

Figure 2.3. Proportion of tree species in each tree condition quadrat per site. Grey is Black Box, red is River Red Gum, green is River Cooba.

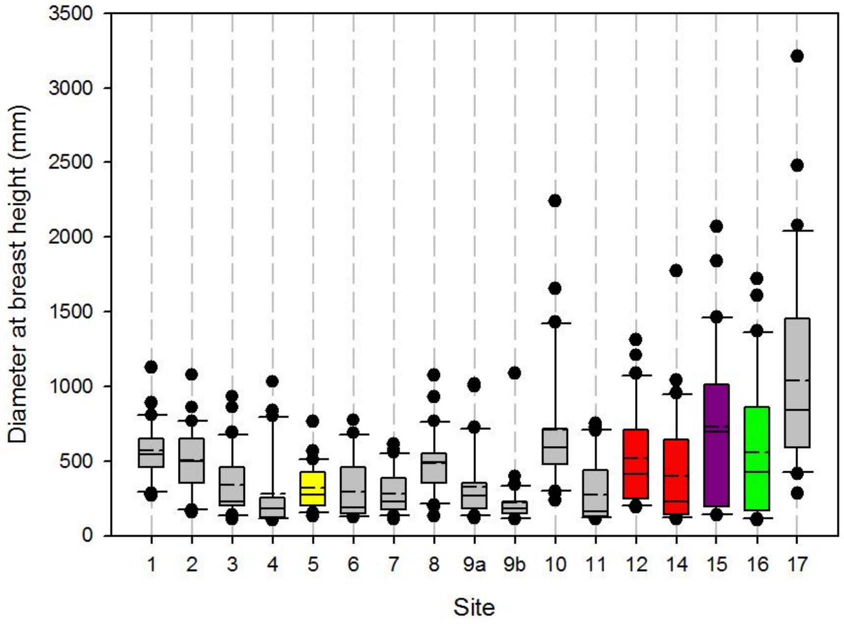

Figure 2.4. Box and whisker plot depicting diameter at breast height for the 17 sites assessed along the Darling Anabranch in 2011. Boxes enclose the 25th to 75th percentiles; whiskers enclose the 10th to 90th percentiles; outliers are identified by closed circles; dashed line within box plots represents the mean and the solid line represents the median. Grey boxes are sites dominated by Black Box, yellow boxes are sites co-dominated by Black Box and River Red Gum, red boxes are sites dominated by River Red Gum, purple boxes are sites co-dominated by River Red Gum and River Cooba, green boxes are sites dominated by River Cooba (refer to Table 2.1).

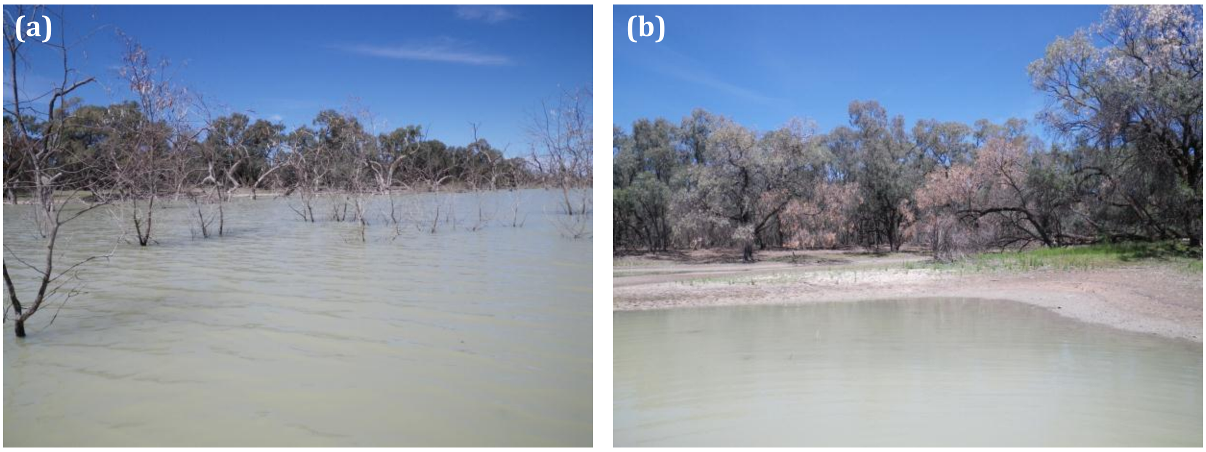

Figure 2.5. Tree die-back due to extended inundation, **(a)** River Red Gum saplings at site 6, and **(b)** mature Black Box at site 9b. Photographer: Deborah Bogenhuber, MDFRC, October 2011.

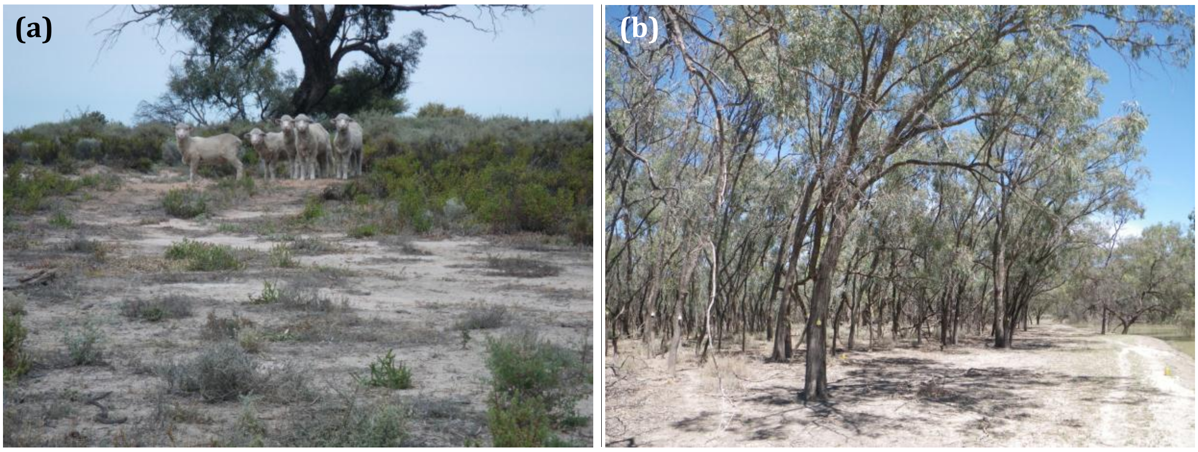

Figure 2.6. Evidence of grazing **(a)** domestic stock at site 16, **(b)** sheep tracks and grazed understorey at site 9b. Photographers: **(a)** Deborah Bogenhuber, MDFRC, October 2011, **(b)** Danielle Linklater, MDFRC, October 2011.

2.3.2. Tree condition

Tree Condition Index

Tree Condition Index (TCI) scores were calculated for each site by summing the crown extent and crown density scores, with a maximum possible score of 14. Details of crown extent and crown density scores and categories are contained within Bogenhuber et al (2011). Tree condition categories assigned for TCI scores are shown in Table 2.2. Categories are denoted within this report by **VERY GOOD**, **GOOD**, **MODERATE**, **POOR**, **VERY POOR** and **APPEARS DEAD**. Trees in moderate, poor or very poor condition are considered to be stressed.

TCI scores for sites 1 to 17 are displayed in Figure 2.7. Mean TCI at eight sites (6, 7, 9a, 10, 12, 14, 15, 16) is **GOOD**, the remaining nine sites are all in **MODERATE** condition. Sites 1 and 4 recorded the lowest mean TCI scores (7.6 for both sites; Figure 2.7). Sites 1 to 4 are notable for their lower TCI scores (Figure 2.7).

Two trees at each of sites 3 (River Cooba) and 4 (Black Box) appeared dead at the time of survey, recording TCI scores of 0. Site 7 recorded the highest TCI score (14; **VERY GOOD** condition) for an individual tree (Figure 2.7).

Across the Anabranch as a whole there was an increase in Tree Condition Index (TCI) from 2010 to 2011 (Figure 2.8). In 2011, a higher proportion of trees surveyed were in **GOOD** and **VERY GOOD** condition (19.4 and 1.2% respectively) compared with 2010 (8.1 and 0.4% respectively), and a lower proportion were in **MODERATE** or **POOR** condition (75.1 and 3.3% respectively) compared with 2010 (81 and 9% respectively; Figure 2.8).

Table 2.2. Tree Condition Index score and condition category

TCI score	Condition category
>12	very good
>10 – 12	good
>6 – 10	moderate
>4 – 6	poor
>0 – 4	very poor
0	appears dead

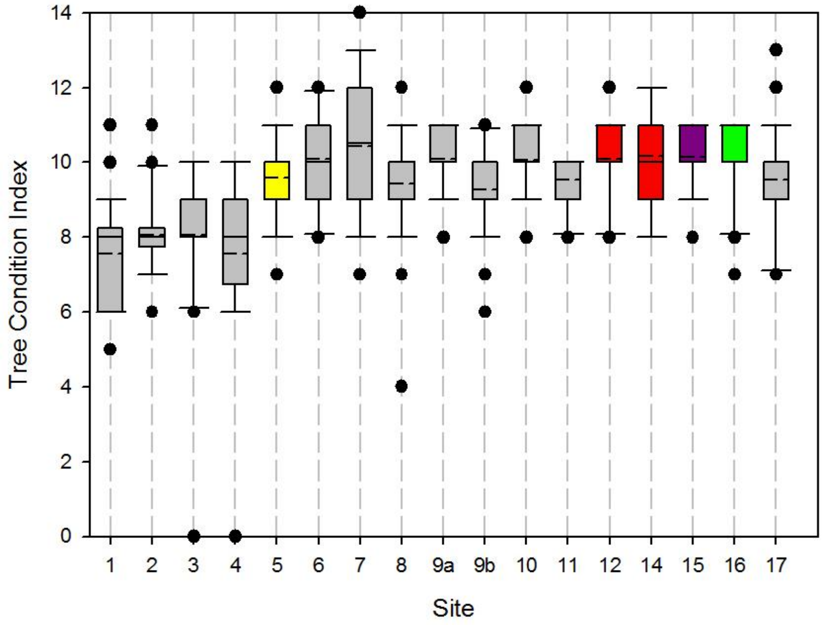

Figure 2.7. Box and whisker plot depicting Tree Condition Index for the 17 sites assessed along the Darling Anabranch in 2011. Boxes enclose the 25th to 75th percentiles; whiskers enclose the 10th to 90th percentiles; outliers are identified by closed circles; dashed line within box plots represents the mean and the solid line represents the median. Grey boxes are sites dominated by Black Box, yellow boxes are sites co-dominated by Black Box and River Red Gum, red boxes are sites dominated by River Red Gum, purple boxes are sites co-dominated by River Red Gum and River Cooba, green boxes are sites dominated by River Cooba (refer to Table 2.1).

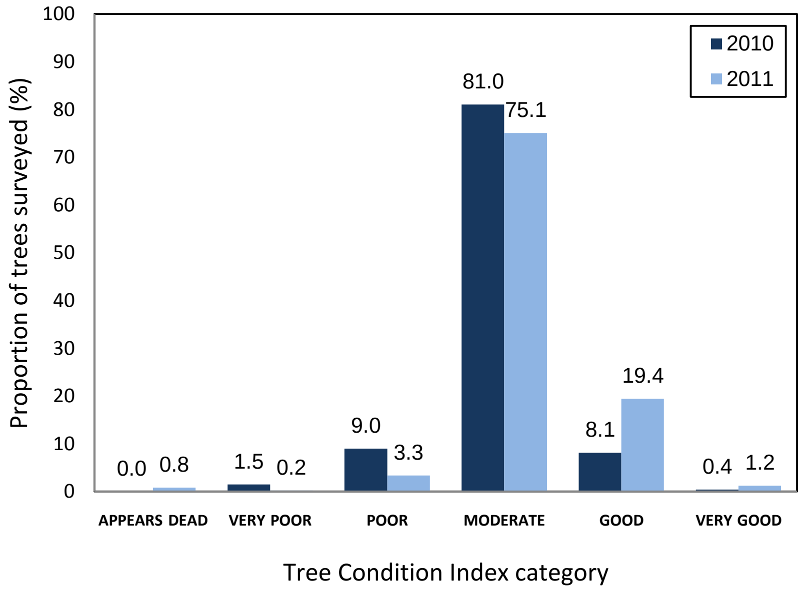

Figure 2.8. Proportion of trees surveyed along the Darling Anabranch in each Tree Condition Index category for 2010 and 2011. (Actual percentages are shown above each bar.)

Species patterns in Tree Condition Index

The three riparian tree species show distinct differences in condition. TCI scores for River Red Gum fall mostly above 10 (**GOOD**), while most Black Box and River Cooba trees recorded TCI scores less than 10 (**MODERATE**) (Figure 2.9b). River Red Gum has undergone the largest increase in tree condition from 2010 to 2011, with an increase in mean TCI from 8.78

(**MODERATE**) to 10.48 (**GOOD**) (Figure 2.9). Black Box also improved in condition, from a mean TCI of 8.41 to 9.13, remaining in the **MODERATE** category. River Cooba condition overall declined, from a mean TCI of 10.05 in 2010 (**GOOD**) to 9.38 (**MODERATE**) in 2011 (Figure 2.9).

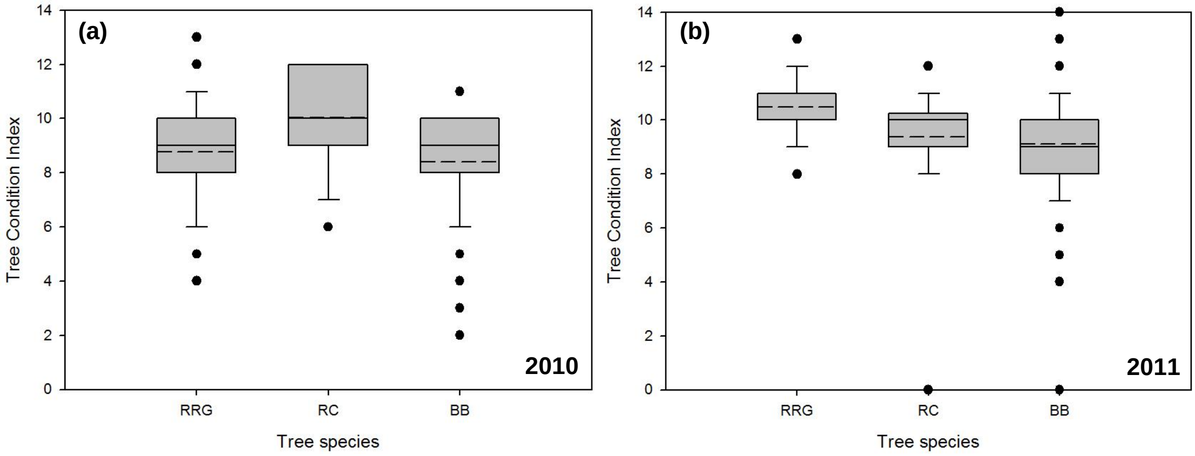

Figure 2.9. Box and whisker plot depicting Tree Condition Index of trees surveyed along the Darling Anabranch for River Red Gum (RRG), River Cooba (RC) and Black Box (BB) in **(a)** 2010 (RRG, n = 94; RC, n = 40; BB, n = 346) and **(b)** 2011 (RRG, n = 94; RC, n = 42; BB, n = 374). Boxes enclose the 25th to 75th percentiles; whiskers enclose the 10th to 90th percentiles; outliers are identified by closed circles; dashed line within box plots represents the mean and the solid line represents the median.

Bark condition

Bark condition of River Red Gum trees improved between 2010 and 2011 (mean = -0.34 and -0.14 respectively). Overall the proportion of trees recording no bark cracking increased to almost 90% of all trees surveyed, and the proportion of trees recording **SCARCE** and **COMMON** bark cracking declined to 10% overall. Across the eight sites where River Red Gum are monitored, bark condition improved at five sites (5, 7, 12, 14 and 17), remained the same at one site (15), and declined at two sites (10 and 16), which previously recorded no bark cracking.

2.3.3. Tree response

Potential trajectory

The potential trajectory (PT) of trees, that is, whether their condition is declining, improving or stable, was calculated by combining new tip and epicormic growth scores and subtracting the leaf die-off score for each tree within a site. Reproductive extent and mistletoe load have been excluded as they may be influenced by factors other than tree condition, such as season and bird populations (Wallace 2009).

PT scores for sites 1 to 17 are displayed in Figure 2.10. All sites display positive mean scores. Site 9b (Black Box) had the highest mean PT score (2.37). Sites 5, 11 and 17 had the highest PT scores (4) for individual trees (all Black Box) (Figure 2.10).

The condition of trees that have scores for positive parameters (new tip and epicormic growth) is considered likely to either increase or remain stable in the short-term. Trees that have negative scores (leaf die-off) may be expected to decrease in condition, particularly if those negative scores are not accompanied by one or more positive attributes. An analysis of this theory for trees surveyed along the Darling Anabranch over two years however shows a very poor relationship between PT scores of individual trees in 2010 and the change in tree condition (TCI scores) of the same trees from 2010 to 2011 (R^2 = 0.0034; Figure 2.11). Interpretation of PT scores in terms of predicting tree condition in the short term should therefore be made with caution. The value in using this index for interpreting tree condition along the Darling Anabranch will be examined again after the third year of monitoring.

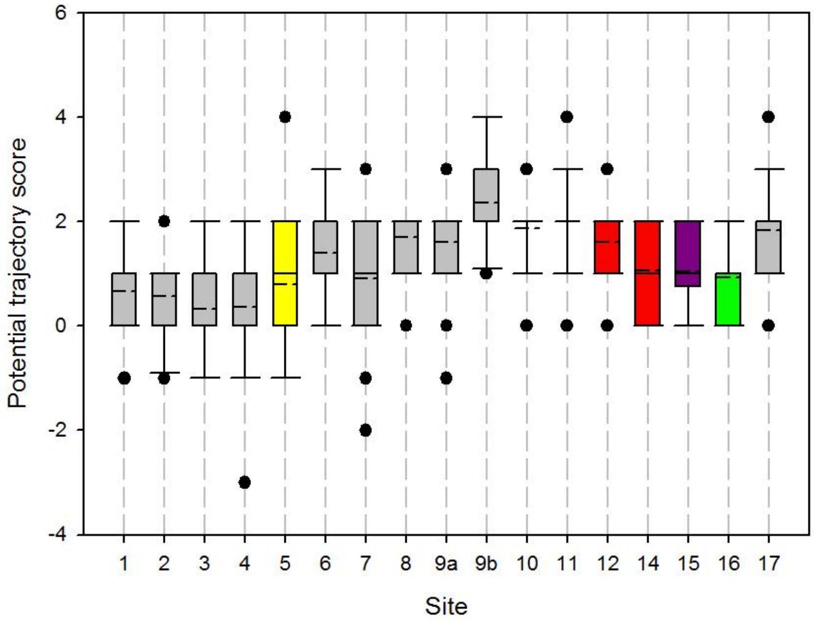

Figure 2.10. Box and whisker plot depicting potential trajectory for the 17 sites assessed along the Darling Anabranch in 2011. Boxes enclose the 25th to 75th percentiles; whiskers enclose the 10th to 90th percentiles; outliers are identified by closed circles; dashed line within box plots represents the mean and the solid line represents the median. Grey boxes are sites dominated by Black Box, yellow boxes are sites co-dominated by Black Box and River Red Gum, red boxes are sites dominated by River Red Gum, purple boxes are sites co-dominated by River Red Gum and River Cooba, green boxes are sites dominated by River Cooba (refer to Table 2.1).

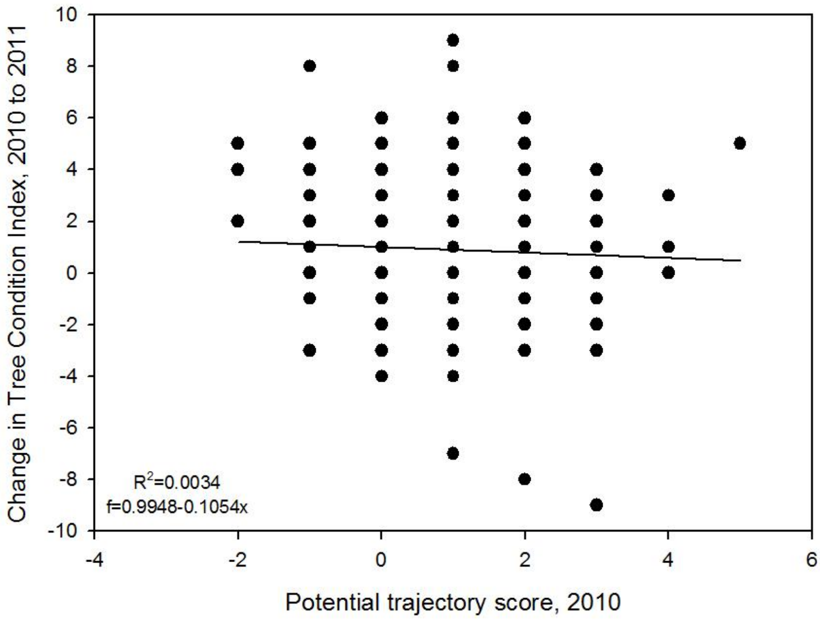

Figure 2.11. Change in Tree Condition Index from 2010 to 2011 *versus* 2010 potential trajectory score of trees surveyed along the Darling Anabranch. Regression line calculated by the formula shown (R^2 = 0.0034).

Mistletoe and reproductive extent

Mistletoe was observed at only five sites on a total of ten trees; it was recorded as **SCARCE** on eight trees and **COMMON** on two trees. Reproduction was observed at all sites on almost all trees (Figure 2.12); only 18 trees (3.5%) recorded no reproductive material out of 510 trees surveyed. Mean reproductive extent scores ranged between **SCARCE** and **COMMON** (between 1 and 2) at most sites, five sites recorded mean reproductive extent scores higher than **COMMON** (sites 1, 2, 3, 6, 7; Figure 2.12).

Reproductive extent increased considerably in 2011 compared with the 2010 surveys, particularly at sites located at, and upstream of, the Old Anabranch and Redbank Creek junction (sites 1 to 6; Figure 2.12). Only two sites decreased in average reproductive extent, site 10 near Bunnerungee Bridge, and site 17 in the influence of Murray River Lock and Weir 9 (Figure 2.12).

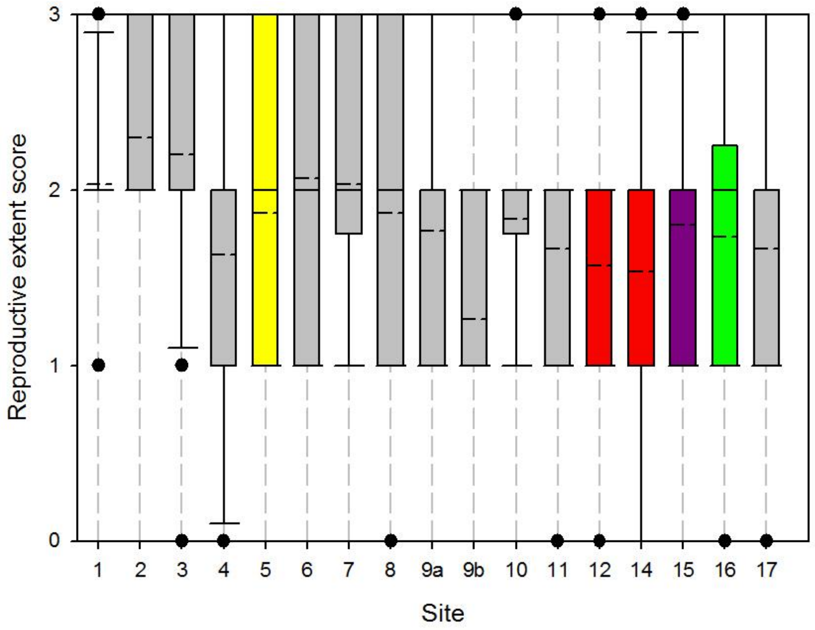

Figure 2.11. Box and whisker plot depicting reproductive extent scores for the 17 sites assessed along the Darling Anabranch in 2011. Boxes enclose the 25th to 75th percentiles; whiskers enclose the 10th to 90th percentiles; outliers are identified by closed circles; dashed line within box plots represents the mean and the solid line represents the median. Grey boxes are sites dominated by Black Box, yellow boxes are sites co-dominated by Black Box and River Red Gum, red boxes are sites dominated by River Red Gum, purple boxes are sites co-dominated by River Red Gum and River Cooba, green boxes are sites dominated by River Cooba (refer to Table 2.1).

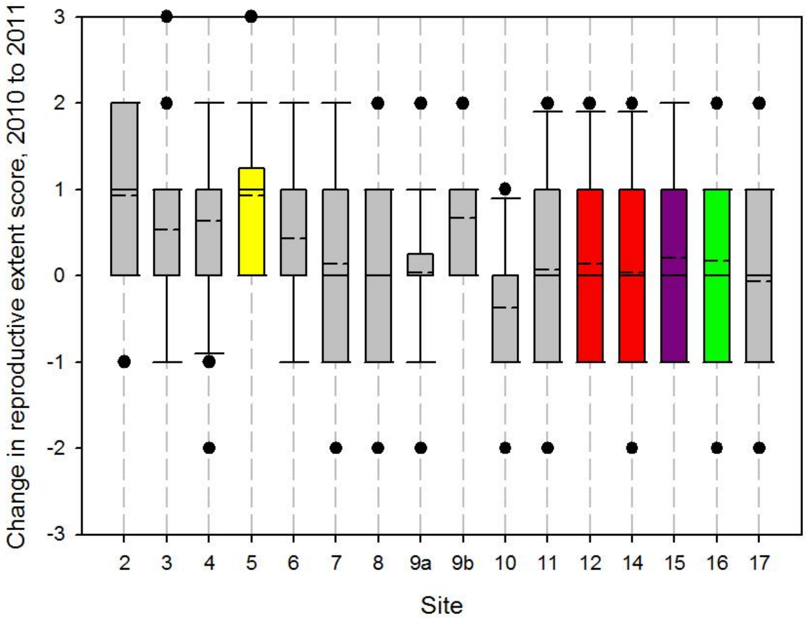

Figure 2.12. Box and whisker plot depicting change in average reproductive extent score from 2010 to 2011 for sites 2 to 17 along the Darling Anabranch. Boxes enclose the 25th to 75th percentiles; whiskers enclose the 10th to 90th percentiles; outliers are identified by closed circles; dashed line within box plots represents the mean and the solid line represents the median. Grey boxes are sites dominated by Black Box, yellow boxes are sites co-dominated by Black Box and River Red Gum, red boxes are sites dominated by River Red Gum, purple boxes are sites co-dominated by River Red Gum and River Cooba, green boxes are sites dominated by River Cooba (refer to Table 2.1).

2.3.4. Assessment of combined parameters for 2010 and 2011

Statistical analysis of all recorded tree condition and response parameters (except bark condition, which is recorded only for River Red Gum) detected a significant interaction between site and year (P = 0.0001). Pair-wise comparisons between 2010 and 2011 for each site detected significant changes in tree condition at all sites (P ≤ 0.0173) except 11, 15 and 16.

In 2011 there were significant differences in tree condition and response between most sites. Sites 3, 4, 5, 7 and 17 were significantly different from all other sites. Sites 1 and 2 were significantly different from all sites except each other; the remaining sites had some similarities among them.

Principle Component Analysis (PCA) was used to summarise patterns in condition and response variables across all sites, for 2010 and 2011 (Figure 2.13). Assessments are based on the mean score for each variable at the site scale, for each year.

A PCA is a visual representation of how similar (or different) samples are from one another. Those that are close together are more similar than those that are further apart. Variables are shown as vectors on the PCA (correlation > 0.4). The direction and length of each vector indicate its relative influence on the distribution of samples. For example, site 10 in 2010 is strongly influenced by mistletoe (Figure 2.13). The data shows that nine trees recorded mistletoe at this site in 2010 (the maximum number of trees recording mistletoe at other sites was two), abundance was **COMMON** on five trees, and **SCARCE** on the remaining four.

There is no clear grouping of sites within the PCA (Figure 2.13) however some patterns can be drawn out. Sites that recorded **GOOD** TCI scores (refer to Section 2.3.2) include 15 and 16 for both 2010 and 2011, and in 2011, sites 6, 7, 9a, 10, 12 and 14. All of these sites are located towards the top right of the PCA, influenced by crown extent and crown density (Figure 2.13). PERMANOVA results show similarities between most of these sites in 2011 with the exception of sites 7 and 12. Sites that recorded the lowest TCI scores occur towards the left of the PCA and include site 7 in 2010 and sites 1 to 4 in 2011 (Figure 2.13). The position of site 3 in 2010 reflects the relatively high occurrence of epicormic growth, which was recorded on every tree (mean score = 1.47). It is unclear what is influencing the position of site 8 in 2010 in the ordination; TCI was not particularly low, and die-off was not particularly abundant (mean = -1.03).

The Old Darling Anabranch sites (1, 2 and 3) cluster together in 2011, along with site 3 from 2010 (Figure 2.13). These sites all exhibit similar topography, channel morphology, and substrate, and have been subject to a relatively 'natural' flow regime, receiving flows from the Darling River only during times of high flow. PERMANOVA detected no significant difference between sites 1 and 2 in 2011 (P = 0.4913).

Sites 15 and 16 group tightly together for both years. These sites are in the influence of Murray River Lock and Weir 9, and are more or less permanently inundated due to regulation of the Murray River. Site 14 in 2011 is located close to this group, this site was permanently inundated between the 2010 and 2011 surveys due to a combination of high water levels in the Murray River and flows down the Darling Anabranch, and appears to be similar in tree condition and response to weir pool sites. Interestingly, site 6 in 2011 also falls into this group. Site 6, located on Tandou Creek, dried towards the end of the drought (shortly before the 2010 surveys), however it is usually inundated for most of the year to supply water to Tandou Farm for irrigation (S. Field, Tandou Farm, pers. comm.). Its position within the PCA indicates that tree condition and response is similar to that at permanently inundated weir pool sites. PERMANOVA results detected no significant differences between these sites in 2011.

The position of most sites is quite different for 2010 and 2011, with the exception of sites 15 and 16 in the Murray River Lock 9 weir pool, and site 11 (Figure 2.13). This is supported by PERMANOVA tests which found significant differences between years for all sites except 11, 15 and 16 (P = 0.0587, 0.2242 and 0.2467 respectively). Site 3 also shows little change from 2010 to 2011, although PERMANOVA results indicate that it is significant (P = 0.0173).

Site 7 shows a large shift from left (2010) to right (2011), influenced by crown extent and crown density – mean TCI at site 7 increased substantially between 2010 and 2011 from 6.93 to 10.43.

The distribution of site 10 in 2010 and 2011 is influenced by response variables including new tip growth, reproduction and mistletoe. There was an increase in leaf die-off in 2011 and a decrease in mistletoe (described above), both negative response variables. In addition, new tip growth increased in 2011, and there was a decrease in reproductive extent (both positive response variables).

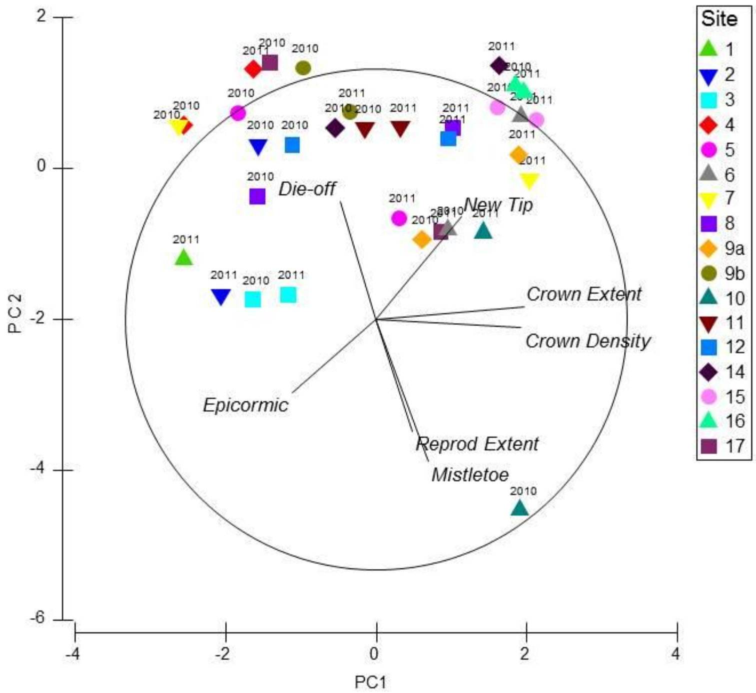

Figure 2.13. Principal Component Analysis comparing average tree condition and response across sites 1 to 17 along the Darling Anabranch in 2010 and 2011.

2.4. Discussion

Overall tree condition has improved throughout the Darling Anabranch between 2010 and 2011. This response was expected following the 2010/11 flood, and the fact that the riparian species monitored are known to respond positively to watering following an extended dry period (e.g. Akeroyd et al 1998, Roberts and Marston 2011).

The reproductive response of trees to the 2010/11 flood was consistently high across all sites. There is some suggestion that in good conditions, riparian tree species will invest energy into new growth rather than reproductive material (Jensen et al 2008a). Whilst reproductive extent was high at sites with low scores for new tip growth in 2010 and 2011, the inverse was not the case. Jensen et al (2008b) found that growth of reproductive material including buds, flowers and fruit increased for healthier River Red Gum and Black Box trees on the lower Murray River floodplain. The increase in both tree condition and reproductive extent at survey sites in 2011 support this.

Black Box

Black Box condition improved slightly in 2011, although most trees remain in the **MODERATE** category. Black Box trees can be slow to respond to flooding, due to both individual tree physiology and soil characteristics. Modelling has shown that soil hydraulic properties are a major influence on both the magnitude and timing of the response observed in Black Box trees after flooding, particularly in salt-stressed populations (Slavich et al 1999). Leaching of salts from the soil profile is severely limited on heavy clay soils (Akeroyd et al 1998). On such soils, leaching of salt may be limited to the root zone, by floodwater travelling through root channels to penetrate at deeper levels beneath the soil than in areas of bare soil (Bramley et al 2003). Jolly and Walker (1996) found that on heavy clay soils floodwaters infiltrated the soil profile around Black Box trees after flood recession. Although soil surveys indicate minimal salinisation of soils at monitoring sites along the Darling Anabranch (Cahill et al 2012), heavy clay soils have been observed at many sites and soil mapping of the region indicates the presence of compact and non-cracking clays associated with Black Box communities (Walker 1991). Detailed soil profiles taken near Stony Crossing at the entrance to Lake Nearie have classified the soil as saline non-cracking clays (DECC 2008).

Sites 1 to 4, all dominated by Black Box, recorded the lowest tree condition across the Darling Anabranch. These sites exhibit gently sloping to flat topography on heavy clay soils. It is possible that leaching of floodwaters into the soil is occurring at a slow rate and that there will be a lag in the response of Black Box trees to the 2010/11 flood.

The ability of Black Box trees to respond quickly to flooding may also be dependent upon their sapwood area, which limits leaf area and therefore capacity for transpiration (Doody et al 2009). If trees are at their maximum capacity for transpiration, a short-term response to flooding may not be observed (Bramley et al 2003). Instead energy will be invested in producing new sapwood (Doody et al 2009) and further response may occur some time after flooding. Sites 1 to 4 experienced drought conditions between 2001 and 2010 and it is reasonable to assume that trees have developed a significant level of stress, and that they possibly reached maximum transpiration rates during the 2010/11 flood. If this is so, and floodwaters continue to penetrate the soils in this part of the floodplain, we can expect an improvement in condition of Black Box at these sites during 2012 surveys.

The relatively large increase in Black Box condition at site 7 (average increase of 3.24 compared with an overall average increase of 0.86) could be due to the sandy red loam substrate and steep banks. It is likely that the floodwaters had a flushing effect through the soil, washing out accumulated salt and contributing to the dramatic improvement in tree condition. These results support findings for Black Box at Chowilla where trees on sandier soils showed improvement in the short term following flooding (Akeroyd et al 1998). In addition, new tip growth was recorded on 29 of the 30 trees in 2010 at site 7, 14 of these recorded a score of 2 (**COMMON**) and two trees recorded a score of 3 (**ABUNDANT**). These trees may therefore have already begun to improve in condition in response to higher than average rainfall, prior to flooding.

River Red Gum

River Red Gum trees showed the largest improvement in condition from 2010 to 2011, with less trees exhibiting bark cracking, and nearly half of the trees surveyed considered to be in **GOOD** or **VERY GOOD** condition in 2011. Soil salinity (EM31) surveys suggest flushing of saline groundwater and the presence of freshwater lenses at some sites following flooding (Cahill et al 2012). This may account for the improvement in River Red Gum stands, the condition of which can be predicted by depth and salinity of groundwater (Cunningham et al 2011). Further improvement in River Red Gum condition can be expected in the short-term under continuing favourable conditions.

River Cooba

In contrast to the response of River Red Gum and Black Box, River Cooba declined in condition in 2011. In 2010 nearly half of the trees surveyed were in good condition, this decreased in 2011 to less than one quarter, with a corresponding increase in **MODERATE** trees from 47.5% in 2010 to 71.4% in 2011.

Forty-two River Cooba trees were surveyed at seven of the 17 monitoring sites. At sites 8, 12 and 14 there was an increase in condition, all individual trees that improved were considered **MODERATE** in 2010. The majority of trees assessed (n = 27) occurred at sites 15 and 16 in the influence of Murray River Lock and Weir 9, 63% of which declined in condition. These sites experienced higher than average water levels for a prolonged period both before and during the 2010/11 flood, due to increased weir pool levels in the Murray River prior to the lower Darling flood. The majority of River Cooba trees surveyed at these sites occur on the edge of the channel and were inundated for an extended period (as much as one year). River Cooba is unlikely to survive continuous flooding, a maximum duration of two to three months is recommended for vigorous growth (Roberts and Marston 2011). The decline in condition is probably a response to long-term flood conditions, and condition may continue to decline if a dry period does not occur soon.

