Understorey Vegetation Monitoring of Chowilla Environmental Watering Sites 2004-08

Jason Nicol, James Weedon and Kelly Marsland

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Executive Summary

The decline in tree (*Eucalyptus camaldulensis* and *Eucalyptus largiflorens*) condition in recent years on the Chowilla Floodplain has become 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 health could be significantly improved by watering temporary wetlands, which has led to an expansion of the program to 17 sites across the Chowilla Floodplain. Furthermore, anecdotal evidence suggested that understorey condition would improve in response to watering due to the recruitment of flood dependent and amphibious species. The aims of this study were to investigate the response of the understorey vegetation to watering and assess the following Living Murray (TLM) targets for the Chowilla Icon Site (Murray Darling Freshwater Research Centre 2010):

- 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 (*Eucalyptus camaldulensis* var. *camaldulensis*), black box (*Eucalyptus largiflorens*), river coobah (*Acacia stenophylla*) and lignum (*Muehlenbeckia florulenta*),
- maintain or improve the area and diversity of grazing sensitive plant species and
- limit the extent of invasive (increaser) species including weeds.

Surveys were undertaken at 16 wetlands using the methods outlined in Zampatti *et al.* (2006) 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. In addition, the change in the abundance of functional groups pre and post-watering was compared using Group Average Clustering and Indicator Species Analysis.

At all sites, except Brandy Bottle Lagoon, the floristic composition changed significantly through time. At wetlands where pre and post-watering surveys were undertaken, there was a significant decline in terrestrial species and an increase in flood dependent and amphibious species. In wetlands that were watered for a second or third time the plant community generally changed significantly; however, this was due to changes in the abundance of flood dependent or amphibious species. The response of the plant community was generally short-lived (less than 12 months) with terrestrial taxa and bare soil replacing the flood dependent and amphibious species; however, the majority of flood dependent species are short-lived annuals and many amphibious species behave as annuals in temporary wetlands.

Twenty-eight exotic taxa were present in moderate to high numbers in wetlands that were watered and 26 of the 28 taxa recruited in response to watering. However, ten of the 16 sites surveyed showed no significant increase in the abundance of exotic taxa in response to watering.

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. However, the change in abundance of functional groups was consistent between wetlands and elevations regardless of the aforementioned factors.

Overstorey germination was variable between sites. *Eucalyptus camaldulensis* seedlings were present in ten of the 16 surveyed wetlands, *Muehlenbeckia florulenta* in four and *Acacia stenophylla* in two (*Eucalyptus largiflorens* seedlings were not present in any wetlands). It is unclear why overstorey regeneration was patchy because adult plants were present at all sites.

The results showed that watering is an appropriate management action to increase the abundance of flood dependent species, grazing sensitive species and (in most cases) watering has created conditions suitable for the germination of overstorey species. The increase in area and diversity (albeit limited; approximately 5% of the floodplain) of flood dependent and grazing sensitive taxa and suitable conditions for regeneration has meant that watering has resulted in the aforementioned targets are being met compared with doing nothing. However, there is evidence to suggest that the response of the plant community to watering is short-lived and that multiple watering events (in the absence of natural or regulated flooding) may be required to increase the abundance of flood dependent species over the long-term. In addition, several species of exotic pest plants, which may require control in the future, were present in significantly higher numbers post-watering; therefore, this target is not being met. However, exotics will also recruit as a result of natural flooding and watering poses no greater risk.

1. Introduction

The Chowilla floodplain is the largest remaining area of floodplain habitat in the lower Murray system that has not been intensively developed (Sharley and Huggan 1995). The system occupies an area of 1,770 km^2 that straddles Lock and Weir number 6 near the South Australia, New South Wales and Victoria border and comprises of 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 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 Mlday^{-1}, which would inundate approximately 30% of the floodplain, occurred on average once every two years and large floods of 100,000 Mlday^{-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 current cycle of extended drought, coupled with river regulation and water abstraction, has meant that large overbank flows have 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 are 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 understorey floodplain community at Chowilla. The understorey 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 understorey species in the Murray Darling Basin are short-lived annuals, which die when flooded but germinate as flood waters recede (but not in response to rainfall) and; 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 anecdotal evidence to suggest this has occurred on the Chowilla floodplain due to the high abundance of terrestrial drought tolerant species (Weedon and Nicol 2006) 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 (K. Holland pers. comm.). 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, flooding temporary wetlands by pumping (or gravity feeding in the case of Pipeclay Billabong) will reintroduce the flooding disturbance (at the wetland scale) that has been lost from the majority of the floodplain in recent times. It is expected that the terrestrial and drought tolerant perennial floodplain species will die when flooded and, when water levels recede, flood dependent species will germinate from the seed bank and colonise the bare exposed sediment.

The aim of the monitoring program was to determine whether flood dependent understorey species recruit as a result of watering and assess whether engineered flooding of temporary wetlands is an appropriate management action to achieve the following TLM targets outlined in the Asset Environmental Management Plan for the Chowilla Icon Site (Murray Darling Freshwater Research Centre 2010):

- 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 and
- limit the extent of invasive (increaser) species including weeds.

2. Methods

2.1. Environmental Watering Monitoring Sites

Vegetation surveys were undertaken at 16 temporary wetlands across the Chowilla Anabranch system, all of which were recipients of environmental water (Figure 1). Pre and post-watering surveys were undertaken where possible; however, the understorey monitoring program was not established until 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.

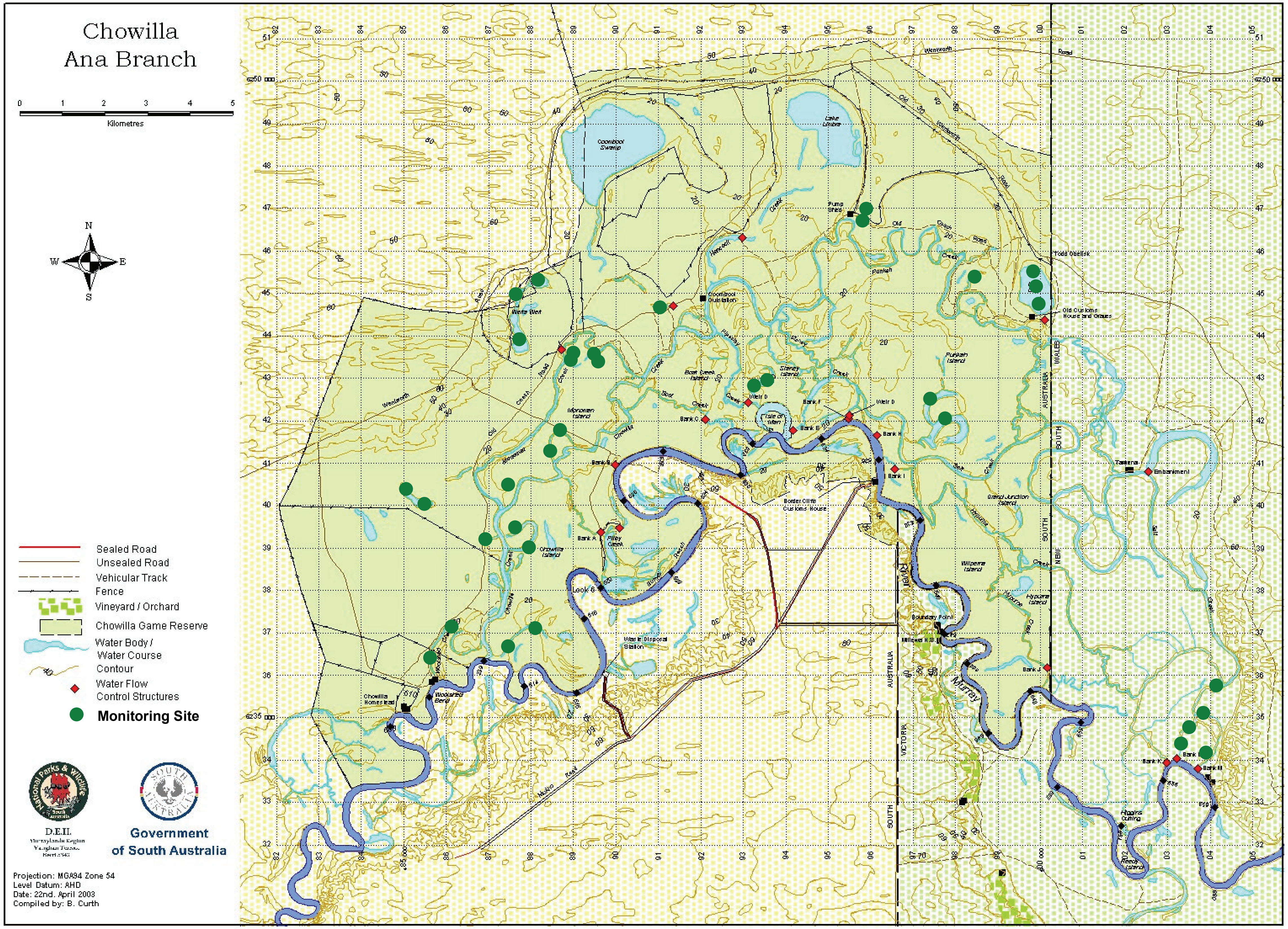


Figure 1: Location of monitoring sites (Department for Environment and Heritage).

Table 1: List of environmental watering sites and watering and survey dates.

Wetland	Site	Dates Watered	Survey Dates
Brandy Bottle Lagoon	Brandy Bottle	December 2005, August 2006	November 2005, June 2007
Chowilla Island Loop	Chowilla Island Loop 1	March 2005, January 2006	November 2005, February 2007, February 2008
Chowilla Island Loop	Chowilla Island Loop 2	March 2005, January 2006	November 2005, February 2007, February 2008
Chowilla Oxbow	Chowilla Oxbow 1	February 2006	June 2005, November 2005, February 2007, February 2008
Chowilla Oxbow	Chowilla Oxbow 2	February 2006	June 2005, November 2005, February 2007, February 2008
Coppermine Waterhole	Coppermine 1	February 2005, October 2006	June 2005, November 2005, June 2006, February 2008
Coppermine Waterhole	Coppermine 2	February 2005, October 2006	June 2005, November 2005, June 2006, February 2008
Kulcurna Black Box	Kulcurna B1	November 2005	June 2005, November 2005
Kulcurna Black Box	Kulcurna B2	November 2005	June 2005, November 2005
Kulcurna Red Gum	Kulcurna 1	March 2005, November 2005, January 2006, August 2006	June 2005, November 2005, February 2008
Kulcurna Red Gum	Kulcurna 2	March 2005, November 2005, January 2006, August 2006	June 2005, November 2005, February 2008
Kulcurna Red Gum	Kulcurna 3	March 2005, November 2005, January 2006, August 2006	June 2005, November 2005, February 2008
Lake Littra	Lake Littra 1	September 2004, December 2005	June 2005, November 2005, February 2007, February 2008
Lake Littra	Lake Littra 2	September 2004, December 2005	June 2005, November 2005, February 2007, February 2008
Lake Littra	Lake Littra 3	September 2004, December 2005	June 2005, November 2005, February 2007, February 2008
Monoman Depression	Monoman Depression	March 2006	November 2005, February 2007, February 2008
Monoman Island Horseshoe	Monoman Island Horseshoe 1	July 2004, December 2005	November 2005, June 2007, February 2008
Monoman Island Horseshoe	Monoman Island Horseshoe 2	July 2004, December 2005	November 2005, February 2007, February 2008
Pipe Clay Creek Backwater	Pipeclay Creek Backwater 1	August 2004	June 2005, June 2006, February 2008
Pipe Clay Creek Backwater	Pipeclay Creek Backwater 2	August 2004	June 2005, June 2006, February 2008
Punkah Island Horseshoes	Punkah Island Horseshoe 1	May 2005, August 2006	November 2004, January 2005, June 2006, February 2008
Punkah Island Horseshoes	Punkah Island Horseshoe 2	May 2005, August 2006	November 2004, January 2005, February 2008
Punkah Depression	Punkah Depression 1	January 2006, August 2006	November 2005, February 2007, February 2008
Punkah Depression	Punkah Depression 2	January 2006, August 2006	November 2005, February 2007, February 2008
Punkah Flood Runner	Punkah Flood Runner 1	January 2006, August 2006	November 2005, June 2007, February 2008
Twin Creeks	Twin Creeks 01	November 2004, April 2005	June 2005, November 2005, June 2006, February 2008
Twin Creeks	Twin Creeks 02	November 2004, April 2005	June 2005, November 2005, June 2006, February 2008
Twin Creeks	Twin Creeks 03	November 2004, April 2005	June 2005, November 2005, June 2006, February 2008
Twin Creeks	Twin Creeks 04	November 2004, April 2005	June 2005, November 2005, June 2006, February 2008
Werta Wert	Werta Wert Central 1	August 2004, November 2005	June 2005, November 2005, June 2006, February 2008
Werta Wert	Werta Wert Central 2	August 2004, November 2005	June 2005, November 2005, June 2006, February 2008
Werta Wert	Werta Wert Central 3	August 2004, November 2005	June 2005, November 2005, June 2006, February 2008
Werta Wert	Werta Wert North 1	August 2004, November 2005	June 2005, November 2005, June 2006, February 2008
Werta Wert	Werta Wert North 2	August 2004, November 2005	June 2005, November 2005, June 2006, February 2008
Werta Wert	Werta Wert North 3	August 2004, November 2005	June 2005, November 2005, June 2006, February 2008
Werta Wert	Werta Wert South 1	August 2004, November 2005	June 2005, November 2005, June 2006, February 2008
Werta Wert	Werta Wert South 2	August 2004, November 2005	June 2005, November 2005, June 2006, February 2008
Werta Wert	Werta Wert South 3	August 2004, November 2005	June 2005, November 2005, June 2006, February 2008
Woolshed Creek	Woolshed Creek 01	April 2005, August 2006	November 2004, January 2005, February 2008
Woolshed Creek	Woolshed Creek 02	April 2005, August 2006	November 2004, January 2005, February 2008

