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Understory Vegetation Monitoring of Chowilla Environmental Watering Sites 2008-12

Jason Nicol

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Executive Summary

The decline in tree (*Eucalyptus camaldulensis* and *Eucalyptus largiflorens*) condition between 2000 and 2010 on the Chowilla Floodplain was (and in some areas of the floodplain still is) a major concern for managers of the system. Recognition of this issue led to a trial watering of a small flood runner on Monoman Island in spring 2003. The results from this trial showed that tree condition could be significantly improved by watering temporary wetlands, which has led to an expansion of the program to 19 sites across the Chowilla Floodplain. Anecdotal evidence suggested that the understory plant community could also benefit from watering; hence, a monitoring program was established in 2004 (Nicol *et al.* 2010b). Results from monitoring understory vegetation between 2004 and 2008 provided evidence that understory condition improved in response to watering due to the recruitment of floodplain and amphibious species. The aims of this study were to continue and expand the monitoring program established by Nicol *et al.* (2010b) to gain a better understanding of the understory vegetation dynamics in temporary wetlands in response to watering and natural flooding and assess the following The Living Murray (TLM) targets for the Chowilla Icon Site (Murray Darling Freshwater Research Centre 2010):

- Target 5: improve the area and diversity of grass and herblands.
- Target 6: improve the area and diversity of flood dependent understory vegetation.
- Target 7: provide conditions suitable for regeneration and seedling survival of all vegetation targets including (but not limited to) river red gum, black box, river coobah and lignum.
- Target 8: maintain or improve the area and diversity of grazing sensitive plant species.
- Target 9: limit the extent of invasive (increaser) species including weeds.

Surveys were undertaken at nine wetlands using the methods outlined in Zampatti *et al.* (2011) and Weedon and Nicol (2006). The change in floristic composition through time (pre- and post-watering where possible) was compared using NMS ordination, PERMANOVA and Indicator Species Analysis.

At wetlands where pre- and post-watering surveys were undertaken, there was a significant decline in terrestrial species and an increase in floodplain and amphibious species. In wetlands that were watered on multiple occasions the plant community generally changed significantly due to changes in the abundance of different flood dependent or amphibious species.

The response of the plant community to watering varied between wetlands and elevations within wetlands. Different vegetation communities developed between wetlands and elevations within wetlands in response to watering, probably due to differences in water regime, soil type, seed bank composition and survey season.

Overstorey germination was variable between sites. *Eucalyptus camaldulensis* seedlings were present in six of the nine surveyed wetlands and *Acacia stenophylla* in five (*Eucalyptus largiflorens* seedlings were not present in any wetlands). *Muehlenbeckia florulenta* germinated in large numbers in and around Lake Littra but only after flooding. It is unclear why overstorey regeneration was patchy as adult plants were present at all sites.

The results showed that watering is an appropriate management response to improve the area and diversity of grass and herblands (target 5), increase the abundance of flood dependent understorey vegetation (target 6), in some cases provided conditions suitable for the germination of overstorey species (target 7) and improved the area of grazing sensitive species (target 8). There is evidence to suggest that multiple watering events (in the absence of natural or regulated flooding) may be required to maintain flood dependent species over the long-term. However, several species of exotic pest plants that may require control in the future were present in significantly higher numbers post-watering; therefore, target 9 has not been met for several sites (although the risk of invasive species recruitment is no higher for watering compared with natural flooding).

1 Introduction

The Chowilla floodplain is the largest remaining area of floodplain habitat in the lower Murray system that has not been developed (Sharley and Huggan 1995). The system occupies an area of 16,500 ha that straddles Lock and Weir number 6 near the South Australia, New South Wales and Victoria border and comprises a range of temporary and permanent wetlands (O'Malley and Sheldon 1990; Sharley and Huggan 1995). The biological significance of the system has been recognised locally, regionally, nationally and internationally with listings under the Ramsar Convention (O'Malley and Sheldon 1990), Directory of Important Wetlands in Australia (Australian Nature Conservation Agency 1996) and as one of the Living Murray (TLM) Initiative's six icon sites. The listing of the system as a wetland of international significance under the Ramsar Convention (the system forms part of the Riverland Ramsar site) and TLM icon site is largely due to its river red gum (*Eucalyptus camaldulensis* var. *camaldulensis*) and black box (*Eucalyptus largiflorens*) woodlands.

The Chowilla Floodplain has been severely impacted by river regulation and water abstraction, particularly the reduction in frequency and duration of overbank flows and subsequent changes to ground water levels and salinities (e.g. O'Malley and Sheldon 1990; Eldridge *et al.* 1993; Sharley and Huggan 1995; Taylor *et al.* 1996; Walker *et al.* 1996; Kingsford 2000; Overton and Jolly 2004). Historically flows of 50,000 ML day^{-1}, which would inundate approximately 30% of the floodplain, occurred on average once every two years and large floods of 100,000 ML day^{-1}, which occurred on average once every three years, now occur on average every three and ten years, respectively (O'Malley and Sheldon 1990). The recent cycle of extended drought, coupled with river regulation and water abstraction, has meant that prior to 2010-11 large overbank flows had not occurred in the Chowilla system since 1996.

Roberts and Marston (2000) reported that *Eucalyptus camaldulensis* tress required flooding every three years to maintain condition and *Eucalyptus largiflorens* every five years; hence, many trees in the Chowilla system prior to 2010-11 were showing signs of severe stress. The reduced flooding frequency and changes to groundwater levels and soil salinity have been implicated in the decline in condition of *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* (Eldridge *et al.* 1993; Roberts and Marston 2000; Murray Darling Basin Commission 2003; Overton and Jolly 2004).

The reduction in flooding frequency has also had serious implications for the understory floodplain community at Chowilla. The understory vegetation of the River Murray floodplain, similar to other floodplain systems, is adapted to periodic disturbances that remove much of the extant vegetation and leave open areas for new plants to colonise (e.g. Gippel and Blackham 2002; Shafroth *et al.* 2002; Dixon 2003; Nicol 2004). The majority of the floodplain understory species in the Murray-Darling Basin (MDB) are short-lived annuals, which die when flooded but germinate as flood waters recede (but not in response to rainfall); therefore, require flooding to regenerate (Cunningham *et al.* 1981; Nicol 2004). These species are adapted to regular disturbance by floods (an example of Grime's (1979) r-selected species) and will be replaced by more competitive species if flooding frequencies are reduced. There is evidence to suggest this has occurred on the Chowilla floodplain due to the high abundance of terrestrial drought tolerant and salt tolerant species between 2006 and 2010 (Gehrig *et al.* 2012) that are common in the surrounding non-floodplain habitats (e.g. *Atriplex* spp. *Sclerolaena divaricata, Maireana* spp.), which have historically not occurred on the floodplain (James Robertson pers. comm.).

The decline in condition of the two eucalypt species present on the floodplain led to a trial watering of a small temporary creek (Monoman Island Horseshoe) in spring 2003 with the aim to improve the condition of the fringing *Eucalyptus camaldulensis* trees. The success of the initial trial led to the watering of other wetlands in the Chowilla system (and throughout the Lower Murray) to improve tree condition.

In addition to potential improvement in overstorey condition, watering temporary wetlands by pumping will reintroduce the flooding disturbance (at the wetland scale) that has been lost from the majority of the floodplain between 1996 and 2010. Nicol *et al.* (2010a) and Gehrig *et al.* (2012) provided evidence that watering temporary wetlands did reintroduce the flooding disturbance that extirpates terrestrial species and when water levels receded, floodplain and amphibious species recruited.

<u>Flows to the Chowilla Floodplain</u>

Prior to river regulation there was greater variability in flow (and in turn water level) and the Chowilla Floodplain was inundated more frequently (usually every year), for longer duration and greater depth (Maheshwari *et al.* 1995). Since river regulation commenced early last century, small to medium sized floods have generally been lost from the lower Murray resulting in floodplain inundation occurring less frequently, for shorter periods with lower flood peaks (Maheshwari *et al.* 1995).

From 1996 to 2010, the MDB experienced the most severe drought in recorded history (Bond *et al.* 2008). Below average stream flows, coupled with upstream extraction and river regulation, resulted in reduced inflows to South Australia (Timbal and Jones 2007), which prior to August 2010 were insufficient to inundate the floodplain (MDBA 2011) (Figure 1).

In early 2010, inflows into the River Murray were anticipated to be very low and the drought in the southern MDB was expected to continue. However, from June 2010 to May 2011 total inflow volumes were among the highest on record and the patterns of inflows were atypical compared to historical flows (Murray-Darling Basin Authority 2011). Until the end of November 2010, inflows were the highest since 2000, but not unusual compared to historical flows. However, inflows during summer 2010-11 were the highest on record (~ 6,700 GL), more than double the previous highest record of ~2,980 GL in the summer of 1992-93 (Murray-Darling Basin Authority 2011).

The increase in inflows in the summer of 2010-11 resulted in widespread flooding across the MDB. In the River Murray system, the extent of flooding varied considerably due to the pattern of rainfall and the nature of the floodplain. By the end of May 2011, the total annual flow into South Australia was ~14,000 GL, which was the highest total since 1975-76. During this period, flow into South Australia peaked at 93,000 ML day^{-1}, in February 2011. Flows of a magnitude between 90,000 to 100,000 ML day^{-1} (in combination with increased local rainfall) are estimated to inundate between 62.7–74.6% (11,100 – 13,200 ha) of the Chowilla Floodplain area (Sharley and Huggan 1995, cited in Cale 2009), where the delineation between floodplain and highland is based upon the extent of the 1956 flood (Overton and Doody 2010). Large flows with maximums of ~100,000 ML day^{-1} typically last for about three months as unregulated events (Sharley and Huggan 1995), but the 2010/11 high flows and floodplain inundation persisted for about 11 months. Hence for the first time in ten years, flows not only inundated all temporary wetland (including all environmental watering sites) and red gum (*Eucalyptus camaldulensis*) woodland and wetland areas, but also reached some black box (*Eucalyptus largiflorens*) communities (Murray-Darling Basin Authority 2011).

Flows remained high throughout winter and spring 2011 peaking at 41,000 ML day^{-1} in August 2011 and remained above 15,000 ML day^{-1} throughout the summer. These flows were confined to the channel and were insufficient to inundate large areas of floodplain; nevertheless, low lying temporary wetlands (including all environmental watering sites) were flooded.

The Asset Environmental Management Plan (AEMP) for the Chowilla Floodplain (Department of Water, Land and Biodiversity Conservation 2006) identified a number of targets for management of the various components of the Chowilla Floodplain ecosystem that were later revised (Murray Darling Freshwater Research Centre 2010) and more recently have been presented in the Chowilla Floodplain Environmental Water Management Plan (MDBA 2012). Four targets were identified for understorey vegetation, namely, "improve the area and diversity of grass and herblands" (Target 5), "improve the area and diversity of flood dependent understorey vegetation" (Target 6), "provide conditions suitable for regeneration and seedling survival of all vegetation targets including (but not limited to) river red gum, black box, river coobah and lignum" (Target 7), "maintain or improve the area and diversity of grazing sensitive plant species" (Target 8) and "limit the extent of invasive (increaser) species, including weeds" (Target 9). Evaluation of the progress towards achieving these targets requires both baseline data and ongoing monitoring, particularly after large flood events or interventions.

The aim of the monitoring program was to continue the one established by Nicol *et al.* (2010b) to determine whether flood dependent (floodplain, amphibious and emergent) understory species recruit as a result of watering and assess whether engineered flooding of temporary wetlands is an appropriate management action to achieve the aforementioned TLM targets outlined in the Asset Environmental Management Plan for the Chowilla Icon Site (Murray Darling Freshwater Research Centre 2010). However, due to the duration and timing of high flows since summer 2010-11, assessment of the benefits of watering alone was not possible at some sites. At these sites the combined benefit of watering and flooding is reported.

2 Methods

2.1 Environmental Watering Monitoring Sites

Vegetation surveys were undertaken at nine temporary wetlands across the Chowilla Anabranch system, all of which were recipients of environmental water, primarily to improve overstorey condition (*Eucalyptus camaldulensis*, *Eucalyptus largiflorens, Acacia stenophylla* and *Muehlenbeckia florulenta*) (Figure 1). Pre and post-watering surveys were undertaken where possible; however, the understory monitoring program was not established until after several sites had already been watered (Table 1). Due to differences in infiltration and geomorphology, wetlands dried at different rates and post-watering surveys were undertaken at different times (Table 1). A list of all monitoring sites and GPS coordinates is given in Appendix 1.

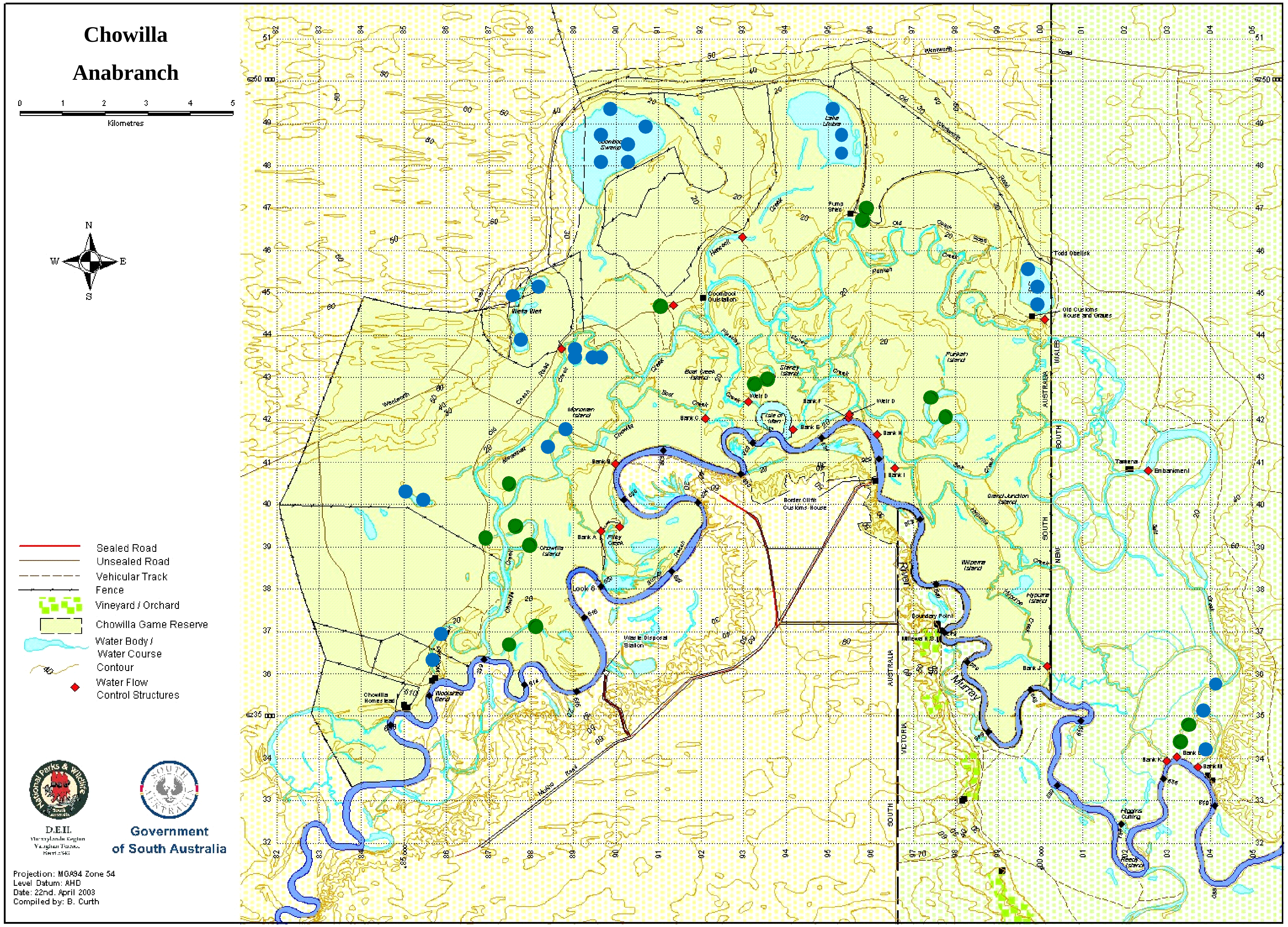


Figure 1: Location of all understory vegetation monitoring sites in wetlands that received environmental water. The sites denoted by the blue circles are discussed in this report, the remainder (the sites represented by the green circles) were surveyed by Nicol *et al.* (2010b) (Department for Environment and Heritage).

Table 1: List of environmental watering sites and when they were watered and surveyed.

Wetland	Season Watered	Survey Dates
Coombool Swamp	Autumn 2010	March 2010
Coppermine Waterhole	Summer 2004-05, Spring 2006, Spring 2009	February 2008, November 2008, February 2012
Kulcurna Red Gum flood runner	Autumn 2005, Spring 2005, Summer 2005-06, Winter 2006, Spring 2009	June 2005, November 2005, February 2008, November 2008
Lake Limbra	Autumn 2010	November 2004, January 2005, June 2005, February 2010, February 2012
Lake Littra	Spring 2004, Summer 2005-06, Spring 2009	June 2005, November 2005, February 2008, August 2009, February 2012
Monoman Island Horseshoe	Spring 2003, Winter 2004, Summer 2005-06, Spring 2009	November 2005, February 2008, August 2009
Twin Creeks	Spring 2004, Autumn 2005, Spring 2009	June 2005, November 2005, February 2008, February 2009, February 2012
Werta Wert Wetland	Winter 2004, Spring 2005, Spring 2009	June 2005, November 2005, June 2006, February 2008, February 2009, February 2012
Woolshed Creek	Autumn 2005, Winter 2006, Spring 2009	November 2004, January 2005, February 2008, November 2008,

2.2 Vegetation Surveying Protocol

The survey methods were the same as used by Weedon and Nicol (2006) and Zampatti *et al.* (2011) for monitoring floodplain understory at Chowilla. Quadrat size was determined by species area curves, which resulted in quadrats with dimensions of 15 x 1 m that resulted in over 90% of the species present being sampled (Figure 2). Species abundances were determined by frequencies; each quadrat was divided into 15, 1 x 1 m cells and the presence or absence of species was noted for each cell. This resulted in a score for each species of between zero (not present in the quadrat) and 15 (present in each cell) for each quadrat. Cells with no living plants were scored as "Bare soil". Placement of the quadrats in the wetland depended on geomorphology.