Of interest is the apparent death of two River Cooba trees assessed at site 3. In 2010 these two trees were **MODERATE**, with **ABUNDANT** epicormic growth and mistletoe recorded as **COMMON**. Many of the trees at sites 12 and 14 scored similar or lower TCI scores in 2010 and showed an improvement in condition in 2011. However, epicormic growth and mistletoe were not recorded on these latter trees. This indicates that these response variables may be important in detecting greater levels of stress in River Cooba when their initial crown condition falls in the **MODERATE** category. The greater levels of stress may be due to factors such as boring by insects or saline groundwater, which were not monitored in this project. It could be hypothesized that once River Cooba trees reach a certain level of stress (such as those monitored at site 3) they are unable to respond positively to a flood, instead the additional stress caused by a flood could result in their death. The death of stressed trees (particularly River Red Gum) after flooding has been observed in other parts of the lower Murray River (M. Henderson, MDFRC, pers. comm.; Dr T Wallace, pers. comm., referenced in Jensen et al 2008b).

Weir pool sites

There was a decline in overall tree condition at sites 15 and 16, largely due to the decline in River Cooba which are co-dominant and dominant respectively. Although River Red Gum condition increased overall, there was an increase in bark cracking at site 16, indicating higher levels of stress for these trees. Tree condition quadrats at these sites are close to the edge of the channel on gently sloping ground, and trees remained inundated for an extended period. We suggest that the decline in tree condition at these sites is due to extended inundation and that a dry phase (i.e., a lowering of the weir pool to 'normal' low flow levels) is required to prevent further decline.

Site 17, also in the influence of Murray River Lock and Weir 9, did not show the same decline in condition. This is largely because no River Cooba trees were assessed at this site – the decline in condition of this species was responsible for the overall decline in tree condition recorded at sites 15 and 16. Site 17 also differs in tree stand structure and site geomorphology, with larger and presumably older trees more widely spaced, on a steep slope. The trees within the tree condition quadrat are mostly at higher elevations than at sites 15 and 16, and therefore were not inundated for as long.

Grazing

Grazing impacts from native and exotic fauna were evident at almost all sites, with the greatest impacts from domestic stock (Figure 2.14). This is likely to have had a long term impact on the riparian community. In a study conducted along the Murrumbidgee River, River Red Gum seedlings and saplings were almost absent at sites subject to grazing, compared with densities of greater than 1000 seedlings per hectare where stock had been excluded for 50 years or more (Robertson and Rowling 2000). Areas without grazing for long periods of time also had higher tree densities, which in turn had a strong positive relationship with understorey species richness. Grazing may therefore not only impact upon riparian tree communities, but ultimately control understorey species richness (Robertson and Rowling 2000).

Indirect effects of livestock grazing include soil compaction, which can reduce infiltration of floodwaters and therefore the ability of floodplain trees to uptake water during and after a flood (Jolly and Walker 1996).

The inclusion of additional sites not subject to grazing (e.g. within Nearie Lake Nature Reserve) and/or the establishment of stock exclusion plots at current monitoring sites would allow the impact of grazing on tree condition and recruitment to be quantified.

Figure 2.14(a) Repeatedly grazed Black Box *Eucalyptus largiflorens* sapling at site 8, and **(b)** grazed *Eucalyptus* seedlings at site 12. Photographer: D. Bogenhuber, MDFRC, October 2011.

Meeting ecological objectives

The interim ecological objective for riparian tree communities along the Darling Anabranch is to maintain sustainable communities in the riparian zone. To ascertain whether this objective is being met information is required on recruitment and community structure of riparian tree species.

Previous studies (e.g. George et al 2005, Henderson et al 2011) have shown recruitment of eucalypt species on the lower Murray River floodplain to be insufficient for long-term population viability. Inadequate recruitment of Black Box in particular has been demonstrated at sites on the lower Murray River, with implications that populations are in severe decline (e.g. Henderson et al 2011, George et al 2005).

Some information collected during these surveys provides an indication of potential recruitment including the occurrence of seedlings and juveniles within understorey vegetation survey quadrats. Monitoring of in-channel regeneration is a component of the DAAMMP that has not been carried out due to the channel being inundated throughout the monitoring period. We may observe sapling regeneration once the channel becomes dry. The extent of reproductive material, monitored as part of the tree condition and response surveys, indicates potential seed production. For River Red Gum and Black Box however the amount of reproductive material does not necessarily relate to germination or recruitment. Both these species do not maintain a soil seed bank and unless suitable conditions follow seed release from the canopy and germination, recruitment does not occur (Jensen et al 2008a, Roberts and Marston 2011).

There was an increase in the number of *Eucalyptus* seedlings recorded in understorey vegetation surveys compared with 2010, with a total of 287 records. At least 137 of these were Black Box seedlings. This information alone does not indicate recruitment, and is not collected specifically to monitor recruitment of River Red Gum and Black Box. Nevertheless it will be interesting to compare 2012 understorey vegetation surveys to see whether these seedlings have recruited into the vegetation community.

It is unknown whether River Cooba forms a persistent seed bank, but it is considered unlikely (Roberts and Marston 2011). Seed longevity for this species is not known, and germination under field conditions is poorly understood (Roberts and Marston 2011). Reproductive material was present on nearly all trees surveyed in 2011, and over half recorded reproductive extent scores of 2 or 3 (**COMMON** or **ABUNDANT**), a distinct increase compared with 2010 and likely to be a response to flooding (Figure 2.15). After major floods River Cooba seedlings may be abundant along the flood line although survival is typically low (Cunningham et al 1992). This was not observed along the Darling Anabranch following the 2010/11 flood – seedlings were recorded only 20 times in understorey surveys (compared with 43 times in 2010). Recruitment following the 2010/11 flood therefore does not appear to be occurring at a level that could sustain River Cooba populations in the long term.

Limitations on recruitment are not well understood (Roberts and Marston 2011). Environmental watering may be achieving results in the short term with regards to increases in tree condition, however without recruitment, or the knowledge of why recruitment is not occurring, the application of water may not be achieving the desired ecological objectives.

We recommend that stand condition and recruitment information be collected for the riparian tree species along the Darling Anabranch in order to determine the sustainability of these populations. This would also enable landscape scale modelling of tree condition using remote sensing, which has been carried out for The Living Murray Icon sites and proven to be an effective technique for accurately mapping stand condition across a major river system (Cunningham et al 2009). Finally, this information would lead to more confidence in setting targets for future management of environmental flows through the Darling Anabranch.

Figure 2.15. (a) River Cooba *Acacia stenophylla* trees at site 8 with abundant seed pods present, **(b)** close-up image of seed pods. Photographer: D. Bogenhuber, MDFRC, October 2011.

3. Natural organic matter load

3.1. Introduction

Natural organic matter (NOM) load, including leaf litter, twigs, bark and reproductive material from riparian trees (e.g. flowers, seed capsules), is an important contributor of dissolved organic carbon and nutrients to streams (Baldwin 1999, Francis and Sheldon 2002). Carbon and nutrients fuel in-channel productivity and form the basis of aquatic food webs. Allochthonous (transported into the channel from elsewhere, e.g. from the floodplain) carbon and nutrients are believed to be an important component in the functioning of lowland river systems (Junk et al 1989). This has been confirmed by recent work at Barmah Forest (Cook et al 2011), which found that terrestrial carbon inputs were the most important source of carbon immediately after flooding, and were incorporated into both the aquatic and terrestrial food webs.

The amount of terrestrially-derived carbon inputs will be influenced by the dominant riparian species (Bogenhuber et al 2011, Brookes et al 2007), their density and condition (Wallace 2009), season (Baldwin and Mitchell 2000, Jensen et al 2008a), frequency and duration of inundation (Baldwin 1999, Briggs and Maher 1983, Glazebrook and Robertson 1999), and disturbances such as grazing (Robertson and Rowling 2000). For example, litter loadings for River Red Gum are generally higher than those for Black Box (Bogenhuber et al 2011, Wallace 2009, Brookes et al 2007).

Anabranches are particularly important sources of carbon for river systems, storing carbon during dry and low flow periods, and transporting it to the river during periods of higher flow and flood (McGinness and Arthur 2011). Monitoring of NOM for the Darling Anabranch Adaptive Management Monitoring Program (DAAMMP) provides an estimate of the potential source of carbon and nutrients for the Darling Anabranch and ultimately the lower Murray River, and estimates its distribution and abundance both temporally and spatially.

DAAMMP ecological objectives

For the context of condition monitoring, the interim objective for particulate natural organic matter loading is:

- Maintain distribution and abundance of particulate natural organic material

3.2. Methods

3.2.1. Site changes

One additional site was established in 2011, site 1, at which natural organic matter (NOM) loading was assessed. NOM loading was recorded beneath the first ten trees in the tree condition quadrat, one River Cooba and nine Black Box. For location of site 1 and all other sites established in 2010 refer to Figure 1.1 Section 1.

3.2.2. Survey methodology

NOM loading was assessed within the drip line of the first 10 trees in the tree condition quadrat at each site. All recognisable tree-derived (leaf litter, twigs, bark and reproductive material) organic material down to the soil horizon was collected from within a pseudo-randomly selected 1 m^2 quadrat. During dry conditions material was collected and weighed to the nearest gram on site. After rain events or if leaf litter was wet or damp, material was collected and air dried before weighing. The weight of NOM was given a category as per Table 3.1. Categories are denoted in this document by **VERY LOW**, **LOW**, **MODERATE**, **HIGH** and **VERY HIGH**.

Table 3.1. NOM loading categories used in the DAAMMP

Description	Weight (gm^{-2})
Very low	0-500
Low	501-1000
Moderate	1001-2000
High	2001-3000
Very high	>3001

3.2.3. Limitations

NOM loads are recorded in association with the tree beneath which the quadrat is located, and therefore with either Black Box, River Red Gum or River Cooba. The assumption is that the leaf litter directly below the crown of a particular tree is associated with that tree. This is not always the case, especially in more dense stands of trees, where several to many trees may be contributing to the leaf litter below any single tree. Nevertheless, in most instances at Darling Anabranch monitoring sites where trees occur in dense stands they are of the same species and the same age class. This reduces the risk of associating NOM loading with the wrong species or size tree.

The distribution of leaf litter may also be influenced by wind, movement of water over the soil surface, and grazing and trampling impacts.

3.3. Results

3.3.1. Results for 2011

Natural organic matter (NOM) loading for each site is displayed in Figure 3.1. In terms of mean NOM loading, the majority of sites (nine) recorded **LOW** NOM loading (categories as per Table 3.1; Figure 3.2), seven sites recorded **MODERATE** NOM, and only one site recorded **HIGH** NOM loading (site 15; Figure 3.1). Loading was variable within sites however, with seven sites recording **VERY HIGH** NOM loads in at least one of the ten 1 m^2 quadrats surveyed (Figure 3.1).

NOM loading for each of the three tree species is displayed in Figure 3.3. Median NOM loading is highest for River Red Gum and lowest for River Cooba. However, NOM loading within sites was highly variable even for the same tree species. River Cooba recorded the highest NOM load in a single quadrat (9411 gm^{-2}, site 1).

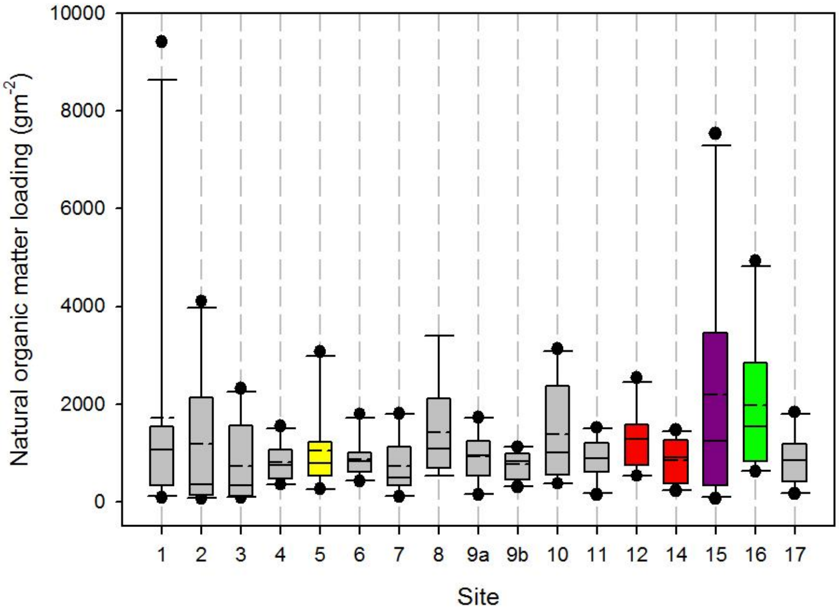

Figure 3.1. Box and whisker plot depicting natural organic matter loading for the 17 sites assessed along the Darling Anabranch in 2011. Boxes enclose the 25th to 75th percentiles; whiskers enclose the 10th to 90th percentiles; outliers are identified by closed circles; dashed line within box plots represents the mean and the solid line represents the median. Grey boxes are sites dominated by Black Box, yellow boxes are sites co-dominated by Black Box and River Red Gum, red boxes are sites dominated by River Red Gum, purple boxes are sites co-dominated by River Red Gum and River Cooba, green boxes are sites dominated by River Cooba.

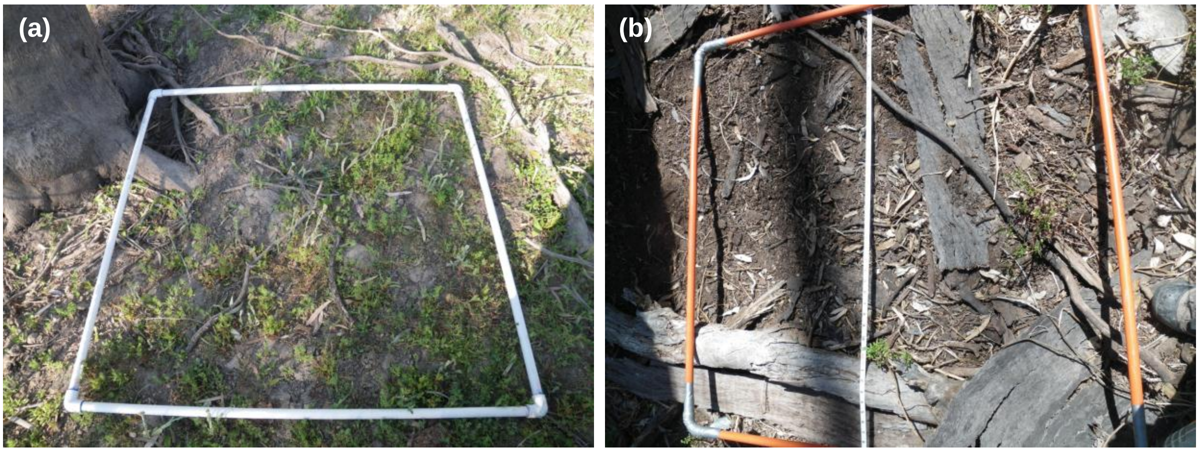

Figure 3.2. Examples of natural organic matter quadrats demonstrating LOW NOM loads **(a)** site 2, September 2011, and **(b)** site 7, October 2011. Photographer: Deborah Bogenhuber, MDFRC.

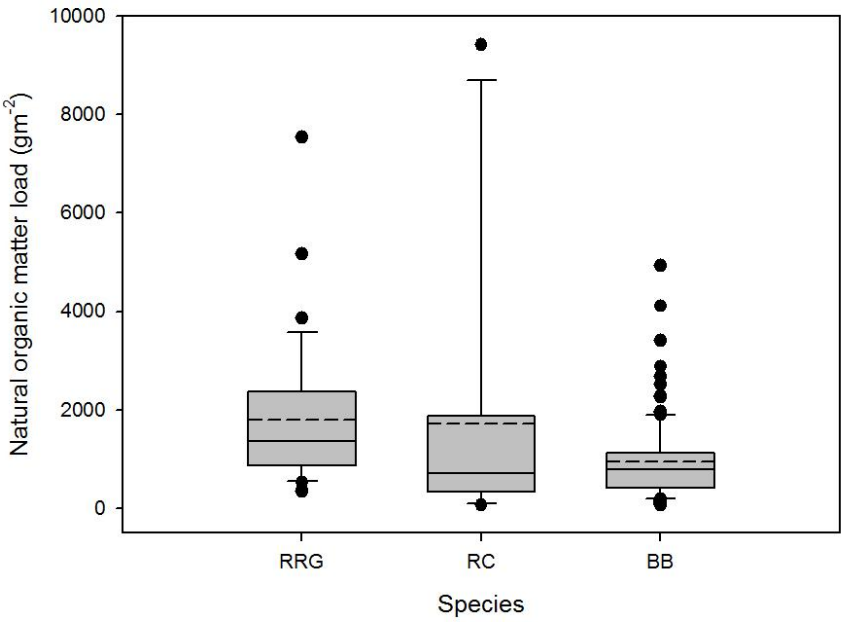

Figure 3.3. Box and whisker plot representing natural organic matter loading recorded under River Red Gum (RRG, n = 33), River Cooba (RC, n = 10) and Black Box (BB, n = 126) trees along the Darling Anabranch in 2011. Boxes enclose the 25th to 75th percentiles; whiskers enclose the 10th to 90th percentiles; outliers are identified by closed circles; dashed line within box plots represents the mean and the solid line represents the median.

Relationship between NOM and tree parameters

Figure 3.4 displays the relationship between NOM and the diameter at breast height (DBH) of trees under which each quadrat is sampled. It shows a general increase in NOM load with larger trees, particularly for River Red Gum. The River Cooba tree containing a **VERY HIGH** NOM load beneath it is large for this species (393 mm, compared to the mean and median DBH of River Cooba trees surveyed along the Darling Anabranch of 240 and 191 mm, respectively), although it remains relatively small in DBH compared with Black Box and River Red Gum.

The relationship between NOM load and Tree Condition Index (TCI) is displayed in Figure 3.5. The graph shows a relationship whereby NOM load increases with increasing TCI score, when the TCI score is between 5 and 11. NOM loads for trees that appear dead (TCI = 0) vary between **VERY LOW** and **HIGH** (Figure 3.5). These trees have declined in condition since the 2010 surveys, and those with **MODERATE** to **HIGH** NOM loads were observed to have recently dropped their leaves; field observations indicate that this occurred after flood waters receded. The trend for increasing NOM loads as TCI scores increase does not follow for trees with higher TCI scores (TCI = 12, Figure 3.5).

Interpretation of these relationships is limited by the methodology, whereby the tree beneath which NOM is collected is not always the sole source of litter. This is discussed in Section 3.2.3.

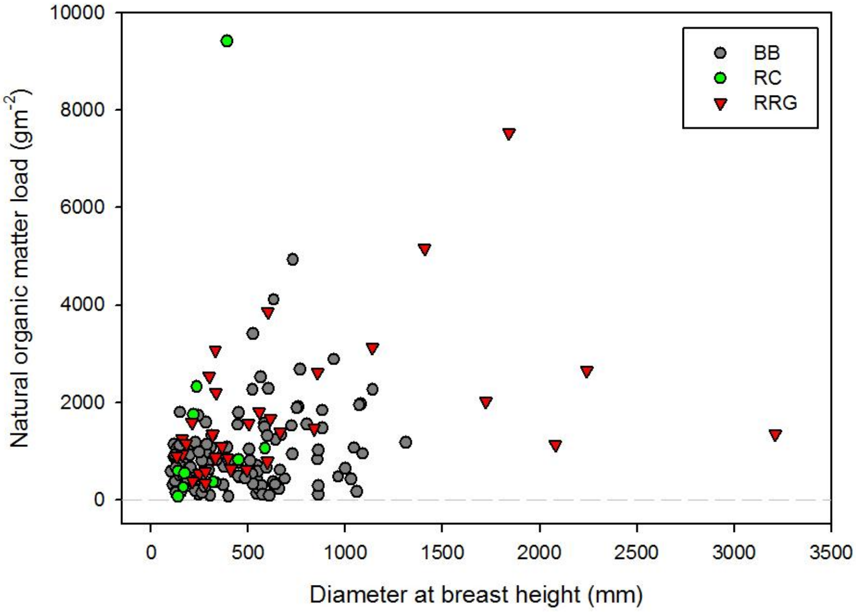

Figure 3.4. Relationship between diameter at breast height and natural organic matter load displayed for each species for sites 1 to 17 surveyed along the Darling Anabranch in 2011.

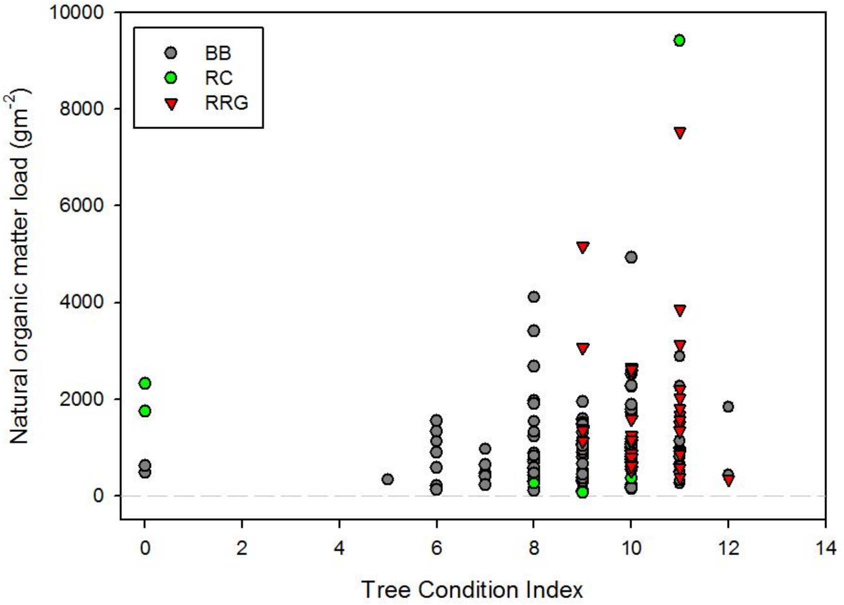

Figure 3.5. Relationship between Tree Condition Index and natural organic matter load displayed for each species for sites 1 to 17 surveyed along the Darling Anabranch in 2011.

3.3.2. Comparison of 2010 to 2011

Natural organic matter (NOM) loads were generally lower in 2011, compared with 2010 (Figure 3.6). This was particularly the case for River Red Gum, with very few quadrats under River Red Gum trees recording an increase in NOM load, and several recording large decreases with a maximum decrease of 13499 gm^{-2} at site 5 (Figure 3.6). Sites 7, 9b and 11 experienced the smallest changes in NOM loading from 2010 to 2011.

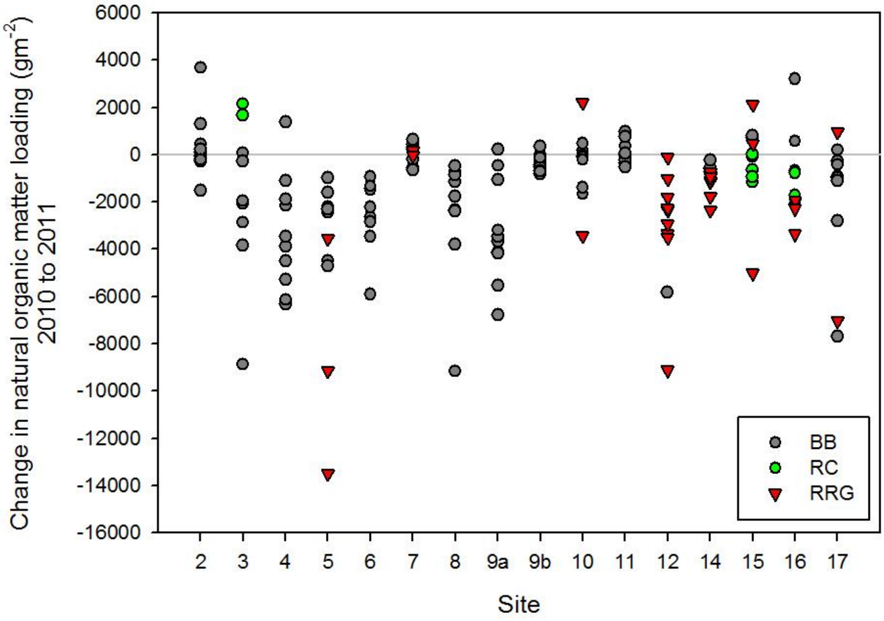

Figure 3.6. Change in natural organic matter loading from 2010 to 2011 surveyed at sites 1 to 17 along the Darling Anabranch displayed for each species.

3.4. Discussion

Trends in natural organic matter loads

Observations by MDFRC following the summer 2010/11 flood were that much of the leaf litter at the monitoring sites (especially leaves and small woody debris) had been removed from the riparian zone, the flood effectively 're-setting' this component of the floodplain (Figure 3.2). The natural organic matter (NOM) loads recorded therefore primarily represent litter fall since flood recession (beginning in May 2011), and were considerably lower than in 2010. Surveys were carried out in spring and as peak litter fall is in late spring/summer (of River Red Gum at least, Robertson et al 1999, Glazebrook and Robertson 1999, Hladyz et al 2011b, Watkins et al 2010), our NOM loadings are probably underestimates of annual litter fall. It is possible that the high level of grazing observed throughout the Darling Anabranch during the 2011 surveys contributed to the low litter levels (Muston et al 2004). Despite these factors, loadings for both River Red Gum and Black Box are comparable to elsewhere on the Murray River floodplain (Brookes et al 2007, Glazebrook and Robertson 1999, Wallace 2009, Wallace and Lenon 2010, Watkins et al 2010).

NOM loadings were higher for River Red Gum than Black Box, consistent with 2010 surveys and other studies on the lower Murray River floodplain (Bogenhuber et al 2011, Wallace 2009, Brookes et al 2007). To our knowledge there are no published estimates of River Cooba NOM loading. In this study, River Cooba loads have ranged from as little as 72 gm^{-2} to 9411 gm^{-2} (the highest NOM load for a single quadrat in 2011). The low number of River Cooba replicates (n = 10) makes interpretation of results for this species problematic.

Results of 2011 surveys support 2010 survey results indicating that NOM loads are highest for trees in **GOOD** condition, decreasing as trees become more stressed, but also decreasing for trees in **VERY GOOD** condition (Bogenhuber et al 2011). The general trend for decreasing NOM load with decreasing tree condition is inconsistent for trees that appeared dead, which recorded **HIGH** NOM loads up to 2314 gm^{-2}. Field observations for these trees suggest that they died between the 2010 and 2011 monitoring, shedding canopy foliage after floodwaters had receded.

The importance of natural organic matter

It is generally accepted that *Eucalyptus* litter is an important source of energy for lowland streams in Australia (e.g. Reid et al 2008). During floods, NOM and dissolved organic carbon (DOC) is transported from the floodplain into rivers (Tockner et al 1999), becoming the most important source of carbon (compared with autochthonous carbon, or carbon produced within the channel, which can be the major source of carbon during periods of low or no flow in streams and waterholes, e.g. Hein et al 2003, Cook et al 2011, Bunn et al 2003, Reid et al 2008). Although the effects of the flood, in terms of allochthonous carbon inputs to the main channel, may be short-lived (Gawne et al 2007), the contribution of carbon due to flooding has been estimated to be substantial (Gawne et al 2007, Robertson et al 1999).

Carbon that is released from litter material upon inundation is referred to as dissolved organic carbon (DOC). For River Red Gum litter at least, much higher levels of DOC are released from leaves than other types of litter (e.g. gum nuts, bark) (O'Connell et al 2000, Sheldon and Thoms 2006). Release of DOC occurs rapidly following inundation (Francis and Sheldon 2002, Hladyz et al 2011b) and is greater during summer (Robertson unpublished data in Robertson et al 2001). Further, fresh RRG leaves have much higher levels of bio-available DOC and phosphorus than terrestrially aged leaves (Baldwin 1999).

Several studies recently have investigated the transfer of carbon from River Red Gum leaf litter to the aquatic food web via biofilms. Biofilms consist of microorganisms such as fungi, algae and bacteria encased in a protective coating, which form on surfaces regularly in contact with water. The process of leaf litter "conditioning" refers to the formation of biofilms on the surface of the litter, which improves the digestibility and nutritional quality of allochthonous carbon (Hladyz et al 2011a). Through the use of stable isotope analysis, the source of carbon utilised by organisms higher up in the food web can be traced. Reid et al (2008) found allochthonous detritus to be the major energy source for primary consumers and animals higher in the food web including predatory macroinvertebrates, yabbies (*Cherax destructor*) and fish, utilised through associated biofilms. Cook et al (2011) also found that allochthonous carbon was incorporated into both the aquatic and terrestrial food web following flooding.

Much of the existing literature on carbon and nutrient sources for river channels concern exchange with floodplains. Some work on in-channel features, particularly within large lowland rivers, highlight their function as similar to wetlands or floodplains (Francis and Sheldon 2002, Sheldon and Thoms 2006). The ecological roles of anabranches have scarcely been investigated, in particular the exchange of carbon and nutrients between anabranches and the river (McGinness and Arthur 2011). Two studies however found that DOC concentrations in anabranch channels were much higher than in the main river channel (McGinness and Arthur 2011, McGinness et al 2002), concluding that ephemeral anabranches act as temporary storages of carbon and nutrients, which become available to the main river ecosystem during connection phases.

Meeting ecological objectives

The distribution and abundance of particulate NOM throughout the Darling Anabranch appears to be have been maintained in the short term based on 2011 results. Monitoring litter loads provides an indication of potential carbon and nutrients available for transfer to the river during a flood, which for the Darling Anabranch is probably substantial (e.g. see Wallace and Lenon 2010). The importance of NOM to the Darling Anabranch ecosystem including the aquatic and terrestrial food webs however is unknown.

Existing literature indicates that summer floods result in maximum release of DOC and phosphorus from allochthonous detritus, and subsequent transfer of carbon to both the aquatic and terrestrial food webs (e.g. Baldwin 1999). With continued flows (and potentially another overbank flood) in the Darling Anabranch in summer of 2011/12 and a likely increase in NOM loads (due to increased tree condition and projected further increases, see Section 2), there is the potential for greater productivity within the aquatic ecosystem.

However, most knowledge of carbon and nutrient transfer from terrestrial litter to the aquatic environment in the Murray-Darling Basin is from systems where River Red Gum is the dominant riparian species. The Darling Anabranch is dominated by Black Box, and the majority of allochthonous material (and therefore potential source of carbon and nutrients) is from Black Box trees (total NOM load of Black Box litter at survey sites was double that of River Red Gum litter in 2011). In addition River Cooba is a significant component of several sites monitored in this study, and no published literature exists on the contribution of River Cooba litter to river channel food webs.

Further study into the sources of carbon being utilised by the food web within the Darling Anabranch, during different stages of the hydrograph, would provide insight into the role of NOM and its importance in the Darling Anabranch ecosystem (and potentially the lower Murray River) with implications for management of future environmental flows through the system.

4. Understorey vegetation

4.1. Introduction

In naturally ephemeral systems such as the Darling Anabranch, native riparian plant species have adapted to highly variable wetting and drying cycles. Understorey plant communities in riparian zones respond rapidly to changing hydrological conditions (Blom and Voesenek 1996), at both the individual species and community level (e.g. Blom et al 1990, Blom et al 1994).

Most wetland plants including emergent macrophytes and riparian understorey herb species, germinate best in saturated soils, most common on flood recession (Roberts and Marston 2000). A study at Menindee Lakes on germination from the seed bank found that strandlines, where receding water levels have deposited organic material, supported germination and recruitment more than surrounding soil in most cases (Nicol 2004). Nicol (2004) also found that most species germinated only when soil was exposed, and not when submerged.

There is limited study into vegetation dynamics and the role of the seed bank in ephemeral systems (Nicol 2004), particularly in the Darling River system. However, observations indicate that the return of wetting and drying cycles to previously regulated, ephemeral systems tends to promote flowering, seed production, germination and recruitment of native species over exotic species (MWWG research, unpublished data). Reinstating wetting and drying cycles, after a dry period, also increases the diversity and abundance of amphibious (flood tolerant and dependent) species over drought tolerant species (Henderson et al 2010, Walters et al 2010).

Understorey surveys as part of the Darling Anabranch Adaptive Management Monitoring Program (DAAMMP) represent the most comprehensive vegetation surveys conducted along the Darling Anabranch. In 2011 monitoring sites varied in the hydrological conditions experienced in the preceding year. Sites were grouped into four categories based on recent hydrology (specifically, flood recession characteristics), described in Table 4.1 below and are denoted within this section by **NAT**, **REGS**, **REGV** and **WP**.

Table 4.1. Description of hydrology classes of sites along the Darling Anabranch, 2011.

Hydrology class	Key	Description	Sites
Natural	**NAT**	Experienced a flood followed by ‘natural’ flood recession	1 to 5
Regulated stable	**REGS**	Experienced a flood and prolonged inundation due to regulation	6 to 9a
Regulated variable	**REGV**	Experienced a flood followed by recession, regulated by 183 Dam	9b to 14
Weir pool	**WP**	Within Murray River Lock 9 weir pool (permanently inundated)	15 to 17

DAAMMP Ecological objectives

The ecological objectives for understorey vegetation are:

- Limit the extent of recognised weeds as invasive (increaser) species
- Maintain sustainable communities of flood tolerant understorey vegetation
- Maintain sustainable communities of flood dependent understorey vegetation

In this section, results of the 2011 understorey surveys are presented and discussed according to hydrology classes, and with an examination of the relationship between the understorey community and recent hydrology.

4.2. Methods

A detailed description of methods including limitations, conservation status, and use of plant names and plant identification, is contained within (Bogenhuber et al 2011).

4.2.1. Site changes

Site 1 was an additional site established in 2011, the remaining 16 sites were the same as those surveyed in 2010 (see Figure 1.1 Section 1).

Floodplain quadrats at two sites (9b and 17) were established at inconsistent elevations across the four replicate transects in 2010. At the time of survey in 2010 these elevations had experienced similarly long-dry conditions and were considered to be valid replicates. In 2011 however the flood was observed to have reached the lower of the Floodplain elevations but not the higher at both these sites. Additional Floodplain quadrats were therefore established to replicate the lower elevations; those established at higher elevations ('Floodplain high') were also surveyed to maintain regular time-series data for these quadrats.

4.2.2. Survey information

The following information was collected at each site during understorey vegetation surveys:

- Plant species present in each of 15, 1m^2 cells, at each of four elevations – In-channel, Mid-bank, Tree-line and Floodplain – of four replicate transects
- Presence of leaf litter within each 1m^2 cell when estimated to cover more than 50% of the cell area (visual estimate)
- Inundation of quadrats and approximate depth of water when inundated
- Photo points

Where plants were unable to be identified in the field, samples were collected for later identification in the laboratory using botanical keys.

4.2.3. Functional groups

Plant species were classified (following data collection) into one of 12 functional groups (Table 4.2). The classification of species is based upon that of Brock and Casanova (1997) and Reid and Quinn (2004), with the addition of the categories "F" for floating unattached species, "A" for amphibious species identified to family or genus level only, and "Uk" for unknown/unidentified species. Species not recorded by either of those studies were assigned to one of the same set of functional groups based on field observations and information in *Plants of Western New South Wales* (Cunningham et al 1992). In some circumstances species have been classified broadly (e.g. T, instead of Tdr or Tda). This has occurred for some "unknown" species, and where species were identified to genus or family level only. Species unable to be identified due to lack of plant material (e.g. a highly grazed specimen or emergent seedling) were classified as "Uk". Additional categories to Brock and Casanova's (1997) and Reid and Quinn's (2004) functional groups are indicated in Table 4.2.

Table 4.2. Plant functional groups used to classify species recorded along the Darling Anabranch

Functional group code	Functional group description
S	Submerged plants (do not tolerate drying)
F*	Floating, unattached species
AT	Amphibious: fluctuation-tolerating species – emergent species (cope with fluctuations of water presence/absence by enduring the range of water conditions without major change in morphology or growth
Ate	Species which are mostly monocotyledons (emergent plants that tolerate wetting and drying)
Atl	Species which are dicotyledons and require damp conditions (low growing plants that tolerate wetting and drying)
Atw	Amphibious (woody); flood tolerators, woody species
AR	Amphibious: fluctuation-responder species – floating species (change their growth pattern or morphology in response to the presence/absence of water)
Arf	Species which have floating leaves in their aquatic phases and also grow stranded on damp ground
Arp	Species with various growth characteristics, featuring morphological plasticity
T	Terrestrial plants
Tdr	Terrestrial: dry (terrestrial plants that typically do not tolerate flooding)
Tda	Terrestrial: damp (terrestrial plants that grow in damp places)
A*	Amphibious - species identified to family or genus level only
Uk*	Unknown – unidentified species

* Functional group categories additional to those of Brock and Casanova (1997) and Reid and Quinn (2004)

4.2.4. Data analysis

Microsoft Excel MSTM was used to generate pie graphs for visual representation of functional group data for each site and overall. Multivariate patterns in understorey vegetation community composition were analysed by both functional groups and species data for combined 2010 and 2011 data. No transformation was applied as understorey data is in the form of abundance 'scores', and not true abundances. The Bray-Curtis resemblance measure was used to generate resemblance matrices, with the addition of a dummy value to account for cells that had no species recorded (e.g. bare ground). Resemblance matrices were subjected to permutational multivariate analysis of variance (PERMANOVA) (Anderson et al 2008).

For comparisons of functional group composition between elevations, sites and years, PERMANOVA was based on a three-way design, with the factors "elevation", "site" and "year" fixed and crossed. Species composition was compared between hydrology classes and elevations for 2011 using a two-way PERMANOVA design, with the factors "site" and "elevation" fixed and crossed. Significant (higher-order) interaction effects ($P < 0.05$) were followed by simple-main effect (pair-wise) tests. Analysis was performed using 9999 permutations under a reduced model.

Non-metric multi-dimensional scaling (nMDS) was used to visualise overall differences in community composition (group- and species-wise, as above) between years, sites and elevations. For MDS displaying the relationship between elevations, data was averaged across replicates for each elevation within sites, for each year. For MDS displaying relationships among years and sites, data was averaged across sites for each year.

All multivariate analyses were repeated with sites grouped into hydrology categories (factor = "hydrology").

PERMANOVA and MDS ordinations were generated within the software package PRIMER v6 utilising the PERMANOVA+ add in (Anderson et al 2008).

For all analyses data collected from 'Floodplain high' elevations were excluded. 'Leaf litter' and 'inundation', recorded in field surveys, were also excluded from multivariate analyses.

For functional group analysis all amphibious groups (see Table 4.2 above) except Atw were combined into "A" due to the low number of species in each "A" sub-group. Atw represent the three riparian tree species and are therefore considered separately. Unknown species were grouped into the following functional groups: A, Tdr, Tda, Uk.