2.2. Vegetation Surveying Protocol

The survey methods were the same as used by Weedon and Nicol (2006) and Zampatti *et al.* (2006) for monitoring floodplain understorey at Chowilla. Quadrat size was determined by species area curves, which resulted in quadrats with dimensions of 15 x 1 m (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.

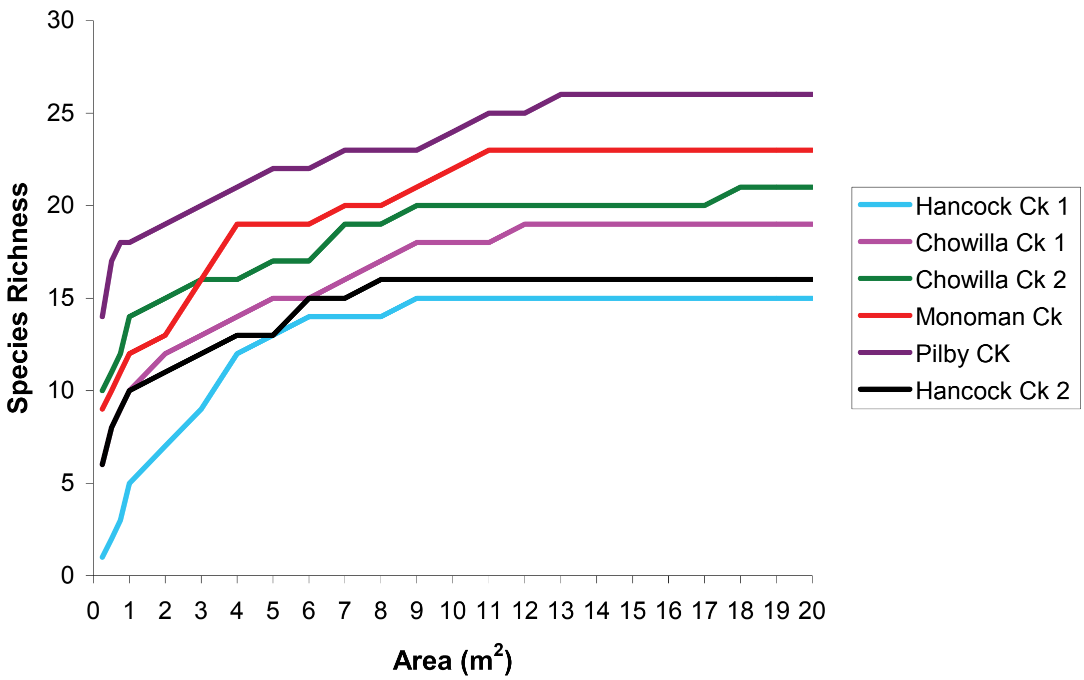


Figure 2: Species area curves for six sites in the Chowilla system.

In wide temporary creeks with gently sloping banks (Woolshed Creek, Chowilla Oxbow, Punkah Island Horseshoes 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) and +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).

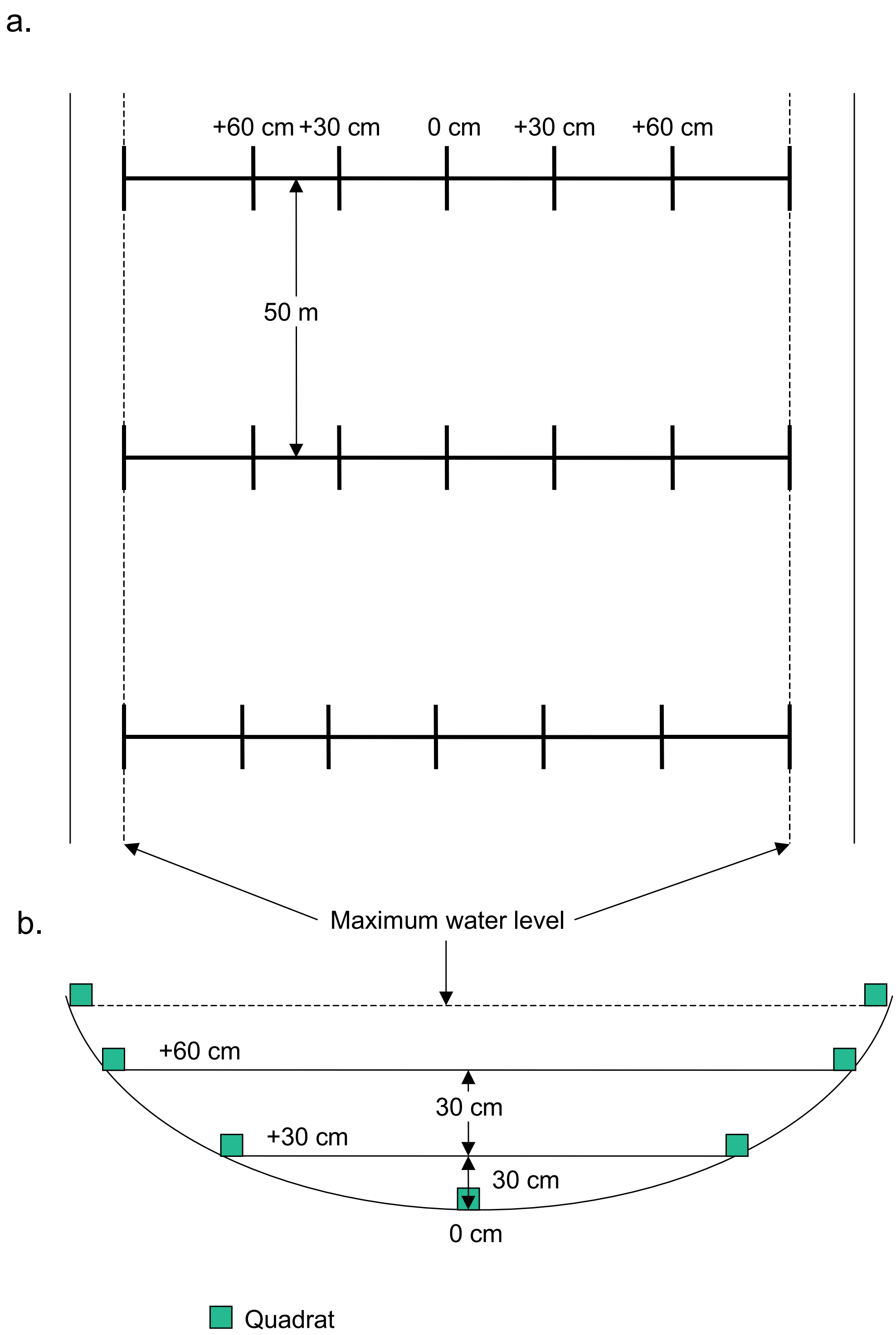


Figure 3: Sampling strategy for wide temporary creeks with gently sloping banks, a. plan view and b. cross section.

In the temporary creeks where the banks were too steep or the channel too narrow to place quadrats on the banks (Kulcurna Red Gum, Kulcurna Black Box, Twin Creeks, Punkah Flood

Runner, Chowilla Island Loop and Monoman Island Horseshoe) three quadrats, 50 m apart were established at the base of the channel at each site (Figure 4).

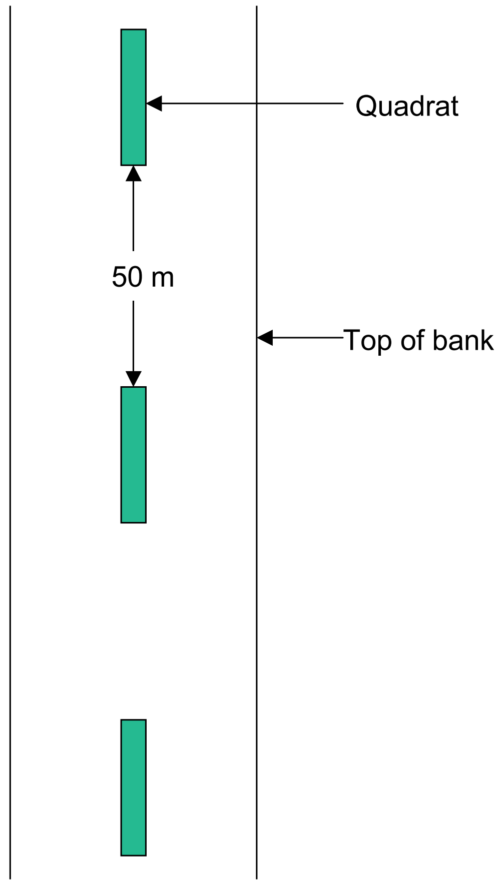


Figure 4: Sampling strategy for narrow temporary creeks with steep banks.

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 (Lake Littra, Werta Wert North Lagoon, Werta Wert South Lagoon and Werta Wert Central Lagoon) three sites were surveyed in each wetland (Figure 5). In the smaller wetlands either two (Pipeclay Creek Backwater and Punkah Depression) or one (Monoman Depression and Brandy Bottle Lagoon) sites were surveyed.

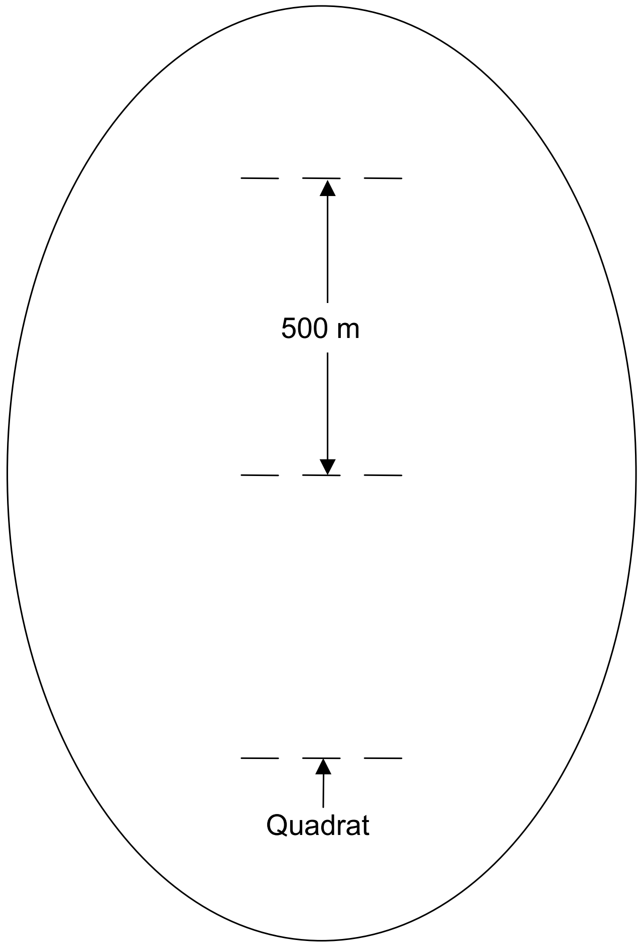


Figure 5: Sampling strategy for wide shallow temporary wetlands and lakes.