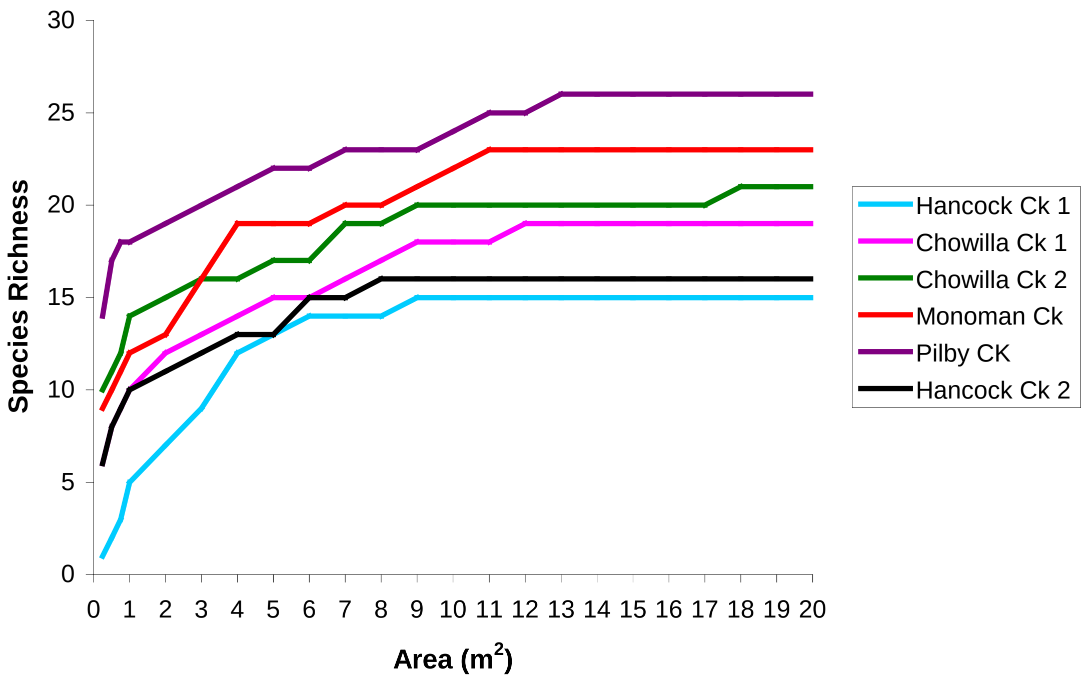


Figure 2: Species area curves for six wetlands in the Chowilla system, which were used to determine the most efficient vegetation sampling technique.

In wide temporary creeks with gently sloping banks (Woolshed Creek and Coppermine Waterhole) transects were established 50 m apart and quadrats were placed at three elevations: 0 cm (the base of the channel), +30 cm (30 cm above the base of the channel), +60 cm (60 cm above the base of the channel) (Figure 3). In Coppermine Waterhole quadrats were also established at the maximum water level (Figure 3).

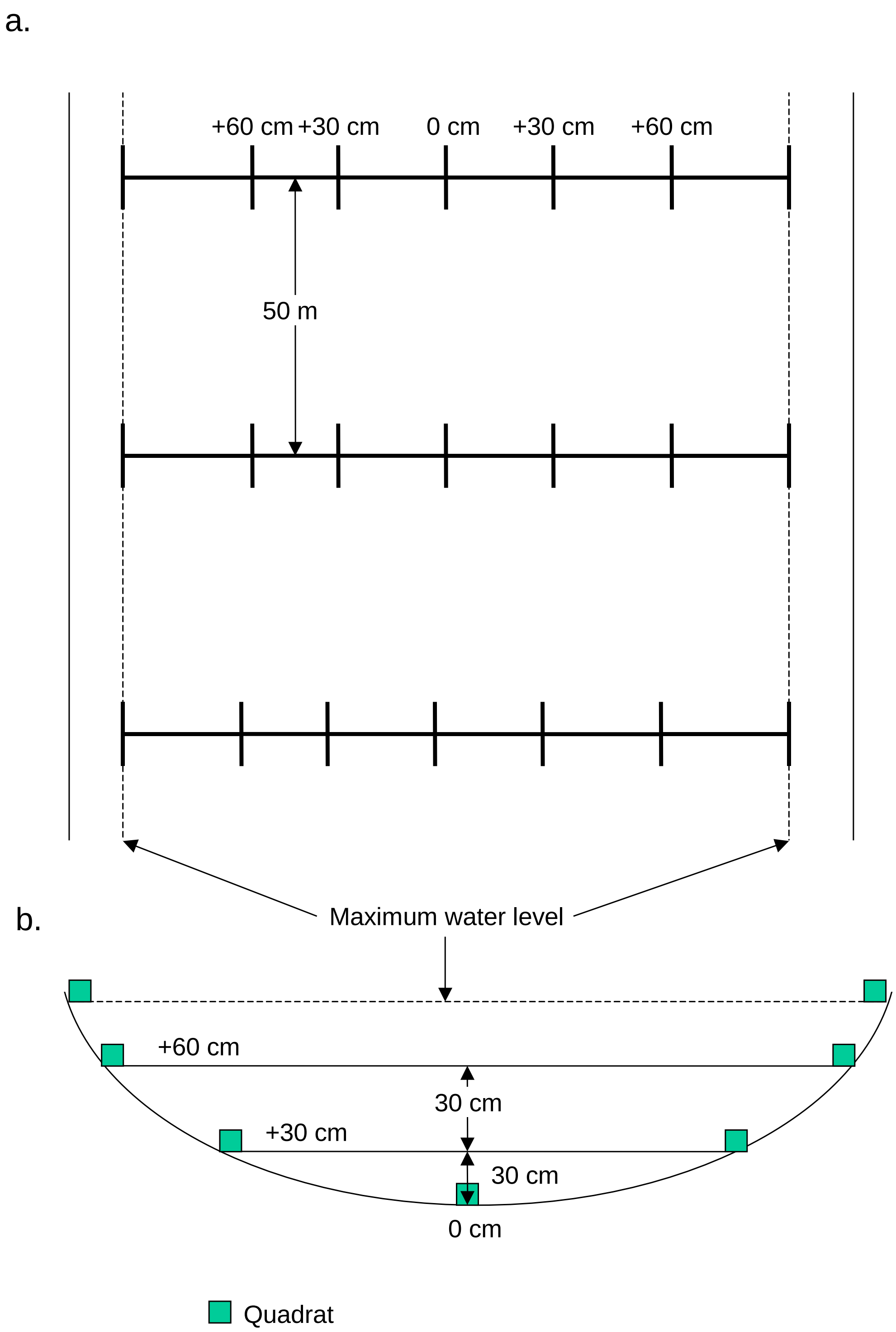


Figure 3: Sampling strategy for wide temporary creeks with gently sloping banks, a. plan view and b. cross section.

In the temporary creeks with steep banks (Kulcurna Red Gum, Twin Creeks and Monoman Island Horseshoe) three quadrats, 50 m apart were established at the base of the channel at each site and (from November 2008) at the high water mark (Figure 4).

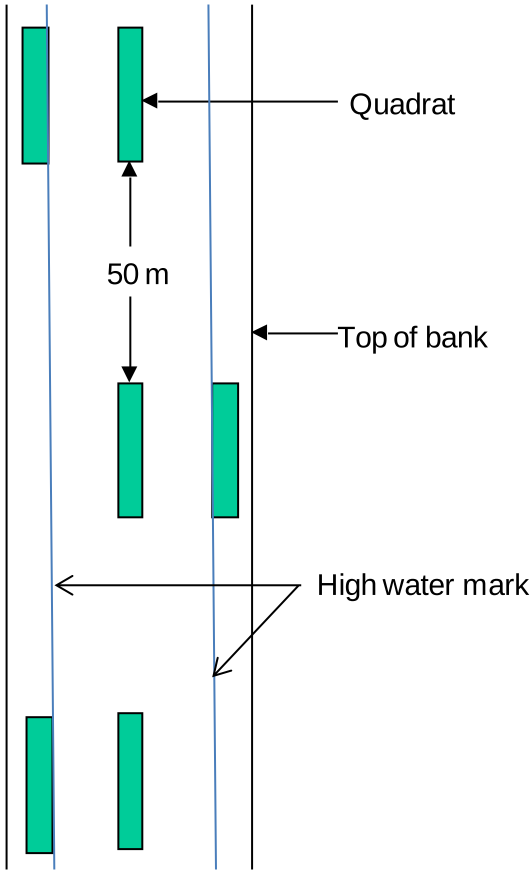


Figure 4: Sampling strategy for narrow temporary creeks with steep banks.

In temporary lakes or wide shallow temporary wetlands three quadrats 50 m apart were established on the bed of the wetland. In the larger wetlands (Coombool Swamp, Lake Littra, Lake Limbra, Werta Wert North Lagoon, Werta Wert South Lagoon and Werta Wert Central Lagoon) three sites were surveyed in each wetland (Figure 5). From November 2008 sites were established on the edges of all wetlands except Lake Limbra (due to the plant community being the same on the wetland bed and edge).

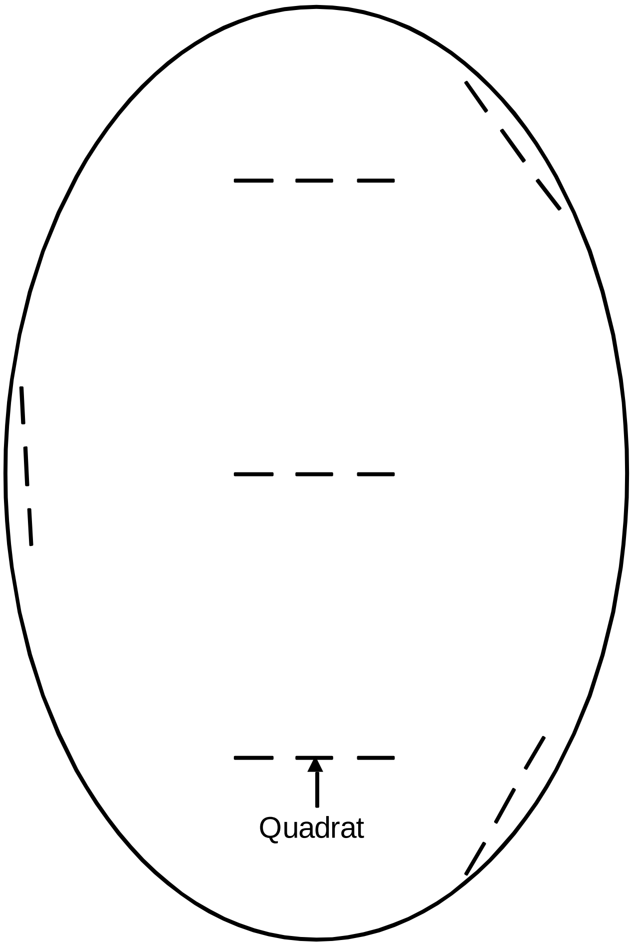


Figure 5: Sampling strategy for wide shallow temporary wetlands and lakes.

2.3 Plant Identification and Nomenclature

Plants were identified using keys in Cunningham *et al.* (1981), Jessop and Tolken (1986), Sainty and Jacobs (1994), Dashorst and Jessop (1998), Romanowski (1998) and Jessop *et al.* (2006). Nomenclature follows Barker *et al.* (2005).

2.4 Functional Groups

Due to the large number of taxa present in the Chowilla system (405 taxa have been recorded in the system since 1988) a functional approach was developed to assess TLM targets. Plants were classified into functional groups based on water regime preferences outlined in Table 2 and the position they occupy in relation to flooding depth and duration is outlined in Figure 6. The functional classification was based on the classification framework devised by Brock and Casanova (1997), which was based on species present in wetlands in the New England

Tablelands region of New South Wales and modified by Nicol *et al.* (2010) to reflect the vegetation of the Chowilla system.

The use of a functional group approach to assess change through time and potential impacts of management strategies has several advantages compared to a species or community based approach:

- species with similar water regimes preferences are grouped together, which simplifies systems with high species richness (especially where there are large numbers of species with similar water regime preferences),
- predictions about the response of the plant community are made based on processes and does not require prior biological knowledge of the system,
- is transferrable between systems,
- robust and testable models that predict the response of a system to an intervention or natural event can be constructed, which can in turn be used as hypotheses for monitoring programs.

However there are limitations of the approach, which include:

- loss of information on species or communities (especially if there are species or communities of conservation significance or there is a pest plant problem),
- uncertainty regarding which species should be classified into which functional group,
- important factors (e.g. salinity) are often not taken into consideration (additional factors can be included; however, this can often complicate the functional classification and in systems where there is low species richness the number of groups may be greater than the number of species).

Table 2: Functional classification of plant species based on water regime preferences (Nicol *et al.* 2010a).

Functional Group	Abbreviation	Water Regime Preference	Examples
Amphibious fluctuation responders floating	Afrf	Static or fluctuating water levels, responds to fluctuating water levels by having some or all organs floating on the water surface. Most species require permanent water to survive.	*Azolla* spp., *Lemna* spp., *Potamogeton tricarinatus*
Amphibious fluctuation responders plastic	Afrp	Fluctuating water levels, plants respond morphologically to flooding and drying (e.g. increasing above to below ground biomass ratios when flooded).	*Persicaria lapathifolium, Ludwigia peploides, Rumex bidens, Myriophyllum* spp.
Amphibious fluctuation tolerators emergent	Afte	Fluctuating water levels, plants do not respond morphologically to flooding and drying and will tolerate short-term submergence (<2 weeks).	*Cyperus gymnocaulos, Juncus usitatus, Juncus aridicola, Cyperus difformis, Cyperus exaltatus*

Functional Group	Abbreviation	Water Regime Preference	Examples
Amphibious fluctuation tolerators low growing	Aftl	Fluctuating water levels, plants do not respond morphologically to flooding and drying and are generally small herbaceous species.	*Limosella australis, Crassula helmsii, Cyperus pygmaeus*
Amphibious fluctuation tolerators woody	Aftw	Fluctuating water levels, plants do not respond morphologically to flooding and drying and are large perennial woody species.	*Eucalyptus camaldulensis, Eucalyptus largiflorens, Acacia stenophylla*
Emergent	E	Static shallow water <1 m or permanently saturated soil.	*Typha* spp., *Phragmites australis, Schoenoplectus validus, Bolboschoenus caldwellii*
Submerged k-selected	Sk	Permanent water.	*Vallisneria americana, Potamogeton crispus, Zanichellia palustris*
Submerged r-selected	Sr	Temporary wetlands that hold water for longer than 4 months.	*Ruppia tuberosa, Lepilaena australis, Lamprothamnium macropogon*
Flood dependent	Fd	Temporary inundation, plants germinate on newly exposed soil after flooding but not in response to rainfall.	*Epaltes australis, Centipeda minima, Glinus lotoides*
Terrestrial Damp species	Tda	Will tolerate inundation for short periods (<2 weeks) but require high soil moisture throughout their life cycle.	*Carduus tenuiflorus, Chenopodium murale*
Terrestrial Dry species	Tdr	Will not tolerate inundation and tolerates low soil moisture for extended periods.	*Atriplex vesicaria*, *Rhagodia spinescens, Enchylaena tomentosa*
Salt tolerant	Sat	Water regime preference can vary from permanent shallow water to dry 90% of the time but all species are tolerant to high soil or water salinity.	*Halosarcia pergranulata, Pachycornia triandra, Sclerolaena brachyptera*

Nicol *et al.* (2010b) compared the plant communities and abundances of functional groups before and after watering in 16 wetlands across the Chowilla Floodplain from 2004 to 2008. They found that the changes in the plant community were inconsistent between wetlands; however, the changes in abundances of functional groups before and after watering were consistent across sites (Nicol *et al.* 2010b).

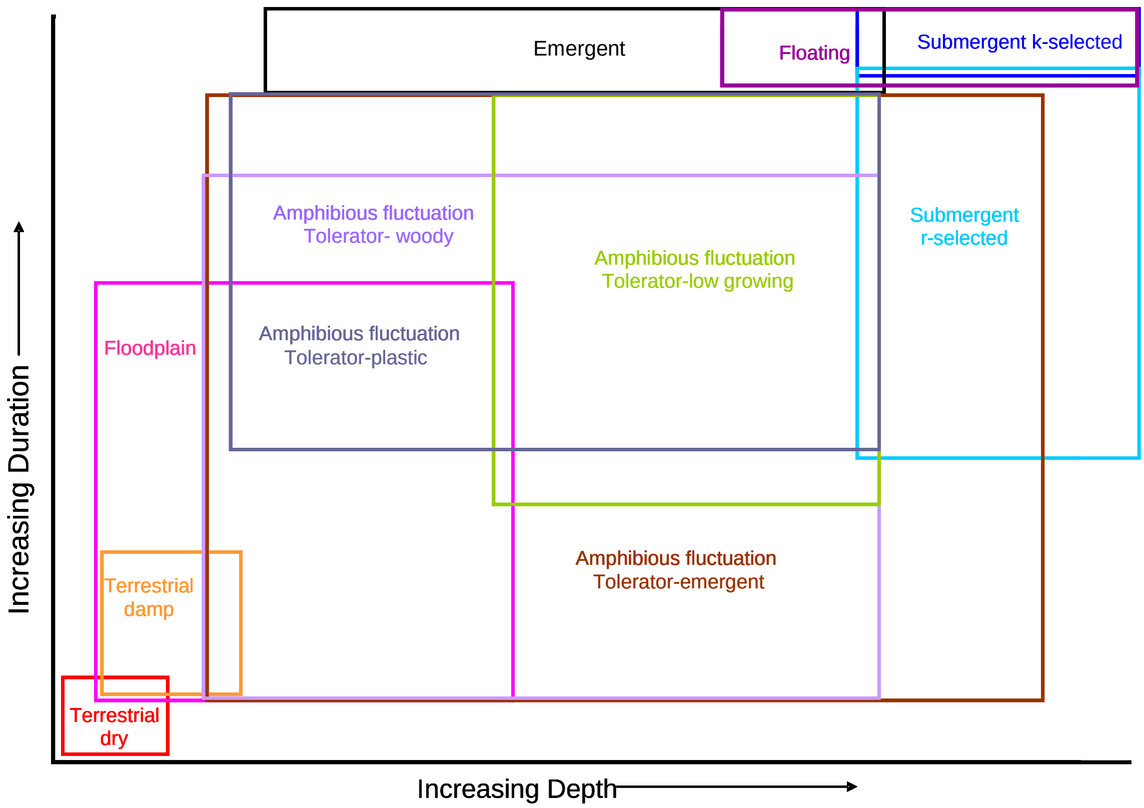


Figure 6: Plant water regime functional groups in relation to depth and duration of flooding (the salt tolerant group is not included because there are salt tolerant species in all functional groups).