4.3. Results

4.3.1. Site description

The diversity and condition of the understorey community varied greatly across sites. At some sites the understorey was highly diverse with dense plant cover, dominated by terrestrial damp and amphibious species, other sites had a depauperate understorey in poor health, often associated with grazing impacts (Figure 4.1).

Photo points for 2010 and 2011 for each site are displayed in Appendix B.

Many sites were still inundated at the time of survey due to regulation. The number of quadrats inundated at each site in 2010 and 2011 are shown in Figure 4.2. Sites in the influence of Murray River Lock and Weir 9 and just upstream (12 to 17) were inundated to approximately the same level in both survey years, upstream sites (1 to 6) had less water present in 2011, and sites in the middle section of the Darling Anabranch (7 to 11) experienced much more inundation; site 9a for example had only two Floodplain quadrats above the water line (Figure 4.2).

Some leaf litter was present at all sites, although upstream of the Old Darling Anabranch-Redbank Creek junction in very low amounts (sites 1 to 6; Figure 4.3). Compared with 2010 there was substantially more leaf litter present downstream of 183 Dam (sites 9b to 17; Figure 4.3). Site 10 recorded the most leaf litter, in nearly 160 1m^2 quadrats (two thirds) and also had the biggest increase in leaf litter compared with 2010 (Figure 4.3). The largest decrease in leaf litter was at site 5 (Figure 4.3).

While many sites appeared to have responded positively to the favourable conditions prior to monitoring in 2011, others appeared to have declined in condition since 2010, at least visually (Figure 4.4, and see also Appendix B). There were also many sites that were inundated at the time of survey, with understorey quadrats submerged in some cases by more than two metres of water, resulting in no plant species being recorded in those quadrats (Figure 4.2, Figure 4.4c).

Figure 4.1(a) Diverse understorey including terrestrial damp and amphibious species, **(left)** site 16, **(right)** close-up showing Small Knotweed *Polygonum plebeium*, Blue-rod *Stemodia florulenta*, Smooth Heliotrope *Heliotropium curassavicum**, Spreading Nut-heads *Epaltes australis* and Sneezeweed *Centipeda spp.*, site 14, **(b)** selective grazing of Native Spinach *Tetragonia tetragonioides* by Black-tailed Native Hens **(left)** showing scale of grazing and **(right)** close-up, site 6, **(c)** depauperate understorey with evidence of grazing **(left)** by sheep, site 8, and **(right)** by rabbits and goats, site 7. Photographer: D. Bogenhuber, MDFRC, October/November 2011.

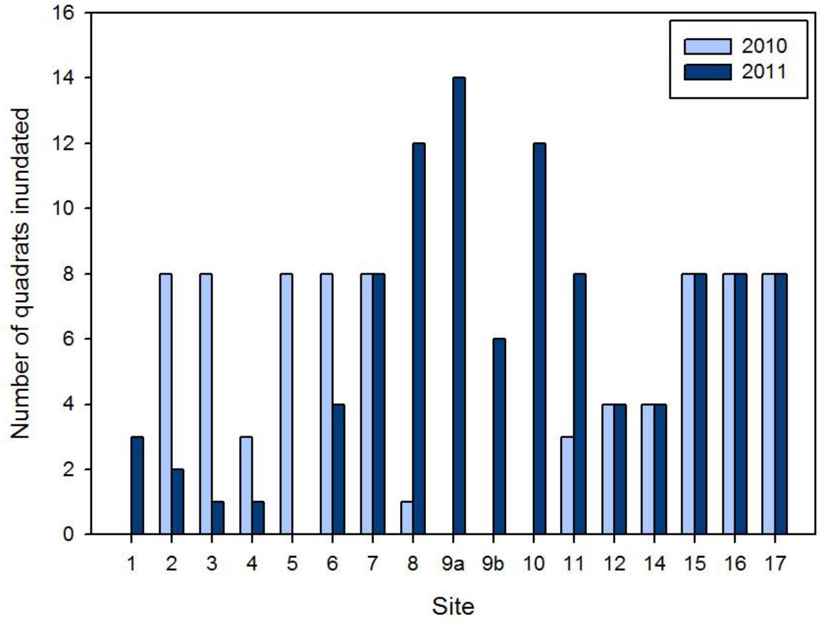

Figure 4.2. Number of 15 x 1 m quadrats inundated at sites 1 to 17 along the Darling Anabranch, 2010 and 2011.

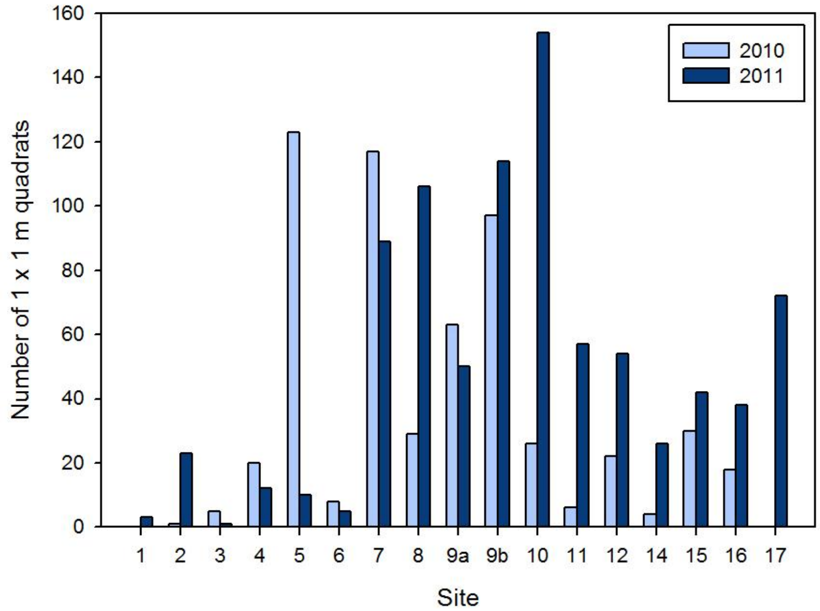

Figure 4.3. Number of 1 x 1 m quadrats containing greater than 50% leaf litter at sites 1 to 17 along the Darling Anabranch, 2010 and 2011.

Figure 4.4(a) Site 17 showing an increase in understorey cover and diversity from 2010 to 2011, **(b)** site 7 showing a dramatic decrease in understorey cover from 2010 to 2011, associated with grazing by rabbits and/or goats, **(c)** site 9a, inundated to above Tree-line quadrat elevation and recording few species relative to 2010 surveys.

4.3.2. Plant species

Species diversity

In total 168 plant species were recorded from the 17 sites surveyed along the Darling Anabranch system between September and November 2011 (refer to Appendix C for species list). This was lower than the number of species recorded in 2010 (209; Figure 4.5). There were however 25 new taxa recorded in 2011, including four amphibious species and nine terrestrial damp species (Table 4.3). Nearly half of these are exotic. This takes the total number of species recorded along the Darling Anabranch in both 2010 and 2011 to 234.

Diversity increased with increasing elevation; 27 species were recorded from In-channel elevations, 65 from Mid-bank elevations, 123 from Tree-line elevations, and the highest number of species was recorded at Floodplain elevations (144) (Figure 4.5). Compared with 2010 species diversity was much lower at Mid-bank and In-channel elevations in 2011 (Figure 4.5).

The most abundant species recorded were Sneezeweed *Centipeda spp*. (2 species, 1284 records, Figure 4.6), Jersey Cudweed *Pseudognaphalium luteoalbum* (678 records), Small Knotweed *Polygonum plebeium* (674 records) and Spreading Nut-heads *Epaltes australis* (663 records). The majority of species (approximately 68%) were recorded less than 50 times, and nearly half were recorded less than 20 times.

121 species are native (72%) and 47 are exotic (28%). No listed threatened species were recorded. Four exotic species are listed as Class 4 weeds under the *Noxious Weed Act* 1993 (NSW) for the Wentworth Shire Council control area, recorded in low abundances (Table 4.4). African Boxthorn *Lycium ferocissimum**, although not recorded in survey quadrats, was noted as present at site 9b.

Table 4.5 provides a summary of the number of plant species (native and exotic) recorded within each hydrology class, and the proportion of native to exotic species at each site. The lowest diversity occurred within the **REGS** hydrology class, with relatively high diversity (55 to 60% of total species) within the other hydrology classes (Table 4.5).

Comparison of species richness across hydrology classes and elevations shows that **NAT** sites have consistently higher species richness at all elevations (Figure 4.7). The lowest species richness at all elevations is at sites in the **REGS** hydrology class (Figure 4.7). Within all hydrology classes species richness was highest at Tree-line and Floodplain elevations. Some individual quadrats recorded extremely high numbers of species, at Tree-line and Floodplain elevations in the **NAT** hydrology class, and at a Tree-line quadrat in the **REGV** hydrology class. The highest number of species (36) recorded in a single quadrat was at the Tree-line elevation in the **NAT** hydrology class (Figure 4.7). In-channel quadrats were not assessed at **WP** sites, and those assessed at **REGS** and **REGV** sites recorded 0 and 2 species respectively (Figure 4.7).

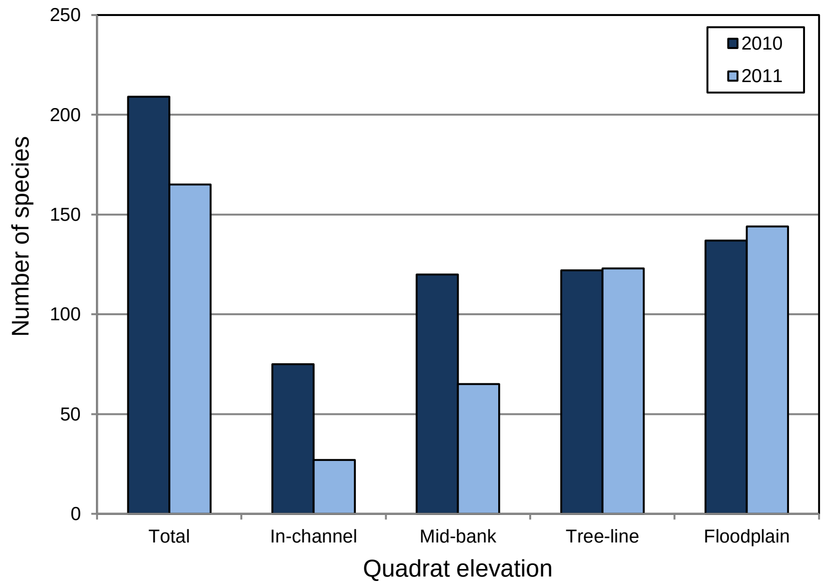

Figure 4.5. Number of species recorded in total and at each quadrat elevation at sites 1 to 17, Darling Anabranch, 2010 and 2011

Table 4.3. New species recorded from sites 1 to 17 along the Darling Anabranch in 2011. Asterisk (*) denotes an exotic species. Ate = Amphibious tolerator emergent; Atl = Amphibious tolerator low-growing; Tda = Terrestrial damp; Tdr = Terrestrial dry.

Species name	Common name	Family	Functional group	Sites found
*Alopecurus geniculatus**	Marsh Foxtail	Poaceae	Tda	2
Alternanthera nodiflora	Common Joyweed	Amaranthaceae	Tda	3,4,8,9b,11,17
*Aster subulatus**	Wild Aster	Asteraceae	Tda	11,14,15
Atriplex nummularia	Old Man Saltbush	Chenopodiaceae	Tdr	5,9b,17
Austrodanthonia setacea	Smallflower Wallaby Grass	Poaceae	Tdr	5,15
Centipeda minima subsp minima	Spreading Sneezeweed	Asteraceae	Atl	12,14,15,17
*Chenopodium murale**	Nettle-leaf Goosefoot	Chenopodiaceae	Tdr	15
Dysphania glomulifera		Chenopodiaceae	Tdr	2,4,6
Geococcus pusillus		Brassicaceae	Tda	4
*Heliotropium supinum**	Prostrate Heliotrope	Boraginaceae	Tda	1,4,5,6,12,16,17
Leiocarpa leptolepis	Pale Plover-daisy	Asteraceae	Tdr	8,10,15
Maireana sedifolia	Pearl bluebush	Chenopodiaceae	Tdr	10
Mentha australis	River Mint	Lamiaceae	Tda	1,2,3,4,5,6
*Mesembryanthemum crystallinum**	Common Ice Plant	Aizoaceae	Tdr	16
*Nicotiana glauca**	Tree Tobacco	Solanaceae	Tdr	7,9b,12
Persicaria decipiens	Slender Knotweed	Polygonaceae	Ate	4
Persicaria lapathifolia	Pale Knotweed	Polygonaceae	Ate	5
*Polypogon monspeliensis**	Annual beardgrass	Poaceae	Tdr	15,17
Pseudoraphis spinescens	Mud Grass	Poaceae	Ate	16
*Rapistrum rugosum**	Turnip weed	Brassicaceae	Tdr	9b
Rorippa eustylis	Watercress	Brassicaceae	Tda	1,2,3,4,5,12,17
*Rosa sp.**	Rose	Rosaceae	Tdr	11
*Sonchus asper**	Prickly Sowthistle	Asteraceae	Tdr	11
*Veronica peregrina**	Wandering Speedwell	Scrophulariaceae	Tda	3,4,5,6,9b
*Xanthium occidentale**	Noogoora Burr	Asteraceae	Tda	5,6,9b,15,16

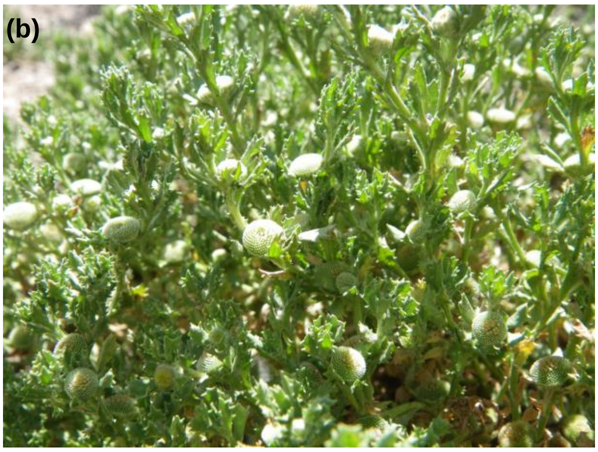

Figure 4.6. The most abundant understorey species recorded along the Darling Anabranch in 2011 condition monitoring surveys, **(a)** Spreading Sneezeweed *Centipeda minima* subsp. *minima* and **(b)** Common Sneezeweed *Centipeda cunninghamii*.

Table 4.4. Class 4 weeds listed under the *Noxious Weed Act* 1993 (NSW) recorded along the Darling Anabranch.

Species name	Common name	Family	Sites recorded	Total abundance score#
*Asphodelus fistulosus**	Onion Weed	Asphodelaceae	10, 17	16
*Lycium ferocissimum**	African Boxthorn	Solanaceae	9b	Not recorded in quadrat
*Marrubium vulgare**	White Horehound	Lamiaceae	10, 11, 17	7
*Xanthium occidentale**	Noogoora Burr	Asteraceae	5, 6, 9b, 15, 16	8

#Abundance is based upon a maximum score of 15 per 1 x 15 m quadrat

Table 4.5. Number and relative proportion of native and exotic plant species in each hydrology class, Darling Anabranch 2011.

	Native species		Exotic species		Total diversity
Hydrology class	diversity	%of total	diversity	%of total	
Natural	73	79	19	21	92
Regulated stable	44	75	15	25	59
Regulated variable	68	68	32	32	100
Weir pool	74	73	28	27	102
All sites	121		47		168

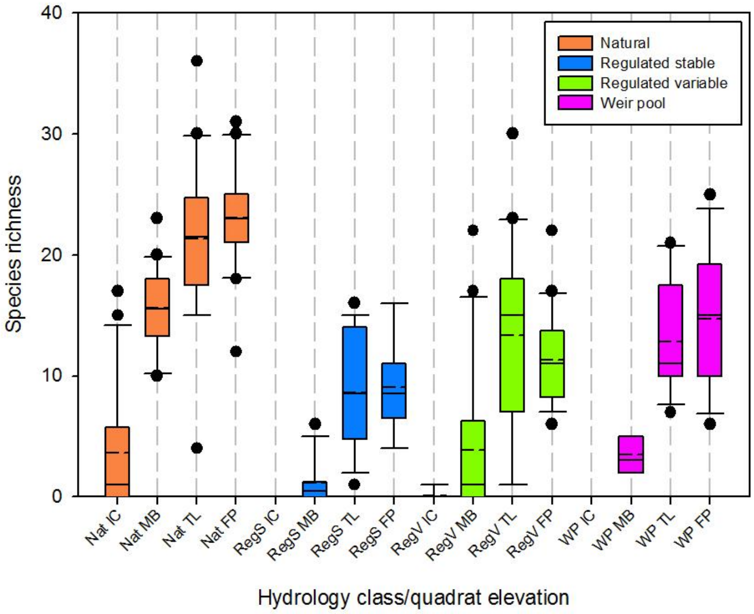

Figure 4.7. Box and whisker plot depicting species richness per quadrat (15 x 1 m) for different hydrology classes along the Darling Anabranch surveyed in 2011. Boxes enclose the 25th to 75th percentiles; whiskers enclose the 10th to 90th percentiles; outliers are identified by closed circles; dashed line within box plots represents the mean and the solid line represents the median. IC = In-channel, MB = Mid-bank, TL = Tree-line, FP = Floodplain.

Families

Plant species were recorded from 39 families, with Chenopodiaceae the most dominant in terms of number of species (Table 4.6). Asteraceae was by far the most dominant family in terms of abundance, where abundance is a measure of the presence of a species in a 1m^2 cell (i.e. a maximum abundance of 15 per quadrat) (Table 4.6).

There were less families recorded in 2011 than in 2010 (39 compared with 46). Two new families were recorded in 2011, Gentianaceae (one native species) and Rosaceae (one exotic species) (Table 4.6). This takes the total number of families recorded along the Darling Anabranch in both 2010 and 2011 to 48.

Table 4.6. Number of species and total abundance by family recorded at Darling Anabranch sites between September and November, 2010 and 2011.

Family	Number of species 2010	Number of species 2011	Abundance* 2010	Abundance* 2011	Family	Number of species 2010	Number of species 2011	Abundance# 2010	Abundance# 2011
Aizoaceae	5	6	924	433	Lamiaceae	3	3	97	262
Amaranthaceae	1	2	15	79	Lemnaceae	1	0	56	0
Apiaceae	1	1	36	9	Lythraceae	1	1	12	192
Asphodelaceae	2	2	110	17	Malvaceae	4	2	104	46
Asteraceae	41	28	1793	3972	Marsiliaceae	1	1	99	101
Boraginaceae	3	2	45	214	Myrsinaceae	1	0	2	0
Brassicaceae	6	7	735	458	Myrtaceae	2	2	132	364
Callitrichaceae	1	1	2	61	Nyctaginaceae	1	1	41	16
Campanulaceae	1	2	11	147	Onagraceae	1	1	2	23
Caryophyllaceae	4	4	292	604	Oxalidaceae	1	0	6	0
Charophyceae	1	0	1	0	Phyllanthaceae	1	1	7	1
Chenopodiaceae	43	41	4591	2393	Plantaginaceae	3	1	172	44
Convolvulaceae	3	2	66	24	Plumbaginaceae	1	1	11	2
Crassulaceae	2	2	324	164	Poaceae	20	12	1773	385
Cucurbitaceae	1	1	10	1	Polygonaceae	6	8	148	1370
Cyperaceae	2	2	109	509	Portulacaceae	1	0	62	0
Euphorbiaceae	1	1	175	62	Proteaceae	1	0	1	0
Fabaceae-Faboideae	7	7	1158	341	Ranunculaceae	2	3	245	571
Fabaceae-Mimosaceae	2	2	61	48	Rosaceae	0	1	0	1
Gentianaceae	0	1	0	442	Scrophulariaceae	3	3	66	772
Geraniaceae	1	0	1	0	Solanaceae	5	5	99	111
Goodeniaceae	3	2	128	158	Urticaceae	1	0	37	0
Haloragaceae	1	2	29	192	Verbenaceae	1	2	26	273
Juncaceae	1	2	16	45	Zygophyllaceae	3	0	66	0

#Abundance is based upon a maximum of 15 records per species per quadrat

Exotic species

Forty-seven exotic species were recorded in 2011 surveys, with a total abundance score of 2113. Both species richness and abundance were lower than in 2010 surveys, which recorded 55 species and a total abundance score of 4448. The largest decrease in exotic species richness and abundance from 2010 to 2011 occurred at In-channel and Mid-bank elevations, although substantial decreases in abundance also occurred at Tree-line and Floodplain elevations. Species richness of exotic plants remained similar at Tree-line elevations from 2010 to 2011 and increased at Floodplain elevations.

Overall exotic species made up 28% of total species identified. The proportion of exotic species at individual sites varied considerably, from 0 (sites 9a and 12) to a maximum of 35% at site 7. Eleven exotic species (23%) were recorded more than 50 times however the majority (32 species, 68 %) were recorded less than 20 times. The highest number and proportion of exotic species were recorded within the **REGV** hydrology class (Table 4.5).

The most abundant exotic species is *Spergularia rubra** (Sandspurrey, Figure 4.8a), recorded 512 times. These records are primarily from sites 1 to 4, at Mid-bank, Tree-line and Floodplain elevations. The most widespread exotic species is *Verbena supina** (Trailing Verbena, Figure 4.8b), recorded at 12 sites throughout the Anabranch system with 167 records in total.

Figure 4.8(a). The most abundant exotic species throughout the Darling Anabranch, Sandspurrey *Spergularia rubra*, **(b)** the most widespread exotic species throughout the Darling Anabranch, Trailing Verbena (*Verbena supina*). Photographer: **(a)** D. Bogenhuber, MDFRC, February 2012, **(b)** D. Bogenhuber/Maari Ma Health Aboriginal Corporation, April 2007.

4.3.3. Functional groups

The proportion of species in each functional group is displayed in Figure 4.9. The vast majority of species (at least 87%) belong to terrestrial functional groups (Figure 4.9) (refer to Section 4.2.3 for explanation of functional groups). No species belonging to the floating or submerged functional groups were recorded in 2011 surveys.

The number of functional groups recorded at different elevations within hydrology classes shows a similar pattern to species diversity, where highest diversity at each elevation occurs within the **NAT** hydrology class and lowest in the **REGS** hydrology class (Figure 4.10). Within hydrology classes, the lowest diversity of functional groups is at In-channel elevations (Figure 4.10). The highest number of functional groups in single quadrats occurred at both Tree-line and Floodplain elevations in all hydrology classes, as well as the Mid-bank elevation within the **NAT** hydrology class (Figure 4.10). Floodplain elevations have consistently lower mean functional group diversity than Tree-line elevations, presumably because amphibious species are not occurring in these quadrats.

The proportion of terrestrial dry species recorded during 2011 condition monitoring along the Darling Anabranch is only slightly lower than in 2010, despite much wetter conditions preceding the 2011 surveys (see Section 1. 3). If we look at abundance scores however, there is a substantial increase in the proportional abundance of amphibious and terrestrial damp plants compared with 2010 (Figure 4.11). The A/F/S group is almost seven times more abundant in 2011 as in 2010 and the abundance of terrestrial damp species more than tripled (Figure 4.11). These groups include the species *Centipeda cunninghamii*, *Centipeda minima* (Figure 4.6), *Pseudognaphalium luteoalbum*, *Epaltes australis* and *Polygonum plebeium* (Figure 4.12), which are among the most abundant species recorded overall (Section 4.3.2).

The Atw functional group includes the riparian tree species along the Anabranch, River Red Gum, Black Box and River Cooba. The increase in abundance for this group (Figure 4.11) is due to the large number of seedlings recorded. In 2010 abundance scores for *Eucalyptus* species seedlings combined were 70 compared with 287 in 2011. The number of River Cooba seedlings however decreased compared with 2010, from 43 records to 20 in 2011.

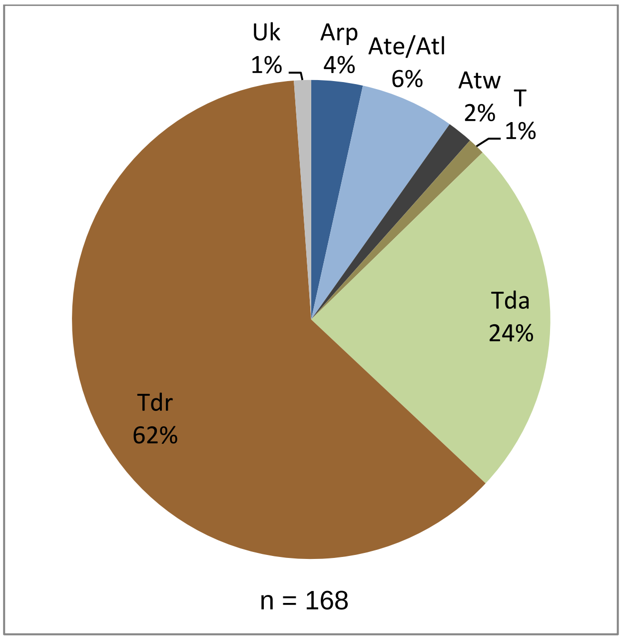

Figure 4.9. Pie chart displaying proportion of total understorey species recorded at sites 1 to 17 along the Darling Anabranch for each functional group in 2011. T = terrestrial, Tda = terrestrial damp, Tdr = terrestrial dry, Uk = Unknown, Arp = amphibious responder, Ate/Atl = amphibious tolerator emergent/low-growing, Atw = amphibious tolerator woody.

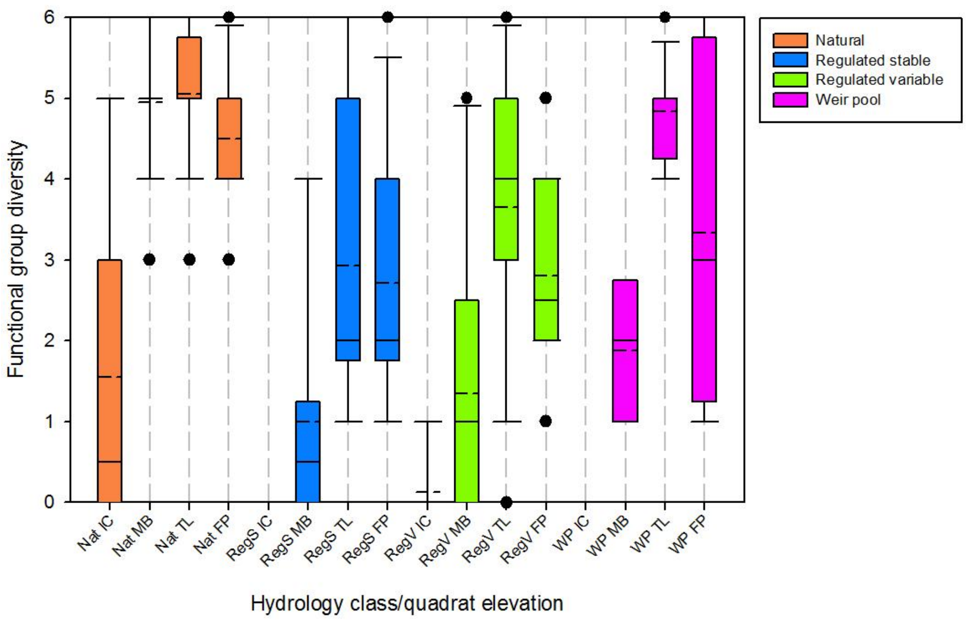

Figure 4.10. Box and whisker plot depicting functional group diversity per quadrat (15 x 1 m) for different hydrology classes along the Darling Anabranch surveyed in 2011. Boxes enclose the 25th to 75th percentiles; whiskers enclose the 10th to 90th percentiles; outliers are identified by closed circles; dashed line within box plots represents the mean and the solid line represents the median. IC = In-channel, MB = Mid-bank, TL = Tree-line, FP = Floodplain.

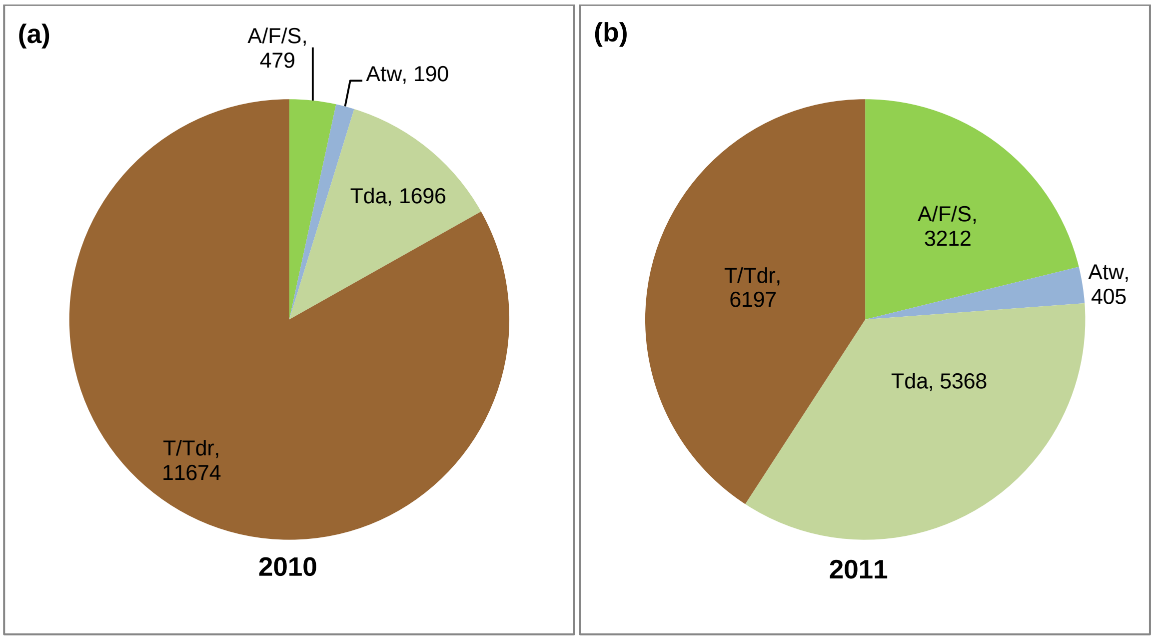

Figure 4.11. Pie chart displaying total abundance scores recorded at sites 1 to 17 along the Darling Anabranch for each functional group category in **(a)** 2010 and **(b)** 2011. Tda = terrestrial damp, T/Tdr = terrestrial/terrestrial dry, A/F/S includes all amphibious, floating and submerged functional groups except Atw (Atw = amphibious tolerator woody).

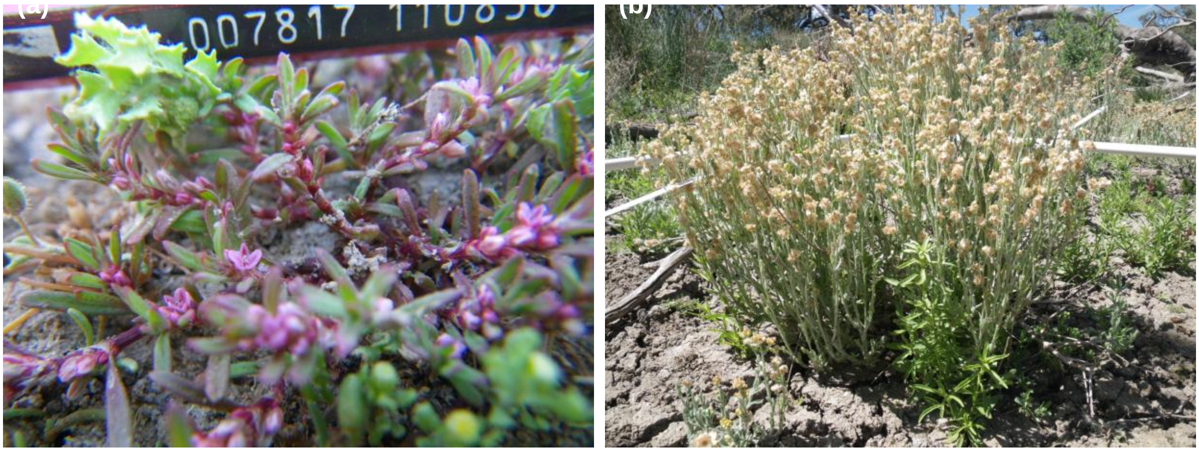

Figure 4.12. Two of the most abundant species recorded along the Anabranch in 2011, **(a)** Small Knotweed *Polygonum plebeium* and **(b)** Jersey Cudweed *Pseudognaphalium luteoalbum*.

4.3.4. Results of data analysis

Statistical analysis

For the purposes of this report results of statistical analyses are presented for hydrology classes (see Table 4.1, this section).

A three-way analysis was carried out with hydrology class (hydro), elevation and year as fixed factors. There was a significant difference in functional group composition for the hydro × elevation × year interaction term (P = 0.0001). Significant differences were also found for all lower order interactions (year × hydro; year × elevation; hydro × elevation).

SITE AND ELEVATION COMPARISONS FOR 2011

The **NAT** hydrology class was significantly different to all other hydrology classes at all elevations. The regulated classes were similar to one another at all elevations except Floodplain

(P = 0.02), and **WP** was significantly different to all other classes at all elevations except Floodplain where it was similar to the **REGV** class (P = 0.4364).

Within hydrology classes there were significant differences between all elevations for both the **REGV** and the **WP** classes. The **NAT** hydrology class had similarities between Mid-bank and Tree-line quadrat elevations (P = 0.2538), and the **REGS** class showed similarities between the Tree-line and Floodplain elevations (P = 0.4696).

SITE AND ELEVATION COMPARISONS BETWEEN 2010 AND 2011

There were significant differences between 2010 and 2011 for all hydrology class-elevation combinations, except for In-channel quadrats in the **NAT** hydrology class (P = 0.2256).

Multivariate patterns

Multi-dimensional Scaling (MDS) was used to visually summarise the patterns in species and functional group composition across hydrology classes, sites, elevations and years. MDS plots are a representation of the underlying relationships in the data, in two-dimensional space. Figure 4.13 displays the relationship in species composition between sites for 2011, displayed in hydrology classes. The vectors show the species which have the strongest influence on the position of sites in the plot. Sites 1 to 5 in the **NAT** hydrology class group together at the left of the plot, influenced by the presence and abundance of the eight species vectors directed to the left, which are primarily terrestrial damp and amphibious species (Figure 4.13); the distribution of site 6 is influenced by Spreading Nut-heads *Epaltes australis*, which was the species recorded most often at this site. Sites toward the top right of the plot (15 and 16 in particular) are influenced by the presence and abundance of Bluebush *Maireana spp* (Figure 4.13). Sites 7, 9a and to a lesser extent 10, were all species poor.

Patterns among elevations and sites are displayed in Figure 4.14, displayed by (a) elevation, and (b) hydrology class. There is a gradient in the distribution of elevations, with In-channel and a lot of the Mid-bank quadrats falling in the bottom right of the plot, Tree-line quadrats distributed centrally moving towards the top left, and Floodplain quadrats distributed in the top left (Figure 4.14a). The distribution of the Floodplain quadrats in particular is influenced by the presence and abundance of the Terrestrial dry species Ruby Saltbush *Enchylaena tomentosa* and Copperburrs *Sclerolaena spp.*, whereas the presence and abundance of the more damp-loving species Sneezeweed *Centipeda spp.*, Small Knotweed *Polygonum plebeium* and Jersey Cudweed *Pseudognaphalium luteoalbum* influence the distribution of many of the Mid-bank and Tree-line quadrats. The spread of Mid-bank quadrats can be explained by differences in recent hydrology of sites (see Table 1.1 Section 1). While some sites were almost dry (1 to 5), others were inundated above the Tree-line (e.g. 8, 9a); Mid-bank quadrats that were inundated by over 1 m of water generally recorded no plants, whereas those with damp sediments were species rich. The position of the In-channel quadrats reflects the lack of diversity found at this elevation. The many points together are quadrats that recorded no species.

Figure 4.14b displays the same information according to hydrology classes. It shows that for the **NAT** hydrology class in particular there is more similarity within this class regardless of elevation than there is between the same elevations in other hydrology classes. Site 6 stands out as being quite similar to the **NAT** sites, at least at the Tree-line and Floodplain elevations (see 4.14a).

Figure 4.15 displays the relationship of (a) functional group composition and (b) species composition, among sites for both years. The two years are clearly different, with sites in 2010 being more similar to one another than in 2011 (Figure 4.15). The vectors in Figure 4.15(a) represent the functional groups Terrestrial dry (Tdr), Terrestrial (T), Terrestrial damp (Tda), Amphibious/Floating/Submerged (A), and Amphibious tolerator woody (Atw). The presence and abundance of species within the Tdr functional group clearly has a much larger influence on sites in 2010 (Figure 4.15). Sites 1 to 6 in 2011 are strongly influenced by the presence and abundance of amphibious and terrestrial damp plants. The location of site 9a in 2011 is due to the low number of species recorded. Figure 4.15(b) shows that sites in 2011 are influenced by the presence and abundance of the following species: Jersey Cudweed *Pseudognaphalium luteoalbum*, Spreading Nut-heads *Epaltes australis*, Spike Centaury *Schenkia spicata*, Sneezeweed *Centipeda spp.* and Small Knotweed *Polygonum plebeium*. The plot suggests that the presence and/or abundance of these species was typically greater in 2011 than in 2010. In 2010 these species were not present in high numbers at any of the sites.