2.3. Plant Identification and Nomenclature

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

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

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*
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*

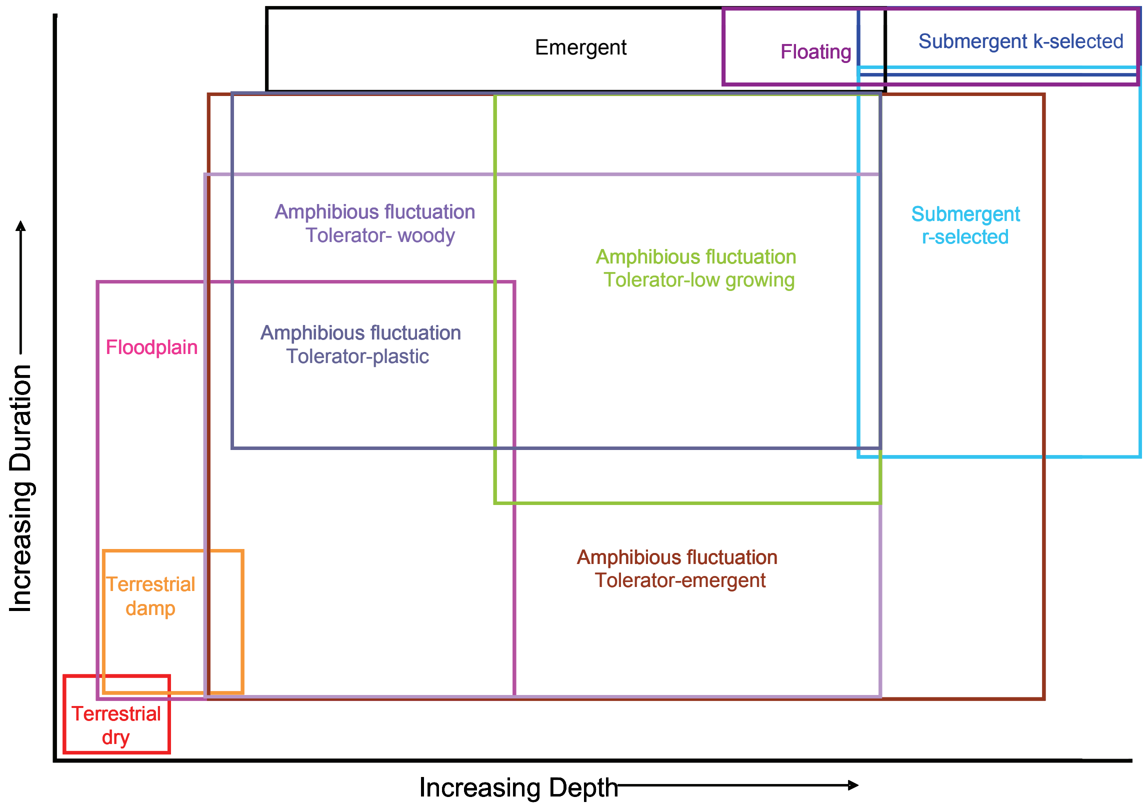


Figure 6: Plant functional groups in relation to depth and duration of flooding (the salt tolerant group is not included because there are salt tolerant species in all functional groups).

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 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, 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.

Changes in the abundance of functional groups (flood dependent, amphibious, terrestrial, salt tolerant and bare soil) before and after watering at randomly selected wetlands were compared using Group Average Clustering (McCune *et al.* 2002) and Indicator Species Analysis (Dufrene and Legendre 1998). The floristic composition of the same wetlands before and after watering was also compared using Group Average Clustering (McCune *et al.* 2002) to validate the use of the functional approach in assessing TLM targets.

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).

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 is 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**			*
Agrostis avenacea	*	*	
Alisma sp.	*		
Alternanthera denticulata	*	*	
Ammania multiflora	*	*	
*Arctotheca calendula**			*
*Aster subulatus**			*
Bolboschoenus caldwellii	*	*	
Brachycome basaltica	*		
*Bromus rubens**			*
*Carrichtera annua**			*
Centaurea sp.*			*
Centipeda minima	*		
Chenopodium pumilio	*		
*Conyza bonariensis**			*
Cotula coronopifolia	*		
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	*		
*Heliotropium amplexicaule**			*
*Heliotropium curassivicum**			*
*Heliotropium europaeaum**			*
*Hordeum vulgare**			*
*Hypochoeris radicata**			*
Iseotopsis graminifolia	*	*	
Isolepis hookeriana	*	*	
Juncus usitatus	*	*	

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

3. Results

3.1. Brandy Bottle Lagoon

Brandy Bottle Lagoon was watered twice during the study period and pre and post-watering surveys were undertaken (Table 1). A useful NMS Ordination solution could not be found due to outliers; hence, a relationship between the quadrats could not be established (McCune and Mefford 2005). The floristic composition at this site did not change significantly between November 2005 (pre-watering) and June 2007 (post-watering) (PERMANOVA: *Pseudo* $F_{1,5}$=1.69, P=0.195), despite being watered twice. Furthermore, there were no significant indicators for either survey (Table 4).

Table 4: Species list and Indicator Species Analysis results comparing the floristic composition between the November 2005 and June 2007 surveys for Brandy Bottle Lagoon (*denotes exotic species; NS=not significant).

Species	Survey Date	*Monte Carlo P*
Ammania multiflora	November 05 (Pre-watering)	NS Uncommon
Atriplex spp.	November 05 (Pre-watering)	NS Uncommon
Bare Soil	November 05 (Pre-watering)	NS Uncommon
Brachycome basaltica	November 05 (Pre-watering)	NS Uncommon
*Bromus rubens**	November 05 (Pre-watering)	NS Uncommon
Chenopodium pumilio	November 05 (Pre-watering)	NS Uncommon
*Conyza bonariensis**	November 05 (Pre-watering)	NS Uncommon
Craspedia chrysantha	November 05 (Pre-watering)	NS Uncommon
Glinus lotoides	November 05 (Pre-watering)	NS Uncommon
Juncus usitatus	November 05 (Pre-watering)	NS Uncommon
Lachnagrostis filiformis	November 05 (Pre-watering)	NS Uncommon
Plantago turrifera	November 05 (Pre-watering)	NS Uncommon
Psuedognaphalium luteo-album	November 05 (Pre-watering)	NS Uncommon
*Rorippa palustris**	November 05 (Pre-watering)	NS Uncommon
Rumex bidens	November 05 (Pre-watering)	NS Uncommon
Sclerolaena divaricata	November 05 (Pre-watering)	NS Uncommon
*Sonchus oleraceus**	November 05 (Pre-watering)	NS Uncommon
Tetragonia tetragonoides	November 05 (Pre-watering)	NS Uncommon
Centipeda minima	June 07 (Post-watering)	NS Uncommon
*Heliotropium amplexicaule**	June 07 (Post-watering)	NS Uncommon
Limosella australis	June 07 (Post-watering)	NS Uncommon
Scleroblitum atriplicinum	June 07 (Post-watering)	NS Uncommon
Solanum sp.	June 07 (Post-watering)	NS Uncommon
Sporobolus mitchelli	June 07 (Post-watering)	NS Uncommon
Trachymene cyanopetula	June 07 (Post-watering)	NS Uncommon
Medicago spp.*	June 07 (Post-watering)	NS Widespread
Polygonum plebium	June 07 (Post-watering)	NS Widespread

3.2. Chowilla Island Loop

Chowilla Island loop was watered twice during the study period and only post-watering surveys were undertaken (Table 1). The plant community changed significantly through time (NMS ordination: Figure 7, PERMANOVA: *Pseudo* $F_{2,17}$=9.85, *P*<0.001) and corrected multiple comparisons showed that each survey was significantly different.

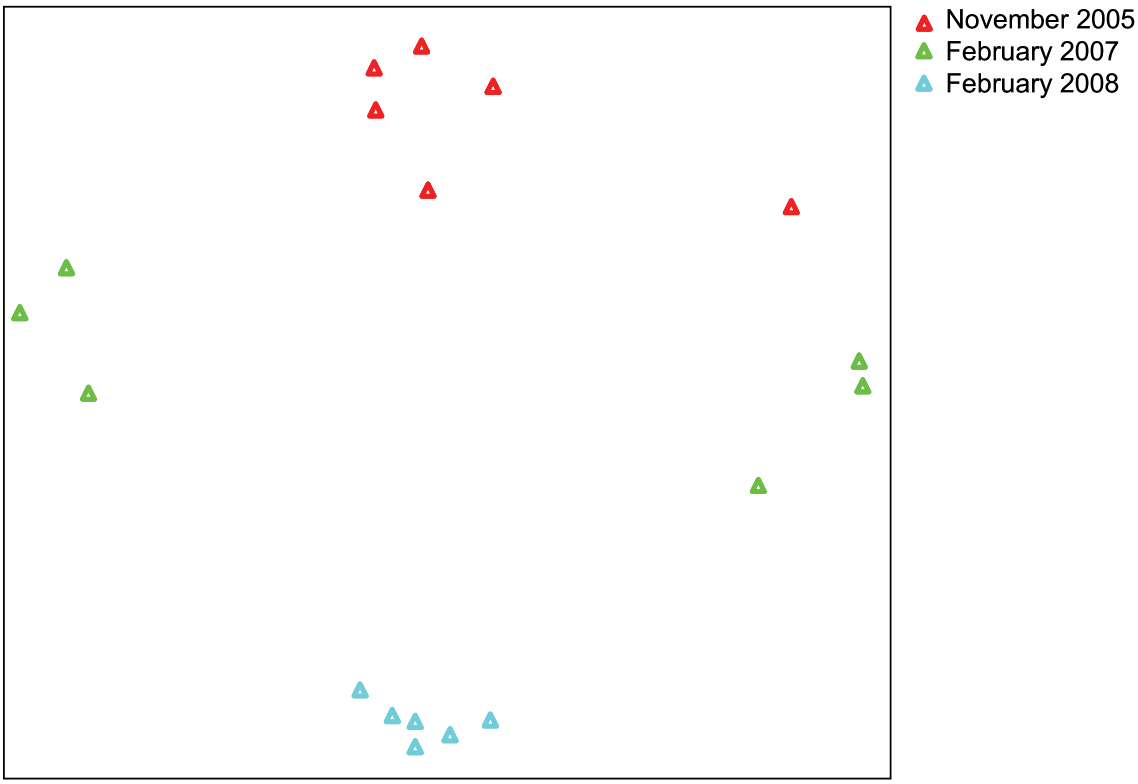


Figure 7: NMS ordination comparing the November 2005, February 2007 and February 2008 surveys for Chowilla Island Loop (stress=0.15).

Alternanthera denticulata, Polygonum plebium, Epaltes australis, Sporobolus mitchellii and *Glinus lotoides* (flood dependent species) and *Cyperus gymnocaulos* and *Eucalyptus camaldulensis* var. *camaldulensis* (amphibious species) significantly decreased in abundance between November 2005 (after the first watering) and February 2007 (after the second watering) (Table 5). There were no significant indicators of the February 2007 survey and in the absence of watering (between February 2007 and February 2008) *Sclerolaena divaricata* (drought tolerant terrestrial species) increased in abundance (Table 5).