2.5 Data Analysis

Floristic composition between survey dates was compared with Non Metric Scaling (NMS) Ordination (McCune *et al.* 2002), permutational multivariate analysis of variance (PERMANOVA) (Anderson 2001; Anderson and Ter Braak 2003) and Indicator Species Analysis (Dufrene and Legendre 1997) using the packages PCOrd 5.12 (McCune and Mefford 2005) and PRIMER 6.1.12 (Clarke and Gorley 2006). The change in abundance of key species related to TLM targets (Table 3) in the Asset Environmental Management Plan for the Chowilla Floodplain Icon Site (Murray Darling Freshwater Research Centre 2010) was used to determine whether the target was met at a particular site. In addition, if *Eucalyptus camaldulensis* var. *camaldulensis, Acacia stenophylla, Muehlenbeckia florulenta* or *Eucalyptus largiflorens* seedlings were observed at any of the sites it was assumed that conditions suitable for regeneration and seedling survival of river red gum, black box, river coobah and lignum were met; nevertheless, follow up surveys will be required to determine whether this target is met in the long-term.

Bray-Curtis (1957) similarities were used to calculate the similarity matrix for all multivariate analyses and α for all tests=0.05 unless multiple comparisons were made, then α was adjusted using the Bonferroni correction (Quinn and Keogh 2002).

2.5.1 Indicator Species Analysis

Dufrene and Legendre's (1997) indicator species analysis combines information on the concentration of species abundance in a particular group (survey date) and the faithfulness of occurrence of a species in a particular group (McCune *et al.* 2002). A perfect indicator of a particular group should be faithful to that group (always present) and exclusive to that group (never occurring in other groups) (McCune *et al.* 2002). This test produces indicator values for each species in each group based on the standards of the perfect indicator. Statistical significance of each indicator value is tested by using a Monte Carlo (randomisation) technique, where the real data are compared against 5000 runs of randomised data (Dufrene and Legendre 1997). For this study, the groups were assigned according to survey date for the comparison of pre- and post-watering surveys of individual wetlands and by cluster groups for the comparison of functional groups across multiple sites. A species that is deemed not to be a significant indicator of a particular group is either uncommon or widespread. An uncommon species is only found in one group but in low numbers and a widespread species is found in more than one group in similar numbers (Dufrene and Legendre 1997). Whether a species was classed as a widespread or uncommon non-significant species was determined by examination of the raw data.

Table 3: List of flood dependent grasses and herbs (Cunningham *et al.* 1981; Nicol 2004), grazing sensitive species and increaser species (Cunningham *et al.* 1981) present on the Chowilla Floodplain (*denotes exotic species).

Species	Flood dependent herb or grass	Grazing Sensitive Species	Increaser Species
*Abutilon theophrasti**			*
Alisma sp.	*		
Alternanthera denticulata	*	*	
Ammania multiflora	*	*	
*Arctotheca calendula**			*
*Aster subulatus**			*
Bolboschoenus caldwellii	*	*	
Brachyscome basaltica	*		
Brachyscome dentata	*		
*Bromus rubens**			*
Calotis hispidula	*		
*Carrichtera annua**			*
Centaurea sp.*			*
Centipeda minima	*		
Chenopodium pumilio	*		
*Conyza bonariensis**			*
Cotula coronopifolia	*		

Species	Flood dependent herb or grass	Grazing Sensitive Species	Increaser Species
Crassula helmsii	*		
Crassula sieberana	*		
*Cuscuta campestris**			*
Cyperus exaltatus	*	*	
Cyperus gymnocaulos	*	*	
*Echium plantagineum**			*
Eleocharis acuta	*	*	
Epaltes australis	*		
Eragrostis australasica	*	*	
Eragrostis dielsii	*	*	
Euphorbia drummondii	*	*	
Glinus lotoides	*		
Glycyrrhiza acanthocarpa	*	*	
Haloragis aspera	*		
Helichrysum luteo-album	*	*	
*Heliotropium amplexicaule**			*
*Heliotropium curassavicum**			*
*Heliotropium europaeum**			*
*Hordeum vulgare**			*
*Hypochoeris radicata**			*
Iseotopsis graminifolia	*	*	
Isolepis hookeriana	*	*	
Juncus usitatus	*	*	
Lachnagrostis filiformis	*	*	
*Lactuca saligna**			*
Limosella australis	*		
Ludwigia peploides ssp. *montevidensis*	*		
Lythrum hyssopifolia	*		
*Malva parviflora**			*
Marsilea angustifolia	*		
Medicago spp.*			*
*Mesembryanthemum crystallinum**			*
Mimulus repens	*		
Mollugo cerviana	*	*	
Morgania floribunda	*		
Myriophyllum elatinoides	*	*	
Myriophyllum verrucosum	*	*	
Paspalum distichum	*	*	
Persicaria lapathifolium	*		
Phragmites australis	*	*	*
*Phyla canescens**			*
Phyllanthus lacunaris	*		

Species	Flood dependent herb or grass	Grazing Sensitive Species	Increaser Species
Plantago turrifera	*		
*Polygonum aviculare**			*
Polygonum plebium	*		
*Polypogon monspeliensis**			*
*Ranunculus scleratus**			*
*Riechardia tingitana**			*
Rorippa islandica	*	*	
*Rorippa palustris**			*
Rumex bidens	*		
Schoenoplectus validus	*		
Scleroblitum atriplicinum	*	*	
Senecio sp.	*	*	
Solanum lacunarium	*		
*Solanum nigrum**			*
Solanum oligacanthum	*		
*Sonchus oleraceus**			*
Sporobolus mitchelli	*	*	
Swainsona greyana	*	*	
Tetragonia tetragonoides	*	*	
Trachymene cyanopetula	*	*	
Typha domingensis	*	*	*
Wahlenbergia fluminalis	*		
*Xanthium occidentale**			*

3 Results

3.1 Coombool Swamp

Only a pre-watering survey was undertaken at Coombool Swamp in March 2010 (Table 1). The wetland was watered shortly after the pre-watering survey and had not dried before it was flooded in summer 2010-11. At total of 22 species (including two exotics and one species listed as rare in South Australia) were recorded, most of which were in the terrestrial and salt tolerant functional groups (Table 4).

Table 4: Species list from Coombool Swamp in March 2010 (*denotes exotic species, #denotes listed as rare in South Australia).

Atriplex spp.
Brachyscome basaltica
Carpobrotus rossii
Craspedia chrysantha
Dissocarpus paradoxus
Enchylaena tomentosa ssp. *tomentosa*
Eragrostis dielsii
Halosarcia pergranulata ssp. *pergranulata*
Maireana microcarpa
*Malva parviflora**
Medicago spp.*
Muehlenbeckia florulenta
Muehlenbeckia horrida#
Osteocarpum acropterum var. *acropterum*
Rhagodia spinescens
Salsola kali var. *kali*
Sarcocornia quinqueflora
Sclerolaena brachyptera
Sclerolaena divaricata
Sclerolaena stelligera
Sida ammophila
Tetragonia tetragonoides

3.2 Coppermine Waterhole

Coppermine waterhole was watered three times (Table 1) and flooded naturally once since 2004. Only post-watering surveys were able to be undertaken (Table 1). The only elevation surveyed since 2008 was the wetland edge because it was the only elevation that had dried by February 2012. The changes through time and in response to watering at the lower elevations are presented in Nicol *et al.* (2010b).

A total of 36 species (including five exotics, one of which is declared noxious in South Australia) were recorded on the edge of Coppermine Waterhole (Table 5). The plant community changed significantly over the study period (PERMANOVA: Pseudo $F_{2,12}$=10.5, P<0.001; NMS ordination, Figure 7) with the plant community being significantly different each time it was surveyed (February 2008≠November 2010≠February 2012).

Figure 7: NMS ordination comparing the February 2008, November 2008 and February 2012 surveys for the edge of Coppermine Waterhole (stress=0.17).

The edge of Coppermine Waterhole was generally dominated by native amphibious and floodplain species (Table 5). Most species were present in similar abundances over the study period; however, *Alternanthera denticulata, Brachyscome dentata, Epaltes australis, Helichrysum luteo-album, Juncus usitatus* and *Xanthium occidentale* were present in significantly higher abundances after the wetland was flooded (Table 5). Furthermore, an additional four native floodplain and one native amphibious species that were absent before the wetlands was flooded were present in low numbers after the wetland was flooded (Table 5).

Eucalyptus camaldulensis var. *camaldulensis* and *Acacia stenophylla* seedlings recruited in response to watering (Table 5). *Muehlenbeckia florulenta* was only present as adult plants.

Table 5: Species list and Indicator Species Analysis results comparing the floristic composition between the February 2008, November 2008 and February 2012 surveys for the edge of Coppermine Waterhole (*denotes exotic species, **denotes declared noxious in South Australia, NS denotes not significantly different).

Species	**Survey Date**	***P***
Brachyscome basaltica	February 2008	<0.001
Senecio cunninghamii	February 2008	0.0205
Acacia stenophylla seedlings	February 2008	NS Widespread
Bare Soil	November 2008	<0.001
Sclerolaena divaricata	November 2008	0.0283
*Atriplex prostrata**	November 2008	NS Uncommon
Einadia nutans	November 2008	NS Uncommon
Enchylaena tomentosa ssp. *tomentosa*	November 2008	NS Uncommon
Eremophila divaricata	November 2008	NS Uncommon
Euphorbia drummondii	November 2008	NS Uncommon
Glycyrrhiza acanthocarpa	November 2008	NS Uncommon
*Mesembryanthemum crystallinum**	November 2008	NS Uncommon
Sclerolaena brachyptera	November 2008	NS Uncommon
Atriplex spp.	November 2008	NS Widespread
Calotis hispidula	November 2008	NS Widespread
Morgania floribunda	November 2008	NS Widespread
Muehlenbeckia florulenta	November 2008	NS Widespread
Brachyscome dentata	February 2012	0.0024
Alternanthera denticulata	February 2012	0.0026
*Xanthium occidentale***	February 2012	0.0209
Epaltes australis	February 2012	0.0214
Juncus usitatus	February 2012	0.0304
Helichrysum luteo-album	February 2012	0.0381
Glinus lotoides	February 2012	NS Uncommon
Marsilea angustifolia	February 2012	NS Uncommon
Polygonum plebium	February 2012	NS Uncommon
Senecio runcinifolius	February 2012	NS Uncommon
Solanum lacunarium	February 2012	NS Uncommon
*Centaurium tenuiflorum**	February 2012	NS Widespread
Centipeda minima	February 2012	NS Widespread
*Conyza bonariensis**	February 2012	NS Widespread
Cyperus gymnocaulos	February 2012	NS Widespread
Eleocharis acuta	February 2012	NS Widespread
Eucalyptus camaldulensis var. *camaldulensis* seedlings	February 2012	NS Widespread
*Heliotropium europaeum**	February 2012	NS Widespread
Iseotopsis graminifolia	February 2012	NS Widespread
Sporobolus mitchelli	February 2012	NS Widespread

3.3 Kulcurna Red Gum

The Kulcurna red gum flood runner was watered five times (Table 1) and flooded once since 2005. Only post watering surveys on the middle of the channel were able to be undertaken and the wetland has remained inundated since spring 2009 (Table 1).

The plant community showed no significant change between June and November 2005 and February 2008 and November 2008 but there was significant change between November 2005 and February 2008 (June 2005=November 2005=February 2008≠November 2008=February 2012; PERMANOVA: *Pseudo* $F_{3,43}$=8.51, *P*<0.001; NMS Ordination: Figure 8).

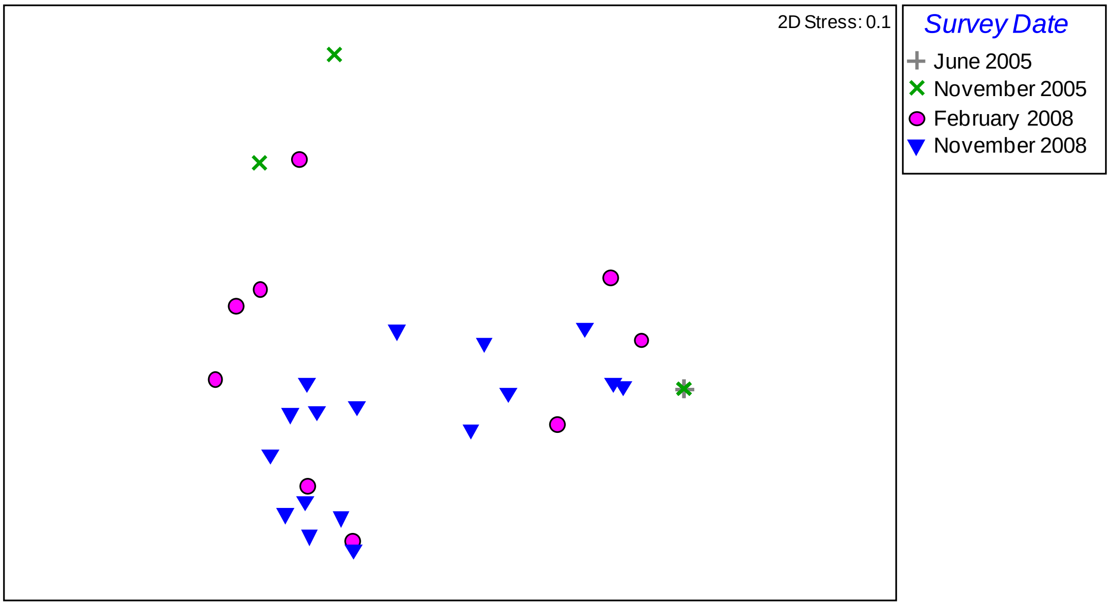


Figure 8: NMS ordination comparing the June 2005, November 2005, February 2008 and November 2008 surveys for Kulcurna Red Gum flood runner (stress=0.10).

In June 2005 the sites were dominated by bare soil and in November 2005 there were low abundances of eight native flood dependent and two native amphibious species but no significant change in floristic composition (Table 6). The native floodplain forbs *Chenopodium pumilio, Centipeda minima* and *Alternanthera denticulata* and *Eucalyptus camaldulensis* var. *camaldulensis* were significantly more abundant in February 2008, and a further four floodplain and one amphibious species were present in low numbers (Table 6). The native floodplain species; *Morgania floribunda* and *Sporobolus mitchelli*, native amphibious species; *Cyperus gymnocaulos* and native terrestrial taxa; *Atriplex* spp. were significantly more abundant in November 2008 (Table 6). However, the exotic species; *Phyla canescens* and *Heliotropium curassavicum* were also more abundant in November 2008 (Table 6).

Table 6: Species list and Indicator Species Analysis results comparing the floristic composition between the June 2005, November 2005, February 2008 and November 2008 surveys for Kulcurna Red Gum flood runner (*denotes exotic species, **denotes declared noxious in South Australia, NS denotes not significantly different).

Species	Survey Date	*P*
Bare Soil	June 2005	0.0013
Enchylaena tomentosa ssp. *tomentosa*	November 2005	NS Uncommon
Eragrostis australasica	November 2005	NS Uncommon
Helichrysum luteo-album	November 2005	NS Uncommon
*Heliotropium amplexicaule**	November 2005	NS Uncommon
Iseotopsis graminifolia	November 2005	NS Uncommon
Isolepis hookeriana	November 2005	NS Uncommon
Mollugo cerviana	November 2005	NS Uncommon
Myriophyllum verucossum	November 2005	NS Uncommon
Plantago turrifera	November 2005	NS Uncommon
Polygonum plebium	November 2005	NS Uncommon
*Rorippa palustris**	November 2005	NS Uncommon
Tetragonia tetragonoides	November 2005	NS Uncommon
Wahlenbergia fluminalis	November 2005	NS Uncommon
*Xanthium occidentale***	November 2005	NS Uncommon
*Heliotropium europaeum**	November 2005	NS Widespread
Chenopodium pumilio	February 2008	0.0003
*Conyza bonariensis**	February 2008	0.0178
Centipeda minima	February 2008	0.0348
Alternanthera denticulata	February 2008	0.0444
Eucalyptus camaldulensis var. *camaldulensis* seedlings	February 2008	0.0473
*Atriplex prostrata**	February 2008	NS Uncommon
Brachyscome basaltica	February 2008	NS Uncommon
*Centaurium tenuiflorum**	February 2008	NS Uncommon
Enchylaena tomentosa ssp. *tomentosa*	February 2008	NS Uncommon
Euphorbia drummondii	February 2008	NS Uncommon
Maireana microcarpa	February 2008	NS Uncommon
Mimulus repens	February 2008	NS Uncommon
Nicotiana velutina	February 2008	NS Uncommon
Senecio cunninghamii	February 2008	NS Uncommon
Senecio runcinifolius	February 2008	NS Uncommon
Atriplex spp.	November 2008	0.0038
Morgania floribunda	November 2008	0.0094
Sporobolus mitchelli	November 2008	0.0185
*Phyla canescens**	November 2008	0.0213
Cyperus gymnocaulos	November 2008	0.0368
*Heliotropium curassavicum**	November 2008	0.0409
*Aster subulatus**	November 2008	NS Uncommon
Glycyrrhiza acanthocarpa	November 2008	NS Uncommon
*Mesembryanthemum crystallinum**	November 2008	NS Uncommon
Muehlenbeckia florulenta	November 2008	NS Uncommon
Persicaria lapathifolium	November 2008	NS Uncommon
Sclerolaena brachyptera	November 2008	NS Uncommon
Sclerolaena divaricata	November 2008	NS Uncommon

3.4 Lake Limbra

Lake Limbra was watered once in autumn 2010 (Table 1) and flooded in summer 2010-11. Pre-watering surveys were undertaken (as part of the fish and macrophytes project, Zampatti *et al.* 2011) in November 2004, January 2005 and June 2005 and in February 2010 prior to watering. One post watering survey was undertaken in February 2012 (Table 1).

A total of four species were recorded in Lake Limbra over the study period (Table 7). The plant community did not change significantly between November 2004 and February 2010; however, after watering and flooding there was a significant change in the plant community (November 2004=January 2005=June 2005=February 2010≠February 2012; PERMANOVA: *Pseudo* $F_{4,44}$=8.98, P<0.001; NMS Ordination: Figure 9).