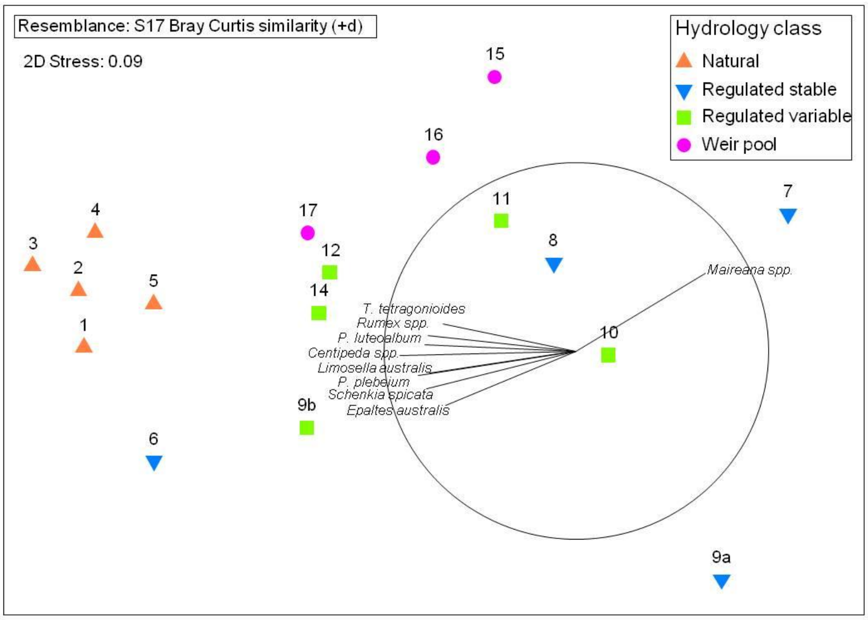

Figure 4.13. MDS plot of species composition across all sites in 2011, Darling Anabranch, displayed by hydrology class. Numbers denote sites.

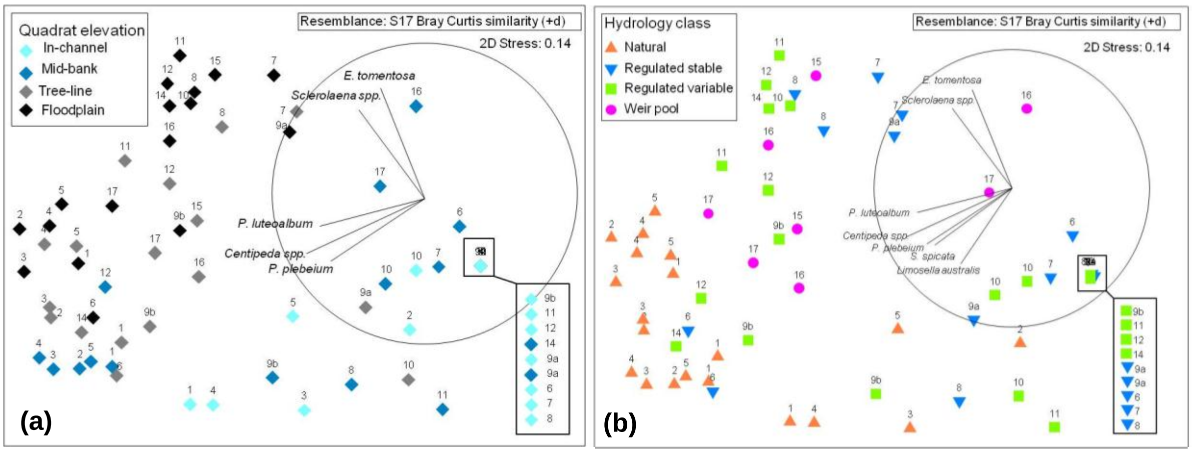

Figure 4.14. MDS plot of species composition of each elevation for sites 1 to 17 along the Darling Anabranch, 2011 **(a)** displayed by elevation, **(b)** displayed by hydrology class. Numbers denote sites.

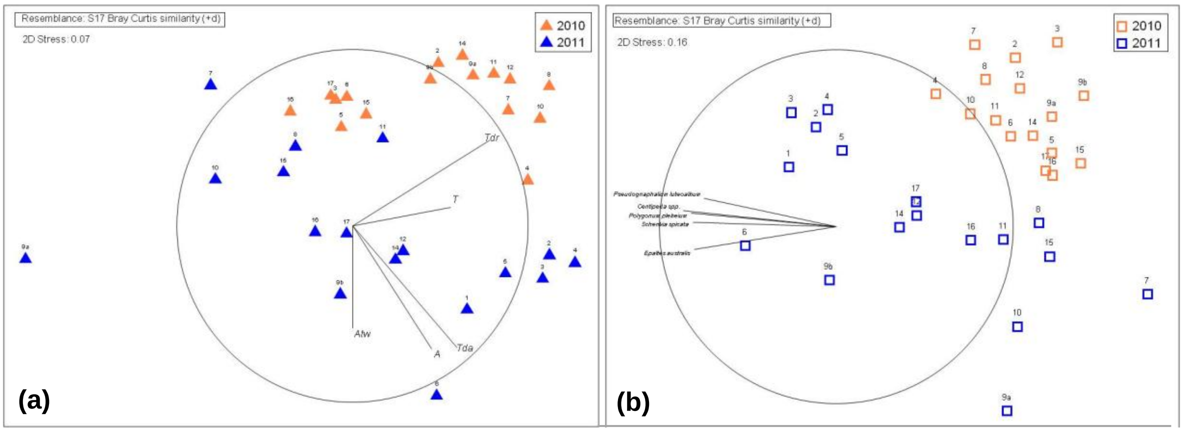

Figure 4.15. MDS plot of **(a)** functional group composition, and **(b)** species composition, across all sites and years for the Darling Anabranch. Tdr = terrestrial dry, Tda = terrestrial damp, T = terrestrial, Atw = amphibious tolerator woody, A = amphibious.

4.4. Discussion

The understorey vegetation community along the Darling Anabranch responded to the prolonged wet conditions from late 2010 up until the survey period in 2011. There was a large shift in the understorey landscape from being dominated by terrestrial dry species to one dominated by amphibious and terrestrial damp plant species. This reflects the conditions at the time of survey in 2011, with many sites having recently exposed damp sediments, following flood recession. These conditions are required for the germination and recruitment of many common plant species along the Darling Anabranch including Blue-rod *Stemodia florulenta*, Spreading Nut-heads *Epaltes australis*, Spreading Sneezeweed *Centipeda minima*, and Australian Mudwort *Limosella australis* (Nicol 2004).

Hydrological differences occurred along the Darling Anabranch, and persisted at the time of monitoring, which resulted in different plant communities being recorded in different parts of the system. The use of hydrology classes is an appropriate way of examining understorey plant community responses along the Darling Anabranch in 2011. Flooding depth, duration and frequency all affect plant community development (Casanova and Brock 2000). Casanova and Brock (2000) found that flood duration had the greatest influence on plant community composition and the findings of this project so far support this. Distinct plant communities occurred within the **NAT** hydrology class, compared with other hydrology classes which experienced longer flooding duration and lacked a 'natural' flood recession. In general, the Old Darling Anabranch region had higher species and functional group diversity, and a lower proportion of exotic species. **NAT** sites were dominated by terrestrial damp and amphibious species, recorded in high abundances, with much lower occurrences of leaf litter than other sites. **WP** sites, which experienced the least fluctuation in water levels prior to monitoring, recorded lowest abundances and with the exception of the sedge *Cyperus gymnocaulos* were dominated by terrestrial dry species and exotic species. **REGS** and **REGV** sites were also dominated by terrestrial dry species and exotic species, and recorded high levels of leaf litter.

The impact of grazing on understorey vegetation, including trampling of vegetation and herbivory, was extremely high at many sites. Much of the grazing impact was from domestic livestock (sheep, cattle) however significant effects were also evident from introduced feral species (rabbits, goats), and native species (Black-tailed Native Hens). This undoubtedly influenced the results of vegetation surveys. Some plant species were observed in quadrats only when protected from grazing, for example by logs and shrubs, which might otherwise have been much more widespread (Figure 4.16). The effects of grazing can ultimately result in the alteration of species composition in wetlands (Crossle and Brock 2002). Species respond differently to grazing, with some species increasing reproductive output and biomass, while other species respond by decreasing reproductive output and biomass (Crossle and Brock 2002). With the long history of grazing in the Darling Anabranch region since the 1860's (Fox 1991) the plant community present today represents a community that has developed under the influence of grazing. It is reasonable to expect that the dominant species are those with adaptations to grazing including a long-lived seed bank, and that species which respond negatively to grazing, with short-lived seed banks, have already been removed from the landscape.

There was a noticeable increase in domestic stock at monitoring sites in 2011 compared with 2010, presumably due to increased feed in the riparian zone after the flood; areas of high productivity are grazed more heavily (Pickard and Norris 1994). Along the Murrumbidgee River, riparian condition was known to be higher in paddocks with lower stocking rates and where there were periods of rest from grazing (Jansen and Robertson 2001). An analysis of the relationship between grazing regimes and understorey vegetation at monitoring sites along the Darling Anabranch would be beneficial to see if the same can be said in this environment.

Figure 4.16. Herbs growing beneath the protection of logs and dead shrubs at site 12, **(a)** showing minimal plant cover in areas easier for stock to graze, and **(b)** close-up of Common Sneezeweed *Centipeda cunninghamii*.

Meeting ecological objectives

One of the ecological objectives for understorey vegetation is to limit the extent of recognised weeds as invasive species. There was a slight increase in the proportion of weed species overall in 2011, to 28%. However, the number of exotic species and their abundance decreased in 2011 and there were less than half as many records of exotic species in 2011 compared with 2010. This is in keeping with other understorey surveys throughout the Murray River from the Hume Dam to the South Australian border have recorded the proportion of exotic species ranging from 9 to 40% (Alexander et al 2008, Catford et al 2011, Henderson et al 2010, Walters et al 2010).

Observations over the first two years of condition monitoring of the Darling Anabranch indicate that exotic plant species tend to dominate in damp areas subject to disturbance such as grazing and flooding. We hypothesise that during extended dry periods native species are favoured, with exotic species colonising areas following more favourable wet conditions. Other work carried out along both the New South Wales and Victorian sides of the lower Murray River has also observed an increase in the abundance of exotic species such as Noogoora Burr *Xanthium occidentale*, Stinkwort *Dittrichia graveolens*, and Lippia *Phyla canescens* following flooding (Cherie Campbell, MDFRC, pers. comm.), at least in the short term. Implications of this are that the drying phase in naturally ephemeral systems in arid regions, such as the Darling Anabranch, are extremely important in discouraging the establishment and spread of exotic plant species.

The distribution of plant communities on floodplains and riparian zones is influenced by the composition of the seed bank and water regime (Webb et al 2006). To maintain a diverse and abundant riparian understorey community, flow regimes need to incorporate appropriate draw-down rates (Nicol 2004) that provide suitable waterlogged conditions for germination, recruitment and replenishment of the seed bank (Webb et al 2006). Results from 2011 demonstrate that meeting the ecological objectives of maintaining communities of flood tolerant and flood dependent understorey vegetation along the Darling Anabranch can be achieved with the appropriate water regime. Widespread flooding along the Darling Anabranch led to a more than three-fold increase in the abundance of terrestrial damp (Tda) plant species and almost a seven-fold increase in the abundance of amphibious (A) plant species. Understorey plant communities within the **NAT** hydrology class were dominated by terrestrial damp and amphibious species, despite the impacts of grazing. Plant communities at sites that experienced inundation throughout 2011 however were still dominated by terrestrial dry species (in quadrats above the water-line). This dominance of terrestrial dry species at inundated sites is due in part to the lack of vegetation recorded from inundated quadrats. No species were recorded in submerged or floating plant functional groups in 2011, and very few species, with low abundances, were recorded from any inundated quadrats. Most of these inundated sites (with the exception of those in the area influenced by Murray River Lock and Weir 9) will experience a draw-down, and we predict that germination following the draw-down will result in vegetation communities being dominated by amphibious and terrestrial damp species.

Of interest is the lack of submerged and to some extent amphibious emergent species recorded throughout the Darling Anabranch system, especially compared with wetlands along the Murray River. We have speculated on whether this is in fact a 'natural' phenomenon, or whether changes in land use and/or river regulation have led to the removal of these functional groups from the system. Or perhaps submerged and amphibious emergent species prefer backwater habitats such as those found around the Anabranch Lakes, which are not monitored as part of the DAAMMP. Recent surveys undertaken by NSW National Parks and Wildlife identified at least one amphibious emergent species (*Cyperus difformis*)[1] at Nearie Lake that has not been recorded along the Darling Anabranch channel (Rita Enke, pers. comm.). To our knowledge no literature exists to inform the question: were aquatic vegetation communities in inundated zones ever a major component of the vegetation community along the Darling Anabranch? It would be of interest to investigate this through a combination of historical research (e.g. landholder recollections, old photographs), seed bank trials and understorey surveys in more stable backwater habitats.

[1] Identification to be confirmed.

5. Individual Site Results

This section presents a summary of results from the second year of condition monitoring (2011) for each site. For presentation and discussion of results over both years of condition monitoring (2010-2011), and for the Darling Anabranch system as a whole, refer to Sections 2 (Tree condition and response), 3 (Natural organic matter) and 4 (Understorey vegetation).

Categories used to describe tree condition and tree response variables, and natural organic matter (NOM) loading, are listed below in Tables 5.1 to 5.3. These categories are denoted within this section by small bold capitals, for example **MODERATE** (tree condition), **SCARCE** (tree response variable), **HIGH** (NOM loading).

For details on how Tree Condition Index is calculated (Table 3.1) refer to Section 2.3.2.

Table 5.1. Tree Condition Index score and condition category.

TCI score	Condition category
>12	very good
>10 – 12	good
>6 – 10	moderate
>4 – 6	poor
>0 – 4	very poor
0	appears dead

Table 5.2. Category scale for reporting new tip growth, epicormic growth, and leaf die off (leaf die off is recorded as negative values to reflect the decline in condition).

Score	Description	Definition		
		New tip growth, epicormic growth, leaf die off	Reproductive extent	Mistletoe load
0	Absent	Effect is not visible	Reproductive material is not visible	Mistletoe is not visible
1	Scarce	Effect is present but not readily visible	Reproductive material is present but not readily visible	Mistletoe is present but not readily visible
2	Common	Effect is clearly visible	Reproductive material is clearly visible	Mistletoe is clearly visible
3	Abundant	Effect dominates the appearance of the tree	Reproductive material dominates the tree's appearance	Mistletoe dominates the tree's appearance

Table 5.3. Categories used to describe NOM loads (gm^{-2}).

Description	Minimum weight (gm^{-2})	Maximum weight (gm^{-2})
Very low	0	500
Low	501	1000
Moderate	1001	2000
High	2001	3000
Very high	>3001	

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Site 1

Site location and description

Site 1 was established 2km upstream of site 2 on the eastern boundary of Wycot Station, neighbouring Whurlie Station, on the Old Darling Anabranch. The site is characterised by grey clay soils on gentle sloping to flat topography. Black Box *Eucalyptus largiflorens* (BB) is the dominant tree species along the edge of the channel. At the time of survey shallow pools of water were present within the channel. Grazing was observed to have influenced vegetation at this site, with sheep and Black-tailed Native-hens (*Gallinula ventralis*) abundant.

Tree condition and NOM load

Species and size: 28 BB trees and two River Cooba *Acacia stenophylla* (RC) trees were assessed. DBH ranged from less than 300 mm to 1125 mm (Figure 5.2a). The mean DBH is 568 mm.

Tree Condition Variables: Both crown extent and crown density varied considerably, from less than 20 to approximately 80%; RC recorded the highest scores (Figure 5.2b). Mean percentages are 43 and 53 respectively. Mean Tree Condition Index is 7.56 (**MODERATE**).

Response Variables: New tip growth was visible on 6 of the 30 trees (mean score = 1); 28 trees supported epicormic growth (mean score = 2). Die-off was evident on 26 of the 30 trees (mean score =-1). Reproduction was **COMMON** for all 30 trees (mean score = 2).

NOM load: NOM load was **MODERATE** for most trees (mean = 1721 gm^{-2}), with the one RC NOM load substantially higher than that of BB (**VERY HIGH**, 9411 gm^{-2}) (Figure 5.3a).

Lignum condition

Mean viability and colour scores are 1 and 5, respectively ($0 < x \leq 5$; All green; Figure 5.3b).

Understorey

A total of 50 species were recorded (Table 5.4); 77% of these belong to terrestrial functional groups (FGs), and 21% belong to amphibious FGs (Figure 5.4). *Centipeda cunninghamii* (Atl) and *Epaltes australis* (Tda) were the most abundant native species with *Spergularia rubra**(Tdr) being the most abundant introduced species.

Floodplain quadrats recorded the highest abundance of native and total species (35 and 38 respectively; Table 5.4), more than double that of In-channel quadrats, which recorded 17 and 18 native and total species respectively. There was a significant difference in species composition between In-channel and Floodplain, and Mid-bank and Floodplain elevations ($P = 0.0292$ and $P = 0.0301$ respectively). No other significant differences were observed.

Figure 5.1. Photopoint for site 1, 2011. Photographer: D. Linklater, MDFRC, September 2011.

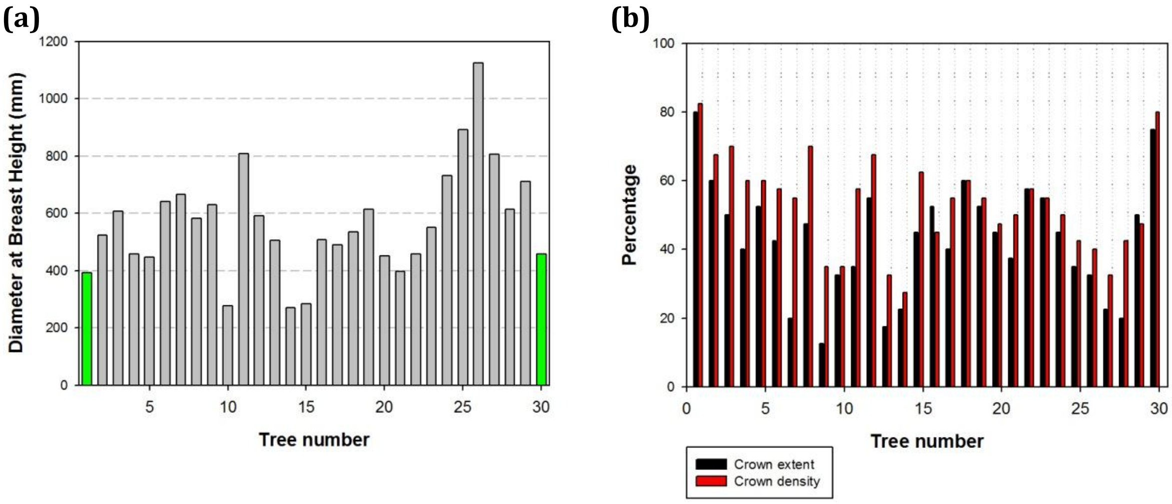


Figure 5.2(a) DBH for all trees assessed at site 1. Grey bars are Black Box, green bars are River Cooba. (b) Crown extent and crown density for all trees assessed at site 1.

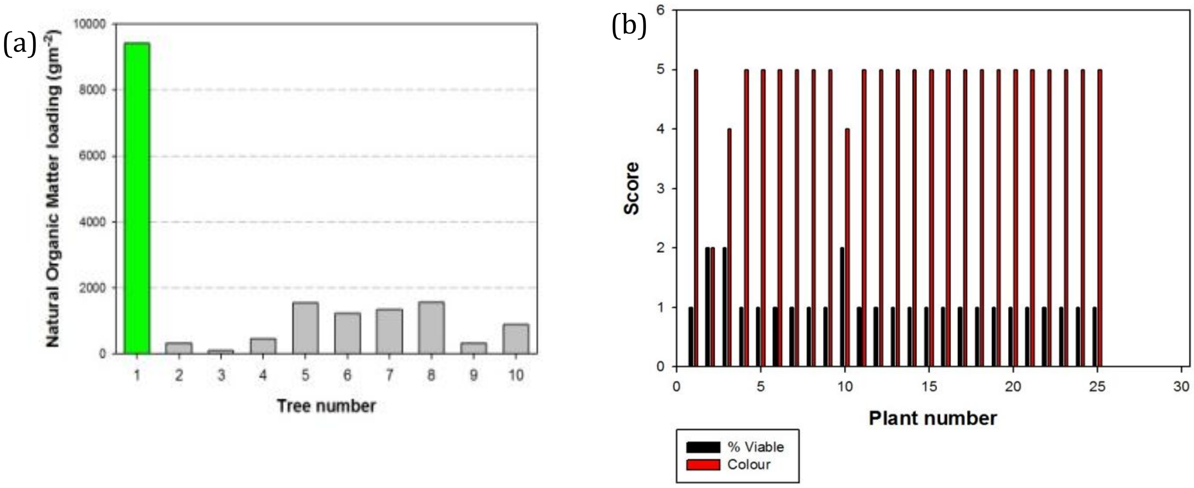


Figure 5.3(a) NOM for all trees assessed at site 1. Grey bars are Black Box, green bars are River Cooba. (b) Lignum viability and colour scores for all plants assessed at site 1.

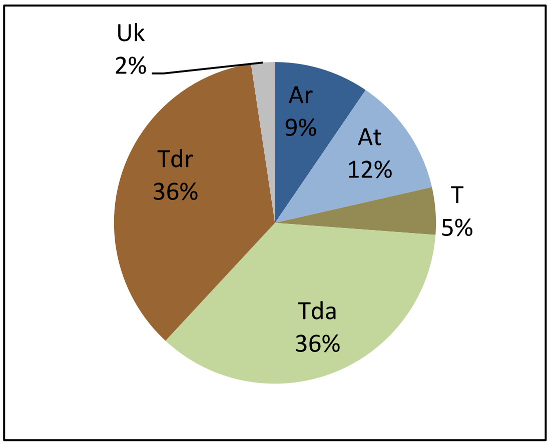


Figure 5.4. Pie chart displaying proportion of understorey plant species in broad functional groups for site 1. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; Ar=Amphibious responder; At=Amphibious tolerator.

Table 5.4. Understorey plant species diversity recorded at site 1.

Elevation	Native species	Exotic species	Total species
In-channel	17	1	18
Mid-bank	28	4	32
Tree-line	28	3	31
Floodplain	35	3	38
Total	45	5	50

Site 2

Site location and description

Site 2 is located on the south side of the Old Darling Anabranch on Wycot Station. The site is dominated by grey clay soils; the channel is narrow and anastomosing. The dominant tree species is Black Box *Eucalyptus largiflorens* (BB) with River Cooba *Acacia stenophylla* (RC) (mostly dead) present along the edge of the channel (Figure 5.5). Shallow pools of water were present within the channel at the time of survey. Grazing was observed to have influenced vegetation, sheep and Black-tailed Native-hens (*Gallinula ventralis*) were abundant at the site. Several pig wallows were observed along the banks of the channel.

Tree condition and NOM load

Species and size: All trees assessed at site 2 were BB. DBH ranged from less than 200 mm to a maximum of 1078 mm (Figure 5.6a); mean DBH is 506 mm.

Tree Condition Variables: Most trees scored between 30 and 60% for both crown extent and crown density (Figure 5.6b); mean percentages are 49% and 55% respectively. The mean Tree Condition Index (TCI) is 8 (**MODERATE**).

Response Variables: Three trees displayed new tip growth (mean score = 1) and 27 trees supported epicormic growth (mean score = 1). Die off was evident on all trees (mean score = -1). All 30 trees displayed visible signs of **COMMON** reproduction (mean score = 2).

NOM load: NOM load was **MODERATE** for most trees (mean = 1191 gm^{-2}), with one tree scoring **HIGH** and one **VERY HIGH** (Figure 5.7).

Understorey

A total of 54 understorey plant species were recorded at site 2 (Table 5.5), 83% of which belong to terrestrial functional groups (FGs), and 15% of which belong to amphibious FGs (Figure 5.8). *Centipeda* spp. (Atl) and *Epaltes australis* (Tda) were the most abundant native species with *Spergularia rubra**(Tdr) being the most abundant introduced species.

Floodplain quadrats recorded the highest abundance of native and total species (40 and 43 respectively; Table 5.5). There was a significant difference in species composition between all elevations (P ≤ 0.0326) except between Mid-bank and Tree-line.

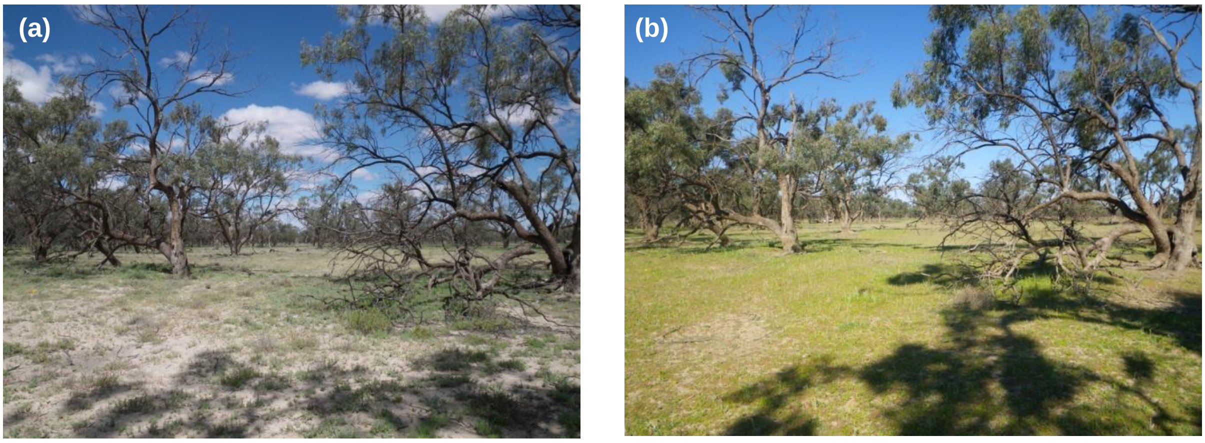


Figure 5.5. Photopoint for site 2 (a) November 2010, (b) September 2011. Photographers: (a) D. Bogenhuber, MDFRC, (b) D. Linklater, MDFRC.

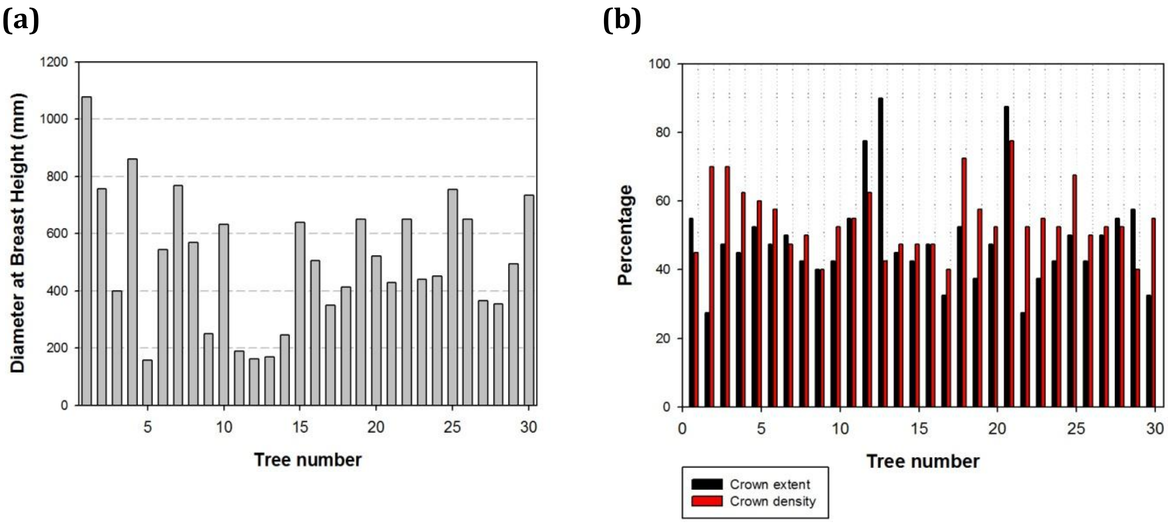


Figure 5.6(a) DBH for all trees assessed at site 2. Grey bars are Black Box. (b) Crown extent and crown density for all trees assessed at site 2.

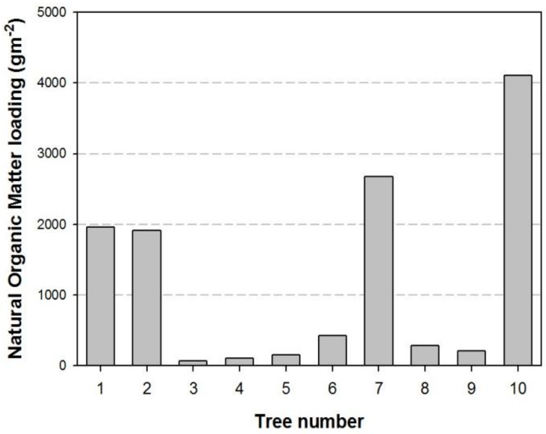


Figure 5.7. NOM for all trees assessed at site 2. Grey bars are Black Box.

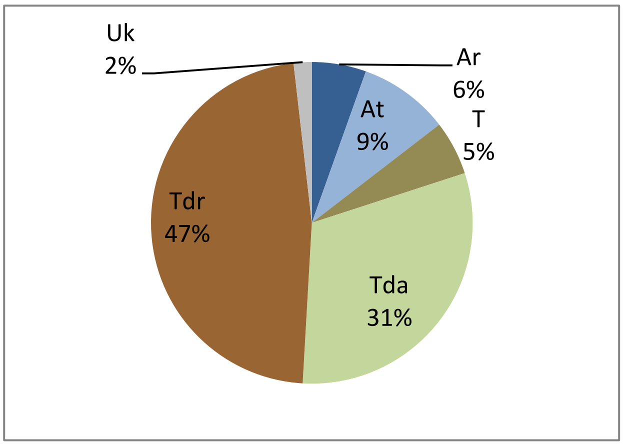


Figure 5.8. Pie chart displaying proportion of understorey plant species in broad functional groups for site 2. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; Ar=Amphibious responder; At=Amphibious tolerator.

Table 5.5. Understorey plant species diversity recorded at site 2.

Elevation	Native species	Exotic species	Total species
In-channel	3	0	3
Mid-bank	20	1	21
Tree-line	31	2	33
Floodplain	40	3	43
Total	50	4	54

Site 3

Site location and description

Site 3 is located east of the Junction Dam on the Old Darling Anabranch on Wycot Station (Figure 1.1 Section 1). The site is dominated by grey clay soils with a shallow anastomosing channel. The dominant tree species is Black Box *Eucalyptus largiflorens* (BB) with River Cooba *Acacia stenophylla* (RC) present along the edge of the channel (Figure 5.9). Shallow pools of water were present within the channel at the time of survey. Grazing was observed to have influenced vegetation at this site, sheep and Black-tailed Native-hens (*Gallinula ventralis*) were abundant. Pigs were observed at this site, with wallows present along the main channel.

Tree condition and NOM load

Species and size: 28 BB trees and two RC trees were assessed. DBH ranged from less than 200 mm to a maximum of 932 mm (Figure 5.10a). The mean DBH is 336 mm.

Tree Condition Variables: Most trees scored between 40 and 70% for both crown extent and crown density (Figure 5.10b); mean percentages are 57 and 43, respectively. The two River Coobas recorded a 0 percentage for both crown extent and crown density, appearing to have died since last year's surveys in November 2010. Mean Tree Condition Index is 8 (**MODERATE**).

Response Variables: New tip growth was visible on 4 of the 30 trees (mean score = 1), 22 of the 30 trees supported epicormic growth (mean score = 1). Die off was evident on the majority of trees (25; mean score = -1). Reproduction was **COMMON** on most trees (28; mean score = 2).

NOM load: NOM load was **VERY LOW** for most BB trees, with one scoring **MODERATE**; RC trees scored **MODERATE** and **HIGH** NOM loads (1745 and 2314 gm^{-2} respectively; Figure 5.11). Mean NOM is 725 gm^{-2}.

Understorey

A total of 62 species were recorded (Table 5.6); 80% of these belong to terrestrial functional groups (FGs), and 18% belong to amphibious FGs (Figure 5.12). *Centipeda spp.* (Atl) and *Pseudognaphalium luteoalbum* (Tda) were the most abundant native species with *Spergularia rubra** being the most abundant introduced species.

Floodplain quadrats recorded the highest abundance of native and total species (39 and 45 respectively; Table 5.6). Species diversity at In-channel elevations was low (6 species recorded Table 5.6). There were significant differences in species composition between all elevations ($P \leq 0.0293$), except between Mid-bank and Tree-line.

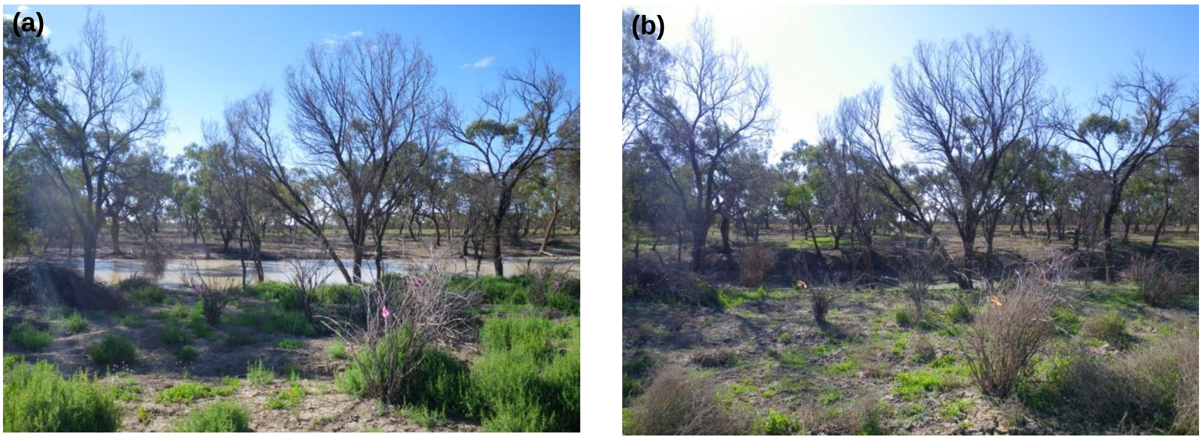


Figure 5.9. Photopoint for site 3, (a) November 2010, (b) September 2011. Photographer: D. Bogenhuber, MDFRC.

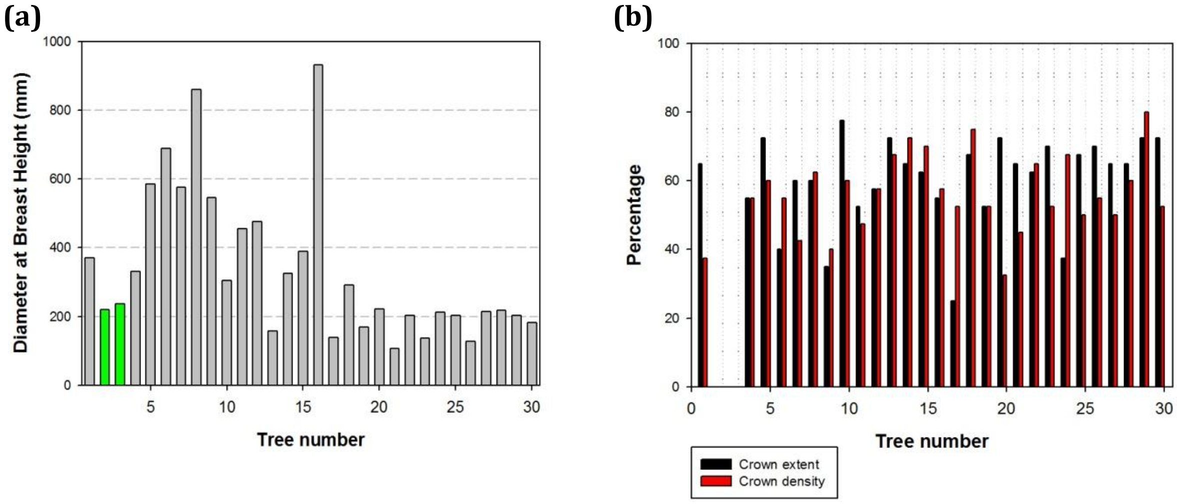


Figure 5.10(a) DBH for all trees assessed at site 3. Grey is Black Box, green is River Cooba. (b) Crown extent and crown density for all trees assessed at site 3.

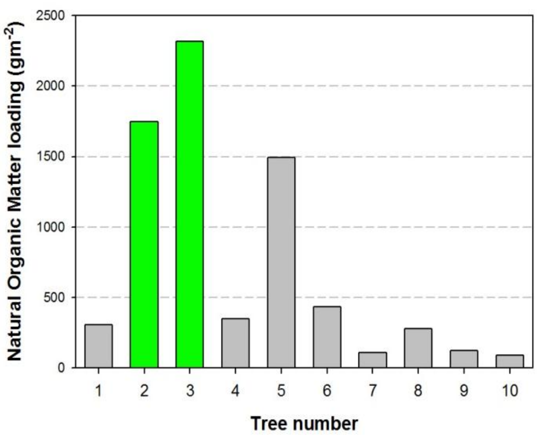


Figure 5.11. NOM for all trees assessed at site 3. Grey is Black Box, green is River Cooba.

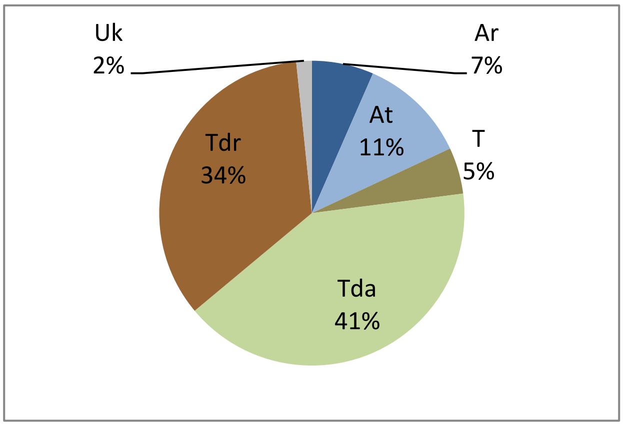


Figure 5.12. Pie chart displaying proportion of understorey plant species in broad functional groups for site 3. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.6. Understorey plant species diversity recorded at site 3.

Elevation	Native species	Exotic species	Total species
In-channel	5	1	6
Mid-bank	23	5	28
Tree-line	33	6	39
Floodplain	39	6	45
Total	53	9	62

Site 4

Site location and description

Site 4 is located on Redbank Creek, just upstream of Junction Dam on Wycot Station. The site is dominated by grey clay soils; the channel is wide and relatively shallow (Figure 5.13). Black Box *Eucalyptus largiflorens* (BB) is the dominant tree species, present along the edge of the channel. Shallow pools of water were present within the channel at the time of survey. Grazing was observed to have influenced vegetation at this site.