Table 5: Species list and Indicator Species Analysis results comparing the floristic composition between the November 2005, February 2007 and February 2008 surveys for Chowilla Island Loop (*denotes exotic species; NS=not significant).

Taxon	Survey Date	*Monte Carlo P*
Cyperus gymnocaulos	November 2005	<0.001
Alternanthera denticulata	November 2005	0.002
Craspedia chrysantha	November 2005	0.002
Polygonum plebium	November 2005	0.002
Sporobolus mitchelli	November 2005	0.008
Epaltes australis	November 2005	0.014
Eucalyptus camaldulensis var. *camaldulensis*	November 2005	0.014
Glinus lotoides	November 2005	0.014
Ammania multiflora	November 2005	NS Uncommon
Centipeda minima	November 2005	NS Uncommon
*Cotula coronopifolia**	November 2005	NS Uncommon
Eleocharis acuta	November 2005	NS Uncommon
Enchylaena tomentosa	November 2005	NS Uncommon
Euphorbia drummondii	November 2005	NS Uncommon
*Heliotropium amplexicaule**	November 2005	NS Uncommon
*Heliotropium curassivicum**	November 2005	NS Uncommon
*Hypochoeris radicata**	November 2005	NS Uncommon
Iseotopsis graminifolia	November 2005	NS Uncommon
Lachnagrostis filiformis	November 2005	NS Uncommon
*Lactuca saligna**	November 2005	NS Uncommon
Limosella australis	November 2005	NS Uncommon
Marsilea angustifolia	November 2005	NS Uncommon
*Mesembryanthemum crystallinum**	November 2005	NS Uncommon
Mimulus repens	November 2005	NS Uncommon
Mollugo cerviana	November 2005	NS Uncommon
Persicaria lapathifolium	November 2005	NS Uncommon
Psuedognaphalium luteo-album	November 2005	NS Uncommon
*Rorippa palustris**	November 2005	NS Uncommon
Rumex bidens	November 2005	NS Uncommon
*Solanum nigrum**	November 2005	NS Uncommon
Bare Soil	November 2005	NS Widespread
Nothoscordum inodorata	November 2005	NS Widespread
Tetragonia tetragonoides	November 2005	NS Widespread
*Abutilon theophrasti**	February 2007	NS Uncommon
*Citrullus lanatus**	February 2007	NS Uncommon
*Paspalum distichum**	February 2007	NS Uncommon
Sclerolaena divaricata	February 2008	0.001
Chenopodium pumilio	February 2008	NS Uncommon
Sclerolaena brachyptera	February 2008	NS Uncommon
Senecio cunninghamii	February 2008	NS Uncommon
Atriplex spp.	February 2008	NS Widespread

3.3. Chowilla Oxbow

Chowilla Oxbow was watered once during the study period and two pre and two post-watering surveys were undertaken (Table 1). The response of the plant community to watering at each elevation was similar. There was no significant difference in the plant community between the June 2005 and November 2005 surveys (pre-watering); however the February 2007 and February 2008 surveys (post-watering) were significantly different from the pre-watering surveys and each other (June 2005=November 2005≠February 2007≠February 2008; PERMANOVA, Table 6, NMS ordination, Figure 8). NMS ordination for the +30 and +60 m elevations (a useful ordination solution could not be found for the 0 cm elevation due to outliers (Figure 8) suggests that the there is a shift in species composition after watering then 12 months later the plant community is transitioning to the pre-watering community.

Table 6: PERMANOVA *Pseudo-F* statistics comparing the change in floristic composition through time for each elevation in Chowilla Oxbow.

Elevation	*df*	*Pseudo-F*	*P*
0 cm	3,23	8.67	<0.001
+0 cm	3,47	27.96	<0.001
+60 cm	3,47	32.79	<0.001

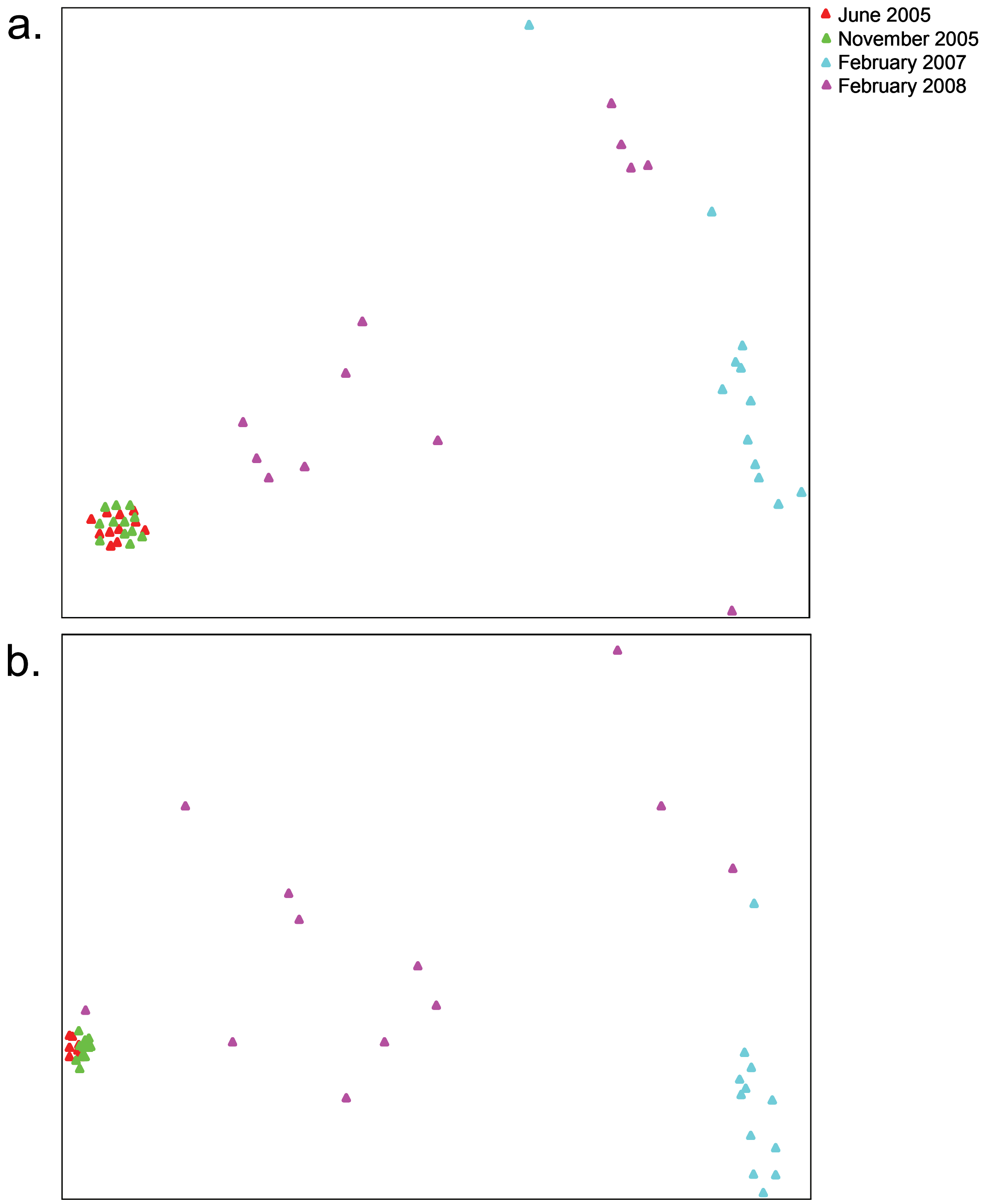


Figure 8: NMS ordination comparing the June 2005, November 2005, February 2007 and February 2008 surveys for Chowilla Oxbow a. +30 cm (stress=0.11) and b. +60 cm (stress=0.14).

Indicator Species Analysis showed that at each elevation bare soil dominated before watering and after watering a diverse assemblage of flood dependent taxa had recruited (Table 7). One year later many of the flood dependent species had significantly declined in abundance (many were absent) and the flora was dominated by desiccation tolerant flood dependent taxa (e.g. *Cyperus gymnocaulos*) and terrestrial species (e.g. *Salsola kali*) (Table 7). There was recruitment of *Eucalyptus* *camaldulensis* post-watering; however, *Heliotropium curassivicum, Heliotropium europaeaum, Polygonum aviculare* and *Conyza bonariensis* (exotic species) were also significantly more abundant post-watering (Table 7).

Table 7: Species list and Indicator Species Analysis results comparing the floristic composition between the June 2005, November 2005, February 2007 and February 2008 surveys for Chowilla Oxbow a. 0 cm, b. +30 and c. +60 cm (*denotes exotic species; NS=not significant).

a.

Taxon	**Survey Date**	***Monte Carlo P***
Bare Soil	June 2005 (Pre-watering)	0.05
Glinus lotoides	February 2007 (Post-watering)	0.0022
Centipeda minima	February 2007 (Post-watering)	NS Uncommon
Epaltes australis	February 2007 (Post-watering)	NS Uncommon
Eucalyptus camaldulensis var. *camaldulensis*	February 2007 (Post-watering)	NS Widespread
Alternanthera denticulata	February 2007 (Post-watering)	NS Widespread
Senecio cunninghamii	February 2008 (Post-watering)	<0.001
Chenopodium pumilio	February 2008 (Post-watering)	<0.001
*Heliotropium curassavicum**	February 2008 (Post-watering)	0.0362
Atriplex spp.	February 2008 (Post-watering)	NS Uncommon
Senecio runcinifolius	February 2008 (Post-watering)	NS Uncommon
Maireana microcarpa	February 2008 (Post-watering)	NS Widespread

b.

Taxon	**Survey Date**	***Monte Carlo P***
Bare Soil	June 2005 (Pre-watering)	<0.001
Centipeda minima	February 2007 (Post-watering)	<0.001
Glinus lotoides	February 2007 (Post-watering)	<0.001
Polygonum plebium	February 2007 (Post-watering)	<0.001
*Heliotropium curassavicum**	February 2007 (Post-watering)	0.002
Alternanthera denticulata	February 2007 (Post-watering)	0.01
Atriplex spp.	February 2007 (Post-watering)	0.0112
Eucalyptus camaldulensis var. *camaldulensis*	February 2007 (Post-watering)	0.0252
Epaltes australis	February 2007 (Post-watering)	0.0284
*Conyza bonariensis**	February 2007 (Post-watering)	NS Uncommon
Euphorbia drummondii	February 2007 (Post-watering)	NS Uncommon
*Heliotropium europaeaum**	February 2007 (Post-watering)	NS Uncommon
Mollugo cerviana	February 2007 (Post-watering)	NS Uncommon
Psuedognaphalium luteo-album	February 2007 (Post-watering)	NS Uncommon
Sclerolaena brachyptera	February 2007 (Post-watering)	NS Uncommon
Sclerolaena divaricata	February 2007 (Post-watering)	NS Uncommon
Sporobolus mitchellii	February 2007 (Post-watering)	NS Widespread
Senecio cunninghamii	February 2008 (Post-watering)	0.0002
Senecio runcinifolius	February 2008 (Post-watering)	0.0002
Chenopodium pumilio	February 2008 (Post-watering)	0.013
Enchylaena tomentosa	February 2008 (Post-watering)	NS Uncommon
*Heliotropium amplexicaule**	February 2008 (Post-watering)	NS Uncommon
Ludwigia peploides	February 2008 (Post-watering)	NS Uncommon
*Solanum nigrum**	February 2008 (Post-watering)	NS Uncommon
Wahlenbergia fluminalis	February 2008 (Post-watering)	NS Uncommon

c.