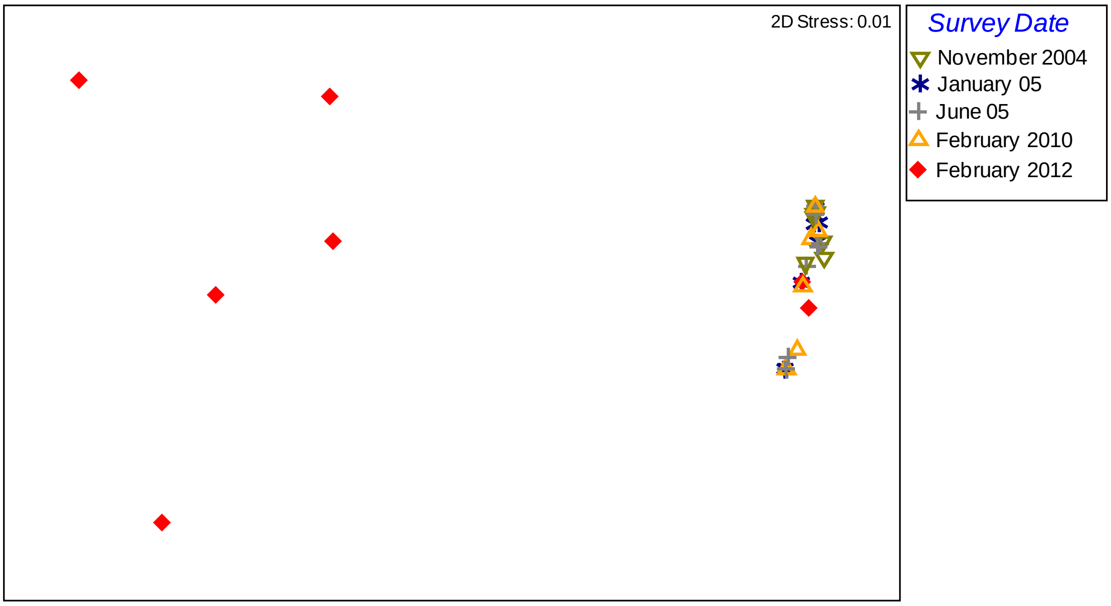


Figure 9: NMS ordination comparing the November 2004, January 2005, June 2005, February 2010 and February 2012 surveys for Lake Limbra (stress=0.01).

Lake Limbra was dominated by the halophyte *Halosarcia pergranulata* spp. *pergranulata* between 2004 and February 2012 (Table 7). The aforementioned species was the only species present from November 2004 to February 2010. After watering and flooding the amphibious species *Mimulus repens* and floodplain species *Alternanthera denticulata* increased in abundance as did the floodplain grass *Sporobolus mitchelli* (albeit in low numbers) (Table 7).

Table 7: Species list and Indicator Species Analysis results comparing the floristic composition between the June 2005, November 2005 and February 2008 surveys for Kulcurna Red Gum flood runner (*denotes exotic species, NS denotes not significantly different).

Species	Survey Date	*P*
Halosarcia pergranulata ssp. *pergranulata*	November 2004	NS Widespread
Mimulus repens	February 2012	<0.001
Alternanthera denticulata	February 2012	0.004
Bare Soil	February 2012	NS Uncommon
Sporobolus mitchelli	February 2012	NS Uncommon

3.5 Lake Littra

Lake Littra was watered three times (Table 1) and flooded once during the study period. Only post-watering surveys were able to be undertaken (Table 1). Five surveys were undertaken on the lakebed and three around the lake edge (from February 2008 onwards).

A total of 32 taxa were recorded on the bed of Lake Littra (including four exotics and one species list as endangered in South Australia) (Table 8a) and 44 from the edge (including eight exotics and one species list as endangered in South Australia) (Table 8b).

The plant community on the lake bed less than 12 months after watering or flooding (June 2005, February 2008 and February 2012) was similar, but the community when surveyed more than 12 months after watering was different on both occasions (June 2005=February 2008=February 2012≠November 2005≠August 2009; PERMANOVA: *Pseudo* $F_{4,54}$=20.98, P<0.001; NMS Ordination: Figure 10a). In contrast, the plant community around the edge of Lake Littra was significantly different each time it was surveyed (February 2008≠August 2009≠February 2012; PERMANOVA: *Pseudo* $F_{2,27}$=19.17, P<0.001; NMS Ordination: Figure 10b).

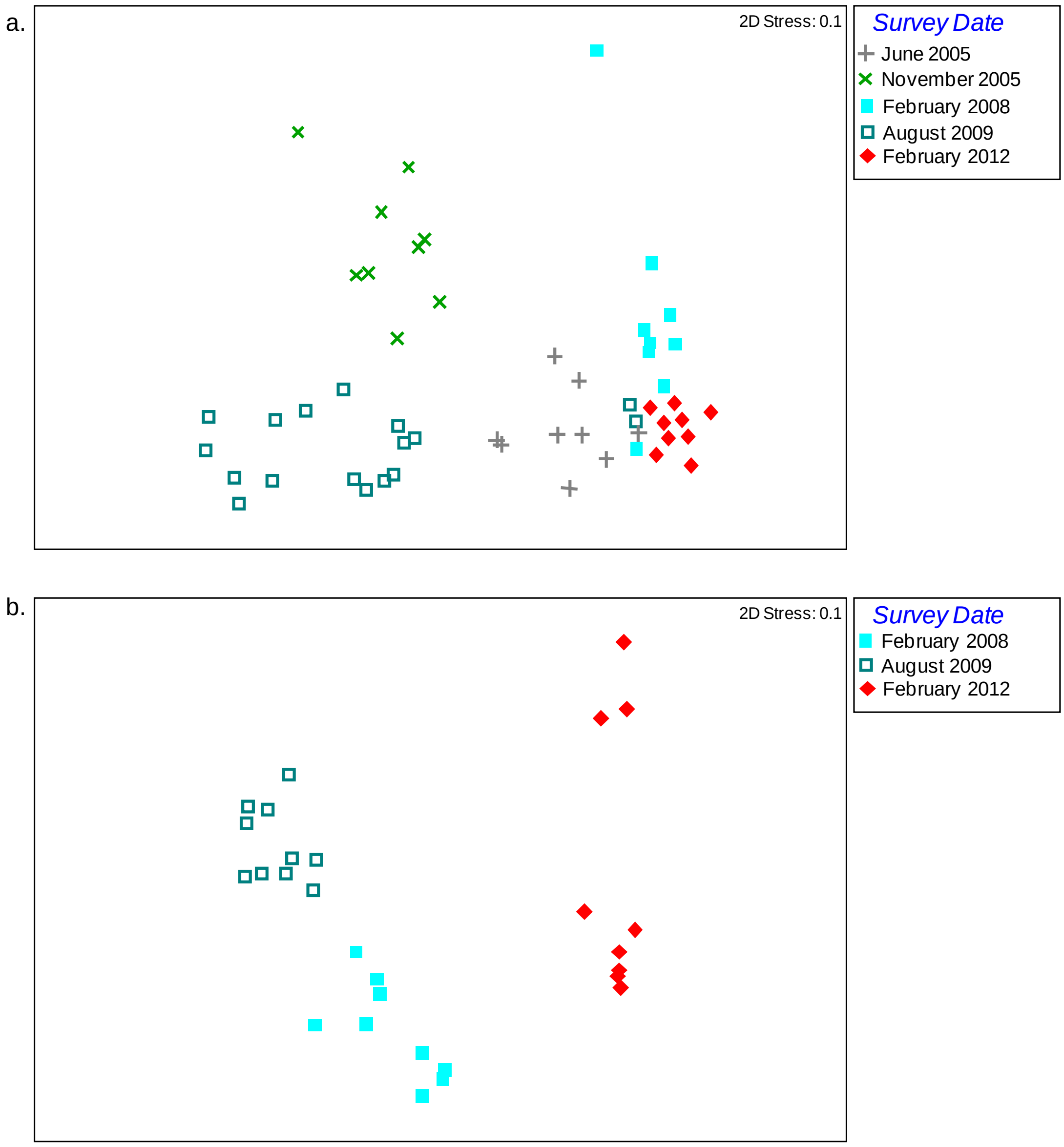


Figure 10: NMS ordination comparing: a. the June 2005, November 2005, February 2008, August 2009 and February 2012 surveys for the bed of Lake Littra (stress=0.1) and b. February 2008, August 2009 and February 2012 surveys for the edge of Lake Littra (stress=0.1).

The plant community on the bed and around the edges of Lake Limbra over the study period was dominated by native amphibious and floodplain herbs, grasses and sedges (Table 8). Exotic species were generally in low numbers, except *Medicago* spp., which germinated after watering or flooding. *Muehlenbeckia florulenta* seedlings only recruited after the flood on the lakebed and around the edge. *Eucalyptus camaldulensis* var. *camaldulensis* recruited in response to watering around the edge of the wetland but were significantly more abundant after the flood (Table 8).

Table 8: Species lists and Indicator Species Analysis results comparing the floristic composition between a. the June 2005, November 2005, February 2008, August 2009 and February 2012 surveys for the bed of Lake Littra and b. February 2008, August 2009 and February 2012 surveys for the edge of Lake Littra (*denotes exotic species, ##denotes species listed as endangered in South Australia, NS denotes not significantly different).

a.

Species	**Survey Date**	***P***
Enchylaena tomentosa ssp. *tomentosa*	June 2005	NS Widespread
*Heliotropium curassavicum**	June 2005	NS Widespread
Lachnagrostis filiformis	November 2005	<0.001
Polygonum plebium	November 2005	<0.001
Atriplex spp.	November 2005	0.0034
Mollugo cerviana	November 2005	0.0147
*Bromus rubens**	November 2005	NS Uncommon
Centipeda minima	November 2005	NS Widespread
Craspedia chrysantha	November 2005	NS Widespread
*Mesembryanthemum crystallinum**	November 2005	NS Widespread
Sclerolaena brachyptera	February 2008	<0.001
Wahlenbergia fluminalis	February 2008	<0.001
Chenopodium pumilio	February 2008	0.0195
Salsola kali var. *kali*	February 2008	NS Uncommon
Sclerolaena divaricata	February 2008	NS Uncommon
Sclerolaena stelligera	February 2008	NS Uncommon
Medicago spp.*	August 2009	<0.001
Sporobolus mitchelli	August 2009	<0.001
Rorippa islandica	August 2009	0.0011
Senecio cunninghamii	August 2009	0.0015
Myosurus minima	August 2009	0.0024
Carpobrotus rossii	August 2009	0.0045
Cyperus gymnocaulos	August 2009	0.0385
Tetragonia tetragonoides	August 2009	0.048
Calotis cuneifolia	August 2009	NS Uncommon
Crassula helmsii	August 2009	NS Uncommon
Crassula sieberana##	August 2009	NS Uncommon
*Polygonum aviculare**	August 2009	NS Uncommon
Ptilotus obovatus	August 2009	NS Uncommon
Rhagodia spinescens	August 2009	NS Uncommon
Scleroblitum atriplicinum	August 2009	NS Uncommon
Muehlenbeckia florulenta	August 2009	NS Widespread
Trachymene cyanopetula	August 2009	NS Widespread
Muehlenbeckia florulenta seedlings	February 2012	0.002
Mimulus repens	February 2012	NS Widespread

b.

Species	Survey Date	*P*
Atriplex spp.	February 2008	<0.001
Brachyscome basaltica	February 2008	<0.001
Eragrostis australasica	February 2008	<0.001
Sclerolaena paradoxa	February 2008	<0.001
Wahlenbergia fluminalis	February 2008	<0.001
Enchylaena tomentosa ssp. *tomentosa*	February 2008	0.0096
Sclerolaena divaricata	February 2008	0.0142
Cyperus gymnocaulos	February 2008	0.0404
Acacia stenophylla	February 2008	NS Uncommon
Maireana microcarpa	February 2008	NS Uncommon
Sclerolaena brachyptera	February 2008	NS Uncommon
*Aster subulatus**	February 2008	NS Widespread
Medicago spp.*	August 2009	<0.001
Sporobolus mitchelli	August 2009	<0.001
Carpobrotus rossii	August 2009	0.0015
Rorippa islandica	August 2009	0.0057
Senecio cunninghamii	August 2009	0.0068
Tetragonia tetragonoides	August 2009	0.0227
Myosurus minima	August 2009	0.0245
Mimulus repens	August 2009	0.13
Calotis cuneifolia	August 2009	NS Uncommon
Chenopodium pumilio	August 2009	NS Uncommon
Crassula helmsii	August 2009	NS Uncommon
Crassula sieberana##	August 2009	NS Uncommon
*Polygonum aviculare**	August 2009	NS Uncommon
Ptilotus obovatus	August 2009	NS Uncommon
Rhagodia spinescens	August 2009	NS Uncommon
Scleroblitum atriplicinum	August 2009	NS Uncommon
Trachymene cyanopetula	August 2009	NS Uncommon
Centipeda minima	February 2012	<0.001
Epaltes australis	February 2012	<0.001
Helichrysum luteo-album	February 2012	<0.001
Muehlenbeckia florulenta seedlings	February 2012	<0.001
Eucalyptus camaldulensis var. *camaldulensis* seedlings	February 2012	0.0016
Morgania floribunda	February 2012	0.0023
Senecio runcinifolius	February 2012	0.0106
Eragrostis dielsii	February 2012	NS Uncommon
Lythrum hyssopifolia	February 2012	NS Uncommon
Polygonum plebium	February 2012	NS Uncommon
*Solanum nigrum**	February 2012	NS Uncommon
*Sonchus oleraceus**	February 2012	NS Uncommon
*Heliotropium curassavicum**	February 2012	NS Widespread
*Heliotropium europaeum**	February 2012	NS Widespread
*Hypochoeris glabra**	February 2012	NS Widespread

3.6 Monoman Island Horseshoe

Monoman Island Horseshoe was watered three times since 2004, once prior to this project commencing in spring 2003 (Table 1) and flooded in summer 2010-11. Only post watering surveys were able to be undertaken. Three surveys were undertaken in the centre of the creek and two on the edge of the channel (from February 2008).

A total of 40 species (including four exotics) were recorded in the middle of the creek (Table 9a) and 22 (including three exotics) from the edge of the channel (Table 9b). In the middle of the creek the plant community was significantly different for each survey (November 2005≠February 2008≠August 2009; PERMANOVA: *Pseudo* $F_{2,27}$=14.12, P<0.001; NMS Ordination: Figure 11a). Similarly, the plant community at the edge of the channel was significantly different for each survey (PERMANOVA: *Pseudo* $F_{1,11}$=2.62, P<0.027; NMS Ordination: Figure 11b).

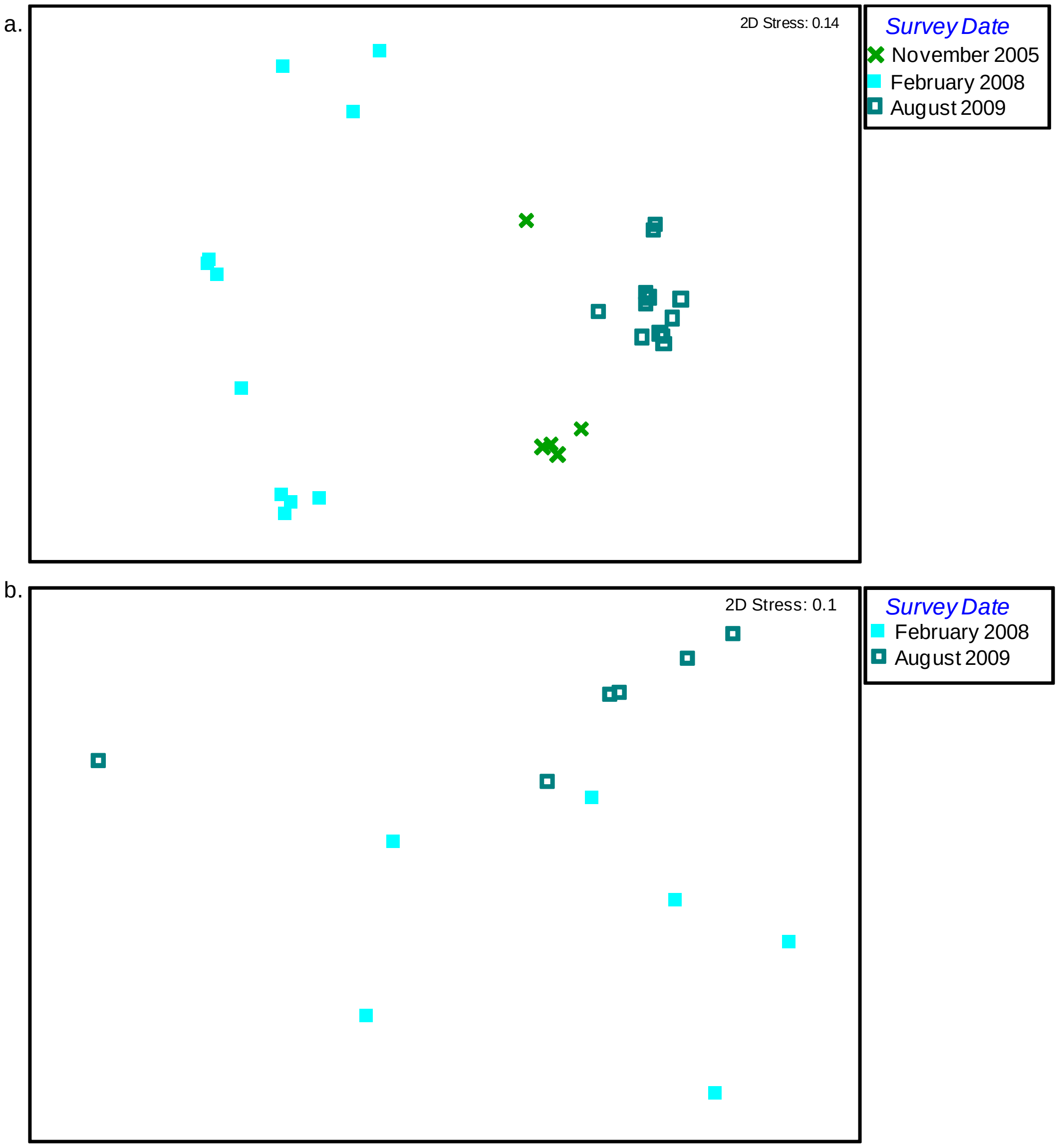


Figure 11: NMS ordination comparing: a. the November 2005, February 2008 and August 2009 surveys for the middle of Monoman Island Horseshoe (stress=0.14) and b. the February 2008 and August 2009 surveys for the edge of Monoman Island Horseshoe (stress=0.1).