Tree condition and NOM load

Species and size: All trees assessed were BB. The majority of trees had a DBH of less than 200 mm, 5 trees had a DBH greater than 600 mm; maximum DBH was 1031 mm (Figure 5.14a). The mean DBH is 280 mm.

Tree Condition Variables: Both crown extent and crown density varied considerably, several trees recorded relatively high crown extent scores, with a maximum percentage of 90, two trees scored a 0 percentage for both crown extent and crown diversity, appearing to have died since 2010 surveys (Figure 5.14b). Mean Tree Condition Index is 7.56 (**MODERATE**).

Response Variables: New tip growth was visible on 19 of the 30 trees (mean score = 1); 13 trees supported epicormic growth (mean score = 1). Die-off was evident on all trees (mean score = -1). Reproduction was **COMMON** for the majority of trees (24) (mean score = 2), with 3 trees scoring **ABUNDANT** (mean score = 3).

NOM load: NOM load was **LOW** to **VERY LOW** for the majority of trees (6) (mean = 812 gm^{-2}), with 4 trees scoring **MODERATE** (Figure 5.15).

Understorey

A total of 61 species were recorded, 81% belong to terrestrial functional groups (FGs) and 17% to amphibious FGs (Figure 5.16). *Centipeda cunninghamii* (Atl) and *Ranunculus pentandrus var. platycarpus* (Tda) were the most abundant native species; *Spergularia rubra**(Tdr) was the most abundant introduced species.

Tree-line and Floodplain quadrats recorded the highest abundance of species (47 and 48 respectively; Table 5.7). There were significant differences in species composition between all elevations (P≤0.029) except between Floodplain and Tree-line.

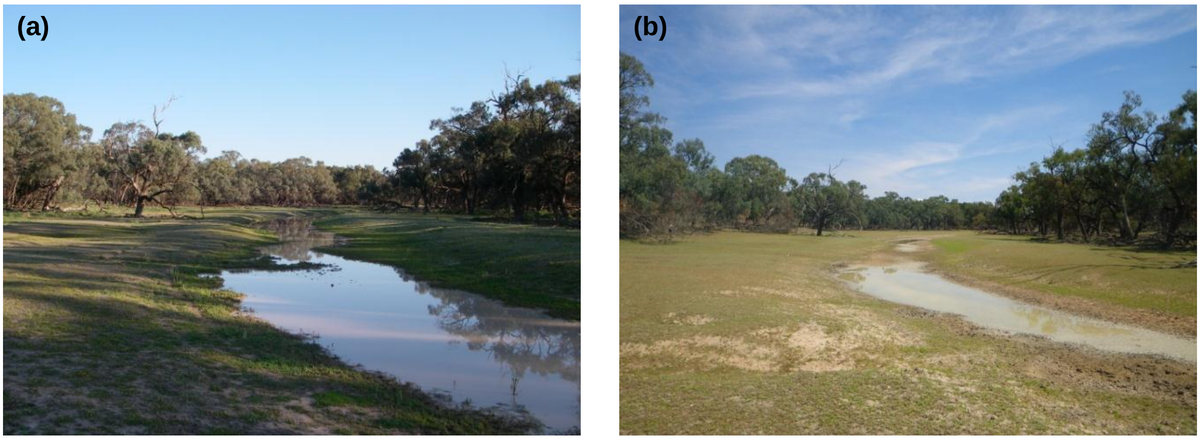


Figure 5.13. Photopoint for site 4, (a) September 2010, (b) October 2011. Photographers: (a) C. Campbell, MDFRC, (b) D. Linklater, MDFRC.

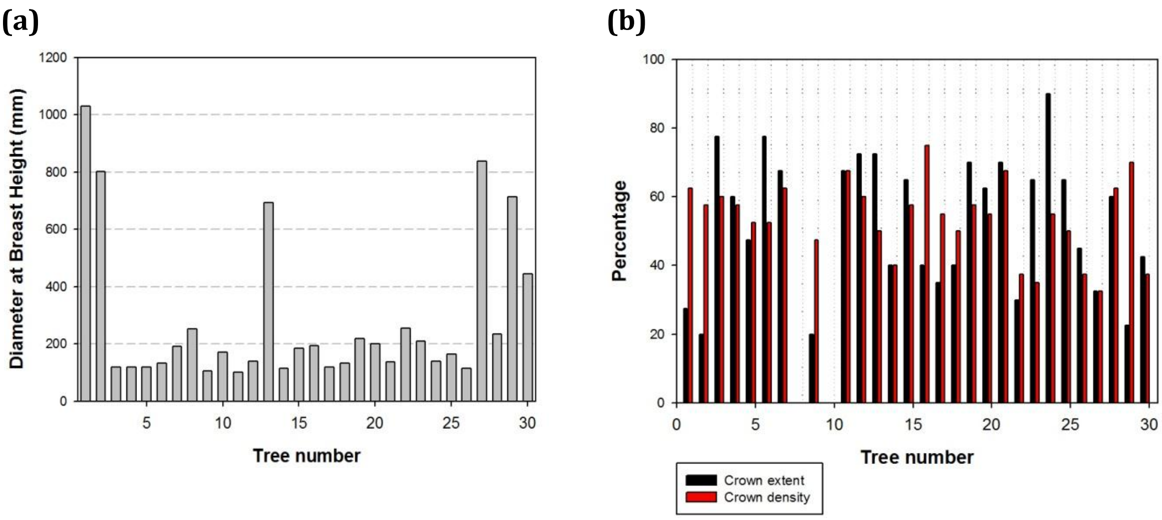


Figure 5.14(a) DBH for all trees assessed at site 4. Grey bars are Black Box. (b) Crown extent and crown density for all trees assessed at site 4.

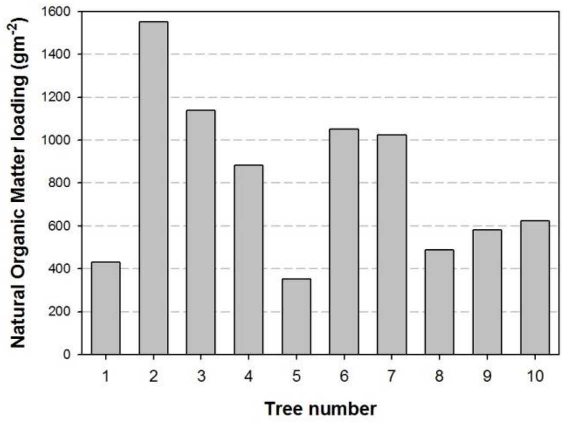


Figure 5.15. NOM for all trees assessed at site 4. Grey bars are Black Box.

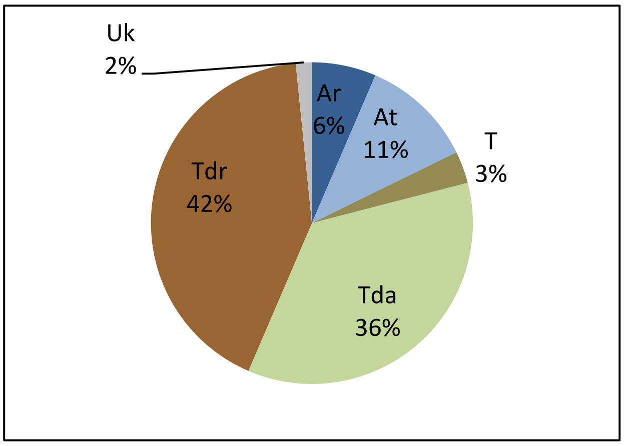


Figure 5.16. Pie chart displaying proportion of understorey plant species in broad functional groups for site 4. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.7. Understorey plant species diversity recorded at site 4.

Elevation	Native species	Exotic species	Total species
In-channel	12	2	14
Mid-bank	24	3	27
Tree-line	39	8	47
Floodplain	41	7	48
Total	51	10	61

Site 5

Site location and description

Site 5 is located on Redbank Creek, just downstream of Packers Crossing on Tandou Station. The site is dominated by grey clay soils and the channel is wide and flat. Black Box *Eucalyptus largiflorens* (BB) and River Red Gum *Eucalyptus camaldulensis* (RRG) are co-dominant along the edge of the channel, with BB extending onto the floodplain. Grazing of selective vegetation was observed at the time of survey, probably by Black-tailed Native-hens (*Gallinula ventralis*), which were observed in high abundance. The site was dry at the time of survey, the channel bed however was damp and small pools of water were present downstream.

Tree condition and NOM load

Species and size: 17 BB and 13 RRG were assessed. DBH varied across the site, the majority of trees (17) had a DBH less than 300 mm; maximum DBH was 766 mm (Figure 5.18a). Mean DBH is 319 mm. Average DBH of RRG was greater than BB (mean = 368 and 281 mm respectively).

Tree Condition Variables: Crown extent and density were between 50 and 80 % (Figure 5.18b); mean percentages are 64 and 68, respectively. Mean Tree Condition Index is 9.6 (**MODERATE**).

Response Variables: New tip growth was visible on 18 trees (mean score = 1); 19 trees supported epicormic growth (mean score = 1). Die-off was evident on the majority of trees (29; mean score = -1). Reproductive extent was **SCARCE** on all trees (mean score = 1). Mistletoe was recorded as **SCARCE** on 1 tree (score = -1).

NOM load: NOM load was mostly **MODERATE** (mean = 1041 gm^{-2}), with two RRG recording **HIGH** (>2000 gm^{-2}; Figure 5.19).

Understorey

A total of 60 species were recorded, 82% belong to terrestrial functional groups (FGs), 15% to amphibious FGs (Figure 5.20). *Polygonum plebeium* (Tda) and *Rumex crystallinus* (Atl) were the most abundant native species with *Spergularia diandra** (Tdr) and *Verbena officinalis** (Tdr) being the most abundant introduced species.

Floodplain quadrats recorded the highest abundance of species (43; Table 5.8). In-channel elevations recorded low species diversity (6 species in total; Table 5.8). Species composition of In-channel elevations was significantly different from all other elevations ($P \leq 0.0293$). A significant difference in species composition was also observed between the Floodplain and Mid-bank elevations ($P = 0.0296$). No other significant differences were observed.

Figure 5.17. Photopoint for site 5, (a) September 2010, (b) October 2011. Photographers: (a) C. Campbell, MDFRC, (b) D. Linklater, MDFRC.

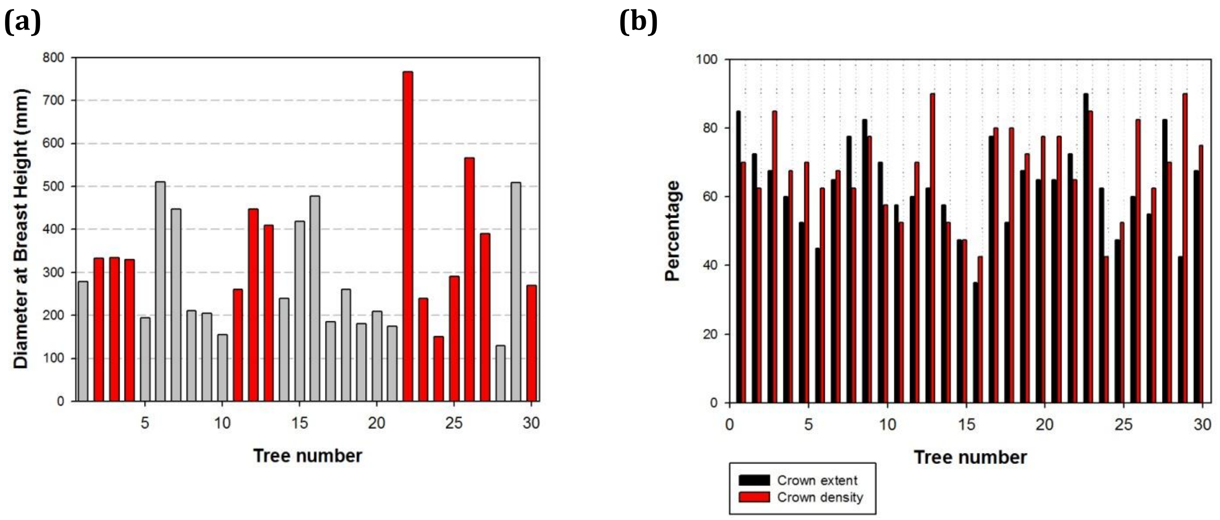


Figure 5.18(a) DBH for all trees assessed at site 5. Grey is Black Box, red is River Red Gum. (b) Crown extent and crown density for all trees assessed at site 5.

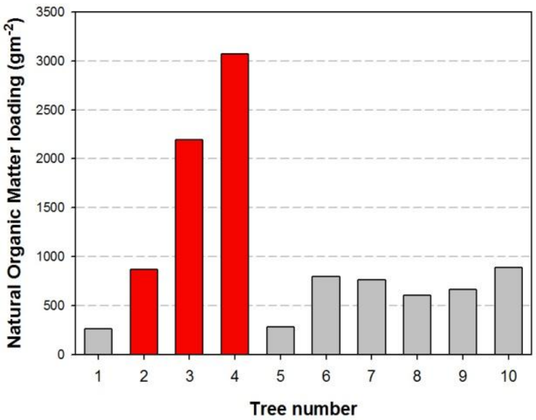


Figure 5.19. NOM for all trees assessed at site 5. Grey is Black Box, red is River Red Gum.

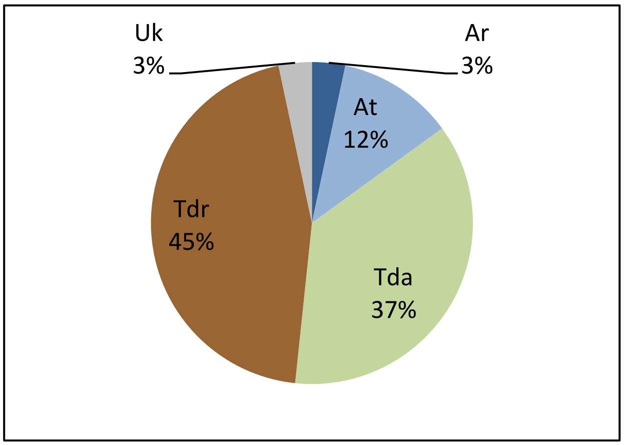


Figure 5.20. Pie chart displaying proportion of understorey plant species in broad functional groups for site 5. Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.8. Understorey plant species diversity recorded at site 5.

Elevation	Native species	Exotic species	Total species
In-channel	5	1	6
Mid-bank	22	6	28
Tree-line	31	6	37
Floodplain	36	7	43
Total	50	10	60

Site 6

Site location and description

Site 6 is located on Tandou Creek, at the Woolshed crossing on Tandou Station. The site is dominated by grey clay soils; the channel is wide and flat (Figure 5.21). The dominant tree species is Black Box *Eucalyptus largiflorens* (BB). Grazing of selective vegetation was observed at this site, probably by Black-tailed Native-hens (*Gallinula ventralis*), which were observed in high abundance. Water levels at site 6 at the time of survey were approximately 0.3 m lower than during the 2010 survey period..

Tree condition and NOM load

Species and size: All trees assessed at site 6 were BB. The majority (19) had a DBH of less than 200 mm; maximum DBH was 774 mm (Figure 5.22a). Mean DBH is 295 mm.

Tree Condition Variables: Crown extent and crown density was relatively good, with most trees scoring between 60 and 80% for both variables (Figure 5.22b); mean percentages are 74 and 70, respectively. The mean Tree Condition Index is 10.1 (**GOOD**).

Response Variables: New tip growth was **COMMON** on all 30 trees (mean score = 2); 15 trees supported epicormic growth (mean score = 1). Die-off was evident on all trees (mean score = -1). Reproductive extent was clearly visible on all 30 trees (mean score = 2).

NOM load: NOM load was **LOW** (mean = 873 gm^{-2}; Figure 5.23).

Understorey

A total of 28 species were recorded, 75% of which belong to terrestrial functional groups (FGs) and 25% to amphibious FGs (Figure 5.24). *Epaltes australis* (Tda) was the most abundant native species, *Verbena supina** (Tda) was the most abundant introduced species.

No species were recorded at In-channel or Mid-bank elevations (Table 5.9), which were inundated by approximately 0.3 and 0.9 m of water, respectively, at the time of survey. Species composition was significantly different between all elevations (P ≤ 0.0296) except In-channel and Mid-bank, which recorded no species.

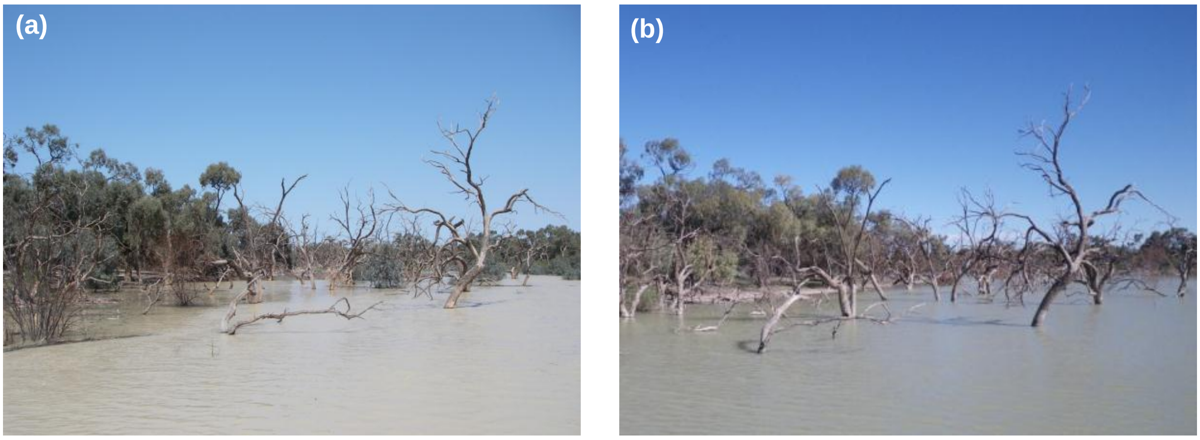


Figure 5.21. Photopoint for site 6, (a) September 2010, (b) October 2011. Photographers: (a) D. Bogenhuber, MDFRC, (b) D. Linklater, MDFRC.

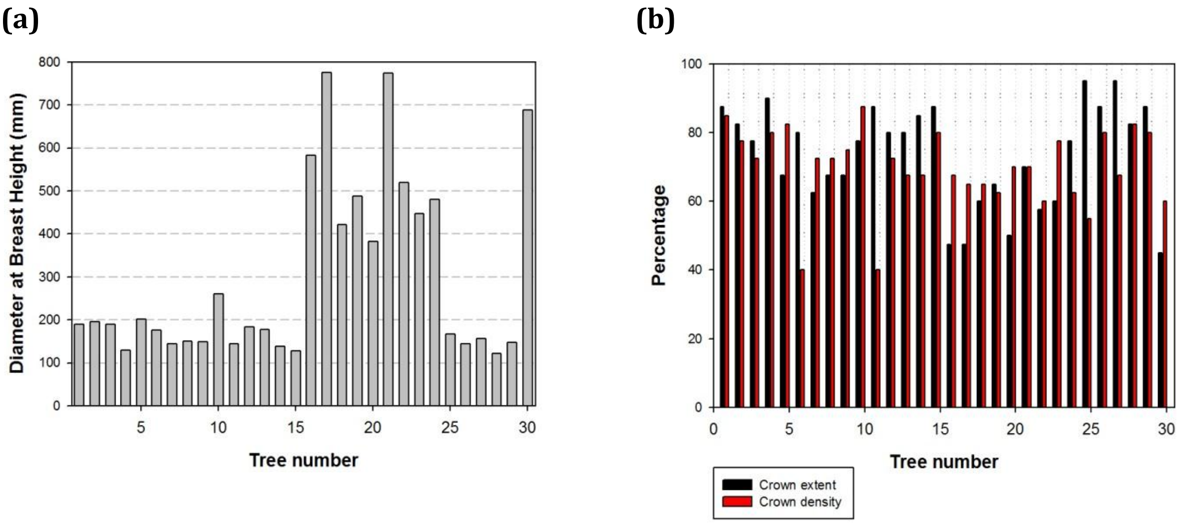


Figure 5.22(a) DBH for all trees assessed at site 6. Grey bars are Black Box. (b) Crown extent and crown density for all trees assessed at site 6.

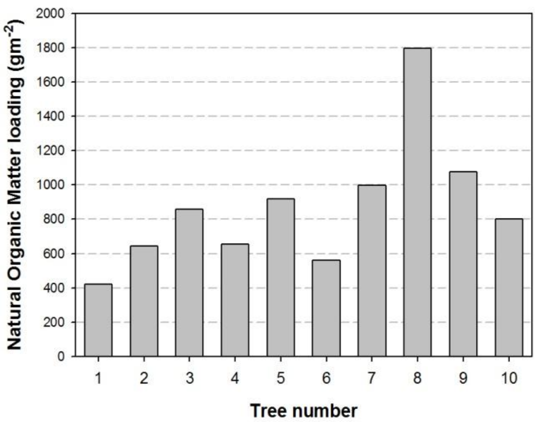


Figure 5.23. NOM for all trees assessed at site 6. Grey bars are Black Box.

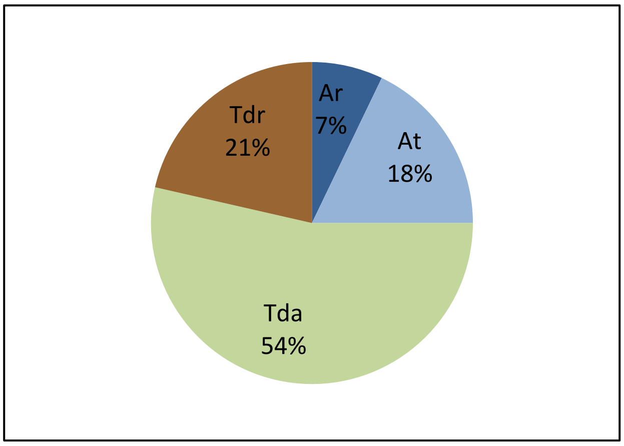


Figure 5.24. Pie chart displaying proportion of understorey plant species in broad functional groups for site 6. Tda=Terrestrial damp; Tdr=Terrestrial dry; Ar= Amphibious regulator; At=Amphibious tolerator.

Table 5.9. Understorey plant species diversity recorded at site 6.

Elevation	Native species	Exotic species	Total species
In-channel	0	0	0
Mid-bank	0	0	0
Tree-line	16	5	21
Floodplain	17	6	23
Total	21	7	28

Site 7

Site location and description

Site 7 is located at Hunters Waterhole on Woodlands Station. The site is characterised by red sandy loam soils. The Anabranch channel is narrow and incised with deep waterholes. Black Box *Eucalyptus largiflorens* (BB) and River Red Gum *Eucalyptus camaldulensis* (RRG) occur on the steep banks (Figure 5.25). Grazing pressure was high at the time of survey, there was evidence of high abundances of rabbits and goats. Water levels were approximately 0.3 m higher than those during the 2010 monitoring period..

Tree condition and NOM load

Species and size: Trees assessed consisted of 21 BB and 9 RRG. DBH varied with 22 of the 30 trees less than 300 mm (4 RRG and 18 BB); maximum DBH recorded was 557 mm (Figure 5.26a). Mean DBH is 279 mm.

Tree Condition Variables: Over half the trees assessed recorded crown extent and crown density percentages above 50% (Figure 5.26b); mean percentages are 73 and 93, respectively. Mean Tree Condition Index is 10.43 (**GOOD**).

Response Variables: New tip growth was observed on 25 of the 30 trees (mean score = 1); 15 trees supported epicormic growth (mean score = 1). Die-off was **SCARCE** on most trees (26; mean score = 1). Reproductive extent was clearly visible on all 30 trees (mean score = 2).

NOM load: NOM load was mostly **LOW** (mean = 724.0gm^{-2}), with RRG NOM scoring **MODERATE** (Figure 5.27).

Understorey

Site 7 was relatively species-poor and dominated by terrestrial species. A total of 20 species were recorded, 90% of which belonged to terrestrial functional groups (FGs), and only 10% to amphibious FGs (Figure 5.28). *Enchylaena tomentosa* (Tdr) was the most abundant native species; *Sisymbrium erysimoides** (Tdr) was the most abundant introduced species.

Floodplain recorded the highest abundance of native species (10; Table 5.10), Tree-line elevations recorded the highest number of exotic species (7; Table 5.10). There was no significant difference in species composition between In-channel and Mid-bank elevations or Tree-line and Floodplain elevations. Significant differences in species composition were detected between all other elevations ($P \leq 0.0309$).

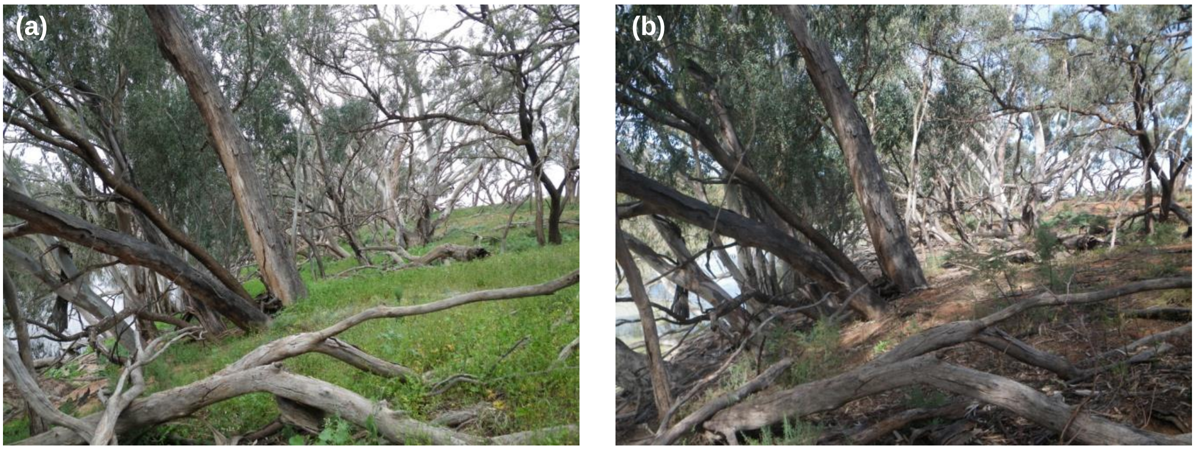


Figure 5.25. Photopoint of site 7, (a) September 2010, (b) October 2011. Photographers: (a) D. Bogenhuber, MDFRC, (b) D. Linklater, MDFRC.

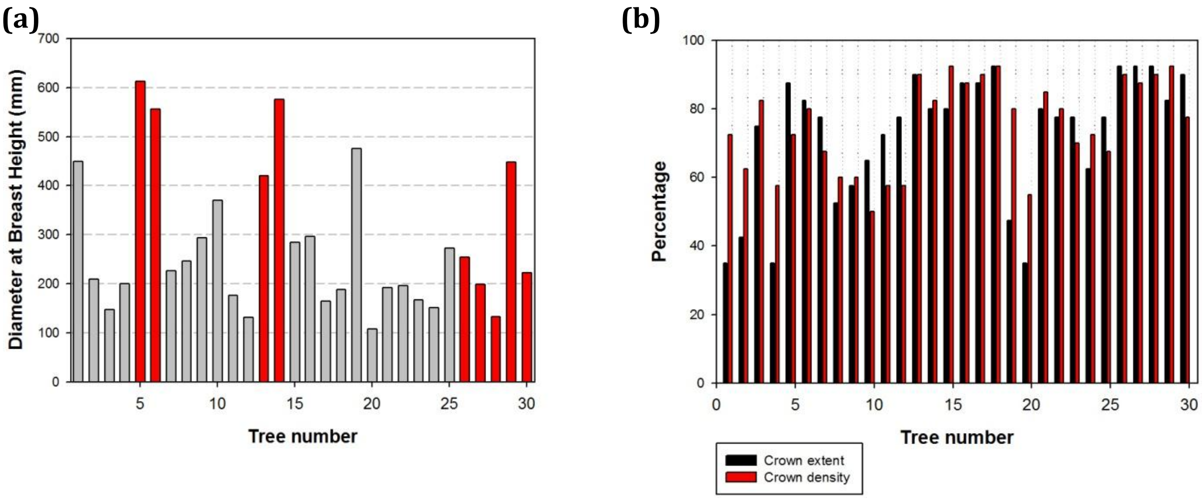


Figure 5.26(a) DBH for all trees assessed at site 7. Grey is Black Box, red is River Red Gum. (b) Crown extent and crown density for all trees assessed at site 7.

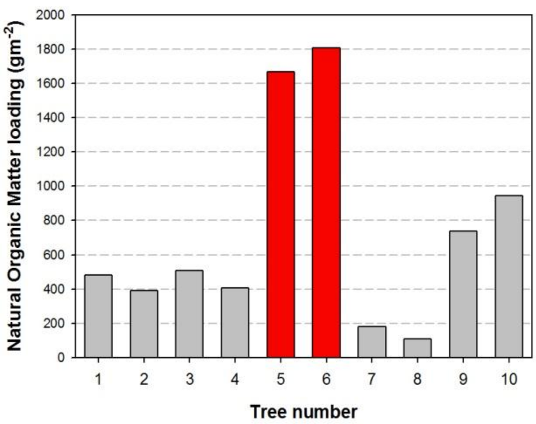


Figure 5.27. NOM for all trees assessed at site 7. Grey is Black Box, red is River Red Gum.

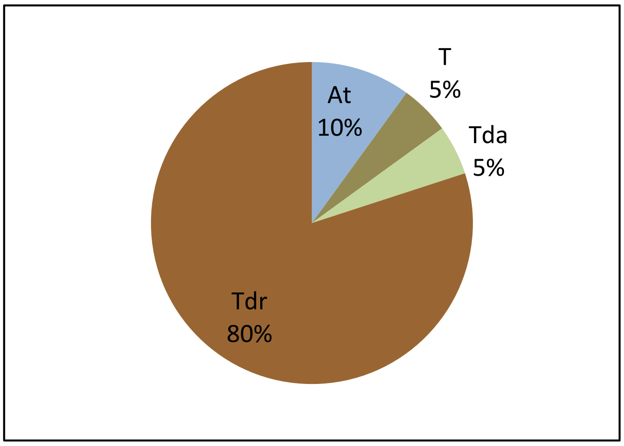


Figure 5.28. Pie chart displaying proportion of understorey plant species in broad functional groups for site 7. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; At=Amphibious tolerator.

Table 5.10. Understorey plant species diversity recorded at site 7.

Elevation	Native species	Exotic species	Total species
In-channel	0	0	0
Mid-bank	1	0	1
Tree-line	7	7	14
Floodplain	10	3	13
Total	13	7	20

Site 8

Site location and description

Site 8 is located upstream of Stony Crossing on the Darling Anabranch, Windamingle Station. The site is dominated by grey clay soils; the channel is very wide and flat (Figure 5.29). Black Box *Eucalyptus largiflorens* (BB) and River Cooba *Acacia stenophylla* (RC) are present along the edge of the channel. Grazing pressure was high at the time of survey, probably from sheep, which were observed at the site. The site was inundated at the time of survey (Figure 5.29).

Tree condition and NOM load

Species and size: Trees assessed consisted of 26 BB and 4 RC. RC had a maximum DBH of 350 mm, the majority of BB had a DBH between 300 and 600 mm; maximum DBH was 1072 mm (Figure 5.30a). Mean DBH is 484 mm.

Tree Condition Variables: Crown extent and crown density were above 60% for the majority of trees, one BB scored less than 20% for both variables (Figure 5.30b). Mean percentage is 66 for both crown extent and density. The mean Tree Condition Index is 9.43 (**MODERATE**).

Response Variables: New tip growth was **COMMON** on all 30 trees (mean score = 2); 22 trees supported epicormic growth (mean score =1). Die-off was evident on all 30 trees (mean score = -1). Reproductive extent was clearly visible on most trees (28; mean score = 2). Mistletoe was recorded as **SCARCE** on 1 tree.

NOM load: NOM load was **MODERATE** (mean = 1412 gm-2), one BB recorded a NOM of 3402 gm^{-2} (Figure 5.31).

Understorey

A total of 35 species were recorded, 89% of which are in terrestrial functional groups (FGs), and 8% in amphibious FGs (Figure 5.32). *Enchylaena tomentosa* (Tdr) was the most abundant native species, *Schismus barbatus** (Tdr) was the most abundant introduced species.

Floodplain recorded the highest abundance of native and total species (21 and 23 respectively; Table 5.11). Significant differences in species composition were observed between almost all elevations ($P \leq 0.0305$) except between Tree-line and Floodplain elevations.

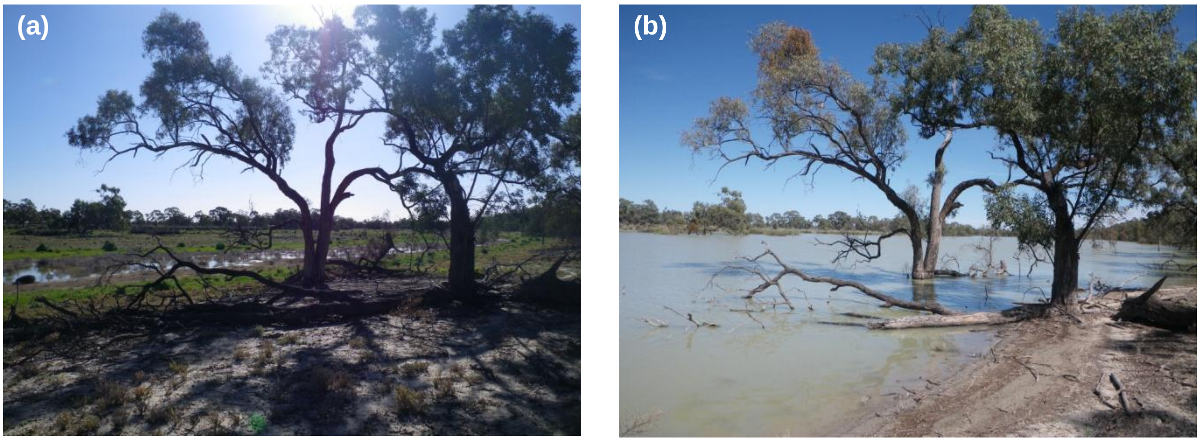


Figure 5.29. Photopoint for site 8, (a) September 2010, (b) November 2011. Photographers: (a) D. Bogenhuber, MDFRC, (b) D. Linklater, MDFRC.

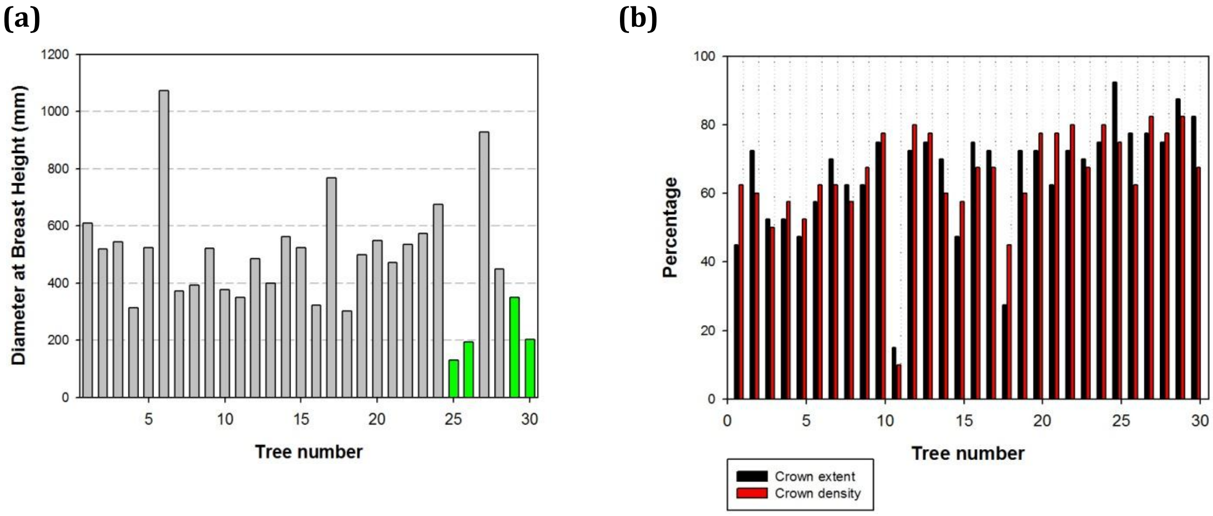


Figure 5.30(a) DBH for all trees assessed at site 8. Grey is Black Box, green is River Cooba. (b) Crown extent and crown density for all trees assessed at site 8.

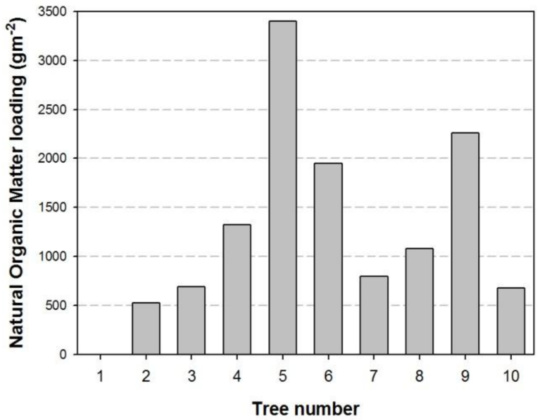


Figure 5.31. NOM for all trees assessed at site 8. Grey is Black Box, green is River Cooba.

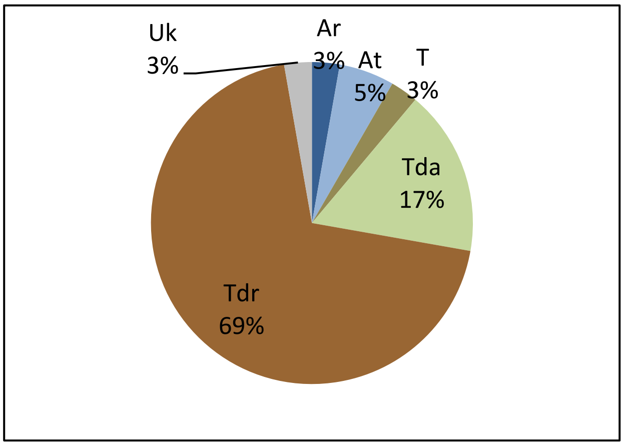


Figure 5.32. Pie chart displaying proportion of understorey plant species in broad functional groups for site 8. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.11. Understorey plant species diversity recorded at site 8.