Taxon	**Survey Date**	***Monte Carlo P***
Bare Soil	June 2005 (Pre-watering)	<0.001
Alternanthera denticulata	February 2007 (Post-watering)	<0.001
Centipeda minima	February 2007 (Post-watering)	<0.001
Eucalyptus camaldulensis var. *camaldulensis*	February 2007 (Post-watering)	<0.001
Glinus lotoides	February 2007 (Post-watering)	<0.001
Senecio cunninghamii	February 2007 (Post-watering)	<0.001
Senecio runcinifolius	February 2007 (Post-watering)	<0.001
Atriplex spp.	February 2007 (Post-watering)	<0.001
*Heliotropium curassavicum**	February 2007 (Post-watering)	0.0108
Sporobolus mitchellii	February 2007 (Post-watering)	0.0116
Polygonum plebium	February 2007 (Post-watering)	0.0164
Psuedognaphalium luteo-album	February 2007 (Post-watering)	0.0182
Epaltes australis	February 2007 (Post-watering)	0.0318
Lachnagrostis filiformis	February 2007 (Post-watering)	NS Uncommon
*Heliotropium amplexicaule**	February 2007 (Post-watering)	NS Uncommon
Isolepis hookeriana	February 2007 (Post-watering)	NS Uncommon
Solanum oligacanthum	February 2007 (Post-watering)	NS Uncommon
*Polygonum aviculare**	February 2008 (Post-watering)	<0.001
*Conyza bonariensis**	February 2008 (Post-watering)	<0.001
Teucrium racemosum	February 2008 (Post-watering)	0.0022
Chenopodium pumilio	February 2008 (Post-watering)	0.0468
Cyperus gymnocaulos	February 2008 (Post-watering)	0.0478
Salsola kali	February 2008 (Post-watering)	0.05
Craspedia chrysantha	February 2008 (Post-watering)	NS Uncommon
Paspalum distichum	February 2008 (Post-watering)	NS Uncommon
Enchylaena tomentosa	February 2008 (Post-watering)	NS Uncommon
Rhagodia spinescens	February 2008 (Post-watering)	NS Uncommon

3.4. Coppermine Waterhole

Coppermine waterhole was watered twice during the study period and only post-watering surveys were undertaken (Table 1). The response of the plant community was similar at each elevation except the wetland edge. There was no significant difference in the plant community between the June 2005 and November 2005 surveys (quadrats were submerged); however, the February 2007 and February 2008 surveys were significantly different from June 2005 and November 2005 and each other (June 2005=November 2005≠June 2006≠February 2008; PERMANOVA, Table 8, NMS ordination, Figure 9a, b and c). At the edge of the wetland the plant community was significantly different each survey (June 2005≠November 2005≠June 2006≠February 2008; PERMANOVA, Table 8, NMS ordination, Figure 9d).

Table 8: PERMANOVA *Pseudo-F* statistics comparing the change in floristic composition through time for each elevation in Coppermine Waterhole.

Elevation	*df*	*Pseudo-F*	*P*
0 cm	3,23	9.72	<0.001
30 cm	3,23	46.55	<0.001
60 cm	3,23	28.79	<0.001
Wetland Edge	3,23	17.99	<0.001

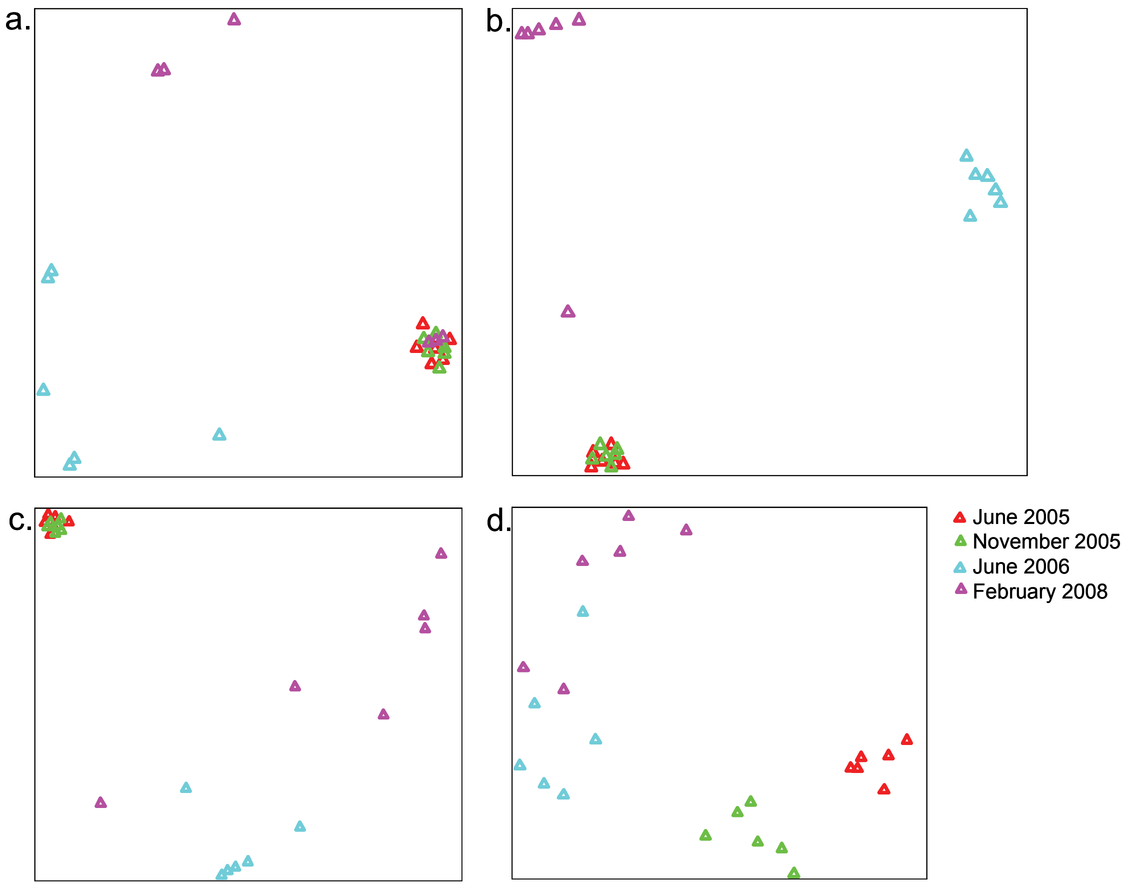


Figure 9: NMS ordination comparing the June 2005, November 2005, June 2006 and February 2008 surveys for Coppermine Waterhole a. 0 cm (stress=0.048), b. +30 cm (stress=0.105), c. +60 cm (stress=0.053) and d. the maximum water level (stress=0.123).

At the 0, +30 and +60 cm elevations, quadrats were generally devoid of vegetation in June and November 2005; however, in June 2006 flood dependent species had recruited and following the second watering (in October 2006) a different community of flood dependent species had recruited (Table 9a, b and c). At the edge of the wetland (maximum water level) a significantly different plant community, dominated by flood dependent species, was present each time the area was surveyed (Table 9d). *Eucalyptus camaldulensis* seedlings were common (especially at the wetland edged); however, several exotic taxa (*Heliotropium europaeaum, Medicago* spp., *Heliotropium amplexicaule, Arctotheca calendula* and *Aster subulatus*), were also abundant at times (Table 9).

Table 9: Species list and Indicator Species Analysis results comparing the floristic composition between the June 2005, November 2005, June 2006 and February 2008 surveys for Coppermine Waterhole a. 0 cm, b. +30 cm, c. +60 cm and d. the maximum water level (*denotes exotic species, #denotes listed as endangered in South Australia).

a.

Taxon	**Survey Date**	***Monte Carlo P***
Bare Soil	June 2005	NS Widespread
Medicago spp.*	June 2006	<0.001
Myriophyllum verrucosum	June 2006	<0.001
Rumex bidens	June 2006	<0.001
Glycyrrhiza acanthocarpa	June 2006	0.0056
Sclerolaena divaricata	June 2006	0.0374
Centipeda minima	June 2006	NS Uncommon
Polygonum plebium	June 2006	NS Uncommon
Sclerolaena brachyptera	June 2006	NS Uncommon
Senecio cunninghamii	June 2006	NS Uncommon
*Sonchus oleraceus**	June 2006	NS Uncommon
Sporobolus mitchellii	June 2006	NS Uncommon
*Heliotropium europaeaum**	February 2008	0.0436
Glinus lotoides	February 2008	NS Uncommon

b.

Taxon	Survey Date	*Monte Carlo P*
Bare Soil	June 2005	0.015
Medicago spp.*	June 2006	<0.001
Myriophyllum verrucosum	June 2006	0.0362
Rumex bidens	June 2006	0.0402
*Arctotheca calendula**	June 2006	NS Uncommon
*Carrichtera annua**	June 2006	NS Uncommon
Chenopodium pumilio	June 2006	NS Uncommon
Glycyrrhiza acanthocarpa	June 2006	NS Uncommon
*Heliotropium curassavicum**	June 2006	NS Uncommon
*Hypochoeris radicata**	June 2006	NS Uncommon
Morgania floribunda	June 2006	NS Uncommon
Polygonum plebium	June 2006	NS Uncommon
Sclerolaena divaricata	June 2006	NS Uncommon
Senecio cunninghamii	June 2006	NS Uncommon
Tetragonia tetragonoides	June 2006	NS Uncommon
*Heliotropium europaeaum**	February 2008	<0.001
Glinus lotoides	February 2008	0.0036
Sporobolus mitchellii	February 2008	0.0274
Centipeda minima	February 2008	0.042
Eucalyptus camaldulensis var. *camaldulensis*	February 2008	NS Uncommon
*Heliotropium amplexicaule**	February 2008	NS Uncommon
Epaltes australis	February 2008	NS Widespread

c.

Taxon	Survey Date	*Monte Carlo P*
Bare Soil	June 2005	0.0278
Medicago spp.*	June 2006	<0.001
Morgania floribunda	June 2006	<0.001
Sporobolus mitchellii	June 2006	<0.001
Sclerolaena brachyptera	June 2006	0.0054
Centipeda minima	June 2006	NS Uncommon
Carrichtera annua	June 2006	NS Uncommon
Euphorbia drummondii	June 2006	NS Uncommon
Halosarcia pergranulata ssp. *pergranulata*	June 2006	NS Uncommon
*Hypochoeris radicata**	June 2006	NS Uncommon
Brachycome basaltica	June 2006	NS Widespread
Epaltes australis	June 2006	NS Widespread
Glycyrrhiza acanthocarpa	June 2006	NS Widespread
*Heliotropium europaeaum**	February 2008	<0.001
Glinus lotoides	February 2008	NS Uncommon
Polygonum plebium	February 2008	NS Uncommon
Psuedognaphalium luteo-album	February 2008	NS Uncommon
Senecio runcinifolius	February 2008	NS Uncommon
Senecio cunninghamii	February 2008	NS Widespread

d.

Taxon	Survey Date	*Monte Carlo P*
Ammania multiflora	June 2005	<0.001
Epaltes australis	June 2005	<0.001
Mimulus repens	June 2005	<0.001
Iseotopsis graminifolia	June 2005	<0.001
Psuedognaphalium luteo-album	June 2005	<0.001
Centipeda minima	June 2005	0.0042
Trachymene cyanopetula	June 2005	0.0052
*Heliotropium amplexicaule**	June 2005	0.0068
Eucalyptus camaldulensis var. *camaldulensis*	June 2005	0.0088
Limosella australis	June 2005	0.0088
*Heliotropium europaeaum**	June 2005	0.0364
Glinus lotoides	June 2005	0.0372
Chenopodium pumilio	June 2005	0.0414
Acacia stenophylla	June 2005	NS Uncommon
Carpobrotus rossii	June 2005	NS Uncommon
Crassula sieberana#	June 2005	NS Uncommon
Euphorbia drummondii	June 2005	NS Uncommon
Muehlenbeckia florulenta	June 2005	NS Uncommon
Morgania floribunda	June 2005	NS Widespread
Craspedia chrysantha	November 2005	<0.001
Isolepis hookeriana	November 2005	<0.001
Juncus usitatus	November 2005	<0.001
Lachnagrostis filiformis	November 2005	<0.001
Rumex bidens	November 2005	<0.001
Senecio cunninghamii	November 2005	<0.001
*Aster subulatus**	November 2005	<0.001
*Lactuca saligna**	November 2005	0.0044
Polygonum plebium	November 2005	0.0046
Myriophyllum verucossum	November 2005	0.0094
Alternanthera denticulata	November 2005	0.0362
*Echium plantagineum**	November 2005	NS Uncommon
Eleocharis acuta	November 2005	NS Uncommon
Malva parviflora	November 2005	NS Uncommon
Marsilea angustifolia	November 2005	NS Uncommon
Paspalum distichum	November 2005	NS Uncommon
*Sonchus oleraceus**	November 2005	NS Uncommon
Wahlenbergia fluminalis	November 2005	NS Uncommon
*Xanthium occidentale**	November 2005	NS Uncommon
Medicago spp.*	June 2006	0.0094
*Arctotheca calendula**	June 2006	NS Uncommon
*Hypochoeris radicata**	June 2006	NS Uncommon
Tetragonia tetragonoides	June 2006	NS Uncommon
Cyperus gymnocaulos	June 2006	NS Widespread

Taxon	Survey Date	***Monte Carlo P***
Sporobolus mitchelli	February 2008	0.001
Brachycome basaltica	February 2008	0.016
*Conyza bonariensis**	February 2008	NS Uncommon

3.5. Kulcurna Black Box

Kulcurna Black Box flood runner was watered once during the study period and pre and post-watering surveys were undertaken (Table 1). The floristic composition before the wetland was watered (November 2005) compared to after the wetland was watered (June 2006) was significantly different (PERMANOVA: *Pseudo* $F_{1,10}$=7.38, *P*=0.0032; NMS Ordination: Figure 10).