The plant community in the centre of the creek and edge of the channel at Monoman Island Horseshoe was dominated by native floodplain, amphibious and emergent (*Typha domingensis* and

Schoenoplectus validus) species (Table 9). Large numbers of *Eucalyptus camaldulensis* var. *camaldulensis* seedlings and small numbers of *Acacia stenophylla* seedlings were present throughout the site, although *Acacia stenophylla* seedlings were restricted to the middle of the creek (Table 9).

Table 9: Species list and Indicator Species Analysis results comparing: a. the November 2005, February 2008 and August 2009 surveys for the middle of Monoman Island Horseshoe and b. the February 2008 and August 2009 surveys for the edge of Monoman Island Horseshoe (*denotes exotic species, NS denotes not significantly different).

a.

Species	Survey Date	*P*
Juncus usitatus	November 2005	<0.001
Limosella australis	November 2005	<0.001
Typha domingensis	November 2005	<0.001
Schoenoplectus validus	November 2005	0.0334
Cyperus exaltatus	November 2005	0.035
Iseotopsis graminifolia	November 2005	0.035
Alternanthera denticulata	November 2005	NS Uncommon
Craspedia chrysantha	November 2005	NS Uncommon
Ludwigia peploides ssp. *montevidensis*	November 2005	NS Uncommon
Rumex bidens	November 2005	NS Uncommon
Ammania multiflora	November 2005	NS Widespread
Lachnagrostis filiformis	November 2005	NS Widespread
Sporobolus mitchelli	November 2005	NS Widespread
Atriplex spp.	February 2008	0.004
Eucalyptus camaldulensis var. *camaldulensis* seedlings	February 2008	0.0178
Bare Soil	February 2008	0.0273
Chenopodium pumilio	February 2008	NS Uncommon
Enchylaena tomentosa ssp. *tomentosa*	February 2008	NS Uncommon
Marsilea angustifolia	February 2008	NS Uncommon
Sclerolaena divaricata	February 2008	NS Uncommon
Cyperus gymnocaulos	February 2008	NS Widespread
Atriplex suberecta	August 2009	<0.001
Polygonum plebium	August 2009	<0.001
Brachyscome basaltica	August 2009	0.0033
Morgania floribunda	August 2009	0.0078
Trachymene cyanopetula	August 2009	0.010
Centipeda minima	August 2009	0.0112
Senecio runcinifolius	August 2009	0.0257
Myriophyllum verucossum	August 2009	0.0347
Acacia stenophylla seedlings	August 2009	NS Uncommon
*Anagallis arvensis**	August 2009	NS Uncommon
Helichrysum luteo-album	August 2009	NS Uncommon
*Heliotropium amplexicaule**	August 2009	NS Uncommon
*Heliotropium curassavicum**	August 2009	NS Uncommon
Mimulus repens	August 2009	NS Uncommon
Myosurus minima	August 2009	NS Uncommon
Rorippa islandica	August 2009	NS Uncommon
Teucrium racemosum	August 2009	NS Uncommon
Epaltes australis	August 2009	NS Widespread
Glinus lotoides	August 2009	NS Widespread
Medicago spp.*	August 2009	NS Widespread

b.

Species	Survey Date	*P*
Sporobolus mitchelli	February 2008	0.0112
Carpobrotus rossii	February 2008	NS Uncommon
Enchylaena tomentosa ssp. *tomentosa*	February 2008	NS Uncommon
Eremophila scoparia	February 2008	NS Uncommon
Euphorbia drummondii	February 2008	NS Uncommon
Maireana microcarpa	February 2008	NS Uncommon
Rhagodia spinescens	February 2008	NS Uncommon
Sclerolaena brachyptera	February 2008	NS Uncommon
Sclerolaena divaricata	February 2008	NS Uncommon
Wahlenbergia fluminalis	February 2008	NS Uncommon
Atriplex spp.	February 2008	NS Widespread
Cyperus gymnocaulos	February 2008	NS Widespread
Eucalyptus camaldulensis var. *camaldulensis* seedlings	February 2008	NS Widespread
Medicago spp.*	February 2008	NS Widespread
*Phyla canescens**	February 2008	NS Widespread
Acacia stenophylla	August 2009	NS Uncommon
Anagallis arvensis*	August 2009	NS Uncommon
Bare Soil	August 2009	NS Uncommon
Rorippa islandica	August 2009	NS Uncommon
Senecio runcinifolius	August 2009	NS Uncommon
Teucrium racemosum	August 2009	NS Uncommon
Brachyscome basaltica	August 2009	NS Widespread
Morgania floribunda	August 2009	NS Widespread

3.7 Twin Creeks

Twin Creeks was watered three times during the study period (Table 1) and flooded in summer 2010-11. Only post-watering surveys were able to be undertaken; with five undertaken in the middle of the creeks and three on the edges (from February 2008 onwards).

A total of 53 taxa (including 11 exotics, two of which are declared noxious in South Australia) were recorded in the middle of the creeks (Table 10a) and 30 recorded on the edges (including two exotics, one of which is declared noxious in South Australia) (Table 10b). There was no significant change in the floristic composition of the middle of the creeks between June 2005 and November 2005 a significant change between November 2005 and February 2008 and another change between February 2008 and February 2009, after which there were no significant changes (June 2005=November 2005≠February 2008≠February 2009=February 2012; PERMANOVA *Pseudo-*$F_{4,80}$=6.41, P<0.001; NMS Ordination: Figure 12a). In contrast, the plant community was significantly different for each survey on the edges of the creeks (February 2008≠February 2009≠February 2012; PERMANOVA *Pseudo-*$F_{2,32}$=7.56, P<0.001; NMS Ordination: Figure 12b).

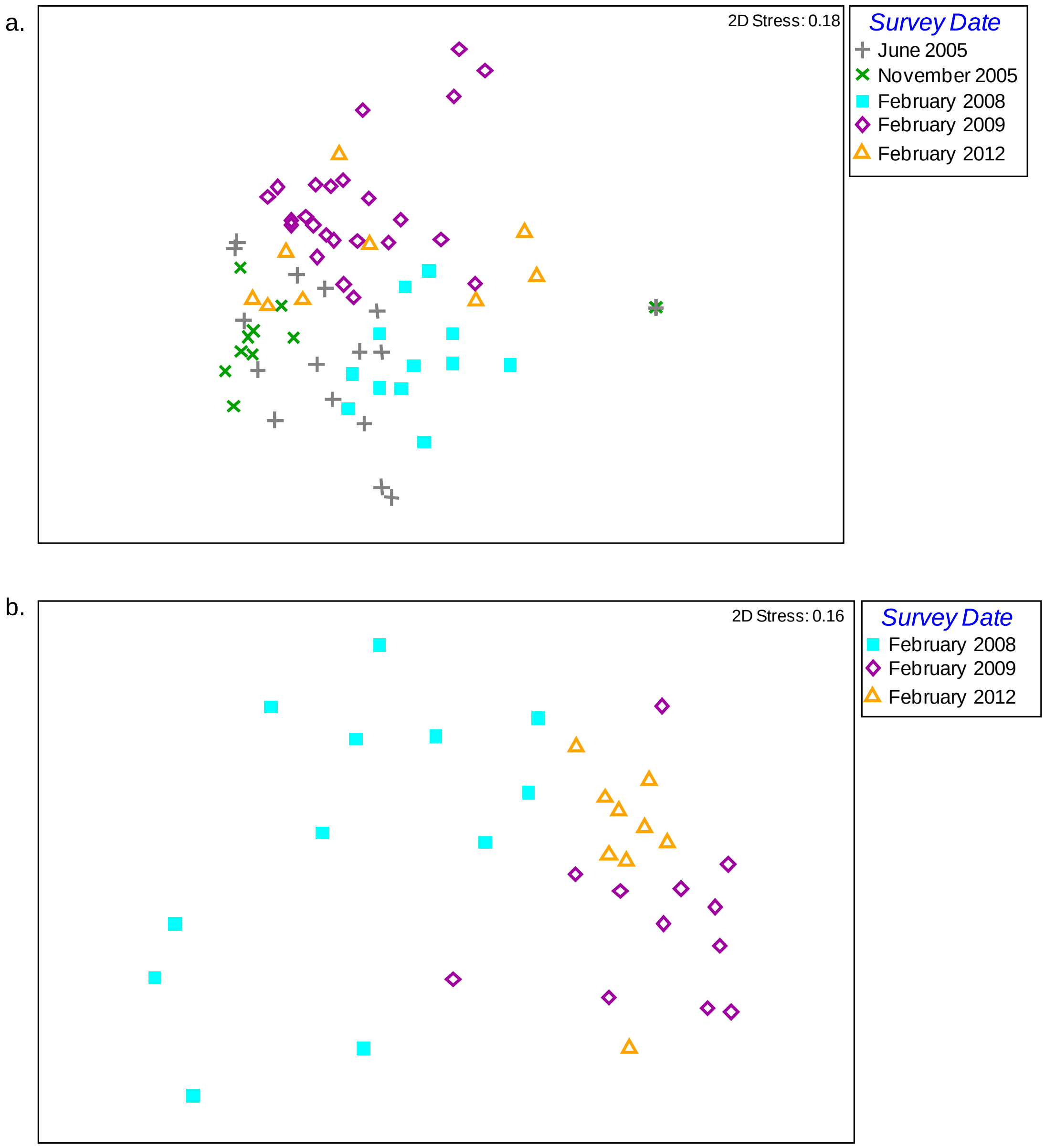


Figure 12: NMS ordination comparing: a. the June 2005, November 2005, February 2008, February 2009 and February 2012 surveys for the middle of Twin Creeks (stress=0.18) and b. the. February 2008, February 2009 and February 2012 surveys for the edge of Twin Creeks (stress=0.16).

Throughout the study period Twin Creeks was dominated by native floodplain and amphibious species (Table 10). Furthermore, *Eucalyptus camaldulensis* and *Acacia stenophylla* seedlings recruited (in the middle of the creeks) in response to watering. However, several exotic taxa were also present (Table 10) including *Xanthium occidentale* and *Echium plantagineum*, which are proclaimed noxious in South Australia.

Table 10: Species list and Indicator Species Analysis results comparing: a. the June 2005, November 2005, February 2008, February 2009 and February 2012 surveys for the middle of Twin Creeks (stress=0.18) and b. the. February 2008, February 2009 and February 2012 surveys for the edge of Twin Creeks (*denotes exotic species, ** denotes proclaimed pest plant).

a.

Species	**Survey Date**	***P***
*Hypochaeris radicata**	June 2005	0.0227
Ammania multiflora	June 2005	NS Uncommon
*Arctotheca calendula**	June 2005	NS Uncommon
Chenopodium pumilio	June 2005	NS Uncommon
*Conyza bonariensis**	June 2005	NS Uncommon
*Echium plantagineum***	June 2005	NS Uncommon
*Heliotropium europaeum**	June 2005	NS Uncommon
Rhodanthe pygmaeum	June 2005	NS Uncommon
Atriplex spp.	June 2005	NS Widespread
Bare Soil	June 2005	NS Widespread
Euphorbia drummondii	June 2005	NS Widespread
Mollugo cerviana	June 2005	NS Widespread
Craspedia chrysantha	November 2005	<0.001
Helichrysum luteo-album	November 2005	<0.001
Tetragonia tetragonoides	November 2005	<0.001
Alternanthera denticulata	November 2005	0.001
Plantago turrifera	November 2005	0.0023
Polygonum plebium	November 2005	0.0035
Centipeda minima	November 2005	0.0053
Wahlenbergia fluminalis	November 2005	0.0073
Carpobrotus rossii	November 2005	0.02
Iseotopsis graminifolia	November 2005	0.0259
Limosella australis	November 2005	0.0481
*Hordeum vulgare**	November 2005	NS Uncommon
Cyperus gymnocaulos	November 2005	NS Widespread
Eucalyptus camaldulensis var. *camaldulensis* seedlings	November 2005	NS Widespread
Lachnagrostis filiformis	November 2005	NS Widespread
Marsilea angustifolia	November 2005	NS Widespread
Rorippa islandica	November 2005	NS Widespread
Eragrostis australasica	February 2008	<0.001
Sclerolaena divaricata	February 2008	<0.001
Acacia stenophylla seedlings	February 2008	NS Widespread
Brachyscome basaltica	February 2008	NS Widespread
Isolepis hookeriana	February 2008	NS Widespread
Sclerolaena brachyptera	February 2008	NS Widespread
Senecio cunninghamii	February 2008	NS Widespread
Calotis hispidula	February 2009	<0.001
Pycnosorus globosa	February 2009	0.003
Calotis cuneifolia	February 2009	NS Widespread
*Centaurium tenuiflorum**	February 2009	NS Widespread
Epaltes australis	February 2009	NS Widespread
Haloragis aspera	February 2009	NS Widespread
Morgania floribunda	February 2009	NS Widespread
*Phyla canescens**	February 2009	NS Widespread
Senecio runcinifolius	February 2009	NS Widespread
Sporobolus mitchelli	February 2009	NS Widespread
Teucrium racemosum	February 2009	NS Widespread
*Xanthium occidentale***	February 2009	NS Widespread

Species	Survey Date	*P*
Goodenia gracilis	February 2012	<0.001
Glinus lotoides	February 2012	0.0136
Glycyrrhiza acanthocarpa	February 2012	0.02
Calotis scapigera	February 2012	0.NS Widespread
*Heliotropium amplexicaule**	February 2012	NS Widespread
Medicago spp.*	February 2012	NS Widespread

b.

Species	Survey Date	*P*
Bare Soil	February 2008	0.0029
Eragrostis australasica	February 2008	0.0048
Atriplex spp.	February 2008	0.0239
Enchylaena tomentosa ssp. *tomentosa*	February 2008	0.0276
Carpobrotus rossii	February 2008	NS Uncommon
Craspedia chrysantha	February 2008	NS Uncommon
Sclerolaena divaricata	February 2008	NS Uncommon
Senecio cunninghamii	February 2008	NS Uncommon
Acacia stenophylla seedlings	February 2008	NS Widespread
Maireana microcarpa	February 2008	NS Widespread
Sclerolaena brachyptera	February 2008	NS Widespread
Calotis hispidula	February 2009	<0.001
Pycnosorus globosa	February 2009	0.0303
*Phyla canescens**	February 2009	0.0904
Glycyrrhiza acanthocarpa	February 2009	NS Uncommon
Helichrysum luteo-album	February 2009	NS Uncommon
Senecio runcinifolius	February 2009	NS Uncommon
Calotis cuneifolia	February 2009	NS Widespread
Centipeda minima	February 2009	NS Widespread
Haloragis aspera	February 2009	NS Widespread
Sporobolus mitchelli	February 2012	<0.001
Goodenia gracilis	February 2012	0.0011
Wahlenbergia fluminalis	February 2012	0.0038
Brachyscome basaltica	February 2012	0.0049
Morgania floribunda	February 2012	0.0124
Epaltes australis	February 2012	0.0158
Alternanthera denticulata	February 2012	0.0163
Calotis scapigera	February 2012	NS Widespread
Euphorbia drummondii	February 2012	NS Widespread
Teucrium racemosum	February 2012	NS Widespread
*Xanthium occidentale***	February 2012	NS Widespread

3.8 Werta Wert Wetland

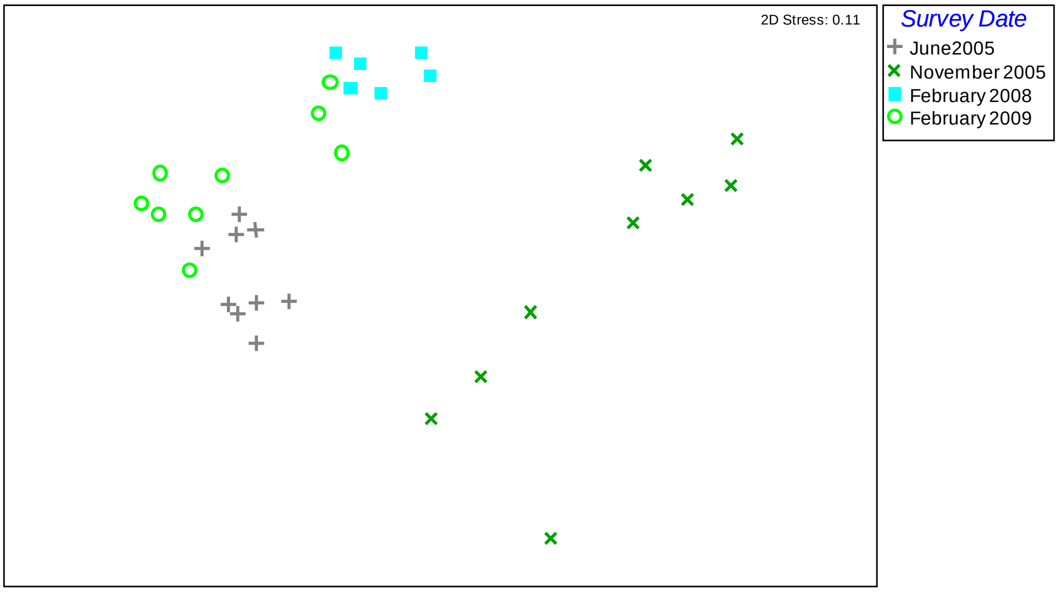
Werta Wert Wetland was watered three times during the study period (Table 1) and flooded in summer 2010-11. Only post-watering surveys were able to be undertaken and due to differences in elevation and bathymetry wetlands dried at different rates (the northern basin is the shallowest and dries the quickest and the southern and central basins remain wet for much longer); hence basins were often surveyed at different times and are treated individually. From February 2008 onwards vegetation surveys were undertaken on the around the edges of the basins in addition to wetland beds.

3.8.1 Southern Basin

In the southern basin of Werta Wert Wetland the wetland bed was surveyed four times and the edge three times (only the wetland edge was dry in February 2012). A total of 23 taxa (including five exotics, one of which is declared noxious in South Australia) were recorded on the wetland bed of the southern basin (Table 11a) and 32 taxa (including seven exotics) were recorded from the edge of the wetland (Table 11b).

The plant community changed significantly through time in the middle and the edge; however, the patterns of change were different. On the wetland bed the plant community was significantly different each survey (June 2005≠November 2005≠February 2008≠February 2009; PERMANOVA $\textit{Pseudo-F}_{3,35}=17.13$, $P<0.001$; NMS Ordination: Figure 13a). Around the edges of the southern basin the plat community changed significantly between February 2008 and February 2009 but there was no significant change from February 2009 to February 2012 (February 2008≠February 2009=February 2012; PERMANOVA $\textit{Pseudo-F}_{2,22}=2.21$, $P=0.01$; NMS Ordination: Figure 13b).

a.



b.