Elevation	Native species	Exotic species	Total species
In-channel	0	0	0
Mid-bank	7	0	7
Tree-line	14	5	19
Floodplain	21	2	23
Total	30	5	35

Site 9a

Site location and description

Site 9a is located on the upstream side of 183 Dam, Wyndham Station. The site is dominated by grey clay soils; the Anabranch channel is wide and undulating to depths over 2m (Figure 5.33). Black Box *Eucalyptus largiflorens* (BB) is the dominant tree species. The water level at site 9a during the 2011 condition monitoring period was elevated due to the operation of 183 Dam and the movement of water from the upstream lakes into the Darling Anabranch channel (Figure 5.33).

Tree condition and NOM load

Species and size: All trees assessed were BB. Most trees had a DBH of less than 400 mm, the maximum DBH was 1017 mm (Figure 5.34a). The mean DBH is 328 mm.

Tree Condition Variables: Crown extent and crown density were relatively good, with most trees scoring between 60 and 80% (Figure 5.34b); mean percentages are 73 and 72, respectively. The mean Tree Condition Index is 10.1 (**GOOD**).

Response Variables: New tip growth and die-off was observed on all 30 trees (mean score = 2 and -1, respectively); 23 trees supported epicormic growth (mean score = 1). Reproductive extent was clearly visible on all 30 trees (mean score = 2). Mistletoe was recorded on 2 trees.

NOM load: NOM load was **LOW** (mean = 933 gm^{-2}), 4 trees had a **MODERATE** loading (Figure 5.35).

Understorey

Site 9a recorded very few understorey species as most of the site was inundated at the time of survey. A total of 7 species were recorded, 63% belonging to terrestrial functional groups (FGs) and 24% belonging to amphibious FGs (Figure 5.36). *Brachyscome melanocarpa* (Tda) was the most abundant native species, no introduced species were recorded.

In-channel quadrats were not assessed due to water depth. Transects 3 and 4 were not assessed; these were completely inundated at the time of survey and unable to be located. Floodplain elevations for transects 1 and 2 were not inundated, but species-poor (Table 5.12). There were no significant differences in species composition detected among any quadrat elevations.

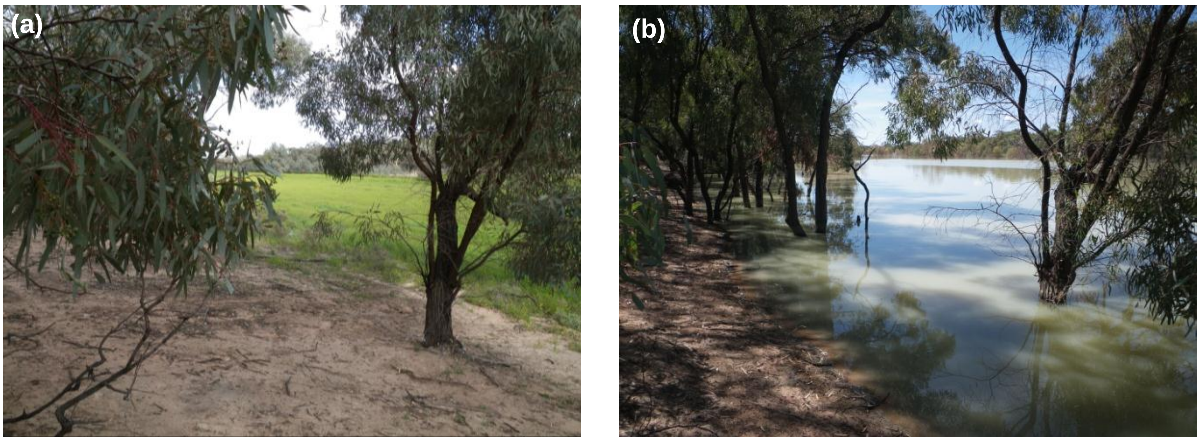


Figure 5.33. Photopoint of Site 9a, (a) October 2010, (b) October 2011. Photographers: (a) D. Bogenhuber, MDFRC, (b) D. Linklater, MDFRC.

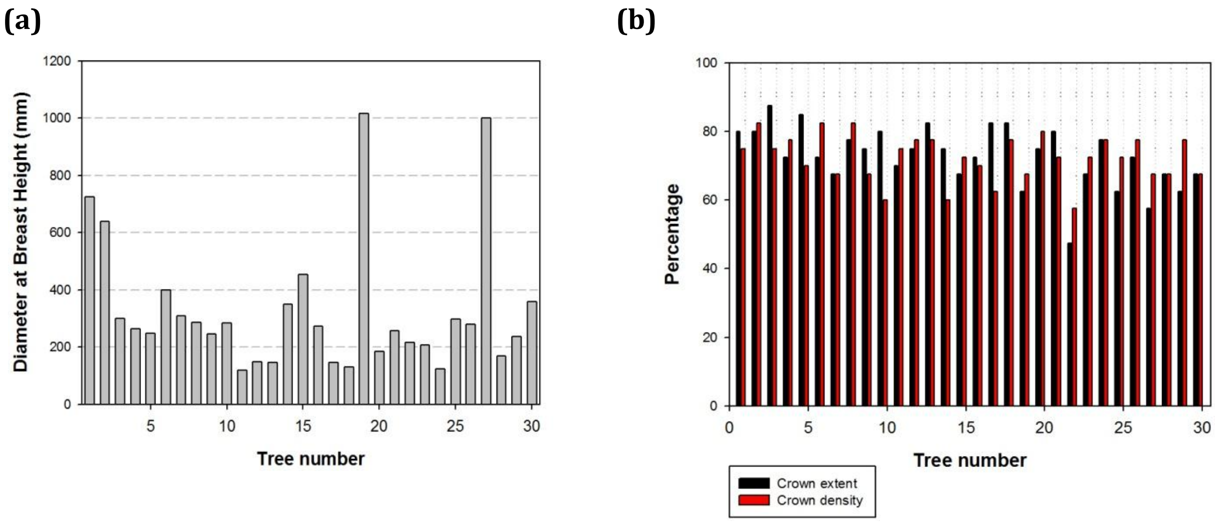


Figure 5.34(a) DBH for all trees assessed at site 9a. Grey bars are Black Box. (b) Crown extent and crown density for all trees assessed at site 9a.

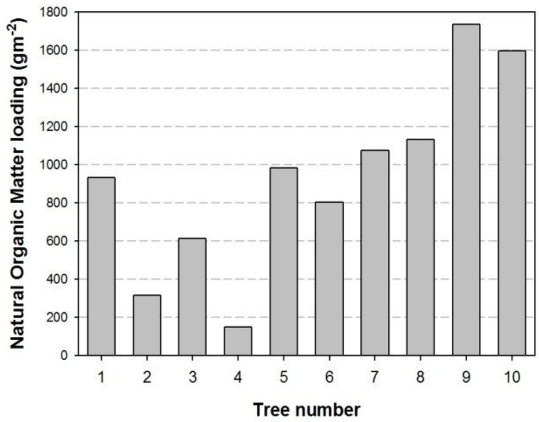


Figure 5.35. NOM for all trees assessed at site 9a. Grey bars are Black Box.

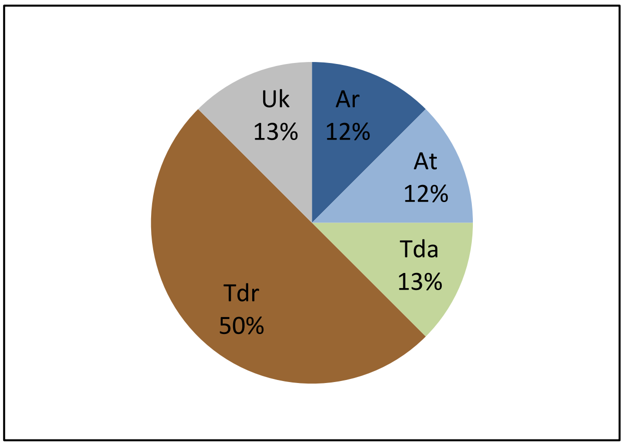


Figure 5.36. Pie chart displaying proportion of understorey plant species in broad functional groups for site 9a. Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.12. Understorey plant species diversity recorded at site 9a.

Elevation	Native species	Exotic species	Total species
In-channel	Not assessed		
Mid-bank	0	0	0
Tree-line	2	0	2
Floodplain	5	0	5
Total	7	0	7

Site 9b

Site location and description

Site 9b is located on the downstream side of 183 Dam, Wyndham Station. The site is dominated by grey clay soils with fringing red sandy loam. The channel is wide and shallow with large flood runners (Figure 5.37). The dominant tree species is Black Box *Eucalyptus largiflorens* (BB). Grazing of selective vegetation was observed at this site, probably by Black-tailed Native-hens (*Gallinula ventralis*), which were observed in high abundance. Water level at the time of surveys was high and flow was considerably rapid due to the release of water through 183 Dam.

Tree condition and NOM load

Species and size: All trees assessed were BB. The majority of trees had a DBH less than 200mm, with a maximum DBH of 1088mm (Figure 5.38a); mean DBH is 220 mm.

Tree Condition Variables: Crown extent and crown density varied between approximately 25 and 80% (Figure 5.38b); mean percentages are 61 and 64, respectively. The mean Tree Condition Index is 9.26 (**MODERATE**).

Response Variables: New tip growth was observed on all 30 trees (mean score =2); 28 trees supported epicormic growth (mean score = 2). Die-off was evident on all 30 trees (mean score = -1). Reproductive extent was **SCARCE** on all 30 trees (mean score = 1).

NOM load: NOM load was **LOW** (mean = 765 gm^{-2}) (Figure 5.39).

Understorey

A total of 44 species were recorded, with 73% belonging to terrestrial functional groups (FGs), and 23% belonging to amphibious FGs (Figure 5.40). *Stemodia florulenta* (Tda) was the most abundant native species; *Conyza bonariensis** (Tdr) the most abundant introduced species.

Floodplain elevations recorded the highest abundance of native and total species (22 and 30 respectively; Table 5.13). Mid-bank elevations also recorded relatively high species diversity (24). Significant differences in species composition were detected between In-channel and Tree-line elevations, and In-channel and Floodplain elevations (P = 0.0285 and P = 0.0304 respectively). No other significant differences were observed.

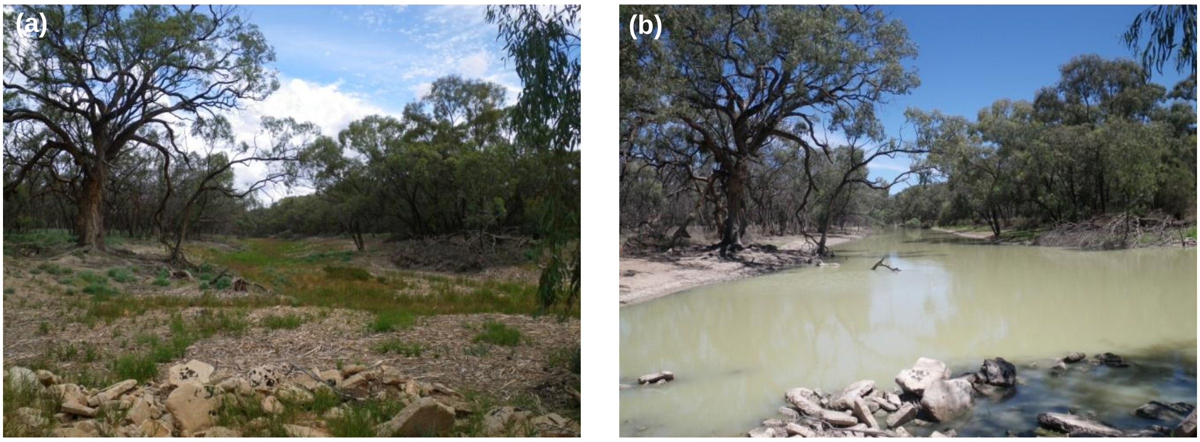
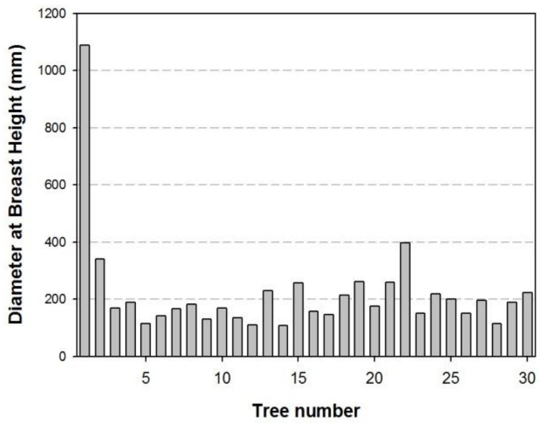


Figure 5.37. Photopoint of Site 9b, (a) October 2010, (b) October 2011. Photographer: D. Bogenhuber, MDFRC.



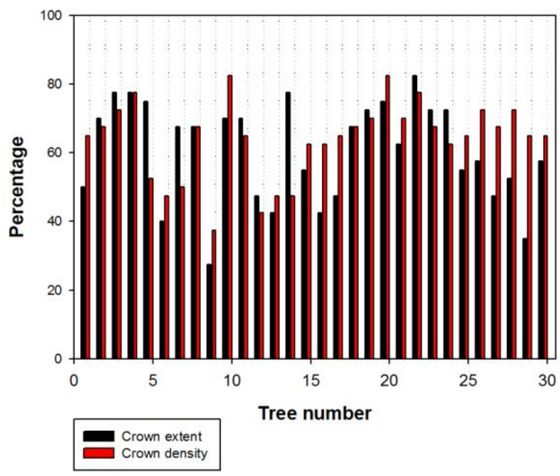


Figure 5.38(a) DBH for all trees assessed at site 9b. Grey bars are Black Box. (b) Crown extent and crown density for all trees assessed at site 9b.

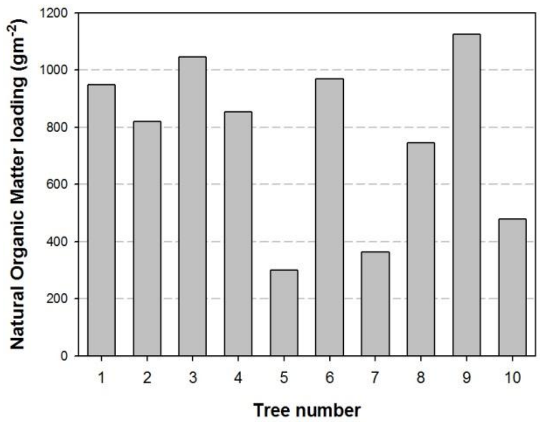


Figure 5.39. NOM for all trees assessed at site 9b. Grey bars are Black Box.

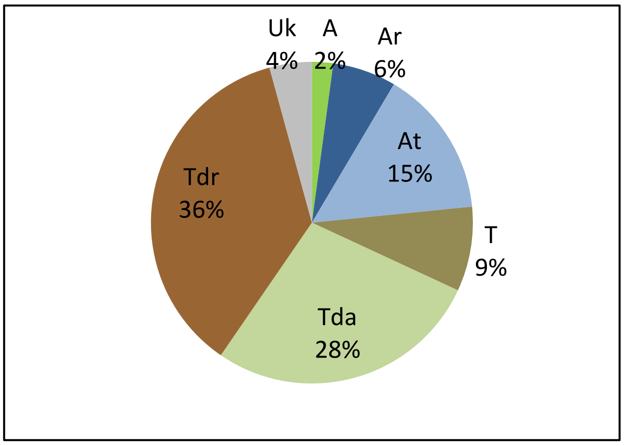


Figure 5.40. Pie chart displaying proportion of understorey plant species in broad functional groups for site 9b. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; A=Amphibious; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.13. Understorey plant species diversity recorded at site 9b.

Elevation	Native species	Exotic species	Total species
In-channel	0	0	0
Mid-bank	15	9	24
Tree-line	5	0	5
Floodplain	22	8	30
Total	32	12	44

Site 10

Site location and description

Site 10 is approximately 1 km upstream of Bunnerungee Bridge on Bunnerungee Station. The site is dominated by red sandy loam. The channel is approximately 50 m wide and shallow (Figure 5.41) with dense regeneration of RRG on the base of the channel. Black Box *Eucalyptus largiflorens* (BB) and River Red Gum *Eucalyptus camaldulensis* (RRG) occur along the edge. The channel was inundated at the time of survey, to a depth of over 2 m.

Tree condition and NOM load

Species and size: 24 BB and 6 RRG were assessed. Most RRG had a DBH greater than 1000 mm, all BB had a DBH less than 1000 mm (Figure 5.42a). Maximum DBH was 2240 mm; mean DBH is 711 mm.

Tree Condition Variables: Crown extent and crown density scored above 60% for the majority of trees, crown density was slightly higher for most trees (Figure 5.42b); mean percentages are 69 and 74, respectively. The mean Tree Condition Index is 10.06 (**GOOD**).

Response Variables: New tip growth was visible on all 30 trees (mean score = 2); the majority of trees supported epicormic growth (28; mean score = 1). Die-off was evident on all 30 trees (mean score =1). Reproductive extent was clearly visible on all trees (mean score = 2). Mistletoe was recorded as **SCARCE** on 4 trees (mean score = -1).

NOM load: NOM load overall was **MODERATE** (mean = 1387 gm^{-2}), one tree (RRG) recorded a NOM load of **VERY HIGH** (3132 gm^{-2}) and most BB recorded **LOW** NOM loads (Figure 5.43).

Understorey

A total of 30 species were recorded, with 86% belonging to terrestrial functional groups (FGs) and 11% belonging to amphibious FGs (Figure 5.44). *Atriplex spp.* (Tdr) and *Austrostipa scabra* (Tdr) were the most abundant native species with *Asphodelus fistulosus** (Tdr) being the most abundant introduced species.

Floodplain elevations recorded the highest abundance of native, exotic and total species (21, 7 and 28 respectively; Table 5.14). Species composition was significantly different between Floodplain and all other elevations (P ≤ 0.0289). No other significant differences were observed.

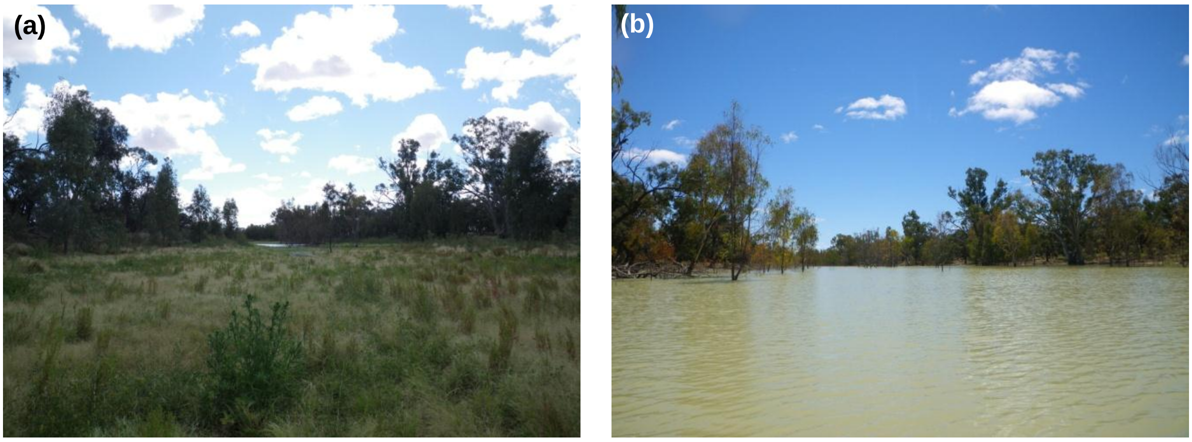


Figure 5.41. Photopoint of site 10, (a) October 2010, (b) November 2011. Photographers: (a) D. Bogenhuber, MDFRC, (b) D. Linklater, MDFRC.

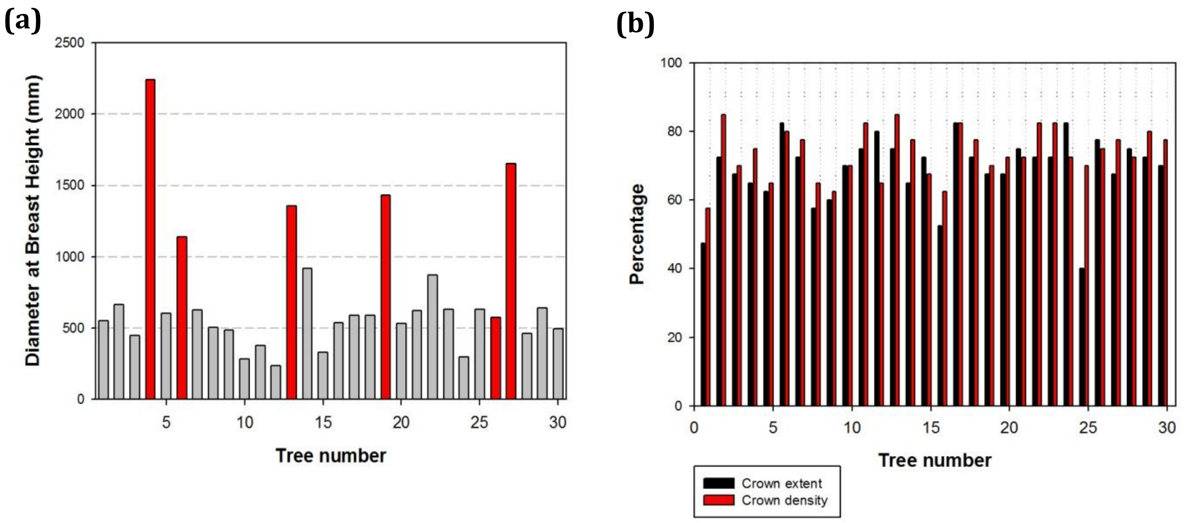


Figure 5.42(a) DBH for all trees assessed at site 10. Grey is Black Box, red is River Red Gum.[2] (b) Crown extent and crown density for all trees assessed at site 10.

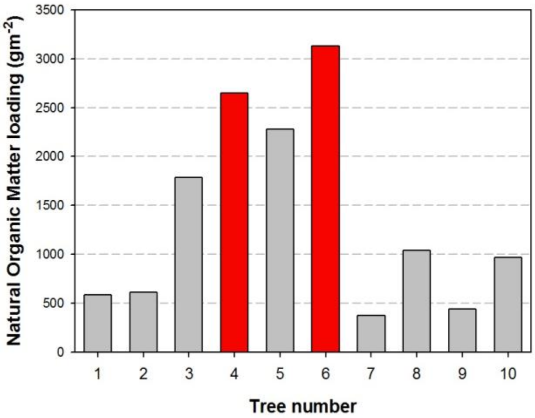


Figure 5.43. NOM for all trees assessed at site 10. Grey is Black Box, red is River Red Gum.

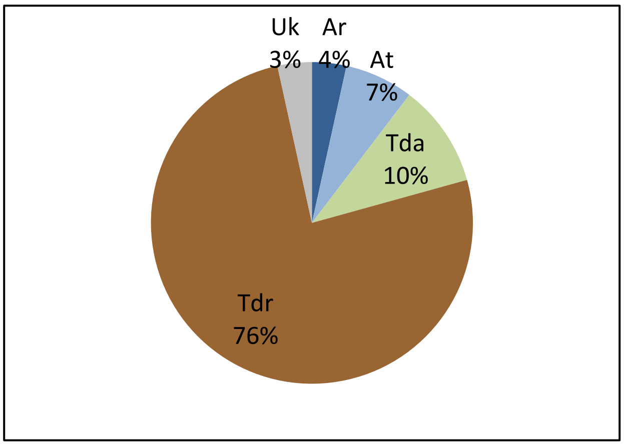


Figure 5.44. Pie chart displaying proportion of understorey plant species in broad functional groups for site 10. Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.14. Understorey plant species diversity recorded at site 10.

Elevation	Native species	Exotic species	Total species
In-channel	0	0	0
Mid-bank	1	0	1
Tree-line	1	0	1
Floodplain	21	7	28
Total	23	7	30

2 In 2010, DBH of tree number 4 (RRG) differs due to measuring 3 limbs; in 2011 the trunk below the split was measured.

Site 11

Site location and description

Site 11 is located near Lake Toora on the Darling Anabranch, Toora Station. The site is characterised by grey clay soils and steep banks. The Anabranch channel is relatively deep with a flood runner to the north-east of the main channel. The dominant tree species is Black Box *Eucalyptus largiflorens* (BB) (Figure 5.42). Site 11 was inundated at the time of survey, with a relatively high flow passing through the site.

Tree condition and NOM load

Species and size: All trees assessed were BB. The majority of trees (21) recorded a DBH of less than 200 mm (Figure 5.43a), maximum DBH was 750 mm; mean DBH is 275 mm.

Tree Condition Variables: Crown extent and crown density percentages were between 40 and 80 across the site (Figure 5.43b); mean percentages are 66 and 67, respectively. The mean Tree Condition Index is 9.53 (**MODERATE**).

Response Variables: New tip growth was visible on all 30 trees (mean score =2), with 27 trees supporting epicormic growth (mean score = 1). Die-off was evident on all trees (mean score = -1). Reproductive extent was clearly visible on 29 of the 30 trees (mean score = 2).

NOM load: NOM load was **VERY LOW** to **MODERATE** (mean = 888 gm^{-2}, Figure 5.44).

Understorey

A total of 58 species were recorded, with 88% belonging to terrestrial functional groups (FGs) and 10% belonging to amphibious FGs (Figure 5.45). *Enchylaena tomentosa* (Tdr) was the most abundant native species with *Solanum nigrum** (Tdr) and *Sonchus asper** (Tdr) being the most abundant introduced species.

Tree-line quadrats recorded the highest abundance of native, exotic and total species (39, 14 and 53 respectively; Table 5.15). Significant differences in species composition were detected between all elevations (P ≤ 0.0314).

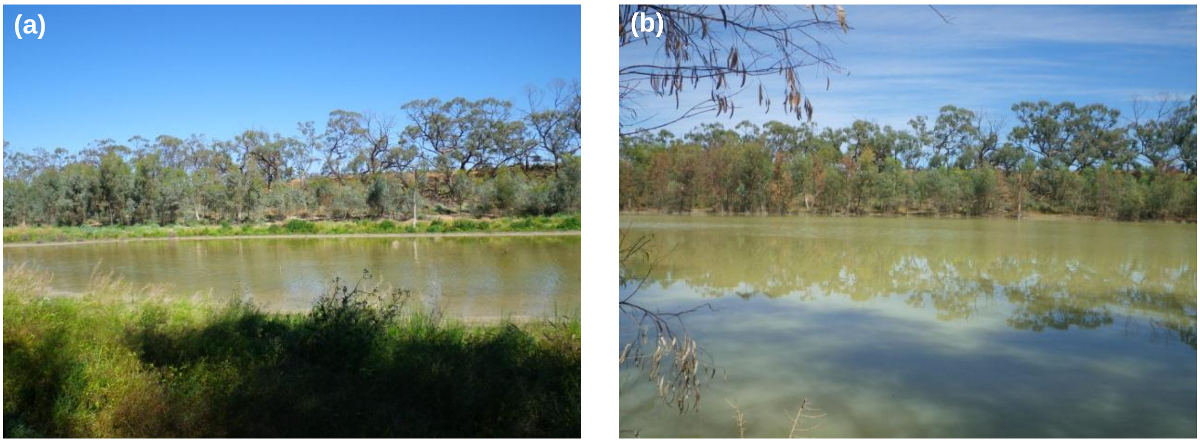


Figure 5.42. Photopoint of site 11, (a) October 2010, (b) November 2011. Photographers: (a) D. Bogenhuber, MDFRC, (b) D. Linklater, MDFRC.

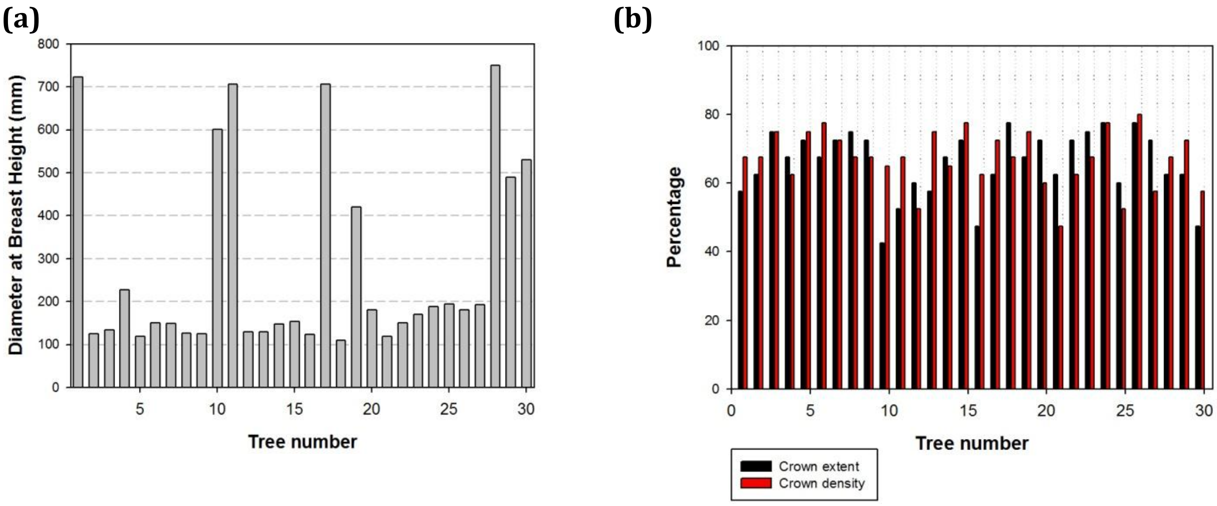


Figure 5.43(a) DBH for all trees assessed at site 11. Grey bars are Black Box.[3] (b) Crown extent and crown density for all trees assessed at site 11.

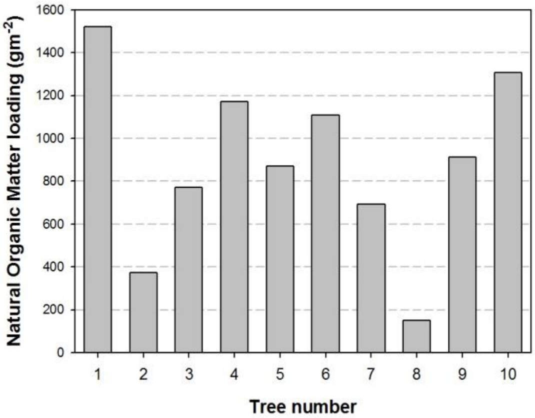


Figure 5.44. NOM for all trees assessed at site 11. Grey bars are Black Box.

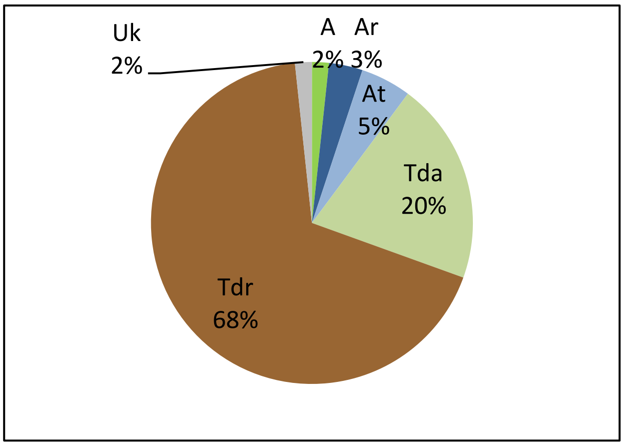


Figure 5.45. Pie chart displaying proportion of understorey plant species in broad functional groups for site 11. Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; A=Amphibious; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.15. Understorey plant species diversity recorded at site 11.

Elevation	Native species	Exotic species	Total species
In-channel	0	0	0
Mid-bank	1	0	1
Tree-line	39	14	53
Floodplain	22	1	23
Total	43	15	58

3 In 2010, tree number 1 was incorrectly displayed with a DBH of 2076 mm.

Site 12

Site location and description

Site 12 is located upstream of Warra's Dam (now removed), on Warrananga Station, near "The Lake". The site is dominated by grey clay soils with relatively flat topography. The channel is approximately 30 m wide and shallow. The overstorey consists of mixed species Black Box *Eucalyptus largiflorens* (BB), River Red Gum *Eucalyptus camaldulensis* (RRG) and River Cooba *Acacia stenophylla* (RC). Long-dead RRG are present within the channel, presumably drowned (Figure 5.46). The water level at the time of survey was dropping, with an observed decline of approximately one metre over a two week period.

Tree Condition and NOM load

Species and size: Trees assessed consisted of 6 BB, 21 RRG and 3 RC. DBH varied considerably, with all RC (3) and 12 RRG recording a DBH of less than 400 mm and all BB trees recording a DBH greater than 800 mm (Figure 5.47a). Mean DBH is 519 mm.

Tree Condition Variables: Crown extent and crown density were between 60 and 90% for the majority of trees (Figure 5.47b); mean percentages are 72 for both variables. The mean Tree Condition Index is 10.1 (**GOOD**).

Response Variables: New tip growth was visible on the majority of trees (29; mean score = 1); 27 trees supported epicormic growth (mean score = 1). Die-off was evident on 29 trees (mean score = 1). Reproductive extent was clearly visible on 28 of the 30 trees (mean score = 2).

NOM load: NOM loading overall was **MODERATE** (mean = 1275 gm^{-2}; Figure 5.48).

Understorey

A total of 52 species were recorded with 85% belonging to terrestrial functional groups (FGs), and 13% to amphibious FGs (Figure 5.49). *Enchylaena tomentosa* (Tdr) was the most abundant native species with *Heliotropium curassavicum** (Tda) being the most abundant introduced species.

Site 12 is notable in that no introduced species were recorded, and also that species diversity was relatively even across Mid-bank, Tree-line and Floodplain elevations (Table 5.16). Significant differences in species composition were detected between all elevations (P ≤ 0.0313).

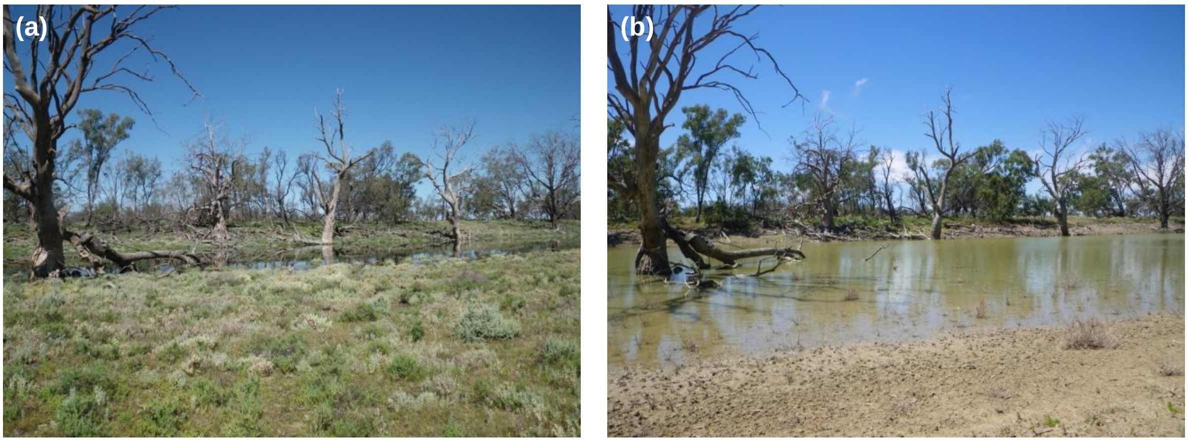


Figure 5.46. Photopoint for site 12, (a) October 2010, (b) November 2011. Photographers: (a) D. Bogenhuber, MDFRC, (b) D. Linklater, MDFRC.

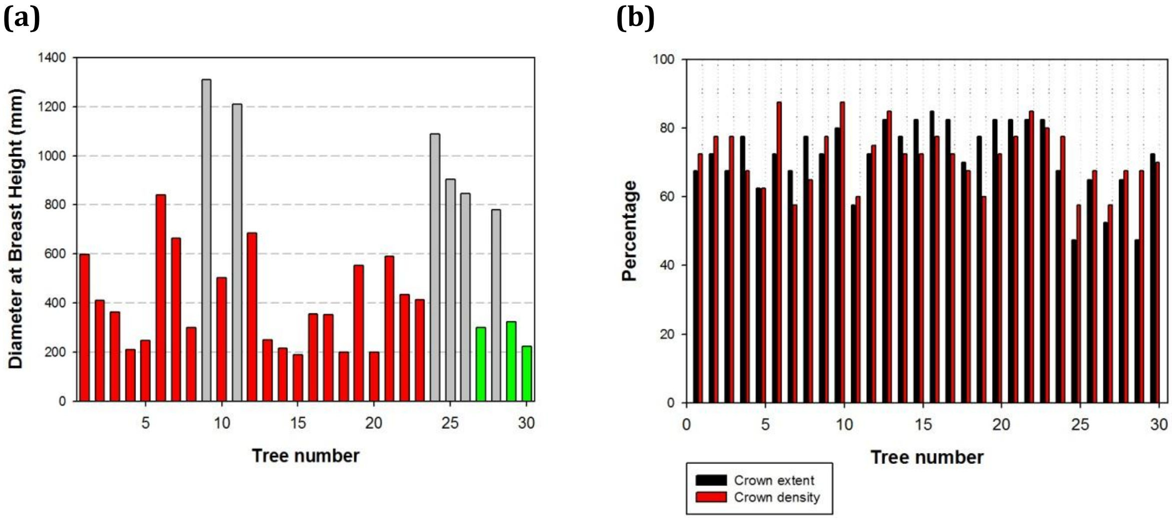


Figure 5.47(a) DBH for all trees assessed at site 12. Grey is Black Box, red is River Red Gum, green is River Cooba. (b) Crown extent and crown density for all trees assessed at site 12.

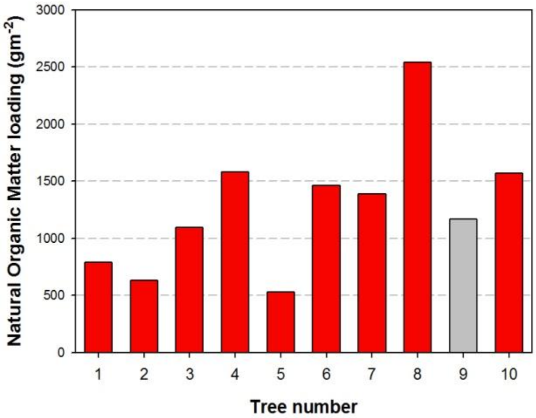


Figure 5.48. NOM for all trees assessed at site 12. Grey is Black Box, red is River Red Gum.