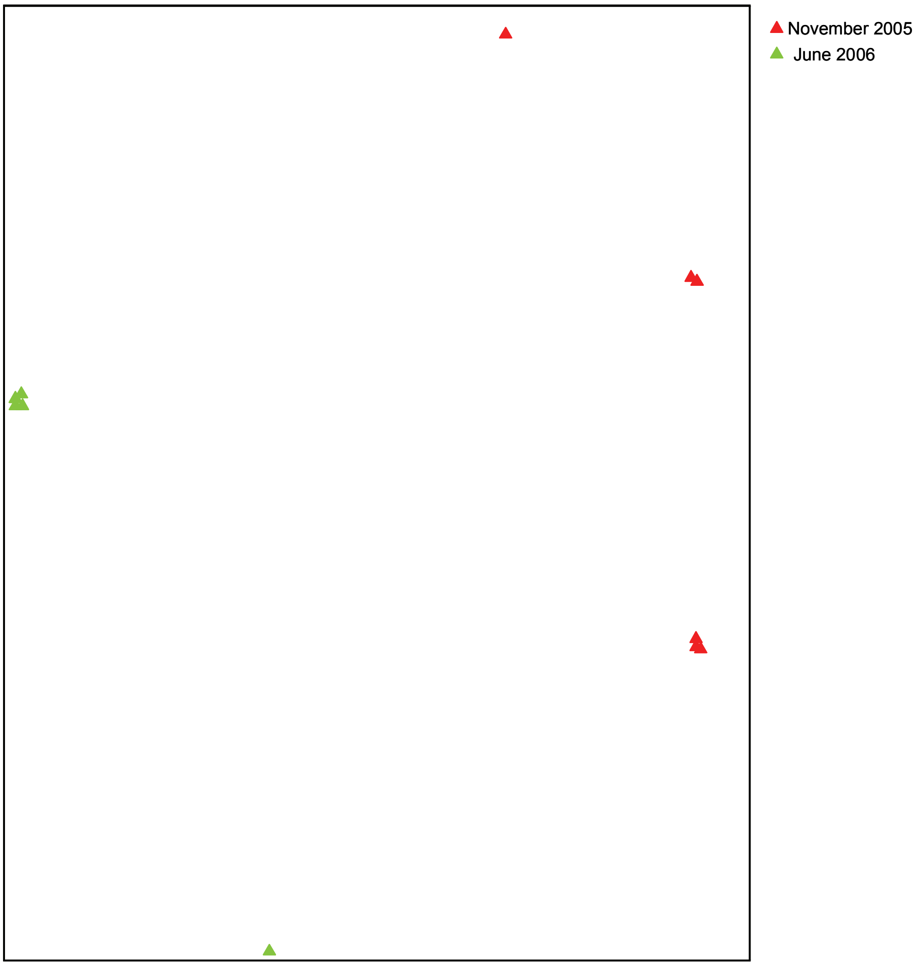


Figure 10: NMS ordination comparing the November 2005 and June 2006 surveys for Kulcurna Black Box flood runner (stress=0.152).

Despite the significantly different floristic composition between the two surveys there were only three significant indicators: bare soil and *Wahlenbergia fluminalis* were significant indicators of the June 2006 (post-watering) survey and *Spergularia marina* of the November 2005 (pre-watering) survey (Table 10). The majority of species (28) were present exclusively in the pre-watering survey in low abundances (uncommon non-significant species) (Table 10).

Table 10: Species list and Indicator Species Analysis results comparing the floristic composition between the November 2005 and June 2006 surveys for Kulcurna Black Box flood runner (*denotes exotic species; NS=not significant).

Species	Survey Date	*Monte Carlo P*
*Spergularia marina**	November 05 Pre-watering)	0.0044
Alisma sp.	November 05 (Pre-watering)	NS Uncommon
Ammania multiflora	November 05 (Pre-watering)	NS Uncommon
*Arctotheca calendula**	November 05 (Pre-watering)	NS Uncommon
Bolboschoenus caldwellii	November 05 (Pre-watering)	NS Uncommon
*Bromus rubens**	November 05 (Pre-watering)	NS Uncommon
Centipeda minima	November 05 (Pre-watering)	NS Uncommon
Craspedia chrysantha	November 05 (Pre-watering)	NS Uncommon
Enchylaena tomentosa	November 05 (Pre-watering)	NS Uncommon
Epaltes australis	November 05 (Pre-watering)	NS Uncommon
Eragrostis australasica	November 05 (Pre-watering)	NS Uncommon
*Heliotropium amplexicaule**	November 05 (Pre-watering)	NS Uncommon
*Heliotropium europaeum**	November 05 (Pre-watering)	NS Uncommon
*Hordeum vulgare**	November 05 (Pre-watering)	NS Uncommon
*Lactuca saligna**	November 05 (Pre-watering)	NS Uncommon
Limosella australis	November 05 (Pre-watering)	NS Uncommon
Marsilea angustifolia	November 05 (Pre-watering)	NS Uncommon
*Mesembryanthemum crystallinum**	November 05 (Pre-watering)	NS Uncommon
Nothoscordum inodorata	November 05 (Pre-watering)	NS Uncommon
Plantago turrifera	November 05 (Pre-watering)	NS Uncommon
*Rorippa palustris**	November 05 (Pre-watering)	NS Uncommon
Sclerolaena brachyptera	November 05 (Pre-watering)	NS Uncommon
Sclerolaena divaricata	November 05 (Pre-watering)	NS Uncommon
Senecio sp.	November 05 (Pre-watering)	NS Uncommon
*Sonchus oleraceus**	November 05 (Pre-watering)	NS Uncommon
Sporobolus mitchelli	November 05 (Pre-watering)	NS Uncommon
Tetragonia tetragonoides	November 05 (Pre-watering)	NS Uncommon
*Xanthium occidentale**	November 05 (Pre-watering)	NS Uncommon
Alternanthera denticulata	November 05 (Pre-watering)	NS Widespread
Atriplex spp.	November 05 (Pre-watering)	NS Widespread
*Hypochoeris radicata**	November 05 (Pre-watering)	NS Widespread
Morgania floribunda	November 05 (Pre-watering)	NS Widespread
Psuedognaphalium luteo-album	November 05 (Pre-watering)	NS Widespread
Wahlenbergia fluminalis	June 06 (Post-watering)	0.0022
Bare Soil	June 06 (Post-watering)	0.015
Euphorbia drummondii	June 06 (Post-watering)	NS Uncommon
Cyperus gymnocaulos	June 06 (Post-watering)	NS Widespread

3.6. Kulcurna Red Gum

The Kulcurna red gum flood runner was watered four times during the study period and only post watering surveys were undertaken (Table 1). The plant community showed no significant change between June and November 2005 but there was significant change between November 2005 and February 2008 (June 2005=November 2005≠ February 2008; PERMANOVA: *Pseudo* $F_{2,26}$=7.44, P<0.001; NMS Ordination: Figure 11).

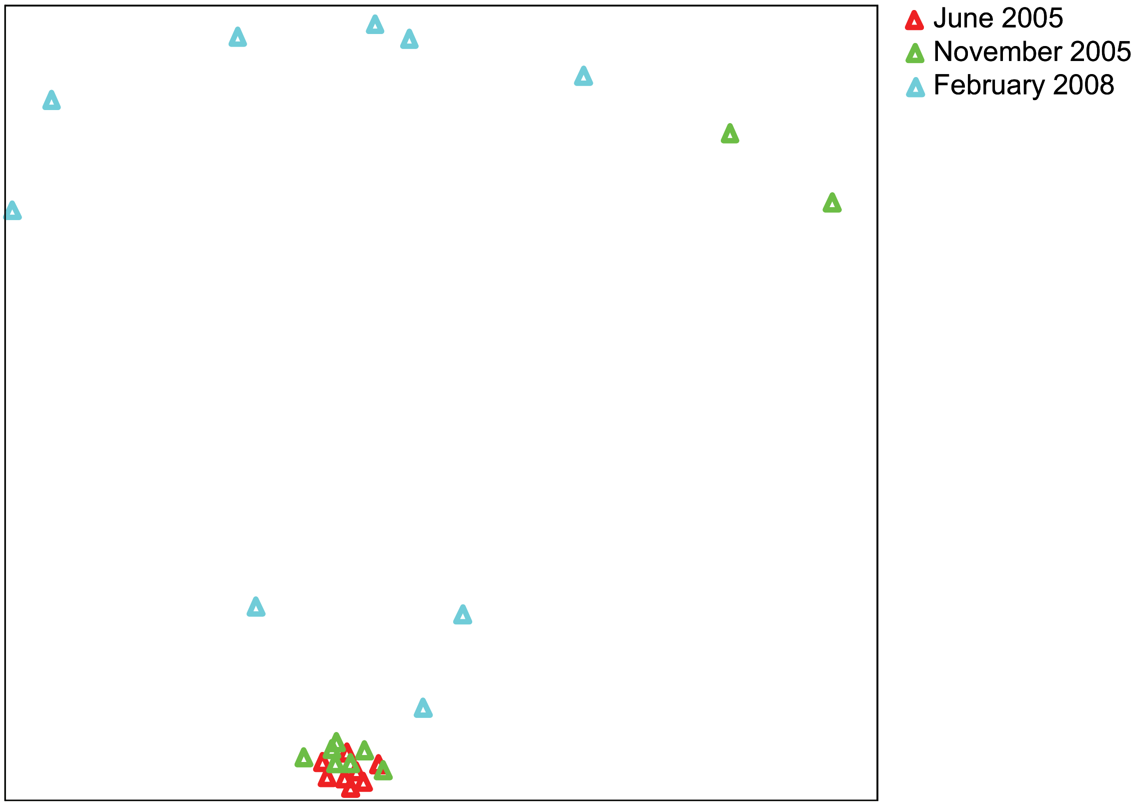


Figure 11: NMS ordination comparing the June 2005, November 2005 and February 2008 surveys for Kulcurna Red Gum flood runner (stress=0.047).

In June 2005 the sites was dominated by bare soil and in November 2005 there were low abundances of 14 flood dependent species but no significant change in floristic composition (Table 11). In February 2008, five flood dependent taxa were present in significantly higher abundances (including *Eucalyptus camaldulensis* var. *camaldulensis*) and a further five flood dependent taxa were only present in the aforementioned survey in low numbers (Table 11).

Table 11: 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=not significant).