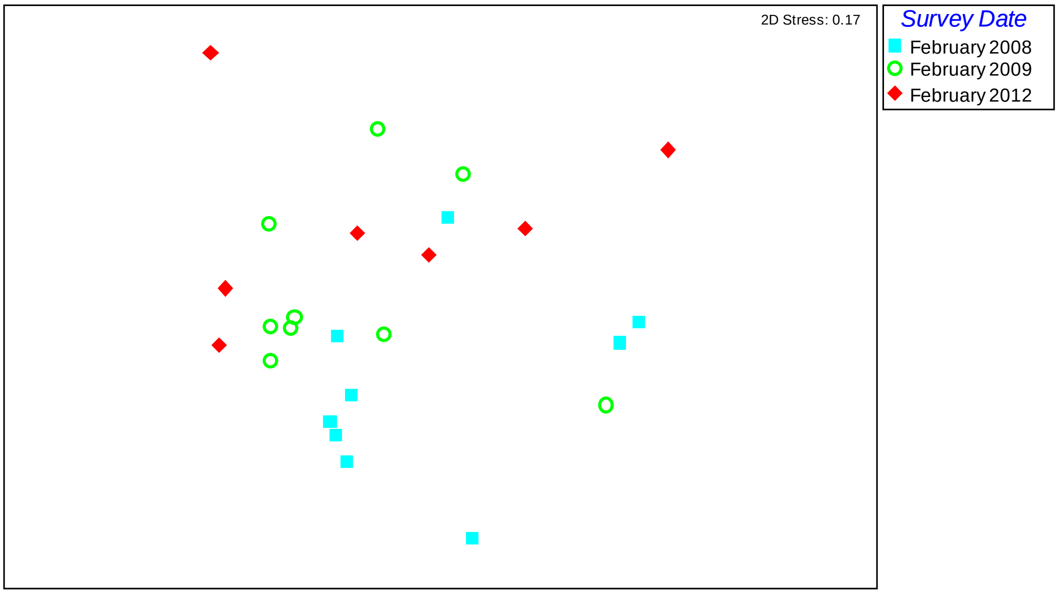


Figure 13: NMS ordination comparing: a. the June 2005, November 2005, February 2008, February 2009 and February 2012 surveys for the bed of the southern basin of Wert a Wert wetland (stress=0.11) and b. the. February 2008, February 2009 and February 2012 surveys for edge the southern basin of Werta Wert (stress=0.17).

The southern basin of Werta Wert Wetland was dominated by native floodplain and amphibious taxa throughout the study period (Table 11). However, there were a higher proportion of exotics compared with other sites and the parasitic plant *Cuscuta campestris*, which is declared noxious in South Australia, was abundant on the wetland bed in November 2005 (Table 11a). Despite the large number of adult *Eucalyptus camaldulensis* var. *camaldulensis* trees growing around the edge of the basin, no seedlings were observed.

Table 11: Species list and Indicator Species Analysis results comparing a. the June 2005, November 2005, February 2008 and February 2009 and February 2012 for the bed of the southern basin of Wert a Wert wetland and b. the. February 2008, February 2009 and February 2012 surveys for edge the southern basin of Werta Wert Wetland (*denotes exotic species, ** denotes proclaimed pest plant, NS denotes not significantly different).

a.

Species	Survey Date	*P*
*Heliotropium europaeum**	June 2005	<0.001
Centipeda minima	June 2005	0.0077
Myriophyllum verrucosum	June 2005	NS Widespread
Atriplex spp.	November 2005	<0.001
Chenopodium pumilio	November 2005	<0.001
Craspedia chrysantha	November 2005	<0.001
Polygonum plebium	November 2005	<0.001
Rumex bidens	November 2005	<0.001
Lachnagrostis filiformis	November 2005	0.0016
*Heliotropium amplexicaule**	November 2005	0.0032
Medicago spp.*	November 2005	0.0129
*Cuscuta campestris***	November 2005	0.0462
Alternanthera denticulata	November 2005	0.0473
Aster subulatus	November 2005	NS Uncommon
*Malva parviflora**	November 2005	NS Uncommon
Wahlenbergia fluminalis	November 2005	NS Uncommon
Brachyscome basaltica	November 2005	NS Widespread
Eucalyptus camaldulensis var. *camaldulensis*	November 2005	NS Widespread
Glycyrrhiza acanthocarpa	November 2005	NS Widespread
Sporobolus mitchelli	November 2005	NS Widespread
Bare Soil	February 2008	0.0485
Enchylaena tomentosa ssp. *tomentosa*	February 2008	NS Uncommon
Glinus lotoides	February 2009	<0.001
Calotis hispidula	February 2009	NS Widespread

b.

Species	Survey Date	*P*
Brachyscome basaltica	February 2008	<0.001
*Heliotropium curassavicum**	February 2008	NS Uncommon
Wahlenbergia fluminalis	February 2008	NS Uncommon
Bare Soil	February 2008	NS Widespread
Cyperus gymnocaulos	February 2008	NS Widespread
Sporobolus mitchelli	February 2008	NS Widespread
Calotis hispidula	February 2009	0.0237
Epaltes australis	February 2009	0.0342
Atriplex suberecta	February 2009	NS Uncommon
*Centaurium tenuiflorum**	February 2009	NS Uncommon
Eragrostis dielsii	February 2009	NS Uncommon
Glinus lotoides	February 2009	NS Uncommon
Atriplex spp.	February 2009	NS Widespread
Glycyrrhiza acanthocarpa	February 2009	NS Widespread
Morgania floribunda	February 2009	NS Widespread
Helichrysum luteo-album	February 2012	0.0152
Ennepogon nigricans	February 2012	NS Uncommon
*Sonchus oleraceus**	February 2012	NS Uncommon

Species	Survey Date	*P*
*Abutilon theophrasti**	February 2012	NS Widespread
Alternanthera denticulata	February 2012	NS Widespread
Brachyscome dentata	February 2012	NS Widespread
Calotis cuneifolia	February 2012	NS Widespread
Centipeda minima	February 2012	NS Widespread
Chenopodium pumilio	February 2012	NS Widespread
*Conyza bonariensis**	February 2012	NS Widespread
Enchylaena tomentosa ssp. *tomentosa*	February 2012	NS Widespread
Eucalyptus camaldulensis var. *camaldulensis*	February 2012	NS Widespread
*Heliotropium europaeum**	February 2012	NS Widespread
Lythrum hyssopifolia	February 2012	NS Widespread
Maireana microcarpa	February 2012	NS Widespread
Medicago spp.*	February 2012	NS Widespread
Sclerolaena brachyptera	February 2012	NS Widespread
Senecio runcinifolius	February 2012	NS Widespread

3.8.2 Central Basin

In the central basin of Werta Wert Wetland the wetland bed was surveyed four times and the edge twice (the central basin was inaccessible in February 2012). A total of 24 taxa (including four exotics) were recorded on the wetland bed of the central basin (Table 12a) and 19 taxa (including three exotics, one of which is declared noxious in South Australia) were recorded from the edge of the wetland (Table 12b).

The plant community changed significantly through time on the wetland bed (June 2005≠November 2005≠February 2008≠February 2009; PERMANOVA $Pseudo\text{-}F_{3,32}=21.45$, $P<0.001$; NMS Ordination: Figure 14a) and the edge (PERMANOVA $Pseudo\text{-}F_{1,17}=8.06$, $P<0.001$; NMS Ordination: Figure 14b) with the plant community significantly different for each survey.

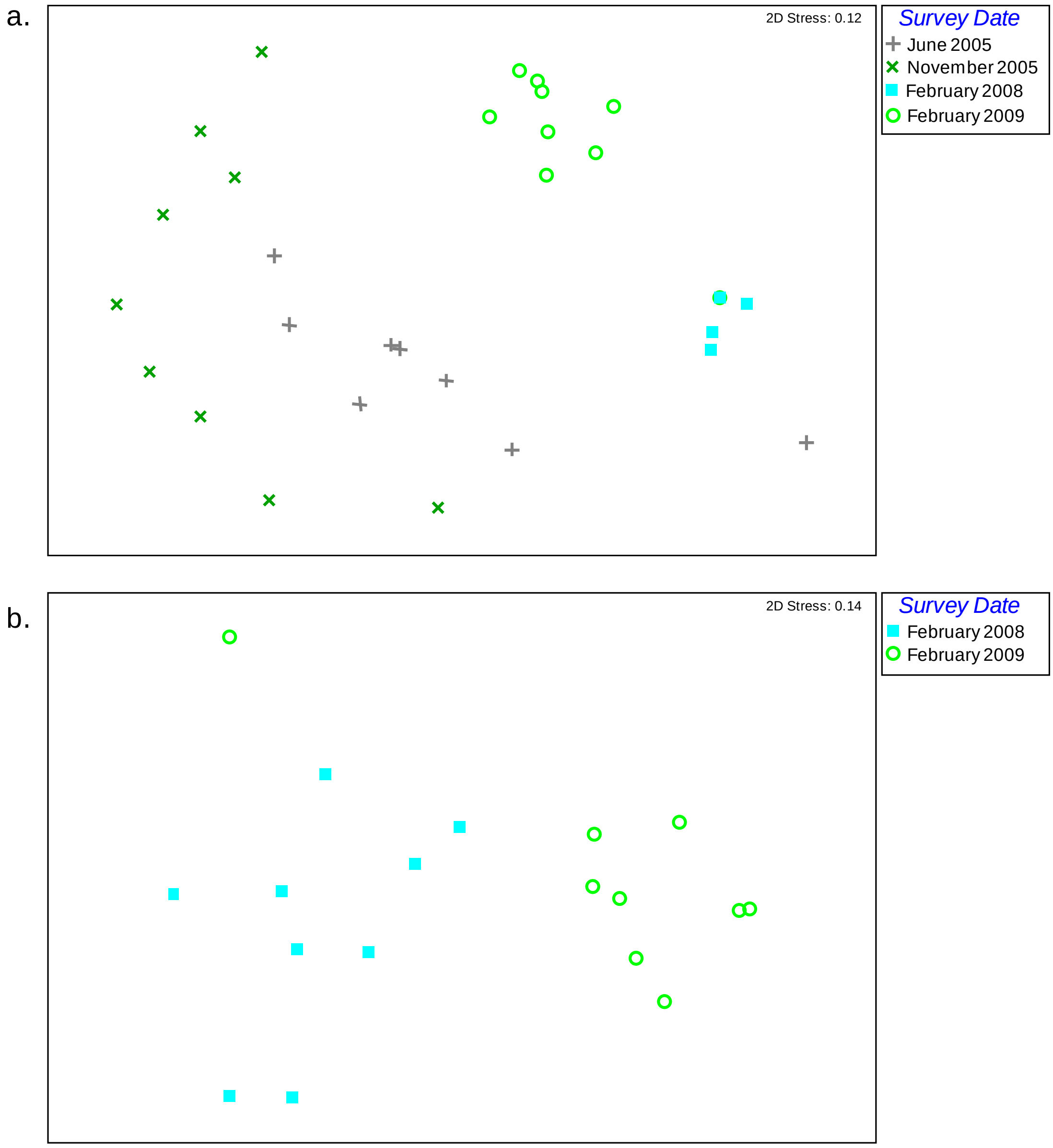


Figure 14: NMS ordination comparing: a. the June 2005, November 2005, February 2008 and February 2009 for the bed of the central basin of Wert a Wert Wetland (stress=0.12) and b. the. February 2008, and February 2009 surveys for edge the central basin of Werta Wert Wetland (stress=0.14).

Similar to the southern basin, the plant community was dominated by native amphibious and floodplain species throughout the study period (Table 12). There were a lower proportion of exotics present compared with the southern basin; however, *Xanthium occidentale* (declared noxious in South Australia) was present around the edge of the wetland during both surveys (Table 12b). In contrast to the southern basin, *Eucalyptus camaldulensis* var. *camaldulensis* seedlings recruited on the wetland bed and around the edges in the central basin (Table 12).

Table 12: Species list and Indicator Species Analysis results comparing a. the June 2005, November 2005, February 2008 and February 2009 surveys for the bed of the central basin of Wert a Wert wetland and b. the. February 2008 and February 2009 surveys for edge the southern basin of Werta Wert (*denotes exotic species, ** denotes proclaimed pest plant, NS denotes not significantly different).

a.

Species	Survey Date	*P*
Glinus lotoides	June 2005	0.0043
Glycyrrhiza acanthocarpa	June 2005	NS Uncommon
Eucalyptus camaldulensis var. *camaldulensis* seedlings	June 2005	NS Widespread
Medicago spp.*	June 2005	NS Widespread
Brachyscome basaltica	November 2005	<0.001
Centipeda minima	November 2005	<0.001
Myriophyllum verrucosum	November 2005	<0.001
Polygonum plebium	November 2005	<0.001
Chenopodium pumilio	November 2005	0.0012
Helichrysum luteo-album	November 2005	0.0013
*Abutilon theophrasti**	November 2005	0.0014
Craspedia chrysantha	November 2005	0.0463
Eragrostis dielsii	November 2005	NS Uncommon
*Heliotropium amplexicaule**	November 2005	NS Uncommon
Limosella australis	November 2005	NS Uncommon
Alternanthera denticulata	November 2005	NS Widespread
Atriplex spp.	November 2005	NS Widespread
Epaltes australis	November 2005	NS Widespread
Isolepis hookeriana	November 2005	NS Widespread
Lachnagrostis filiformis	November 2005	NS Widespread
Mimulus repens	November 2005	NS Widespread
Plantago turrifera	November 2005	NS Widespread
Sporobolus mitchelli	November 2005	NS Widespread
Bare Soil	February 2008	NS Uncommon
*Heliotropium europaeum**	February 2009	0.0016

b.

Species	Survey Date	*P*
Brachyscome basaltica	February 2008	<0.001
Atriplex spp.	February 2008	NS Widespread
Bare Soil	February 2008	NS Widespread
Cyperus gymnocaulos	February 2008	NS Widespread
Dodonea attenuata	February 2008	NS Widespread
Enchylaena tomentosa ssp. *tomentosa*	February 2008	NS Widespread
Morgania floribunda	February 2008	NS Widespread
Centipeda minima	February 2009	<0.001
Epaltes australis	February 2009	<0.001
Glycyrrhiza acanthocarpa	February 2009	0.0014
Helichrysum luteo-album	February 2009	0.0315
Alternanthera denticulata	February 2009	NS Widespread
Atriplex suberecta	February 2009	NS Widespread
Calotis hispidula	February 2009	NS Widespread
*Centaurium tenuiflorum**	February 2009	NS Widespread
Eucalyptus camaldulensis var. *camaldulensis* seedlings	February 2009	NS Widespread
*Heliotropium europaeum**	February 2009	NS Widespread
Polygonum plebium	February 2009	NS Widespread

Species	Survey Date	*P*
Sporobolus mitchelli	February 2009	NS Widespread
*Xanthium occidentale***	February 2009	NS Widespread

3.8.3 Northern Basin

In the northern basin of Werta Wert Wetland the wetland bed was surveyed six times and the edge three times. A total of 41 taxa (including 13 exotics, one of which is declared noxious in South Australia) were recorded on the wetland bed (Table 13a) and 35 taxa were recorded around the edge (including 13 exotics, two of which are declared noxious in South Australia) (Table 13b).

The floristic composition of the wetland bed changed significantly through time with the plant community being significantly different each survey, except the June 2006 and February 2008 surveys where the plant community was similar (June 2005≠November 2005≠June 2006=February 2008≠February 2009≠February 2012; PERMANOVA $Pseudo\text{-}F_{5,53}=14.65$, $P<0.001$; NMS Ordination: Figure 15a). The plant community around the edge of the northern basin changed significantly through time with the floristic composition being significantly different each survey (February 2008≠February 2009≠February 2012; PERMANOVA $Pseudo\text{-}F_{2,26}=8.42$, $P<0.001$; NMS Ordination: Figure 15b).

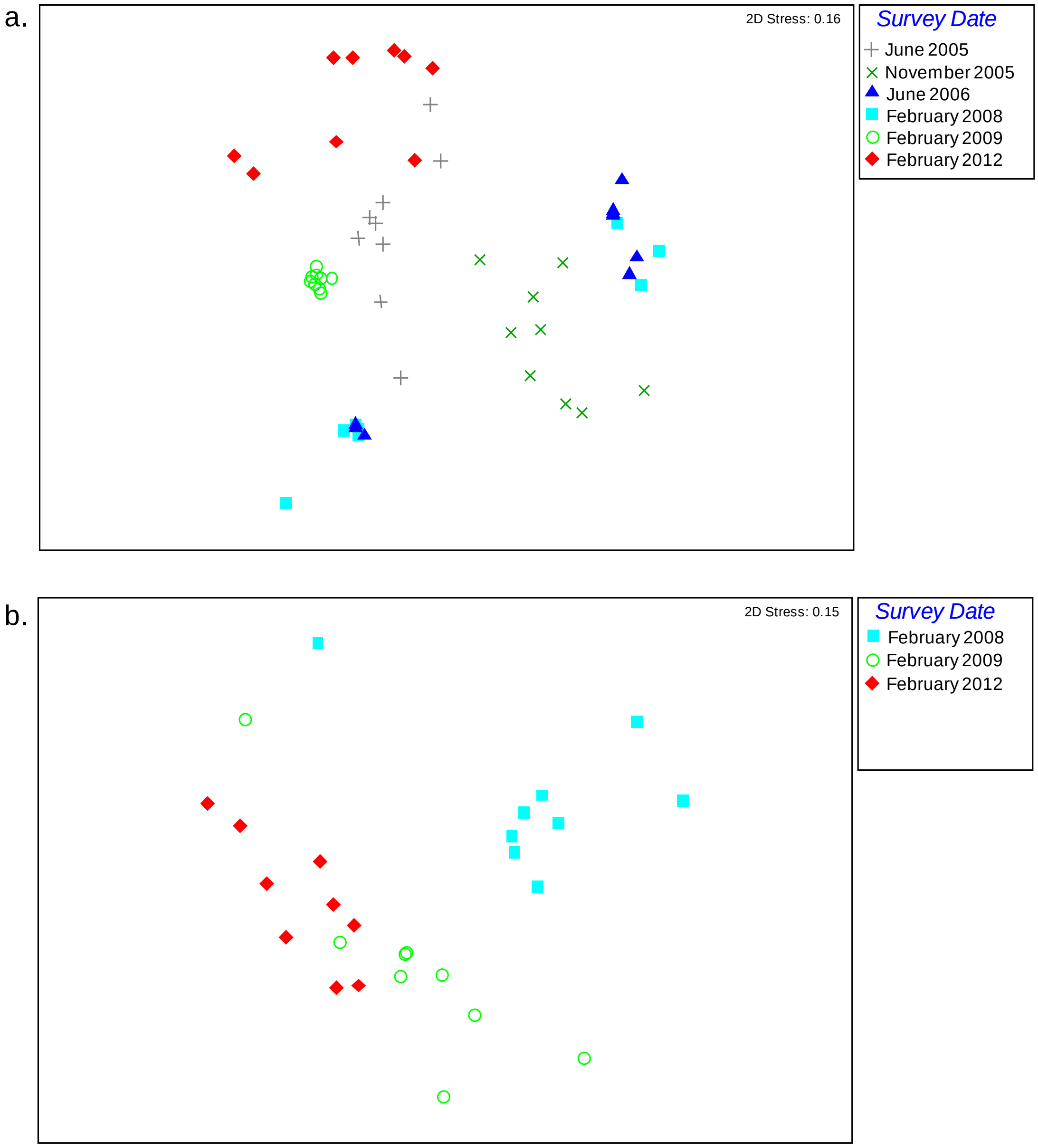


Figure 15: NMS ordination comparing: a. the June 2005, November 2005, June 2006, February 2008, February 2009 and February 2012 surveys for the bed of the northern basin of Wert a Wert wetland. (stress=0.16) and b. the. February 2008, February 2009 and February 2012 surveys for edge the northern basin of Werta Wert (stress=0.15).