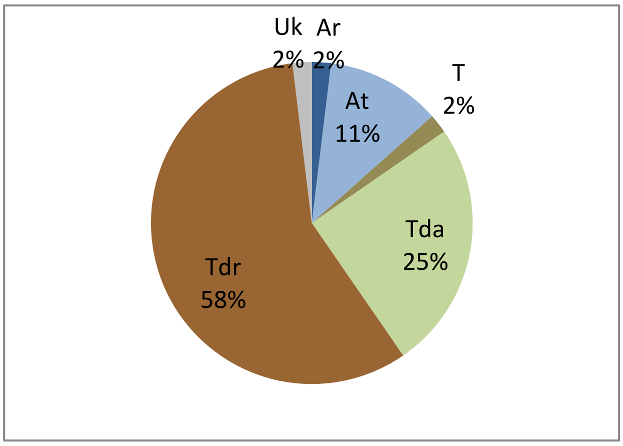


Figure 5.49. Pie chart displaying proportion of understorey plant species in broad functional groups for site 12. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.16. Understorey plant species diversity recorded at site 12.

Elevation	Native species	Exotic species	Total species
In-channel	0	0	0
Mid-bank	27	0	27
Tree-line	25	0	25
Floodplain	27	0	27
Total	52	0	52

Site 14

Site location and description

Site 14 is located upstream of Oakbank Dam on Oakbank Station. The site is dominated by grey clay soils with relatively flat topography. Condition Monitoring was limited to the eastern bank due to access restrictions on the western bank. The channel is wide and relatively deep (Figure 5.50). The overstorey is a mixed canopy of Black Box *Eucalyptus largiflorens* (BB), River Red Gum *Eucalyptus camaldulensis* (RRG) and River Cooba *Acacia stenophylla* (RC). The water level at the time of survey was similar to that observed in 2010, with newly exposed sediments suggesting a recent drop in water level.

Tree condition and NOM load

Species and size: Trees assessed consisted of 7 BB, 19 RRG and 4 RC. DBH varied considerably, with 21 of the 30 trees less than 400 mm, and a maximum DBH of 1775 mm (Figure 5.51a). Mean DBH is 398 mm.

Tree Condition Variables: Crown extent and crown density were relatively good across the site, with the majority of trees scoring greater than 60% for both variables (figure 5.51b); mean percentages are 74 and 70, respectively. The mean Tree Condition Index is 10.16 (**GOOD**).

Response Variables: New tip growth was evident on all 30 trees (mean score = 2); 16 trees supported epicormic growth (mean score = 1). Die-off was evident on all trees (mean score = -1). Reproductive extent was visible on the majority of trees (26; mean score = 2).

NOM load: NOM load was **LOW** (mean = 855 gm^{-2}) (Figure 5.52).

Understorey

A total of 53 species were recorded, 87% belong to terrestrial functional groups (FGs) and 11% to amphibious FGs (Figure 5.53). *Enchylaena tomentosa* (Tdr) was the most abundant native species, *Heliotropium curassavicum** (Tda) and *Conyza bonariensis** (Tdr) were the most abundant introduced species.

In-channel quadrats were not assessed during the 2011 Condition Monitoring as they were inundated to depths over 1.5 m. Floodplain elevations recorded the highest abundance of native species (26; Table 5.17), Tree-line quadrats recorded a high number and proportion of exotic species (11 species, 41%; Table 5.17).

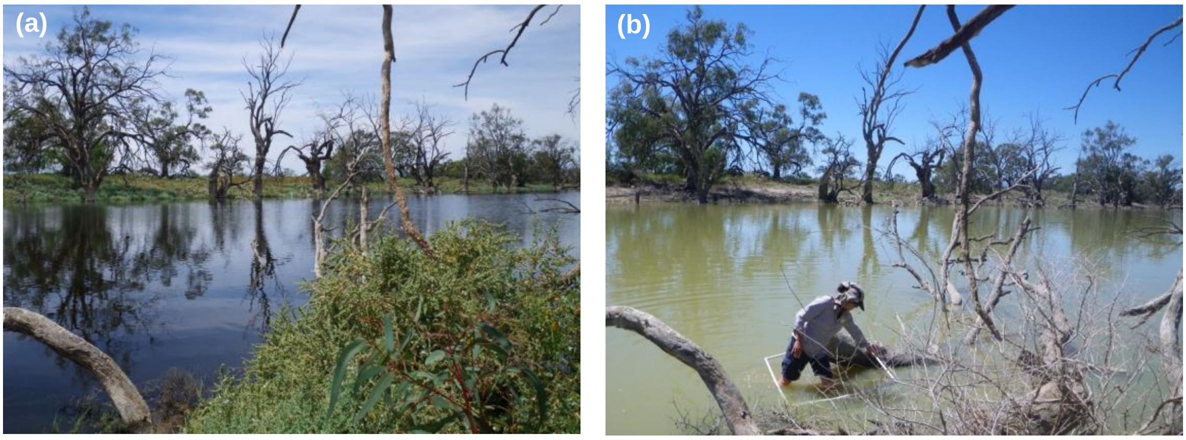


Figure 5.50. Photopoint of site 14, (a) November 2010, (b) November 2011. Photographer: D. Linklater, MDFRC.

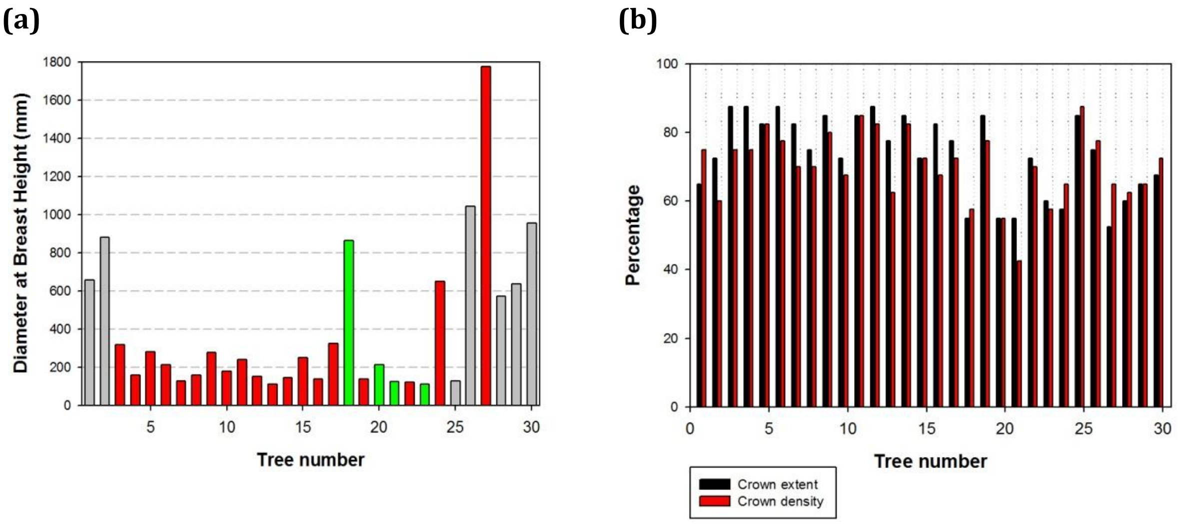


Figure 5.51(a) DBH for all trees assessed at site 14. Grey is Black Box, red is River Red Gum, green is River Cooba. (b) Crown extent and crown density for all trees assessed at site 14.

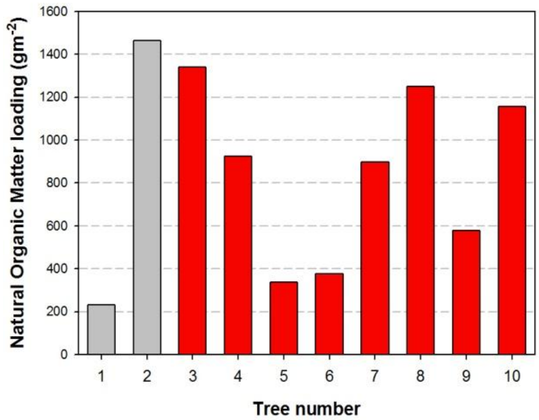


Figure 5.52. NOM for all trees assessed at site 14. Grey is Black Box, red is River Red Gum.

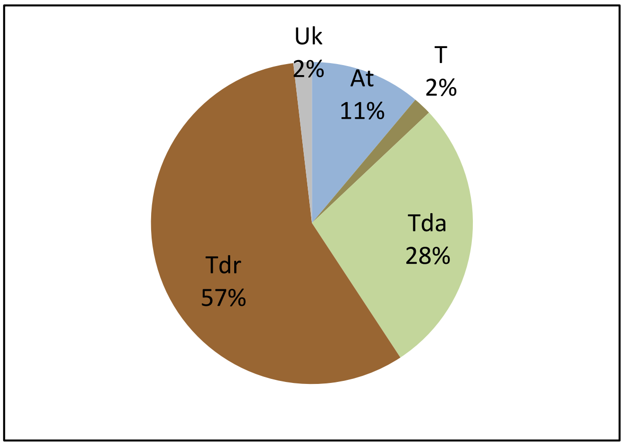


Figure 5.53. Pie chart displaying proportion of understorey plant species in broad functional groups for site 14. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; At=Amphibious tolerator.

Table 5.17. Understorey plant species diversity recorded at site 14.

Elevation	Native species	Exotic species	Total species
In-channel	Not assessed		
Mid-bank	0	0	0
Tree-line	16	11	27
Floodplain	26	3	29
Total	39	14	53

Site 15

Site location and description

Site 15 is approximately 1 km upstream of Oakbank Dam on Oakbank Station. Condition Monitoring was restricted to the steep eastern bank due to access restrictions on the west side. The wide and deep channel is under the influence of the Murray River Lock 9 weir pool (Figure 5.54). The overstorey consists of Black Box *Eucalyptus largiflorens* (BB), River Red Gum *Eucalyptus camaldulensis* (RRG) and River Cooba *Acacia stenophylla* (RC). Newly exposed sediment was observed at the time of survey indicating a recent drop in water level.

Tree condition and NOM load

Species and size: Trees assessed consisted of 6 BB, 12 RRG and 12 RC. DBH varied considerably at this site, the majority of BB had a DBH greater than 600 mm, RRG had the largest DBHs with a maximum of 2070 mm and most RC had a DBH less than 200 mm (Figure 5.55a). Mean DBH is 725 mm.

Tree Condition Variables: The majority of trees recorded crown extent and crown density between 60 and 80% (Figure 5.55b); mean percentages are 72 for both variables. The Tree Condition Index is 10.13 (**GOOD**).

Response Variables: New tip growth was visible on all 30 trees (mean score = 2); 13 of the 30 trees displayed epicormic growth (mean score = 1). Die-off was evident on all 30 trees (mean score = -1). Reproductive extent was clearly visible on all 30 trees (mean score = 2). Mistletoe was recorded as **SCARCE** on 2 trees.

NOM load: NOM load was **HIGH** (mean = 2191 gm^{-2}), with RRG recording **HIGH** to **VERY HIGH** NOM loads and RC recording **LOW** NOM loads (Figure 5.56).

Understorey

A total of 54 species were recorded; 87% belong to terrestrial functional groups (FGs), 13% to amphibious FGs (Figure 5.57). *Cyperus gymnocaulos* (Ate) was the most abundant native species, *Conyza bonariensis** (Tdr) the most abundant introduced species.

In-channel and Mid-bank quadrats were not assessed due to the presence of cows in these quadrats at the time of sampling. Floodplain elevations recorded the highest abundance of native species (25; Table 5.18), Tree-line quadrats recorded a high abundance of exotic species (12 species, 40% of total; Table 5.18). There was a significant difference in species composition between Tree-line and Floodplain elevations (P = 0.0318).

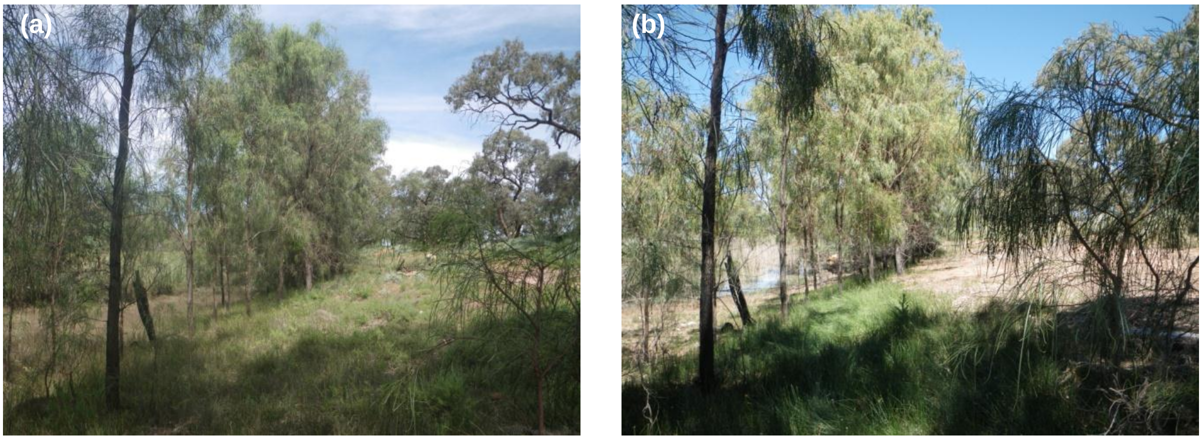


Figure 5.54. Photopoint of site 15, (a) October 2010, (b) November 2011. Photographer: D. Linklater, MDFRC.

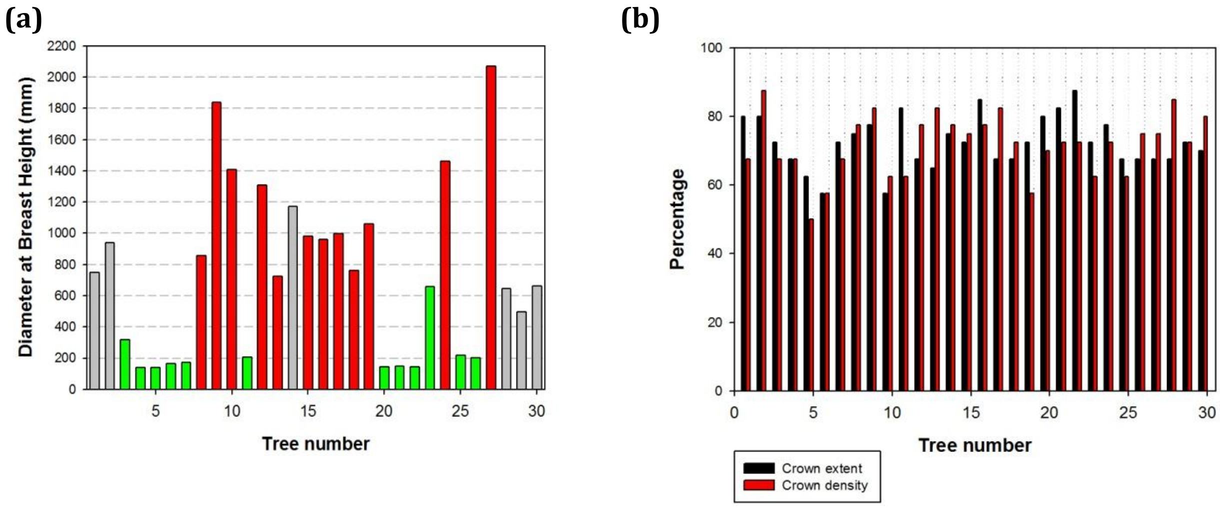


Figure 5.55(a) DBH for all trees assessed at site 15. Grey is Black Box, red is River Red Gum, green is River Cooba.[4] (b) Crown extent and crown density for all trees assessed at site 15.

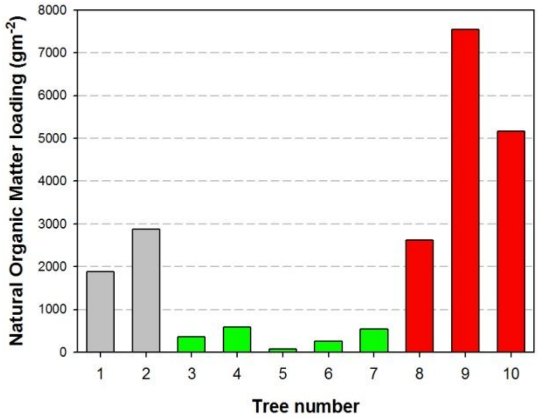


Figure 5.56. NOM for all trees assessed at site 15. Grey is Black Box, red is River Red Gum, green is River Cooba.

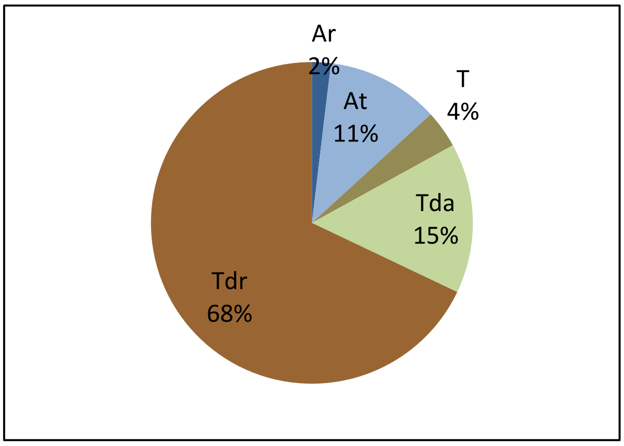


Figure 5.57. Pie chart displaying proportion of understorey plant species in broad functional groups for site 15. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.18. Understorey plant species diversity recorded at site 15.

Elevation	Native species	Exotic species	Total species
In-channel	Not assessed		
Mid-bank	Not assessed		
Tree-line	18	12	30
Floodplain	25	4	29
Total	40	14	54

4 In 2010 tree number 22 was incorrectly displayed with a DBH of 1440 mm.

Site 16

Site location and description

Site 16 is approximately 1 km downstream of Oakbank Dam on 'Oakbank Bend' Station (name adopted by authors). Condition monitoring was carried out on the eastern bank only due to access restrictions on the western bank. The wide and deep channel is under the influence of the Murray River Lock 9 weir pool (Figure 5.58). Salt-affected soils are evident. The canopy consists of Black Box *Eucalyptus largiflorens* (BB), River Red Gum *Eucalyptus camaldulensis* (RRG) and River Cooba *Acacia stenophylla* (RC). Grazing was evident at the time of survey, sheep and Black-tailed Native-hens (*Gallinula ventralis*) were observed at the site. The water level was slightly lower than during the 2010 Condition Monitoring survey period and there was evidence of previous overbank flooding.

Tree condition and NOM load

Species and size: Trees assessed consisted of 9 BB, 6 RRG and 15 RC. The majority of RC had a DBH less than 200mm, the maximum DBH (RRG) was 1721mm (Figure 5.59a). Mean DBH is 556 mm.

Tree Condition Variables: Crown extent and crown density varied across the site from less than 40% to over 90% (Figure 5.59b); mean percentages are 71 for both variables. The mean Tree Condition Index is 10 (**GOOD**).

Response Variables: New tip growth was clearly visible on 29 of the 30 trees (mean score =2); 9 trees supported epicormic growth (mean score = 1). Die-off was evident on most trees (29) (mean score = 1). Reproductive extent was clearly visible on 28 of the 30 trees (mean score = 2).

NOM load: NOM load overall was **MODERATE** (mean = 1976 gm^{-2}), two trees recorded **VERY HIGH** loads (a RRG and a BB, Figure 5.60).

Understorey

A total of 45 species were recorded (Table 5.19), 81% belong to terrestrial functional groups (FGs), and 17% to amphibious FGs (Figure 5.61). *Cyperus gymnocaulos* (Ate) was the most abundant native species; *Heliotropium supinum** (Tda) the most abundant introduced species.

In-channel quadrats were not assessed due to being inundated by over 2 m of water at the time of survey. Floodplain elevations recorded the highest abundance of native, exotic and total species by far (30, 7 and 37 respectively; Table 5.19). Significant differences in species composition were detected between all elevations (P ≤ 0.03).

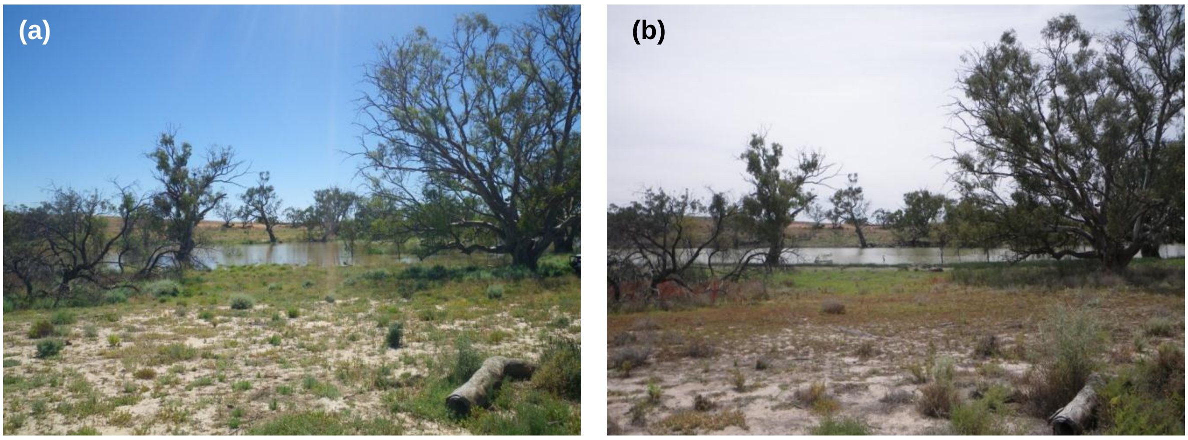


Figure 5.58. Photopoint for site 16, (a) October 2010, (b) October 2011. Photographer: D. Linklater, MDFRC.

(a) (b)

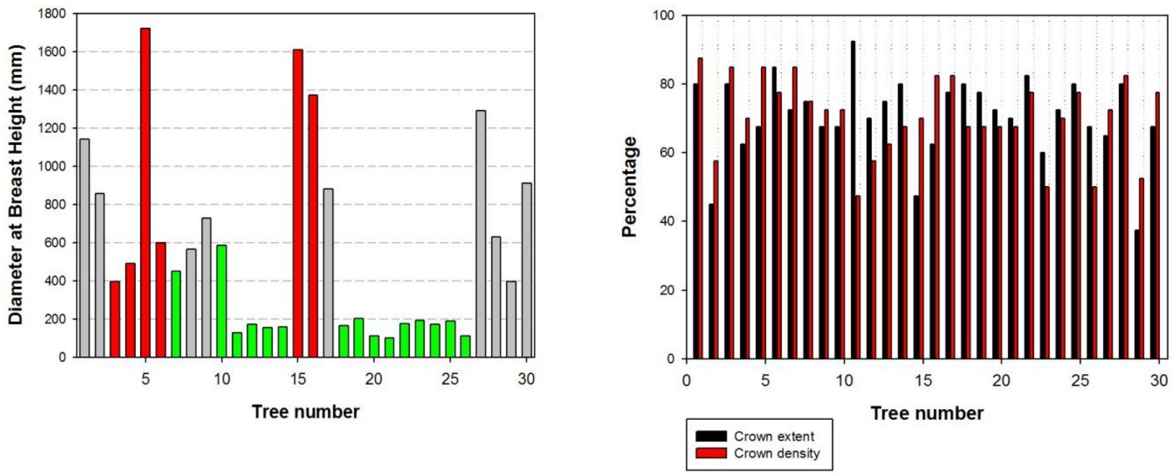


Figure 5.59(a) DBH for all trees assessed at site 16. Grey is Black Box, red is River Red Gum, green is River Cooba. (b) Crown extent and crown density for all trees assessed at site 16.

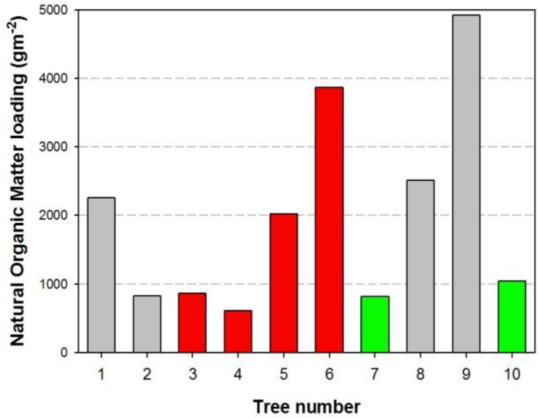


Figure 5.60. NOM for all trees assessed at site 16. Grey is Black Box, red is River Red Gum, green is River Cooba.

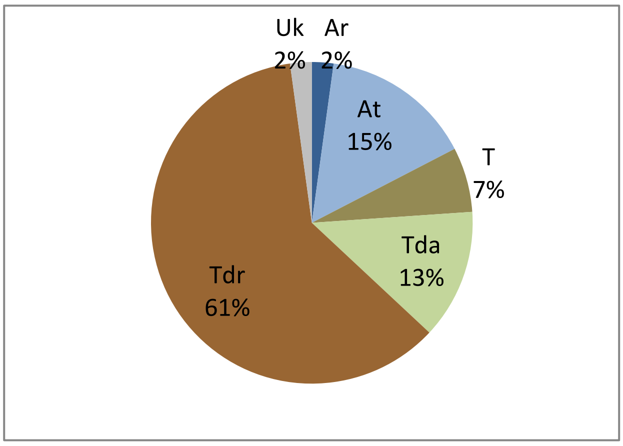


Figure 5.61. Pie chart displaying proportion of understorey plant species in broad functional groups for site 16. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.19. Understorey plant species diversity recorded at site 16.

Elevation	Native species	Exotic species	Total species
In-channel	Not assessed		
Mid-bank	4	1	5
Tree-line	10	4	14
Floodplain	30	7	37
Total	35	10	45

Site 17

Site location and description

Site 17 is located downstream of Oakbank Dam on 'Oakbank Bend' Station (name adopted by authors), in the Murray River Lock 9 weir pool. The site is characterised by grey clay soils on undulating topography and red sandy loam on steep banks. Condition Monitoring was carried out on the eastern side of the channel only, due to access restrictions on the west side. Black Box *Eucalyptus largiflorens* (BB) and River Red Gum *Eucalyptus camaldulensis* (RRG) are the dominant tree species along the edge of the channel (Figure 5.62). Grazing of vegetation was observed at this site. The water level was similar to that during the 2010 condition monitoring survey period; there was evidence of previous overbank flooding.

Tree condition and NOM load

Species and size: 22 BB and 8 RRG were assessed. The majority of BB had a DBH less than 1000 mm; the majority of RRG had a DBH greater than 1500 mm (Figure 5.63a). The maximum DBH (RRG) was 3210 mm; mean DBH is 1035 mm.

Tree Condition Variables: The majority of trees scored greater than 40% for crown extent and crown density (Figure 5.63b); mean percentages are 59 and 71, respectively. The mean Tree Condition Index is 9.53 (**MODERATE**).

Response Variables: New tip growth was visible on 29 trees (mean score = 1); 22 trees supported epicormic growth (mean score = 1). Die-off was observed on 18 of the 30 trees (mean score = -1). Reproductive extent on most trees (28) was clearly visible (mean score = 2).

NOM load: NOM load overall was **LOW** (mean = 858 gm^{-2}) across the site, with 5 trees (3 BB and 2 RRG) recording a **MODERATE** NOM load (Figure 5.64).

Understorey

Site 17 recorded the highest number of species, a total of 82; 88% belonging to terrestrial functional groups (FGs), and 11% belonging to amphibious FGs (Figure 5.65). *Cyperus gymnocaulos* (Ate) was the most abundant native species with *Conyza bonariensis** (Tdr) being the most abundant introduced species.

In-channel quadrats were not assessed due to being inundated by greater than 2 m of water at the time of survey. Floodplain elevations recorded the highest abundance of native, exotic and total species by far (52, 18 and 70 respectively; Table 5.20). Species composition differed significantly between all elevations (P ≤ 0.03).

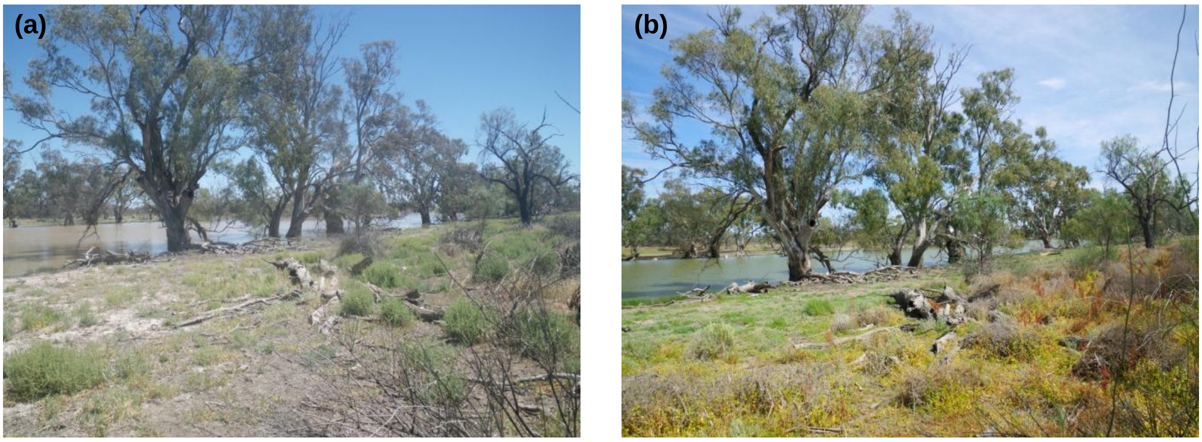
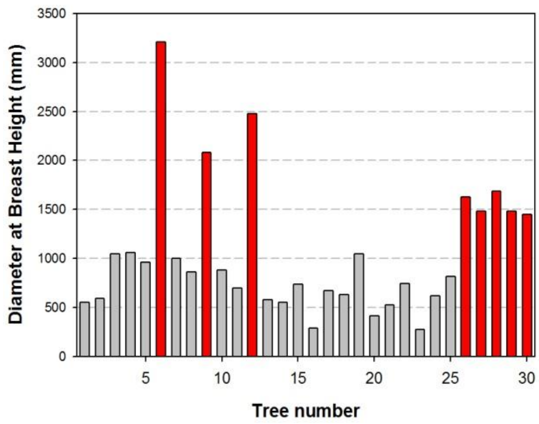


Figure 5.62. Photopoint for site 17, (a) November 2010, (b) October 2011. Photographers: (a) D. Linklater, MDFRC (b) D. Bogenhuber, MDFRC.

(a)



(b)

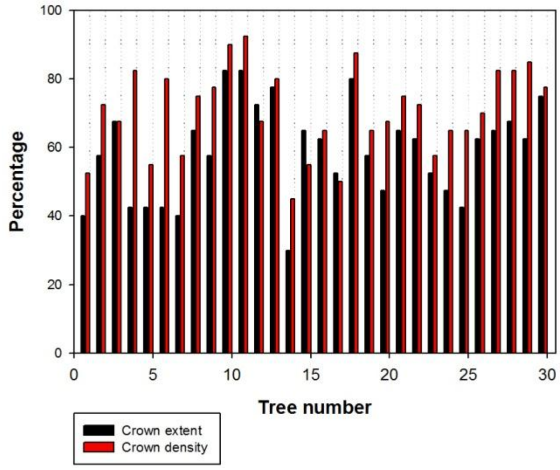


Figure 5.63(a) DBH for all trees assessed at site 17. Grey is Black Box, red is River Red Gum. (b) Crown extent and crown density for all trees assessed at site 17.

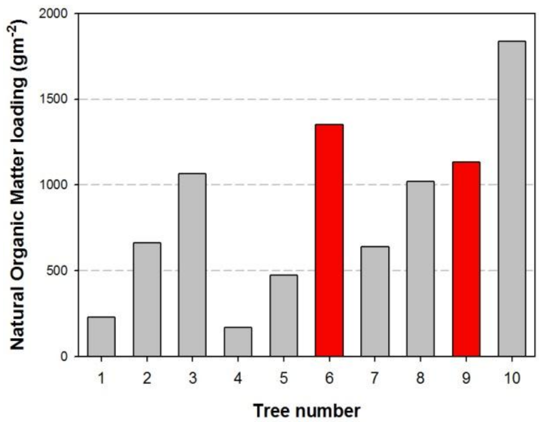


Figure 5.64. NOM for all trees assessed at site 17. Grey is Black Box, red is River Red Gum.

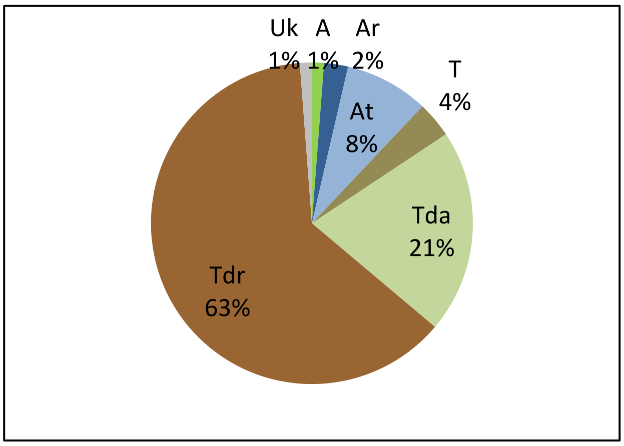


Figure 5.65. Pie chart displaying proportion of understorey plant species in broad functional groups for site 17. T=Terrestrial; Tda=Terrestrial damp; Tdr=Terrestrial dry; Uk=Unknown; A=Amphibious; Ar=Amphibious regulator; At=Amphibious tolerator.

Table 5.20. Understorey plant species diversity recorded at site 17.

Elevation	Native species	Exotic species	Total species
In-channel	Not assessed		
Mid-bank	2	0	2
Tree-line	26	6	32
Floodplain	52	18	70
Total	63	19	82

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Appendix A. Tree condition photo points, 2010 and 2011

Figure A1. Site 1 Photopoint (C. Campbell, MDFRC, 12/09/2011).

Figure A2. Site 2 Photopoint (D. Linklater, MDFRC, 3/11/2010).

Figure A3. Site 2 Photopoint (D. Linklater, MDFRC, 14/09/2011)

Figure A4. Site 3 Photopoint (D. Bogenhuber, MDFRC, 3/11/2010).

Figure A5. Site 3 Photopoint (D. Bogenhuber, MDFRC, 15/09/2011).

Figure A6. Site 4 Photopoint (D. Bogenhuber, MDFRC, 23/09/2010).

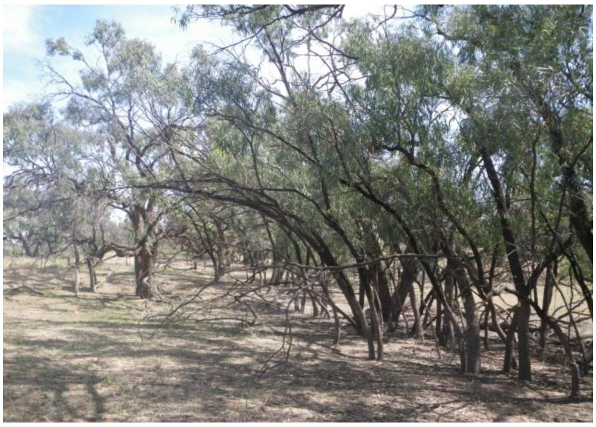

Figure A7. Site 4 Photopoint (D. Linklater, MDFRC, 26/10/2011).

Figure A8. Site 5

Figure A9. Site 5 Photopoint (D. Linklater, MDFRC, 25/10/2011).

Figure A10. Site 6 Photopoint (D. Bogenhuber, MDFRC, 22/09/2010).

Figure A11. Site 6 Photopoint (D. Bogenhuber, MDFRC, 25/10/2011).

Figure A12. Site 7 Photopoint (D. Bogenhuber, MDFRC, 30/09/2010).

Figure A13. Site 7 Photopoint (D. Linklater, MDFRC, 26/10/2011).

Figure A14. Site 8 Photopoint (D. Bogenhuber, MDFRC, 29/9/2010).

Figure A15. Site 8 Photopoint (D. Linklater, MDFRC, 27/10/2011).

Figure A16. Site 9a Photopoint (D. Bogenhuber, MDFRC, 24/09/2010).

Figure A17. Site 9a Photopoint (D. Linklater, MDFRC, 27/10/2011).

Figure A18. Site 9b Photopoint (D. Bogenhuber, MDFRC, 12/10/2010).

Figure A19. Site 9b Photopoint (D. Linklater, MDFRC, 27/10/2011).

Figure A20. Site 10 Photopoint (D. Bogenhuber, MDFRC, 13/10/2010).

Figure A21. Site 10 Photopoint (G. Cranston, MDFRC, 3/11/2011).

Figure A22. Site 11 Photopoint

Figure A23. Site 11Photopoint (D. Linklater, MDFRC, 7/11/2011).

Figure A24. Site 12 Photopoint (D. Bogenhuber, MDFRC, 21/10/2010).

Figure A25. Site 12 Photopoint (D. Linklater, MDFRC, 2/11/2011).

Figure A26. Site 14 Photopoint (D. Linklater, MDFRC, 28/10/2010).

Figure A27. Site 14 Photopoint (D. Linklater, MDFRC, 4/11/2011).

Figure A28. Site 15 Photopoint (D. Linklater, MDFRC, 28/10/2010).

Figure A29. Site 15 Photopoint (D. Linklater, MDFRC, 4/11/2011).

Figure A30. Site 16 Photopoint (D. Linklater, MDFRC, 28/10/2010).

Figure A31. Site 16 Photopoint (D. Linklater, MDFRC, 31/10/2011).

Figure A32. Site 17 Photopoint (D. Linklater, MDFRC, 29/10/2010).

Figure A33. Site 17 Photopoint (D. Bogenhuber, MDFRC, 28/10/2011).

Appendix B. Understorey photo points, 2010 and 2011

Figure B1. Site 1 (D. Bogenhuber, MDFRC, 14/09/2011)

Figure B2. Site 2 (D. Bogenhuber, MDFRC, 3/11/2010).