Taxon	**Survey Date**	***Monte Carlo P***
Bare Soil	June 2005	0.0068
*Heliotropium amplexicaule**	November 2005	NS Uncommon
Iseotopsis graminifolia	November 2005	NS Uncommon
Isolepis hookeriana	November 2005	NS Uncommon
Mollugo cerviana	November 2005	NS Uncommon
Muehlenbeckia florulenta	November 2005	NS Uncommon
Myriophyllum verucossum	November 2005	NS Uncommon
Plantago turrifera	November 2005	NS Uncommon
Polygonum plebium	November 2005	NS Uncommon
Psuedognaphalium luteo-album	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
Epaltes australis	November 2005	NS Widespread
Eragrostis australasica	November 2005	NS Widespread
Morgania floribunda	February 2008	<0.001
Enchylaena tomentosa	February 2008	0.005
Chenopodium pumilio	February 2008	0.0064
Eucalyptus camaldulensis var. *camaldulensis*	February 2008	0.007
Senecio cunninghamii	February 2008	0.025
Alternanthera denticulata	February 2008	NS Uncommon
*Atriplex prostrata**	February 2008	NS Uncommon
Atriplex spp.	February 2008	NS Uncommon
Centipeda minima	February 2008	NS Uncommon
*Conyza bonariensis**	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
Brachycome basaltica	February 2008	NS Widespread
Cyperus gymnocaulos	February 2008	NS Widespread
*Heliotropium curassivicum**	February 2008	NS Widespread
Sporobolus mitchelli	February 2008	NS Widespread

3.7. Lake Littra

Lake Littra was watered twice during the study period and only post watering surveys were undertaken (Table 1). The plant community changed significantly between June 2005 and November 2005; however, changed back and there was no significant difference between the June 2005 and February 2007 (surveys undertaken approximately 12 months after the wetland was watered for the first and second time respectively (Table 1). The plant community was significantly different from all of the other surveys in February 2008 (June 2005=February 2007≠November 2005≠February 2008; PERMANOVA: *Pseudo* $F_{3,35}$=20.41, P<0.001; NMS Ordination: Figure 12).

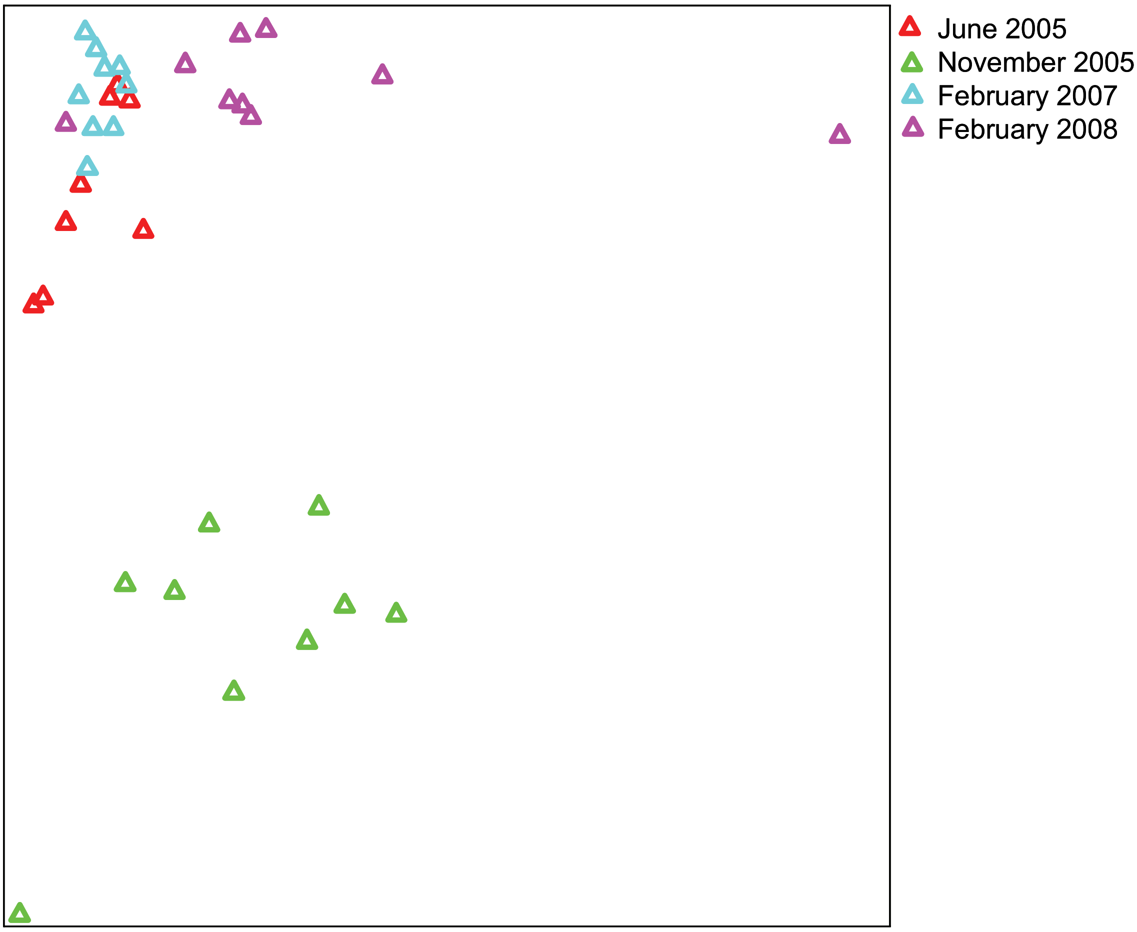


Figure 12: NMS ordination comparing the June 2005, November 2005, February 2007 and February 2008 surveys for Lake Littra (stress=0.123).

There were no significant indicators of the June 2005 and February 2007 surveys (*Mimulus repens* and *Cyperus gymnocaulos* were the dominant species and present in similar abundances in each survey). Flood dependent species were dominant in November 2005 and February 2008;

however, terrestrial species (*Atriplex* spp. and *Sclerolaena brachyptera*) had also recruited and were significant indicators (Table 12). Three exotic taxa were present; however, only *Medicago* spp. was present in large numbers (Table 12).

Table 12: Species list and Indicator Species Analysis results comparing the floristic composition between the June 2005, November 2005, February 2007 and February 2008 surveys for Lake Littra (*denotes exotic species; NS=not significant).

Taxon	Survey Date	*Monte Carlo P*
Epaltes australis	June 2005	NS Uncommon
*Heliotropium curassivicum**	June 2005	NS Uncommon
Cyperus gymnocaulos	June 2005	NS Widespread
Mimulus repens	June 2005	NS Widespread
Lachnagrostis filiformis	November 2005	<0.001
Medicago spp.*	November 2005	<0.001
Polygonum plebium	November 2005	<0.001
Sporobolus mitchelli	November 2005	<0.001
Atriplex spp.	November 2005	0.0038
Mollugo cerviana	November 2005	0.0426
*Bromus rubens**	November 2005	NS Uncommon
Centipeda minima	November 2005	NS Uncommon
Craspedia chrysantha	November 2005	NS Uncommon
*Mesembryanthemum crystallinum**	November 2005	NS Uncommon
Muehlenbeckia florulenta	November 2005	NS Widespread
Sclerolaena brachyptera	February 2008	0.001
Wahlenbergia fluminalis	February 2008	0.0018
Chenopodium pumilio	February 2008	0.05
Salsola kali	February 2008	NS Uncommon
Sclerolaena divaricata	February 2008	NS Uncommon
Sclerolaena stelligra	February 2008	NS Uncommon

3.8. Monoman Depression

Monoman Depression was watered once during the study period and one pre and two post-watering surveys were undertaken (Table 1). A useful NMS Ordination solution could not be found due to outliers; hence, a relationship between the quadrats could not be established (McCune and Mefford 2005). PERMANOVA results (*Pseudo* $F_{2,8}$=17.76, P=0.004) showed that the plant community changed in response to watering and significantly different for each survey.

Before Monoman Depression was watered the plant community was dominated by drought tolerant terrestrial taxa and after watering *Glinus lotoides* (a flood dependent species) was the dominant species (Table 13). One year after the first post-watering survey (the February 2008 survey) the site was almost completely devoid of plants (Table 13).

Table 13: Species list and Indicator Species Analysis results comparing the floristic composition between the November 2005, February 2007 and February 2008 surveys for Monoman Depression (*denotes exotic species; NS=not significant).

Taxon	Survey Date	*Monte Carlo P*
Atriplex spp.	November 2005 (Pre-watering)	0.014
Craspedia chrysantha	November 2005 (Pre-watering)	0.0386
*Mesembryanthemum crystallinum**	November 2005 (Pre-watering)	0.0386
Sclerolaena brachyptera	November 2005 (Pre-watering)	0.0386
*Hordeum vulgare**	November 2005 (Pre-watering)	NS Uncommon
Nothoscordum inodorata	November 2005 (Pre-watering)	NS Uncommon
*Rorippa palustris**	November 2005 (Pre-watering)	NS Uncommon
*Sonchus oleraceus**	November 2005 (Pre-watering)	NS Uncommon
Glinus lotoides	February 2007 (Post-watering)	0.0338
Alternanthera denticulata	February 2007 (Post-watering)	NS Uncommon
Euphorbia drummondii	February 2007 (Post-watering)	NS Uncommon
Heliotropium europaeaum	February 2007 (Post-watering)	NS Uncommon
Sporobolus mitchelli	February 2007 (Post-watering)	NS Widespread
Bare Soil	February 2008 (Post-watering)	0.0358
Sclerolaena divaricata	February 2008 (Post-watering)	NS Uncommon

3.9. Monoman Island Horseshoe

Monoman Island Horseshoe was watered twice during the study period and only post watering surveys were undertaken (Table 1). The two sites were analysed separately because they were surveyed at different times because site 2 dried before site 1. A useful NMS Ordination solution could not be found for either site in Monoman Island Horseshoe due to outliers; hence, a relationship between the quadrats could not be established (McCune and Mefford 2005). PERMANOVA results showed that the plant community changed significantly through time at each site and each survey was significantly different (Table 14).

Table 14: PERMANOVA *Pseudo-F* statistics comparing the change in floristic composition through time for each site in Monoman Island Horseshoe.

Site	***df***	***Pseudo-F***	***P***
Site 1	2,8	9.27	0.004
Site 2	2,8	20.56	0.003

At site 1 in November 2005 the plant community was dominated by *Myriophyllum verrucosum* (which was the only significant indicator); however, a further ten flood dependent and emergent species were present (only in this survey) in low numbers (Table 15a). *Glinus lotoides* and *Medicago* spp. were the dominant taxa after the wetland was watered a second time (there were also ten additional native flood dependent species only present for this survey) and after six months without watering bare soil dominated (Table 15a).

At site two in November 2005 and February 2007 the plant community was a diverse assemblage of native flood dependent, amphibious and emergent species; however, by February 2008 these species had significantly declined in abundance and several terrestrial species were present in low numbers (uncommon non-significant species) (Table 15b).

Eucalyptus camaldulensis seedlings were present in large numbers at both sites throughout the study period and the only exotic taxon that was present in large numbers was *Medicago* spp. (Table 15).

Table 15: Species list and Indicator Species Analysis results comparing the floristic composition between the June 2005, November 2005, February 2007 and February 2008 surveys for Monoman Island Horseshoe a. site 1 and b. site 2 (*denotes exotic species; NS=not significant).

a.

Taxon	Survey Date	*Monte Carlo P*
Myriophyllum verucossum	November 2005	0.037
Centipeda minima	November 2005	NS Uncommon
Cyperus exaltatus	November 2005	NS Uncommon
Iseotopsis graminifolia	November 2005	NS Uncommon
Juncus usitatus	November 2005	NS Uncommon
Lachnagrostis filiformis	November 2005	NS Uncommon
Limosella australis	November 2005	NS Uncommon
Polygonum plebium	November 2005	NS Uncommon
Schoenoplectus validus	November 2005	NS Uncommon
Sporobolus mitchelli	November 2005	NS Uncommon
Typha domingensis	November 2005	NS Uncommon
Glinus lotoides	June 2007	0.0354
Medicago spp.*	June 2007	0.0354
Alternanthera denticulata	June 2007	NS Uncommon
Atriplex spp.	June 2007	NS Uncommon
Chenopodium pumilio	June 2007	NS Uncommon
*Malva parviflora**	June 2007	NS Uncommon
Mollugo cerviana	June 2007	NS Uncommon
Rumex bidens	June 2007	NS Uncommon
Senecio cunninghamii	June 2007	NS Uncommon
Solanum sp.	June 2007	NS Uncommon
Trachymene cyanopetula	June 2007	NS Uncommon
Eucalyptus camaldulensis var. *camaldulensis*	June 2007	NS Widespread
Bare Soil	February 2008	0.0364

b.