Similar to the remainder of Werta Wert Wetland the plant community in the northern basin was dominated by native amphibious and floodplain species; however, there were a large proportion of exotic species including *Marrubium vulgare* and *Xanthium occidentale* (both declared noxious in South Australia) that recruited in response to watering (Table 13). *Eucalyptus camaldulensis* var. *camaldulensis* seedlings recruited around the edge of the wetland but only after the wetland was flooded (Table 13b).

Table 13: Species list and Indicator Species Analysis results comparing a. the June 2005, November 2005, June 2006, February 2008, February 2009 and February 2012 surveys for the bed of the northern basin of Wert a Wert wetland. and b. the. February 2008, February 2009 and February 2012 surveys for edge the northern basin of Werta Wert (*denotes exotic species, ** denotes proclaimed pest plant, NS denotes not significantly different).

a.

Species	*Survey Date*	*P*
Glinus lotoides	June 2005	<0.001
Myriophyllum verrucosum	June 2005	<0.001
*Polypogon monspeliensis**	June 2005	<0.001
Rumex bidens	June 2005	<0.001
Chenopodium pumilio	June 2005	0.0047
Polygonum plebium	June 2005	0.0213
Cyperus gymnocaulos	June 2005	NS Uncommon
*Malva parviflora**	June 2005	NS Uncommon
Mimulus repens	June 2005	NS Uncommon
Rhagodia spinescens	June 2005	NS Uncommon
Wahlenbergia fluminalis	June 2005	NS Uncommon
Atriplex spp.	November 2005	<0.001
Centipeda minima	November 2005	<0.001
Craspedia chrysantha	November 2005	<0.001
*Heliotropium amplexicaule**	November 2005	<0.001
Sporobolus mitchelli	November 2005	<0.001
Sonchus oleraceus	November 2005	0.0023
Alternanthera denticulata	November 2005	0.0041
Tetragonia tetragonoides	November 2005	0.0194
*Bromus rubens**	November 2005	NS Uncommon
*Centaurium tenuiflorum**	November 2005	NS Uncommon
Helichrysum luteo-album	November 2005	NS Uncommon
*Polygonum aviculare**	November 2005	NS Uncommon
*Xanthium occidentale***	November 2005	NS Uncommon
Glycyrrhiza acanthocarpa	November 2005	NS Widespread
*Hypochoeris radicata**	November 2005	NS Widespread
Mollugo cerviana	November 2005	NS Widespread
Enchylaena tomentosa ssp. *tomentosa*	February 2008	0.0195
Isolepis hookeriana	February 2008	0.0207
Trifolium spp.*	February 2008	0.0207
Brachyscome basaltica	February 2008	NS Uncommon
Rorippa islandica	February 2008	NS Uncommon
Trachymene cyanopetula	February 2008	NS Uncommon
*Atriplex prostrata**	February 2008	NS Widespread
Bare Soil	February 2008	NS Widespread
Sclerolaena divaricata	February 2008	NS Widespread
*Abutilon theophrasti**	February 2009	<0.001
*Heliotropium europaeum**	February 2009	<0.001
Ammania multiflora	February 2012	<0.001
Medicago spp.*	February 2012	0.006
Calotis cuneifolia	February 2012	NS Widespread
Marsilea angustifolia	February 2012	NS Widespread

b.

Species	Survey Date	P
Atriplex spp.	February 2008	<0.001
Sclerolaena divaricata	February 2008	<0.001
Enchylaena tomentosa ssp. *tomentosa*	February 2008	0.0014
Haloragis aspera	February 2008	NS Uncommon
Rhagodia spinescens	February 2008	NS Uncommon
Salsola kali var. *kali*	February 2008	NS Uncommon
Brachyscome basaltica	February 2008	NS Widespread
Sclerolaena brachyptera	February 2008	NS Widespread
*Heliotropium europaeum**	February 2009	0.0172
Atriplex suberecta	February 2009	NS Uncommon
Calotis hispidula	February 2009	NS Uncommon
Bare Soil	February 2009	NS Widespread
Alternanthera denticulata	February 2012	<0.001
Centipeda minima	February 2012	<0.001
Eucalyptus camaldulensis var. *camaldulensis* seedlings	February 2012	0.0011
Epaltes australis	February 2012	0.0137
Euphorbia drummondii	February 2012	0.0205
Ammania multiflora	February 2012	0.0212
Medicago spp.*	February 2012	0.0232
Polygonum plebium	February 2012	0.0232
Morgania floribunda	February 2012	0.0243
Brachyscome dentata	February 2012	NS Uncommon
Chenopodium pumilio	February 2012	NS Uncommon
*Citrullus lanatus**	February 2012	NS Uncommon
*Heliotropium amplexicaule**	February 2012	NS Uncommon
Iseotopsis graminifolia	February 2012	NS Uncommon
*Marrubium vulgare***	February 2012	NS Uncommon
Nicotiana velutina	February 2012	NS Uncommon
Senecio runcinifolius	February 2012	NS Uncommon
*Solanum nigrum**	February 2012	NS Uncommon
Tetragonia tetragonoides	February 2012	NS Uncommon
*Xanthium occidentale***	February 2012	NS Uncommon
Cyperus gymnocaulos	February 2012	NS Widespread
Glinus lotoides	February 2012	NS Widespread
Glycyrrhiza acanthocarpa	February 2012	NS Widespread
Sporobolus mitchelli	February 2012	NS Widespread

3.9 Woolshed Creek

Woolshed Creek was watered three times since 2004 and flooded in summer 2010-11 (Table 1). Two pre-watering surveys were undertaken as part of the fish and macrophytes project (Zampatti *et al.* 2011) and two post watering surveys were undertaken (Table 1). The wetland had not dried by February 2012 and the last survey was undertaken in November 2008 (Table 1). Three elevations were surveyed, the bed of the wetland, 30 cm above the wetland bed (+30 cm) and 60 cm above the wetland bed (+60 cm).

A total of 29 taxa (including nine exotics) were recorded at the 0 cm elevation (wetland bed) (Table 15a), 35 taxa (including eight exotics) at +30 cm (Table 15b) and 42 taxa (including eight exotics, one of which is declared noxious in South Australia) (Table 15c). The plant community changed significantly through time at all elevations (Table 14; NMS Ordination: Figure 16) and the change though time was consistent between elevations. There was no significant difference in floristic composition between November 2004 and June 2005 (pre-watering surveys) but the plant community changed significantly between January 2005 and February 2008, after which there was no significant change (post-watering) (November 2004=January 2005=June 2005≠February 2008=November 2008).

Table 14: PERMANOVA *Pseudo-F* statistics comparing the change in floristic composition through time for each elevation in Woolshed Creek.

Elevation	*Pseudo F*	*df*	*P*
0 cm	3.77	4,30	<0.001
+30 cm	8.32	4,54	<0.001
+60 cm	6.80	4,54	<0.001

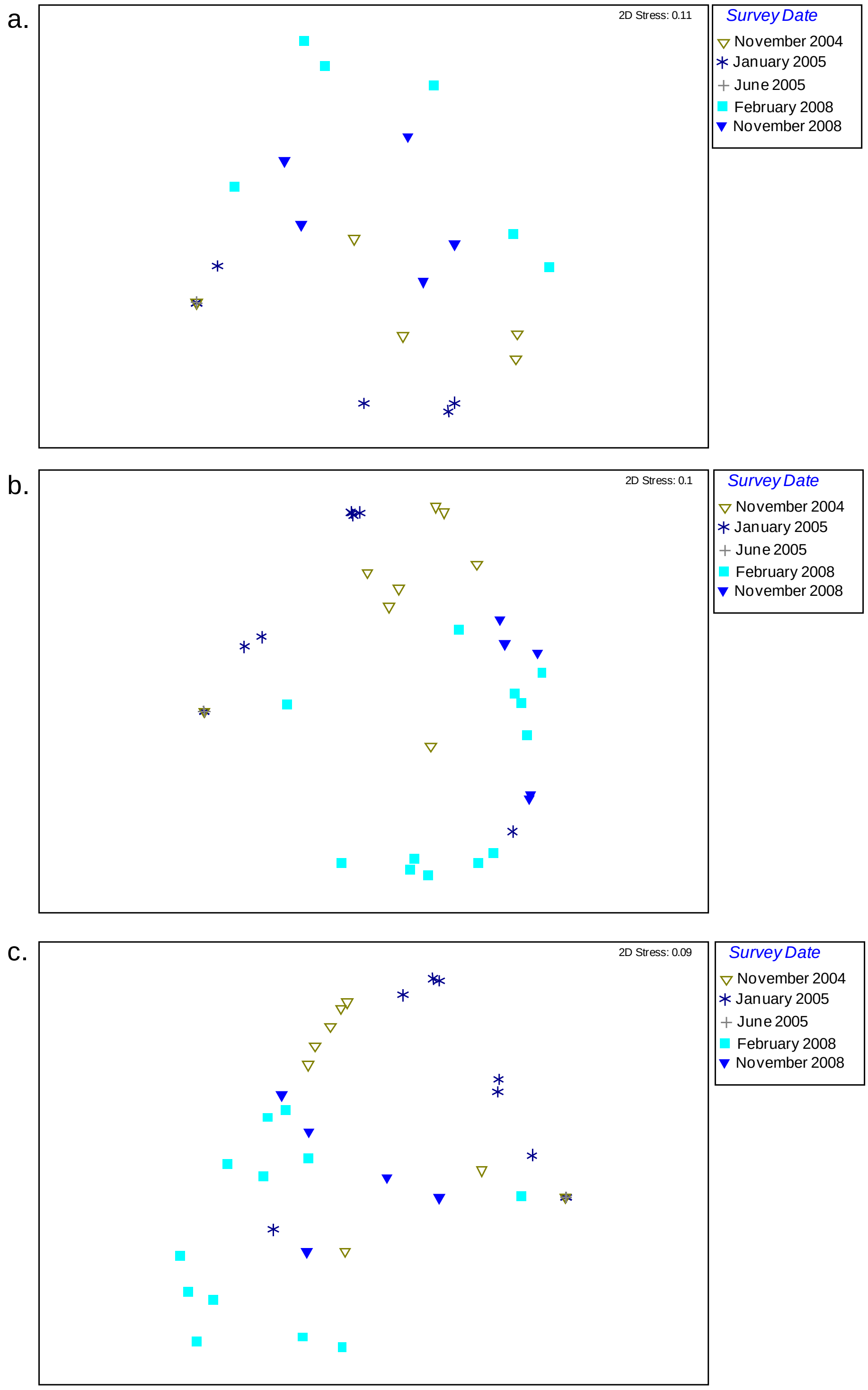


Figure 16: NMS ordination comparing the November 2004, January 2005, June 2005, February 2008 and November 2008 surveys for Woolshed Creek at a. 0 cm (stress=0.11), b. +30 cm (stress=0.1) and c. +60 cm (stress=0.09).

Pre-watering the plant community at all elevations was dominated by bare soil and terrestrial taxa and post watering a diverse community dominated by floodplain and amphibious species was present (Table 15). The +30 and +60 cm elevations had a larger number of flood dependent and amphibious species post-watering than the 0 cm elevation (Table 15). Furthermore, *Eucalyptus camaldulensis* var. *camaldulensis* seedlings were present post-watering at all elevations and *Acacia stenophylla* seedlings were present at the +60 cm elevation (Table 15). *Heliotropium curassavicum* and *Heliotropium europaeum* were the only exotic species present in high numbers post-watering (Table 15).

Table 15: Species list and Indicator Species Analysis results comparing the November 2004, January 2005, June 2005, February 2008 and November 2008 surveys for Woolshed Creek at a. 0 cm, b. +30 cm and c. +60 cm (*denotes exotic species, NS denotes not significantly different).

a.

Species	Survey Date	P
Osteocarpum acropterum var. *acropterum*	November 2004	0.050
Calotis hispidula	November 2004	NS Uncommon
Morgania floribunda	November 2004	NS Uncommon
Alternanthera denticulata	November 2004	NS Widespread
Atriplex spp.	November 2004	NS Widespread
Carpobrotus rossii	November 2004	NS Widespread
Cyperus gymnocaulos	November 2004	NS Widespread
*Mesembryanthemum crystallinum**	November 2004	NS Widespread
Mollugo cerviana	November 2004	NS Widespread
Sporobolus mitchelli	November 2004	NS Widespread
Enchylaena tomentosa ssp. *tomentosa*	January 2005	NS Uncommon
Bare Soil	June 2005	<0.001
Glinus lotoides	February 2008	0.0023
Senecio cunninghamii	February 2008	0.0368
*Heliotropium europaeum**	February 2008	0.0384
Centipeda minima	February 2008	0.0758
*Centaurium tenuiflorum**	February 2008	NS Widespread
Chenopodium pumilio	February 2008	NS Widespread
Epaltes australis	February 2008	NS Widespread
Eucalyptus camaldulensis var. *camaldulensis* seedlings	February 2008	NS Widespread
*Heliotropium amplexicaule**	February 2008	NS Widespread
Medicago spp.*	February 2008	NS Widespread
Polygonum plebium	February 2008	NS Widespread
*Heliotropium curassavicum**	November 2008	0.0093
*Dittrichia graveolens**	November 2008	0.0201
*Urtica urens**	November 2008	NS Uncommon
Glycyrrhiza acanthocarpa	November 2008	NS Widespread
Sclerolaena brachyptera	November 2008	NS Widespread
Sclerolaena divaricata	November 2008	NS Widespread
*Sonchus oleraceus**	November 2008	NS Widespread

b.

Species	Survey Date	P
Osteocarpum acropterum var. *acropterum*	November 2004	0.0051
*Mesembryanthemum crystallinum**	November 2004	0.0108
Carpobrotus rossii	November 2004	0.0206
Brachyscome basaltica	November 2004	NS Uncommon
Calotis hispidula	November 2004	NS Uncommon
Euphorbia drummondii	November 2004	NS Uncommon
Helichrysum luteo-album	November 2004	NS Uncommon
Mollugo cerviana	November 2004	NS Uncommon
*Urtica urens**	November 2004	NS Uncommon
Atriplex spp.	November 2004	NS Widespread
Morgania floribunda	November 2004	NS Widespread
*Rorippa palustris**	November 2004	NS Widespread
Sclerolaena divaricata	November 2004	NS Widespread
Wahlenbergia fluminalis	November 2004	NS Widespread
Enchylaena tomentosa ssp. *tomentosa*	January 2005	NS Uncommon
Bare Soil	June 2005	<0.001
Chenopodium pumilio	February 2008	<0.001
Glinus lotoides	February 2008	<0.001
*Heliotropium europaeum**	February 2008	0.0025
Centipeda minima	February 2008	0.0067
Cyperus exaltatus	February 2008	NS Uncommon
Alternanthera denticulata	February 2008	NS Widespread
Ammania multiflora	February 2008	NS Widespread
*Heliotropium amplexicaule**	February 2008	NS Widespread
Senecio runcinifolius	February 2008	NS Widespread
*Heliotropium curassavicum**	November 2008	<0.001
Eucalyptus camaldulensis var. *camaldulensis* seedlings	November 2008	0.0014
Maireana microcarpa	November 2008	0.0061
*Dittrichia graveolens**	November 2008	NS Uncommon
Senecio cunninghamii	November 2008	NS Uncommon
*Solanum nigrum**	November 2008	NS Uncommon
Cyperus gymnocaulos	November 2008	NS Widespread
Epaltes australis	November 2008	NS Widespread
Glycyrrhiza acanthocarpa	November 2008	NS Widespread
Polygonum plebium	November 2008	NS Widespread
Sporobolus mitchelli	November 2008	NS Widespread

c.