Figure B3. Site 2 (D. Linklater, MDFRC, 14/09/2011).

Figure B4. Site 3 (D. Linklater, MDFRC, 3/11/2010).

Figure B5. Site 3 (D. Bogenhuber, MDFRC, 14/09/2011).

Figure B6. Site 4 (D. Bogenhuber, MDFRC, 23/09/2010).

Figure B7. Site 4 (D. Linklater, MDFRC, 26/10/2011).

Figure B8. Site 5 (D. Bogenhuber, MDFRC, 21/09/2010).

Figure B9. Site 5 (D. Linklater, MDFRC, 25/10/2011).

Figure B10. Site 6 (D. Bogenhuber, MDFRC, 22/09/2010).

Figure B11. Site 6 (D. Bogenhuber, MDFRC, 25/10/2011).

Figure B12. Site 7 (D. Bogenhuber, MDFRC, 30/09/2010).

Figure B13. Site 7 (D. Linklater, MDFRC, 26/10/2011).

Figure B14. Site 8 (C. Campbell, MDFRC, 29/09/2010).

Figure B15. Site 8 (D. Linklater, MDFRC, 1/11/2011).

Figure B16. Site 9a (D. Bogenhuber, MDFRC, 28/09/2010).

Figure B17. Site 9a (D. Linklater, MDFRC, 27/10/2011).

Figure B18. Site 9b (D. Bogenhuber, MDFRC, 12/10/2010).

Figure B19. Site 9b (D. Bogenhuber, MDFRC, 7/11/2011).

Figure B20. Site 10 (D. Bogenhuber, MDFRC, 19/10/2010).

Figure B21. Site 10 (D. Linklater, MDFRC, 3/11/2011).

Figure B22. Site 11 (D. Linklater, MDFRC, 20/10/2010).

Figure B23. Site 11 (D. Linklater, MDFRC, 7/11/2011).

Figure B24. Site 12 (D. Bogenhuber, MDFRC, 20/10/2010).

Figure B25. Site 12 (D. Linklater, MDFRC, 2/11/2011).

Figure B26. Site 14 (D. Bogenhuber, MDFRC, 8/11/2010).

Figure B27. Site 14 (D. Linklater, MDFRC, 4/11/2011).

Figure B28. Site 15 (D. Bogenhuber, MDFRC, 8/11/2010).

Figure B29. Site 15 (D. Linklater, MDFRC, 4/11/2011).

Figure B30. Site 16 (D. Bogenhuber, MDFRC, 9/11/2010).

Figure B31. Site 16 (D. Linklater, MDFRC, 31/10/2011).

Figure B32. Site 17 (D. Linklater, MDFRC, 9/11/2010).

Figure B33. Site 17 (D. Bogenhuber, MDFRC, 28/10/2011).

Appendix C. Understorey species list, 2010 and 2011

Functional group	Scientific name	Common name	Family	Site 1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
T	*Acacia sp seedling (not stenophylla or unknown) (NSW)*	Acacia seedling	Fabaceae-Mimosoideae												10					11
T	*Acacia sp. (NSW)*		Fabaceae-Mimosoideae		10										10			11		
Atw	*Acacia stenophylla juvenile (NSW)*	River Cooba	Fabaceae-Mimosoideae													11		10,11		
Atw	*Acacia stenophylla mature (NSW)*	River Cooba	Fabaceae-Mimosoideae	11	10,11					10								10,11	11	
Atw	*Acacia stenophylla seedling (NSW)*	River Cooba	Fabaceae-Mimosoideae		10	10,11				10			10,11			11		10,11	11	11
Tdr	*Acacia victoriae ssp arida (NSW)*		Fabaceae-Mimosoideae												11					
Tdr	*Actinobole uliginosum*	Flannel Cudweed	Asteraceae				10			10										
Tda	*Alopecurus geniculatus**	Marsh Foxtail	Poaceae		11															
Tda	*Alternanthera denticulata*	Lesser Joyweed	Amaranthaceae		10		10	11	11			10	10	10						
Tda	*Alternanthera nodiflora*	Common Joyweed	Amaranthaceae			11	11				11		11		11					11
Tdr	*Alyssum linifolium**	Flax-leaf Alyssum	Brassicaceae		10	11		10			10	10								
Tdr	*Anagallis arvensis* (NSW)*	Scarlet Pimpernel	Myrsinaceae															10		
Tdr	*Asphodelus fistulosus**	Onion Weed	Asphodelaceae											10,11						11
Tda	*Aster subulatus**	Wild Aster	Asteraceae												11		11	11		
T	*Asteraceae*	Daisy	Asteraceae					11							11					
T	*Asteraceae (exotic)**	Daisy	Asteraceae			10	10	10	10		10		10	10	10	10	10	10		10
Tdr	*Atriplex conduplicata (NSW)*		Chenopodiaceae								10					10,11	10,11			
Tdr	*Atriplex eardleyae*		Chenopodiaceae		10,11	10	10,11	10,11	10	10	10,11	10	10	10	10,11	10,11	10,11	10,11	10,11	10,11
Tdr	*Atriplex holocarpa*	Pop Saltbush	Chenopodiaceae				10	10	10	10	10	10	10	10	10		10		10	10,11
Tdr	*Atriplex leptocarpa*	Slender-fruit Saltbush	Chenopodiaceae		10,11	10,11	10,11	10,11	10		10,11	10		10	10,11	10,11	10,11		10,11	10,11
Tdr	*Atriplex limbata*		Chenopodiaceae				10		10		10							10,11		10,11

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Tdr	*Atriplex lindleyi*		Chenopodiaceae		110,1	10,11	10,11	10,11			10,11	10		10		10,11	10,11	10	10,11	10,11
Tdr	*Atriplex nummularia (NSW)*	Old Man Saltbush	Chenopodiaceae					11					11							11
Tdr	*Atriplex semibaccata*	Creeping Saltbush	Chenopodiaceae			11		10	10				10	10,11	10,11	10	10,11	10	10,11	10
Tdr	*Atriplex sp.*	Saltbush	Chenopodiaceae	11	11	11	10,11	10,11	10	10	10,11	10	10	10,11	10,11	10,11	10,11	10,11	11	11
Tdr	*Atriplex spongiosa*	Pop Saltbush	Chenopodiaceae																	11
Tdr	*Atriplex stipitata*	Mallee Saltbush	Chenopodiaceae		11		10				10		10	10	10					
Tdr	*Atriplex sturtii (NSW only)*		Chenopodiaceae								10									
Tdr	*Atriplex suberecta*	Sprawling Saltbush	Chenopodiaceae		10			10,11						10	10	10		11		
Tdr	*Atriplex vesicaria subsp sphaerocarpa (NSW only)*	Bladder Saltbush	Chenopodiaceae					10												
Tdr	*Austrodanthonia caespitosa*	Ringed Wallaby Grass	Poaceae											10						
Tdr	*Austrodanthonia setacea*	Smallflower Wallaby Grass	Poaceae					11										11		
Tdr	*Austrostipa scabra*	Speargrass	Poaceae						10		10		11	10,11	11			11		11
Tdr	*Austrostipa scabra subsp scabra*	Speargrass	Poaceae																	11
Tdr	*Austrostipa sp.*	Speargrass	Poaceae		10,11	10	10,11		10		10,11		10		10	10	10	10		10
	Bare ground				11	11	10,11	10,11	10,11	10,11	10,11	11	11	11	10,11	10,11				
Tdr	*Boerhavia dominii*	Tarvine	Nyctaginaceae		10								10	10,11	10,11	10	10,11	10	10	10
Tda	*Brachyscome basaltica var gracilis*	Swamp Daisy	Asteraceae							10										
Tdr	*Brachyscome ciliaris*	Variable daisy	Asteraceae												10					
Tdr	*Brachyscome ciliaris var lanuginosa*	Variable daisy	Asteraceae												11			11		
Tdr	*Brachyscome dentata*		Asteraceae			10		10												
Tdr	*Brachyscome leptocarpa (NSW)*	Small Hairy Daisy	Asteraceae		11	11														
Tdr	*Brachyscome lineariloba*	Hard-headed Daisy	Asteraceae				10	10	10	10	10	10	10			10		10		10
Tda	*Brachyscome melanocarpa (NSW only)*	Black-seeded Daisy	Asteraceae			11	10,11	10,11	10,11		10,11	10,11	11	10,11	10,11	10,11	10,11	11	10,11	10,11
T	*Brachyscome sp.*	Daisy	Asteraceae														10			

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Tdr	*Brassica tournefortii**	Meditteranean Turnip	Brassicaceae									10	10	10	10			10		
T	*Brassicaceae*		Brassicaceae				10,11	11	10,11				11		11					11
Tdr	*Bromus hordeaceus* (NSW)*	Soft Brome	Poaceae				10													
Tdr	*Bromus rubens**	Red Brome	Poaceae										10		11					
Tdr	*Bromus sp.*	Brome	Poaceae						10	10	10	10	10	10	10	10		10		10
Tda	*Bulbine alata (NSW)*	Bulbine Lily	Asphodelaceae							10										
Tdr	*Bulbine semibarbata*	Wild Onion	Asphodelaceae																	11
Tda	*Bulbine sp. (NSW)*	Bulbine Lily	Asphodelaceae		10	10	10		10	10	10				10	10	10	10	10	10
Tdr	*Calandrinia eremaea*		Portulacaceae		10		10		10	10	10								10	10
Tdr	*Calendula arvensis**	Field Marigold	Asteraceae														10			
Arp	*Callitriche sonderi*		Callitrichaceae	11			11			10										
Arp	*Callitriche sp.*	Starwort	Callitrichaceae		11	11														
Tdr	*Calocephalus sonderi*	Pale Beauty-heads	Asteraceae				10			10	10									
Tdr	*Calotis cuneifolia*	Purple Burr-daisy	Asteraceae				10,11													
Tdr	*Calotis hispidula*	Bogan Flea	Asteraceae	11	11	11	10,11	10	10	10	10	10	10	10	10	10		10	10	10,11
Tdr	*Calotis sp.*	Burr-daisy	Asteraceae		10		10		10	10	10	10	10	10	10	10				
Tdr	*Carrichtera annua**	Ward's Weed	Brassicaceae					10						10,11	10		10,11			
Tdr	*Carthamus lanatus**	Saffron thistle	Asteraceae											11						
Tdr	*Carthamus sp.**	Thistle	Asteraceae											10						
Tdr	*Centaurea melitensis**	Maltese Cockspur	Asteraceae				10					10	10		11	11				
Tdr	*Centaurea sp.**	Knapweed	Asteraceae											10	10					
Atl	*Centipeda cunninghamii*	Common Sneezeweed	Asteraceae	11	10,11	11	10,11	11		10	10		10,11	10	11	11	11	11	11	11
Atl	*Centipeda minima subsp minima*	Spreading Sneezeweed	Asteraceae													11	11	11		11
Atl	*Centipeda sp.*	Sneezeweed	Asteraceae	11	11	11		11	11	10			11		10				11	11

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Tdr	*Chamaesyce drummondii*	Caustic Weed	Euphorbiaceae		10,11		10		10		10,11	10	10,11	10,11	10,11	10,11	10	10	10,11	10,11
S	*Charophyceae*		Charophyceae												10					
T	*Chenopodiaceae*	Chenopod	Chenopodiaceae						10		10	10				10				11
Tdr	*Chenopodium cristatum*	Crested Goosefoot	Chenopodiaceae		10		10			10		10	10		10		10	10,11	10	10
Tdr	*Chenopodium murale**	Nettle-leaf Goosefoot	Chenopodiaceae															11		
Tda	*Chenopodium nitrariaceum*	Nitre Goosefoot	Chenopodiaceae					10,11			10,11									
Tdr	*Chenopodium pumilio*	Small Crumbweed	Chenopodiaceae			11	10,11	11		10	10	10			10	11			10,11	
Tdr	*Chenopodium sp.*	Crumbweed/Goosefoot	Chenopodiaceae			10	10	10	10	10	10	10	10	10	10					
Tdr	*Cirsium vulgare**	Spear Thistle	Asteraceae							11	10,11		10,11	10,11	10,11	10,11	10,11	10,11	11	
Tdr	*Convolvulus erubescens (NSW-out of range)*	Blushing Bindweed	Convolvulaceae		10	10						10								
Tdr	*Convolvulus remotus*		Convolvulaceae								10	10		11	10		10	11		11
Tdr	*Convolvulus sp*	Bindweed	Convolvulaceae			10				11			10	10,11	11			10		10
Tdr	*Conyza bonariensis**	Flaxleaf Fleabane	Asteraceae			11	11						11	10	11	11	11	11	11	11
Tda	*Craspedia haplorrhiza*		Asteraceae			11														
Tda	*Craspedia sp.*	Billy-buttons	Asteraceae												10	10				
Tda	*Crassula colorata*	Dense Stonecrop	Crassulaceae		11	11														11
Tda	*Crassula decumbens var decumbens*	Stonecrop	Crassulaceae	11	11	11	10,11													
Tda	*Crassula sp.*	Stonecrop	Crassulaceae	11	10,11	11	10,11	10	10,11	10	10	10	10	10	10	10	10	10	10	10
Tda	*Cressa australis*		Convolvulaceae													10		10,11		
Tdr	*Cucumis myriocarpus subsp leptodermis**	Paddy Melon	Cucurbitaceae							10					10					11
Ate	*Cyperaceae*		Cyperaceae				11													
Ate	*Cyperus gymnocaulos*		Cyperaceae										11			10,11		10,11	11	11
Tdr	*Daucus glochidiatus*	Native Carrot	Apiaceae		10,11	10			10	10			10	10	11			10		11
Tdr	*Disphyma crassifolium subsp clavellatum*		Aizoaceae																10,11	10,11

Functional group	Scientific name	Common name	Family	Site 1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Tdr	*Dissocarpus paradoxus*	Canonball Burr	Chenopodiaceae				10				10			10	10		10	10,11		10,11
Tda	*Dittrichia graveolens**	Stinkwort	Asteraceae						11					10		10,11	11			11
Tdr	*Dysphania glomulifera*		Chenopodiaceae		11		11		11											
Tdr	*Dysphania glomulifera subsp. glomulifera*		Chenopodiaceae	11	11	11														
Arp	*Eclipta platyglossa*		Asteraceae							10				10	11	11		11	11	11
Tdr	*Einadia nutans*	Climbing Saltbush	Chenopodiaceae		10,11	11	10,11	10,11	10	10,11	10,11	10	10,11	10,11	10,11	10,11	10,11	10,11	10,11	11
A	*Emergent seedling-aquatic/amphibious*												11		11				11	11
	Emergent seedling-damp				11	10,11	11	10,11		10	10,11		11		10		11			11
Tdr	*Emergent seedling-dry*			11	10,11	10,11	10	10,11	10		10	10	10	10,11		11		10,11	11	11
Tdr	*Emex australis**	Spiny Emex	Polygonaceae							10,11			10,11							
Tdr	*Enchylaena tomentosa (NSW)*	Ruby Saltbush	Chenopodiaceae	11	10,11	10	10,11	10,11	10	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11
Tdr	*Enneapogon avenaceus*	Bottle washers	Poaceae												11					11
Tdr	*Enneapogon gracilis*	Slender Bottle-washers	Poaceae						10											
Tdr	*Enneapogon intermedius (NSW only)*	Nineawn	Poaceae												10					
Tdr	*Enneapogon sp.*	Nineawn	Poaceae		10	10														
Tda	*Epaltes australis (NSW)*	Spreading Nut-heads	Asteraceae	11	10,11	11	10,11	11	11	10,11			11	10	10,11	11	11	11	11	11
Tdr	*Eragrostis dielsii*	Mallee Lovegrass	Poaceae		10,11									10,11	10,11	10,11			11	10,11
Tdr	*Eragrostis sp.*	Love-grass	Poaceae													10				
Tdr	*Erodium sp.*	Crowfoot/Storksbill	Geraniaceae												10					
Atw	*Eucalyptus camaldulensis juvenile*	River Red Gum	Myrtaceae							11				10,11			10,11			
Atw	*Eucalyptus camaldulensis mature*	River Red Gum	Myrtaceae							10,11				10,11		10	11	10,11		11
Atw	*Eucalyptus camaldulensis seedling*	River Red Gum	Myrtaceae							10				10	10	11	10,11			11
Atw	*Eucalyptus largiflorens juvenile*	Black Box	Myrtaceae			10,11	10		10			11		10			10,11			

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Atw	*Eucalyptus largiflorens mature*	Black Box	Myrtaceae	11			10,11	10,11	10	10,11	10,11	10,11	10,11	10,11		10	11	11		
Atw	*Eucalyptus largiflorens seedling*	Black Box	Myrtaceae	11	11	11	11	11	11		10,11		11	10,11	10,11		10			
Atw	*Eucalyptus sp seedling*		Myrtaceae			10		11							10	10,11	11		11	11
T	*Fabaceae - Faboideae (NSW)*		Fabaceae-Faboideae					11					11					11	11	
Tdr	*Gazania rigens**	Treasure Flower	Asteraceae															10		
Tda	*Geococcus pusillus*		Brassicaceae				11													
Tda	*Glinus lotoides (NSW)*		Aizoaceae					11		10	10				10	11				11
Tda	*Glycyrrhiza acanthocarpa (NSW)*	Native Liquorice	Fabaceae-Faboideae												10					11
Tda	*Gnaphalium sp. J (aff. sphaericum) (NSW)*		Asteraceae	11	10,11	10,11	10,11	11			11	10			11	11		11		
Tdr	*Goodenia fascicularis*		Goodeniaceae																	10
Tda	*Goodenia glauca*		Goodeniaceae	11	10,11	10,11	11		10						11	10,11	11			11
Tda	*Goodenia heteromera*		Goodeniaceae			11	10,11		11				11				11	11		11
T	*Goodenia sp.*	Goodenia	Goodeniaceae								10,11						10	10,11	10	10,11
Tda	*Haloragis glauca f. Glauca*		Haloragaceae												11		11			
T	*Haloragis sp.*	Raspwort	Haloragaceae	11	11	11	10,11													11
Tdr	*Hedypnois rhagodioloides**	Cretan Weed	Asteraceae												10					
Tda	*Heliotropium curassavicum* (NSW)*	Smooth Heliotrope	Boraginaceae					11							11	10,11	10,11			11
Tda	*Heliotropium europaeum**	Potato Weed	Boraginaceae														10	10		
T	*Heliotropium sp.*	Heliotrope	Boraginaceae	11	11	11	11													
Tda	*Heliotropium supinum**	Prostrate Heliotrope	Boraginaceae	11			11	11	11							11			11	11
Tdr	*Herniaria cinerea**	Hairy Rupturewort	Caryophyllaceae		11	10,11	10			10	10	10	10	10	10	10		10,11	10	11
Tdr	*Hordeum glaucum**	Northern Barley Grass	Poaceae									10								
Tdr	*Hordeum marinum**	Sea Barley Grass	Poaceae										10							
Tdr	*Hordeum sp.**	Barley Grass	Poaceae		10	10				10	10	10	10	10	10,11	10	10	10	10	10
Tdr	*Hyalosperma glutinosum subsp glutinosum*		Asteraceae												10					

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
I	*Inundated*			11	11	11	10,11	10	10,11	10	10	11	11	11	10	10				
Tdr	*Isoetopsis graminifolia*	Grass Cushions	Asteraceae				10	10				10				10				10
Ate	*Isolepis australiensis*	Club-sedge	Cyperaceae	11	11	11	10,11	11	11				11		10					
Ate	*Juncus bufonius*	Toad Rush	Juncaceae			11	10,11	11												
Ate	*Juncus sp.*	Rush	Juncaceae				10								11					
Tda	*Lachnagrostis filiformis*		Poaceae		10	11	10,11	11					10	10	10,11					
Tdr	*Lactuca serriola**	Prickly Lettuce	Asteraceae											10	10,11	10	10	10		
Tdr	*Lamarckia aurea**	Goldentop	Poaceae							10			10							
T	*Lamiaceae*		Lamiaceae											10						
LL	*Leaf litter >50%*			11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	11
Tdr	*Leiocarpa leptolepis*	Pale Plover-daisy	Asteraceae								11			11				11		
Tdr	*Leiocarpa sp.*	Plover-daisy	Asteraceae												11					
F	*Lemna sp.*		Lemnaceae					10		10										
Tdr	*Lepidium pseudohyssopifolium*	Peppercress	Brassicaceae									10	10					10		
Tdr	*Lepidium sagittulatum (NSW only)*		Brassicaceae																	11
Tdr	*Lepidium sp.*	Peppercress	Brassicaceae		10	10		11			10,11		10	10				10		10
Tdr	*Limonium sinuatum**	Sea Lavender	Plumbaginaceae																11	11
Tdr	*Limonium sp.**	Sea Lavender	Plumbaginaceae											10	10		10		10	
Arp	*Limosella australis*	Australian Mudwort	Scrophulariaceae	11	11	11	11	11	11	10	10		11		10					
Tdr	*Lolium perenne**	Perennial Ryegrass	Poaceae															10		
Arp	*Ludwigia peploides subsp montevidensis*	Water Primrose	Onagraceae				10		11											11
Tdr	*Lycium ferrocissimum**	African Boxthorn	Solanaceae															10		
Tda	*Lythrum hyssopifolia*	Hyssop Loosestrife	Lythraceae			11	10	11	11	10			11			11	11			11
Tdr	*Maireana appressa*	Bluebush	Chenopodiaceae																	10

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Tdr	*Maireana brevifolia*	Small-leaf Bluebush	Chenopodiaceae							11	11			10				10,11		
Tdr	*Maireana eriocladа*	Rosy Bluebush	Chenopodiaceae							10						10				
Tdr	*Maireana pentatropis*	Erect Mallee Bluebush	Chenopodiaceae															10		
Tdr	*Maireana pyramidata*	Black Bluebush	Chenopodiaceae							10										
Tdr	*Maireana sclerolaenoides (NSW)*		Chenopodiaceae											10			10			
Tdr	*Maireana sedifolia*	Pearl bluebush	Chenopodiaceae											11						
Tdr	*Maireana sp.*	Bluebush	Chenopodiaceae							10	10,11		10,11	10,11	10,11	10,11	11	10,11	11	10,11
Tdr	*Maireana turbinata*	Satiny Bluebush	Chenopodiaceae								10,11			10						11
Tdr	*Malacocera tricornis*	Soft Horns	Chenopodiaceae								10					10,11	10,11		10,11	10
Tdr	*Malva parviflora**	Small-flowered Mallow	Malvaceae			11	10,11	10		10,11										11
Tdr	*Malva preissiana*	Native Hollyhock	Malvaceae							10				10						
Tdr	*Malva sp.*		Malvaceae			10	10						10				10	10		10
Tdr	*Malvaceae*		Malvaceae					10						10					10	
Tdr	*Marrubium vulgare**	White Horehound	Lamiaceae				10					10	10	10,11	10,11					11
Arp	*Marsilea drummondii*	Common Nardoo	Marsiliaceae	11	11	11	10,11		10		10	10	10,11							
Tdr	*Medicago minima* (NSW)*	Woolly Burr Medic	Fabaceae-Faboideae				10					10					11			
Tdr	*Medicago polymorpha* (NSW)*	Burr Medic	Fabaceae-Faboideae									10			11					11
Tdr	*Medicago praecox* (NSW)*	Small-leaved Burr Medic	Fabaceae-Faboideae			11	11		10											
Tdr	*Medicago sp.* (NSW)*	Medic	Fabaceae-Faboideae	11	11	10	10,11	10	10	10	10	10	10	10	10,11	10	10	10,11	10	10
Tdr	*Medicago truncatula* (NSW)*	Barrel medic	Fabaceae-Faboideae															11		
Tdr	*Melilotus indicus* (NSW)*	Hexham Scent	Fabaceae-Faboideae			10		11				10	10	10		10,11	10,11			
Tda	*Mentha australis*	River Mint	Lamiaceae	11	11	11	11	11	11											
Tdr	*Mesembryanthemum crystallinum**	Common Ice Plant	Aizoaceae																11	
Tdr	*Mesembryanthemum nodiflorum**	Small Ice Plant	Aizoaceae		10			10								10,11	10	10	10	10
Ate	*Muehlenbeckia florulenta-seedling*	Lignum	Polygonaceae			11	11	11	11				11						11	11

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Ate	*Muehlenbeckia florulenta-mature*	Lignum	Polygonaceae			10,11	10	10	10,11		11	10	10,11				10,11		10,11	10
Tda	*Myosurus australis*		Ranunculaceae	11	11	11	10,11	11		10	10		11	10						
Arp	*Myriophyllum sp.*	Water-milfoil	Myriophyllaceae				10							10	10					
Arp	*Myriophyllum verrucosum*	Red Water-milfoil	Haloragaceae	11		11	11	11			11	11	11	11	11					
Tdr	*Neobassia proceriflora*	Soda Bush	Chenopodiaceae		10	10	10													
Tdr	*Nicotiana glauca**	Tree Tobacco	Solanaceae							11			11			11				
Tdr	*Nicotiana occidentalis subsp obliqua (NSW only)*	Native Tobacco	Solanaceae	11	11		10,11	11		10,11										11
Tdr	*Omphalolappula concava*	Burr Stickseed	Boraginaceae									10	10							
Tdr	*Osteocarpum acropterum var deminuta (NSW)*		Chenopodiaceae		10		10,11	10,11	10	10,11	10,11	10		10		10,11	10,11	10	10	10,11
Tdr	*Oxalis radicosa*		Oxalidaceae													10				
Tdr	*Parapholis incurva**	Coast Barb Grass	Poaceae											10	10	10				
Ate	*Persicaria decipiens*	Slender Knotweed	Polygonaceae				11													
Ate	*Persicaria lapathifolia*	Pale Knotweed	Polygonaceae					11												
A	*Persicaria sp.*	Knotweed	Polygonaceae										11							11
Tdr	*Phalaris minor**	Lesser Canary Grass	Poaceae														10			
Tdr	*Phalaris paradoxa**	Paradoxa Grass	Poaceae											10						
Tda	*Phyllanthus lacunarius*		Phyllanthaceae			11	10													
T	*Phyllanthus sp.*	Spurge	Phyllanthaceae				10				10									
Tda	*Plantago coronopus subsp commutata**	Buck's-horn Plantain	Plantaginaceae							10										
Tda	*Plantago cunninghamii*	Plantain	Plantaginaceae					10		10										
Tda	*Plantago drummondii*	Plantain	Plantaginaceae	11	10,11	10,11	10,11	10,11	10	10	10	10	10	10	10					
T	*Plantago sp.*	Plantain	Plantaginaceae		11				10						10					
T	*Poaceae*	Grass	Poaceae		11	11	11	10	10	11	11	10	10,11	10	10	10,11		10,11	11	11

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Tdr	*Pogonolepis muelleriana*		Asteraceae								10					10				10
Tdr	*Polygonum aviculare**	Wireweed	Polygonaceae											10			11			11
Tda	*Polygonum plebeium*	Small Knotweed	Polygonaceae	11	11	11	10,11	11	11			10	10,11	10	10	11	11			
Tdr	*Polypogon monspeliensis**	Annual beardgrass	Poaceae															11		11
T	*Proteaceae*		Proteaceae															10		
Tda	*Pseudognaphalium luteoalbum (NSW)*	Jersey Cudweed	Asteraceae	11	11	11	10,11	11	11	10	10		11	10	10,11	11	11	11	11	11
Ate	*Pseudoraphis spinescens*	Mud Grass	Poaceae																11	
Tdr	*Psilocaulon tenue* (NSW)*	Wiry Noon-flower	Aizoaceae							11	10			10,11			10	10,11		
Tdr	*Pycnosorus pleiocephalus*	Soft Billy Button	Asteraceae	11					10	10	10	10								
Tda	*Ranunculus pentandrus var platycarpus*	Buttercup	Ranunculaceae	11	11	11	10,11	10,11		10	10,11	10	10,11	10	10		11			
Tda	*Ranunculus pumilio*	Ferny Buttercup	Ranunculaceae	11	11	11	11							11			11			
T	*Ranunculus sp.*	Buttercup	Ranunculaceae			11	10			10					10					
Tdr	*Rapistrum rugosum**	Turnip weed	Brassicaceae										11							
Tdr	*Reichardia tingitana**	False Sowthistle	Asteraceae																10	
Tdr	*Rhagodia spinescens*	Spiny Saltbush	Chenopodiaceae				10	10		10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11	10,11
Tdr	*Rhodanthe corymbiflora*	Small White Sunray	Asteraceae					10												
Tdr	*Rhodanthe floribunda*	Common White Sunray	Asteraceae											10						
Tdr	*Rhodanthe moschata*	Sunray	Asteraceae				10			10					10					
Tdr	*Rhodanthe pygmaea*	Pigmy Sunray	Asteraceae								10									
Tdr	*Rhodanthe stuartiana*	Sunray	Asteraceae									10			10					
Tda	*Rorippa eustylis*	Watercress	Brassicaceae	11	11	11	11	11								11				11
Tdr	*Rosa sp.**	Rose	Rosaceae												11					
Tdr	*Rostraria pumila**	Roughtail	Poaceae		10	10	10,11	10		10	10		10	10	10	10		10		10
Atl	*Rumex crystallinus*	Shiny Dock	Polygonaceae	11	11	11	10,11	11	11				11			11	11		11	11
Tda	*Rumex sp.*	Dock	Polygonaceae				11	10		10				10	10					11

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Tda	*Rumex tenax*	Shiny Dock	Polygonaceae				11						10	10						
Tdr	*Salsola kali var kali (NSW)*		Chenopodiaceae				10			10				10	10		10			
Tdr	*Salvia verbenaca**	Vervain	Lamiaceae											10						
Tdr	*Schenkia spicata (NSW)*	Spike Centaury	Gentianaceae	11	11	11	10,11	11	11		11		11		11	11	11	11	11	
Tdr	*Schismus barbatus**	Arabian Grass	Poaceae	11	10	10	10	10	10	10	10,11	10	10	10	10,11	10	10,11	10,11	10,11	10,11
Tda	*Scleroblitum atriplicinum*	Purple Goosefoot	Chenopodiaceae		11	11	10,11	10				10								
Tdr	*Sclerolaena bicornis (NSW only)*	Goathead Burr	Chenopodiaceae		10,11		10,11	10,11	10	10	10,11			10,11	10,11	10,11	10,11	11	10,11	10,11
Tdr	*Sclerolaena bicornis var bicornis (NSW only)*	Goathead Burr	Chenopodiaceae					10												
Tdr	*Sclerolaena brachyptera (NSW)*		Chenopodiaceae		10		10	10	10		10	10		10	10,11	10,11	10,11	10,11	10,11	10,11
Tdr	*Sclerolaena calcarata (NSW only)*	Redburr	Chenopodiaceae		10	10	10	10,11	10	10	10									
Tdr	*Sclerolaena decurrens*	Green Copperburr	Chenopodiaceae				10		10	11	11				10			10,11	10,11	10,11
Tdr	*Sclerolaena diacantha*	Grey Copperburr	Chenopodiaceae												11					
Tdr	*Sclerolaena divaricata*	Tangled Copperburr	Chenopodiaceae								10					11	11		11	
Tdr	*Sclerolaena eriacantha (NSW only)*		Chenopodiaceae																	11
Tdr	*Sclerolaena intricata*	Poverty Bush	Chenopodiaceae								10,11	10				10,11	10,11		10	
Tdr	*Sclerolaena muricata*	Black Rolypoly	Chenopodiaceae	11	10,11	10,11	10,11	11	10		10,11	10		10,11	10,11	11	10,11	11	10,11	10,11
Tdr	*Sclerolaena muricata var muricata*	Black Rolypoly	Chenopodiaceae		10	10	10,11	11			10,11			10	10,11	10,11	10		10,11	10,11
Tdr	*Sclerolaena muricata var semiglabra*	Black Rolypoly	Chenopodiaceae		10		10,11	11						10	11	10				11
Tdr	*Sclerolaena muricata var villosa*	Black Rolypoly	Chenopodiaceae					11	10		10					10,11			11	
Tdr	*Sclerolaena obliquicuspis*	Limestone Copperburr	Chenopodiaceae											10			10	10,11	10	10
Tdr	*Sclerolaena patenticuspis*	Spear-fruit Copperburr	Chenopodiaceae		10		10		10	10	10	10			10,11		11	11	11	11
Tdr	*Sclerolaena sp.*		Chenopodiaceae		11		10,11	10		10	10	10	10	10	10,11	10,11		10,11		10
Tdr	*Sclerolaena stelligera (NSW)*		Chenopodiaceae		10,11	10	10	10,11	10		10			10			10		10	10

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Tdr	*Sclerolaena tricuspis*	Giant Redburr	Chenopodiaceae				10	10,11	10							10	10		10	
Tdr	*Sclerolaena ventricosa*	Salt Copperburr	Chenopodiaceae						10		10,11		10							
Tda	*Senecio glossanthus*	Groundsel	Asteraceae			11		10,11								10				
Tdr	*Senecio runcinifolius*	Tall Groundsel	Asteraceae	11	11	11	10,11	10,11	10		10	10	10			10,11	11	11		11
T	*Senecio sp.*	Groundsel	Asteraceae		10	10										10				10,11
Tdr	*Sida intricata*	Twiggy Sida	Malvaceae		10						10,11				10,11		11	11		
T	*Sida sp.*	Sida	Malvaceae		10,11	10								10,11				10	10,11	11
Tdr	*Sida species A (NSW only)*	Sida	Malvaceae														10			
Tdr	*Silene gallica**		Caryophyllaceae									10								11
T	*Silene sp.**		Caryophyllaceae		10					10	10	10	10	10	10	10		10		10
Tdr	*Sisymbrium erysimoides**	Smooth Mustard	Brassicaceae			11	10	10,11	10	10,11	10	10	10,11	10	10	10,11	10,11	10	10,11	10,11
Tdr	*Solanum esuriale*	Quena	Solanaceae		10,11	10								10						
Tda	*Solanum lacunarium*	Lagoon Nightshade	Solanaceae														10		10	11
Tdr	*Solanum nigrum**	Black-berry Nightshade	Solanaceae		10		11	11	11	11	11		10,11	10	10,11	10,11	10,11	11		
T	*Solanum sp.*	Nightshade	Solanaceae										10		10					
Tdr	*Sonchus asper**	Prickly Sowthistle	Asteraceae												11					
Tdr	*Sonchus oleraceus**	Common Sowthistle	Asteraceae		10			10		10	10	10	10	10	10	10	10	10		10,11
T	*Sonchus sp.**	Sowthistle	Asteraceae										11		11	11	11	11	11	11
Tdr	*Spergularia diandra**	Lesser Sand-spurrey	Caryophyllaceae					11			10	10								
Tdr	*Spergularia rubra**	Sandspurrey	Caryophyllaceae	11	11	11	10,11	10			11									11
T	*Spergularia sp.*	Sandspurrey	Caryophyllaceae				10				10		10	10	10	10		10	10	
Tda	*Stemodia florulenta*	Blue-rod	Ranunculaceae	11	10,11	11	10	11	10,11	10			10,11	10	11	10,11	11			11
Tdr	*Tecticornia triandra (NSW)*	Desert Glasswort	Chenopodiaceae																10,11	10,11
Tdr	*Tetragonia tetragonioides*	New Zealand Spinach	Aizoaceae	11	10,11	10,11	10,11	10,11	10	10,11	10	10	10	10	10	10,11	10	10,11	10	10,11
Tdr	*Teucrium racemosum*	Grey Germander	Lamiaceae	11	11	11	10,11	10,11	10,11		10,11	10,11	11	10,11	10,11		10,11	11	11	11

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
Tdr	*Tribulus terrestris**	Caltrop	Zygophyllaceae																10	10
Tdr	*Trigonella suavissima*	Coopers Clover	Fabaceae-Faboideae	11	10,11	11	11	10,11							11					
	Unidentified sp. - no tag number			11				11	11	11		11	11	11	11	11			11	
	Unidentified sp. Tag #1056						10													
Tdr	*Unidentified sp. Tag #1371*		Asteraceae											10						
	Unidentified sp. Tag #1964								11											
	Unidentified sp. Tag #542						10													
Tda	*Unidentified sp. Tag #636*			11	11	11														
Tdr	*Urtica sp.*	Nettle	Urticaceae							10		10								
Tdr	*Verbena officinalis**	Common Verbena	Verbenaceae				11	11	11	10			11		11			11		
Tdr	*Verbena sp.*	Verbena	Verbenaceae				10,11								10				10	
Tda	*Verbena supina**	Trailing Verbena	Verbenaceae	11		11	10,11	11	11		11		11	10,11	11		11		11	11
Tda	*Veronica catenata**	Pink Water Speedwell	Scrophulariaceae										10							
Tda	*Veronica peregrina**	Wandering Speedwell	Scrophulariaceae			11	11	11	11				11							
Tdr	*Vicia monantha subsp triflora* (NSW)*		Fabaceae-Faboideae											10						
Tdr	*Vittadinia cervicularis*	New Holland Daisy	Asteraceae																	10
Tdr	*Vittadinia cervicularis var cervicularis*		Asteraceae																	11
Tdr	*Vittadinia eremaea (NSW only)*	New Holland Daisy	Asteraceae				10								10					
Tdr	*Vittadinia gracilis*	Woolly New Holland Daisy	Asteraceae			10					10	10,11		10,11	10,11			10		11
Tdr	*Vittadinia sp.*	New Holland Daisy	Asteraceae		10	10								11						
Tdr	*Vittadinia sulcata*	New Holland Daisy	Asteraceae										10							
Tdr	*Vulpia bromoides**	Squirrel Tail Fescue	Poaceae													10				
Tda	*Wahlenbergia fluminalis*	River Bluebell	Campanulaceae		11		10													
Tdr	*Wahlenbergia gracilenta*	Annual Bluebell	Campanulaceae																	11

Functional group	Scientific name	Common name	Family	Site																
				1	2	3	4	5	6	7	8	9a	9b	10	11	12	14	15	16	17
T	*Wahlenbergia sp.*	Bluebell	Campanulaceae	11	10,11	10,11	11													11
Tda	*Xanthium occidentale**	Noogoora Burr	Asteraceae					11	11				11					11	11	
Tdr	*Zygophyllum ammophilum*	Sand Twinleaf	Zygophyllaceae				10	10		10	10							10		
Tdr	*Zygophyllum iodocarpum*	Violet Twinleaf	Zygophyllaceae					10												