Species	Survey Date	P
*Mesembryanthemum crystallinum**	November 2004	0.0234
Osteocarpum acropterum var. *acropterum*	November 2004	0.0348
Acacia stenophylla seedlings	November 2004	NS Uncommon
Euphorbia drummondii	November 2004	NS Uncommon
Maireana microcarpa	November 2004	NS Uncommon
*Rorippa palustris**	November 2004	NS Uncommon
Wahlenbergia fluminalis	November 2004	NS Uncommon
Carpobrotus rossii	November 2004	NS Widespread
Mollugo cerviana	November 2004	NS Widespread
Enchylaena tomentosa ssp. *tomentosa*	January 2005	NS Uncommon
*Sonchus oleraceus**	January 2005	NS Uncommon
Atriplex spp.	January 2005	NS Widespread
Bare Soil	June 2005	0.0001
Epaltes australis	February 2008	0.0001
Chenopodium pumilio	February 2008	0.0007
Centipeda minima	February 2008	0.002
Glinus lotoides	February 2008	0.0021
Polygonum plebium	February 2008	0.0103
Senecio cunninghamii	February 2008	0.0285
Senecio runcinifolius	February 2008	0.0383
*Heliotropium europaeum**	February 2008	0.0409
*Atriplex prostrata**	February 2008	NS Uncommon
Cyperus exaltatus	February 2008	NS Uncommon
Isolepis hookeriana	February 2008	NS Uncommon
Lachnagrostis filiformis	February 2008	NS Uncommon
Ludwigia peploides ssp. *montevidensis*	February 2008	NS Uncommon
Persicaria lapathifolium	February 2008	NS Uncommon
*Solanum nigrum**	February 2008	NS Uncommon
Conyza bonariensis	February 2008	NS Widespread
Cyperus gymnocaulos	February 2008	NS Widespread
Eragrostis dielsii	February 2008	NS Widespread
Helichrysum luteo-album	February 2008	NS Widespread
*Heliotropium curassavicum**	February 2008	NS Widespread
Morgania floribunda	February 2008	NS Widespread
Sclerolaena brachyptera	February 2008	NS Widespread
*Xanthium occidentale***	February 2008	NS Widespread
Brachyscome basaltica	November 2008	0.0042
Alternanthera denticulata	November 2008	0.0098
Sporobolus mitchelli	November 2008	0.0152
Eucalyptus camaldulensis var. *camaldulensis* seedlings	November 2008	NS Widespread
Glycyrrhiza acanthocarpa	November 2008	NS Widespread
Muehlenbeckia florulenta	November 2008	NS Widespread
Sclerolaena divaricata	November 2008	NS Widespread

Table 16 summarises the response of the plant community to watering for each of the sites monitored and reports on whether TLM targets were met.

Table 16: Summary of the response of the vegetation in each wetland to determine whether TLM targets were achieved.

	Target				
Wetland	**Improve the area and diversity of grass and herblands**	**Provide conditions suitable for regeneration and seedling survival of all vegetation targets including (but not limited to) river red gum, black box, river coobah and lignum**	**Maintain or improve the area and diversity of grazing sensitive plant species**	**Limit the extent of invasive (increaser) species including weeds**	**Comments**
Coombool Swamp	NA	NA	NA	NA	Only one pre-watering survey was undertaken, the plant community was dominated by terrestrial and salt tolerant species (Table 4).
Kulcurna Red Gum	Yes	Yes	Yes	No	A diverse community of flood dependent and amphibious species (many of the species present are sensitive to grazing by domestic stock) was present throughout the study period and *Eucalyptus camaldulensis* seedlings were present in high numbers. The exotic species: *Heliotropium europaeum Conyza bonariensis, Phyla canescens* and *Heliotropium curassavicum* recruited in response to watering (Table 6)
Lake Limbra	Yes	No	Yes	Yes	Prior to watering Lake Limbra was a *Halosarcia pergranulata* monoculture, post-watering *Mimulus repens* and *Alternanthera denticulata* increased in abundance and *Sporobolus mitchelli* recruited in low numbers. *Halosarcia pergranulata* was still dominant post-watering. No exotic species were recorded (Table 7).
Lake Littra	Yes	Yes	Yes	Yes	A diverse community of flood dependent and amphibious species (many of the species present are sensitive to grazing by domestic stock) was present throughout the study period. *Eucalyptus camaldulensis* seedlings recruited around the edge of the lake in response to watering but were even more abundant after the flood. *Muehlenbeckia florulenta* seedlings recruited in large numbers on the lakebed and around the edge but only in response to flooding. *Medicago* spp. was the only exotic present in large numbers (Table 8).
Monoman Island Horseshoe	Yes	Yes	Yes	Yes	A diverse community of floodplain and amphibious species (many of the species present are sensitive to grazing by domestic stock) was present throughout the study period. *Eucalyptus camaldulensis* seedlings were present in high numbers and *Acacia stenophylla* in low numbers. *Medicago* spp. was the only exotic present in large numbers (Table 9).
Twin Creeks	Yes	Yes	Yes	No	A diverse community of flood dependent and amphibious species (many of the species present are sensitive to grazing by domestic stock) was present throughout the study period. *Eucalyptus camaldulensis* and *Acacia stenophylla* seedlings were also observed. However, *Xanthium occidentale, Hypochoeris radicata* and *Phyla canescens* were present in high numbers at times (Table 10)
Werta Wert Wetland	Yes	Yes (central and northern basins)	Yes	No	A diverse community of flood dependent and amphibious species (many of the species present are sensitive to grazing by domestic stock) was present throughout the study period. *Eucalyptus camaldulensis* seedlings recruited in the central and northern basins in response to watering. *Abutilon theophrasti, Heliotropium europaeum, Heliotropium amplexicaule, Sonchus oleraceus, Xanthium occidentale, Malva parviflora, Polypogon monspeliensis* and *Medicago* spp. were present in large numbers at times (Table 11, Table 12 and Table 13)
Woolshed Creek	Yes	Yes	Yes	No	A diverse community of flood dependent and amphibious species (many of the species present are sensitive to grazing by domestic stock) recruited in response to watering and large numbers of *Eucalyptus camaldulensis* and a small number of *Acacia stenophylla* seedlings were observed throughout the wetland. However, *Heliotropium europaeum* and *Heliotropium curassavicum* also increased in abundance in response to watering (Table 15).

4 Discussion

In all wetlands where pre- and post-watering surveys were undertaken the plant community changed significantly in response to watering. The change in floristic composition was due to a decline in the abundance of bare soil and terrestrial taxa and a significant increase in the abundance of floodplain and amphibious taxa (Table 16). Furthermore, the plant community at sites where only post-watering surveys were undertaken were dominated by amphibious and flood dependent taxa (Table 16).

The plant community that developed in response to watering varied between sites and, in all cases where different elevations within sites were monitored, between elevations within wetlands. The differences between sites and elevations was probably due to differences in the duration of inundation (Casanova and Brock 2000), timing of inundation and draw down (Britton and Brock 1994), rate of draw down (Nicol *et al.* 2003; Nicol 2004), soil texture (Nicol 2004), soil salinity (Nicol *et al.* 2010a), seed bank composition (e.g. Keddy and Reznicek 1982; Leck 1989; Brock and Britton 1995; Leck 2003) and initial floristic composition (Nicol 2004). The aforementioned factors influence the floristic composition of wetlands and varied between watering sites (e.g. Hassam 2007) and elevations within wetlands. However, Nicol *et al.* (2010b) showed that the response of the plant community in relation to water regime functional groups was very consistent between sites regardless of the aforementioned factors. The results presented in Nicol *et al.* (2010b) justified the functional approach used to assess the TLM targets.

Expanding the monitoring to include the edges of wetlands as recommended in Nicol *et al.* (2010b) has resulted in a greater understanding of the vegetation dynamics of temporary wetlands. Often the edges have higher species richness than the wetland beds and in all cases there have been different species present. In Lake Littra and the northern basin of Werta Wert Wetland *Eucalyptus camaldulensis* var. *camaldulensis* seedlings only recruited on the edges of the wetlands.

Nicol *et al.* 2010b showed that watering temporary wetlands has resulted in significant (albeit in limited areas) improvements in the area and diversity of grass and herblands and improvements in the area and diversity of grazing sensitive species in every wetland that was watered (Table 16). Repeated watering maintains the areas dominated by floodplain and amphibious taxa and probably improves the sediment seed bank, which contributes to the resilience of the system.

Nicol *et al.* (2010a) suggested that areas that are salinised would not initially respond to watering; nevertheless, Lake Limbra showed a similar (albeit reduced response compared to other sites) to other watered wetland. However, this site was flooded before it dried; therefore, the benefit of watering alone could not be investigated but the fact there was a response indicates that watering is an appropriate management action and could aid in the recovery of salinised areas.

When overbank flows inundated large areas of the Chowilla Floodplain in 2010-11 the plant community, in areas that were inundated, changed in a similar manner to wetlands that were watered (Gehrig *et al.* 2012). There was a significant decrease in the abundance of terrestrial and salt tolerant species and bare soil and a corresponding increase in floodplain and amphibious taxa. However, there were several differences between a natural flood and watering temporary wetlands:

- The area inundated is much greater in a natural flood, even in instances when flow stays within the channel a larger area is inundated around the edges of permanent wetlands, channels and temporary wetlands (Overton *et al.* 2004).
- There is evidence to suggest that hydrochory is an important factor that structures floodplain plant communities. Greater species richness was observed in quadrats that contained strandlines during the condition monitoring fieldwork after the flood in 2010-11 (Gehrig *et al.* 2012).
- *Muehlenbeckia florulenta* generally did not recruit or recruited in very low numbers in areas that were watered; however, a large number of seedlings were recorded on the Chowilla Floodplain after the 2010-11 flood (Gehrig *et al.* 2012).
- Overstorey seedling recruitment in general was much lower in watered wetlands compared with a natural flood (pers. obs.).

Results from this monitoring program, the floodplain condition monitoring program (Gehrig *et al.* 2012) and a project undertaken by Hassam (2007) investigating the relationship between environmental variables and the plant community show that the response of the plant community to watering is typically short-lived, usually less than 12 months. Results from Chowilla reflect results from other temporary wetlands in the MDB such as the Menindee Lakes (Nicol 2004) and Markaranka (Marsland and Nicol 2008; Marsland and Nicol 2009), where 12 months after flooding the plant community is dominated by terrestrial and only the most desiccation tolerant amphibious or flood dependent species (e.g. *Sporobolus mitchelli, Morgania floribunda, Cyperus gymnocaulos*). Many flood dependent and amphibious species are annuals (or perennials that behave as annuals when conditions become unfavourable) that can complete their life cycle in a matter of weeks (Cunningham *et al.* 1981; Nicol 2004). They are examples of Grime's (1979) r-selected species, which are adapted to frequent disturbance (flood and drought), and often have large persistent seed banks and are able to colonise areas rapidly (Nicol 2004).

The seed bank is an important component of floodplain understory vegetation because it provides a mechanism for plant communities to recover after disturbance and the plant community that develops in response to watering is determined, to a large extent, by the seed bank (e.g. Keddy and Reznicek 1982; Leck 1989; Brock and Britton 1995; Leck 2003). The seed banks of wetlands and floodplains in the Chowilla system have not been studied and there is no information regarding floristic composition and longevity. Information regarding seed bank composition can be used to predict the plant species that will recruit in response to watering, identify areas that need to be protected from grazing by domestic stock and aid in pest plant control. There is also no information regarding seed bank longevity and the lack of flooding in some areas may have resulted in these areas having a depauperate seed bank. Natural flooding history gradients that exist across the Chowilla Floodplain could be utilised to compare floristic composition of the seed bank in areas with different flooding frequencies (*sensu* Boulton and Lloyd 1992) to determine if there are areas with depauperate seed banks.

The fate of carbon fixed by understory vegetation in response to watering (or natural flooding) is unknown. Most species do not germinate whilst submerged and carbon is not fixed by plants until the sediment is exposed and hydrologically disconnected from the river. Therefore, floodplain understory probably contributes more to the terrestrial food web than the riverine food web. Nevertheless, understory vegetation probably contributes significantly to floodplain soil carbon and when flooded probably contributes to the riverine food web.

5 Management Implications and Recommendations

Results from this study, the previous understory monitoring program for environmental watering sites (Nicol *et al.* 2010b) and floodplain vegetation condition monitoring (Gehrig *et al.* 2012) demonstrated that watering temporary wetlands is an appropriate management action to achieve TLM targets 5, 6 and 8 in the absence of natural flooding or in times when water scarcity will prevent the operation the Chowilla environmental regulator. Results also showed that the response of watering is short-lived due to the annual life history strategy of the majority of species present (Cunningham *et al.* 1981).

The frequency and duration of watering to maximise the benefit of environmental watering to both the overstorey and understory vegetation is not known. One approach to determine the frequency and duration of watering is to mimic the pre-regulation water regime of the system, which would reinstate the frequent flooding disturbance the majority of understorey species are adapted to (Nicol 2004). Another approach is to monitor the understory vegetation and water when terrestrial species have displaced most of the amphibious and floodplain species. These approaches will give many short-lived flood dependent species more chances to recruit and disadvantage the long-lived flood intolerant species that have probably displaced the short-lived floodplain species in recent times. However, results show that the understory is resilient and able to colonise areas that have not been flooded for over ten years (Gehrig *et al.* 2012) and more suitable triggers for rewatering (to make best use of limited environmental water) may be the very early onset of decline in overstorey condition or salt tolerant species replacing terrestrial species in the understory (*sensu* Nicol *et al.* 2010a).

Overstorey recruitment was patchy in response to watering, compared to natural flooding where it was widespread. In particular, *Muehlenbeckia florulenta* which did not germinate in response to watering but recruited extensively in response to the 2010/11 flood (Gehrig *et al.* 2012) and *Eucalyptus largiflorens* also only recruited in response to flooding (J. Nicol pers. obs.). It is unclear why overstorey recruitment was limited but *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* do not develop soil seed banks (Nicol *et al.* 2004) and hold most of their seed in the canopy (Jensen 2008; Jensen *et al.* 2008). Furthermore, *Muehlenbeckia florulenta* only forms a short-lived soil seed bank (Chong and Walker 2005). These species may be largely dependent on hydrochory for dispersal; hence, the patchy recruitment in response to watering.

Eucalyptus camaldulensis recruitment was generally around the edges of wetlands at the maximum extent of the inundation. Therefore, filling wetlands as full as possible is recommended to ensure *Eucalyptus camaldulensis* seedlings or saplings are not drowned in instances where a wetland is initially partially filled then later filled to a higher level.

The majority of species that recruited in response to watering were native; however, 30 exotic taxa (including four species proclaimed noxious in South Australia, although *Marrubium vulgare* was only present in low numbers) (Table 3) have been recorded or observed in wetlands that were watered. All of the exotic species recorded will recruit in response to falling water levels (Cunningham *et al.* 1981; Nicol 2004) in wetlands that have been watered. Table 17 lists the exotic species that were present in moderate to high numbers and may require control in wetlands that were watered. Furthermore, three species were proclaimed noxious weeds in South Australia and 13 identified as a high or extreme invasion risk by Nicol (2007) as part of the pest plant risk assessment for the operation of the Chowilla regulator. However, Nicol (2007) also stated that regulated flooding does not pose a greater risk of pest plant recruitment than a natural flood with a similar hydrograph.

To minimise the impact of pest plants, monitoring needs to be undertaken to ensure that a control program is established and implemented before the seed bank is replenished. In addition, an assessment of the seed bank could be carried out before the wetland is watered to give an indication of where weed control efforts should be concentrated and what control methods are the most appropriate.

Table 17: List of pest plant species that may require control and wetlands where they were recorded in moderate to high numbers (**denotes proclaimed noxious weed in South Australia, #denotes high or extreme invasion risk as determined by Nicol (2007).

Species	Wetland
Abutilon theophrasti#	Werta Wert Wetland
Arctotheca calendula	Twin Creeks
Aster subulatus	Kulcurna Red Gum, Lake Littra, Werta Wert Wetland
Bromus rubens	Lake Littra, Werta Wert Wetland
Conyza bonariensis	Coppermine, Kulcurna Red Gum, Twin Creeks, Werta Wert Wetland
*Cuscuta campestris***#	Coppermine Waterhole, Werta Wert Wetland
*Echium plantagineum***#	Coppermine Waterhole, Twin Creeks
Heliotropium amplexicaule#	Coppermine Waterhole, Werta Wert Wetland
Heliotropium curassavicum#	Kulcurna Red Gum, Lake Littra, Woolshed Creek
Heliotropium europaeum#	Coppermine Waterhole, Werta Wert Wetland, Woolshed Creek
Hypochoeris radicata#	Coppermine Waterhole, Twin Creeks, Werta Wert Wetland
Lactuca saligna	Coppermine Waterhole
Medicago spp.#	Lake Littra, Monoman Island Horseshoe, Werta Wert Wetland
Mesembryanthemum crystallinum	Lake Littra, Woolshed Creek
Phyla canescens#	Twin Creeks
Polygonum aviculare#	Werta Wert Wetland
Polypogon monspeliensis	Werta Wert Wetland
Rorippa palustris	Twin Creeks, Woolshed Creek
Solanum nigrum#	Woolshed Creek
Sonchus oleraceus	Coppermine Waterhole, Twin Creeks, Werta Wert Wetland
Trifolium spp.#	Werta Wert Wetland
*Xanthium occidentale***#	Coppermine, Twin Creeks, Werta Wert Wetland

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7 Appendices

Appendix 1: Monitoring site GPS coordinates (easting and northing format, map datum WGS 84).

Wetland (Location)	Site	Easting	Northing
Coombool Swamp	Coombool Swamp 1	489491	6247218
Coombool Swamp	Coombool Swamp 2	489213	6247649
Coombool Swamp	Coombool Swamp 3	489355	6247928
Coppermine Waterhole	Coppermine 1	485269	6240208
Coppermine Waterhole	Coppermine 2	485568	6240091
Kulcurna Red Gum	Kulcurna 1	504118	6234315
Kulcurna Red Gum	Kulcurna 2	504251	6234648
Kulcurna Red Gum	Kulcurna 3	503690	6235129
Lake Limbra	Lake Limbra 1	495334	6248147
Lake Limbra	Lake Limbra 2	495397	6248559
Lake Limbra	Lake Limbra 3	495413	6248992
Lake Littra	Lake Littra 1	500081	6245421
Lake Littra	Lake Littra 2	500085	6245220
Lake Littra	Lake Littra 3	499963	6244601
Monoman Island Horseshoe	Monoman Island Horseshoe 1	488421	6241327
Monoman Island Horseshoe	Monoman Island Horseshoe 2	488871	6241679
Twin Creeks	Twin Creeks 1	489592	6243306
Twin Creeks	Twin Creeks 2	489596	6243376
Twin Creeks	Twin Creeks 3	489077	6243258
Twin Creeks	Twin Creeks 4	488844	6243423
Woolshed Creek	Woolshed Creek 1	485587	6236197
Woolshed Creek	Woolshed Creek 2	485919	6237151
Werta Wert	Werta Wert Central Basin 1	487722	6244850
Werta Wert	Werta Wert Central Basin 2	487709	6244930
Werta Wert	Werta Wert Central Basin 3	487627	6244854
Werta Wert	Werta Wert North Basin 1	488041	6245182
Werta Wert	Werta Wert North Basin 2	488191	6245206
Werta Wert	Werta Wert North Basin 3	488288	6245341
Werta Wert	Werta Wert South Basin 1	487611	6243827
Werta Wert	Werta Wert South Basin 2	487698	6243755
Werta Wert	Werta Wert South Basin 3	487905	6243689