Taxon	Survey Date	*Monte Carlo P*
Juncus usitatus	November 2005	0.035
Limosella australis	November 2005	0.035
Myriophyllum verucossum	November 2005	0.035
Typha domingensis	November 2005	0.035
Alternanthera denticulata	November 2005	NS Uncommon
Centipeda minima	November 2005	NS Uncommon
Craspedia chrysantha	November 2005	NS Uncommon
Cyperus exaltatus	November 2005	NS Uncommon
Iseotopsis graminifolia	November 2005	NS Uncommon
Lachnagrostis filiformis	November 2005	NS Uncommon
Ludwigia peploides	November 2005	NS Uncommon
Psuedognaphalium luteo-album	November 2005	NS Uncommon
Schoenoplectus validus	November 2005	NS Uncommon
Chenopodium pumilio	February 2007	0.038
Glinus lotoides	February 2007	0.038
Ammania multiflora	February 2007	NS Uncommon
Brachycome basaltica	February 2007	NS Uncommon
Epaltes australis	February 2007	NS Uncommon
*Heliotropium amplexicaule**	February 2007	NS Uncommon
*Heliotropium europaeaum**	February 2007	NS Uncommon
Isolepis hookeriana	February 2007	NS Uncommon
Polygonum plebium	February 2007	NS Uncommon
Rumex bidens	February 2007	NS Uncommon
Solanum oligacanthum	February 2007	NS Uncommon
Sporobolus mitchelli	February 2007	NS Widespread
Atriplex spp.	February 2008	NS Uncommon
Enchylaena tomentosa	February 2008	NS Uncommon
Sclerolaena divaricata	February 2008	NS Uncommon
Eucalyptus camaldulensis var. *camaldulensis*	February 2008	NS Widespread

3.10. Pipeclay Creek Billabong

Pipeclay Creek Billabong was watered once during the study period and only post-watering surveys were undertaken (Table 1). The plant community changed significantly through time (PERMANOVA *Pseudo* $F_{2,17}$=6.32, P<0.001; NMS ordination, Figure 13) but there was no significant difference between the June 2005 and June 2006 surveys; however, the February 2008 survey was significantly different from the two previous surveys (June 2005=June 2006≠ February 2008).

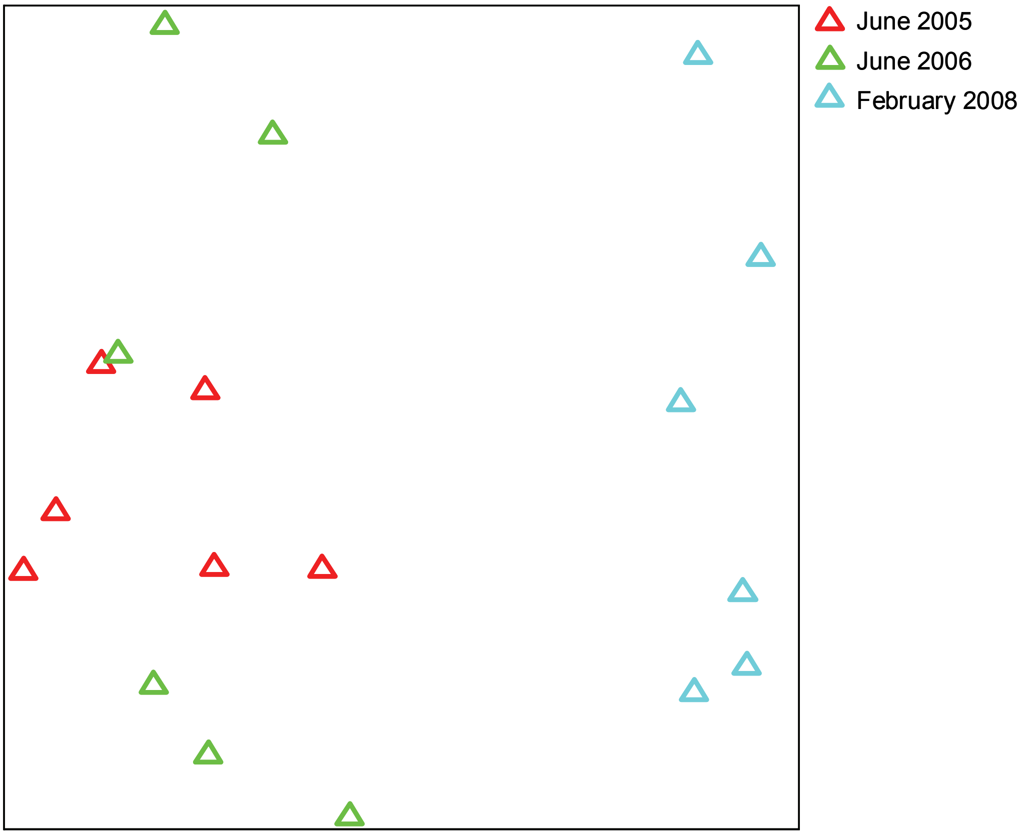


Figure 13: NMS ordination comparing the June 2005, June 2006 and February 2008 surveys for Pipeclay Creek Billabong (stress=0.114).

Despite PERMANOVA detecting no significant differences in the plant community for the June 2005 and June 2006 surveys, each survey had significant indicators (all significant indicators were flood dependent species) (Table 16). The plant community in June 2005 and June 2006 was dominated by native amphibious and flood dependent taxa (14 native species were present in low numbers); however, in February 2008 all of the aforementioned species had died and bare soil dominated (Table 16). *Heliotropium europaeaum* was the only exotic species present in large numbers and there were large numbers of *Eucalyptus camaldulensis* seedlings present over the study period (Table 16).

Table 16: Species list and Indicator Species Analysis results comparing the floristic composition between the June 2005, June 2006 and February 2008 surveys for Pipeclay Creek Billabong (*denotes exotic species; NS=not significant).

Taxon	Survey Date	*Monte Carlo P*
*Heliotropium europaeaum**	June 2005	0.0024
Centipeda minima	June 2005	0.0288
*Heliotropium curassivicum**	June 2005	NS Uncommon
Epaltes australis	June 2005	NS Uncommon
Glinus lotoides	June 2005	NS Uncommon
*Rorippa palustris**	June 2005	NS Uncommon
Polygonum plebium	June 2006	0.0276
Alternanthera denticulata	June 2006	NS Uncommon
Chenopodium pumilio	June 2006	NS Uncommon
Euphorbia drummondii	June 2006	NS Uncommon
Limosella australis	June 2006	NS Uncommon
Marsilea angustifolia	June 2006	NS Uncommon
Morgania floribunda	June 2006	NS Uncommon
Myriophyllum elatinoides	June 2006	NS Uncommon
Myriophyllum verucossum	June 2006	NS Uncommon
Rorippa islandica	June 2006	NS Uncommon
Rumex bidens	June 2006	NS Uncommon
Trachymene cyanopetula	June 2006	NS Uncommon
Eucalyptus camaldulensis var. *camaldulensis*	June 2006	NS Widespread
Sporobolus mitchelli	June 2006	NS Widespread
Bare Soil	February 2008	0.0294
Senecio cunninghamii	February 2008	NS Uncommon
Brachycome basaltica	February 2008	NS Uncommon
*Conyza bonariensis**	February 2008	NS Uncommon

3.11. Punkah Creek Depression

Punkah Creek Depression was watered twice during the study period and one pre and two post-watering surveys were undertaken (Table 1). The plant community changed in response to watering and was significantly different each survey (PERMANOVA *Pseudo* $F_{2,17}=18.59$, $P<0.001$; NMS ordination, Figure 14).

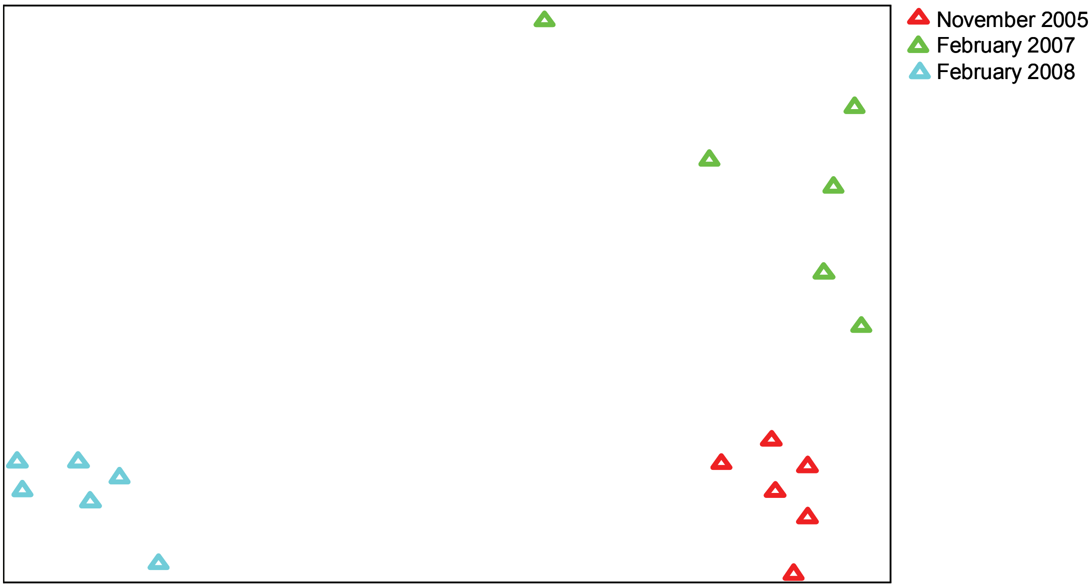


Figure 14: NMS ordination comparing the November 2005, February 2007 and February 2008 surveys for Punkah Depression (stress=0.134).

Before Punkah Creek Depression was watered the plant community was dominated by terrestrial and desiccation tolerant flood dependent species and after watering by flood dependent and amphibious species (Table 17). However, large numbers of *Abutilon theophrasti* and *Heliotropium europaeaum* had recruited in response to watering (Table 17). One year later most of the flood dependent species that were present in February 2007 had died and bare soil was dominant (Table 17).

Table 17: Species list and Indicator Species Analysis results comparing the floristic composition between the November 2005, February 2007 and February 2008 surveys for Punkah Creek Depression (*denotes exotic species; NS=not significant).

Taxon	Survey Date	*Monte Carlo P*
Sporobolus mitchelli	November 2005 (Pre-watering)	0.001
Medicago spp.*	November 2005 (Pre-watering)	0.005
Atriplex spp.	November 2005 (Pre-watering)	0.0086
Eragrostis dielsii	November 2005 (Pre-watering)	0.0162
Tetragonia tetragonoides	November 2005 (Pre-watering)	0.0162
Brachycome basaltica	November 2005 (Pre-watering)	NS Uncommon
*Bromus rubens**	November 2005 (Pre-watering)	NS Uncommon
Craspedia chrysantha	November 2005 (Pre-watering)	NS Uncommon
Enchylaena tomentosa	November 2005 (Pre-watering)	NS Uncommon
*Hordeum vulgare**	November 2005 (Pre-watering)	NS Uncommon
*Mesembryanthemum crystallinum**	November 2005 (Pre-watering)	NS Uncommon
*Riechardia tingitana**	November 2005 (Pre-watering)	NS Uncommon
Rumex bidens	November 2005 (Pre-watering)	NS Uncommon
*Sonchus oleraceus**	November 2005 (Pre-watering)	NS Uncommon
*Spergularia marina**	November 2005 (Pre-watering)	NS Uncommon
Myriophyllum verucossum	February 2007 (Post-watering)	0.0024
*Heliotropium europaeaum**	February 2007 (Post-watering)	0.0072
Typha domingensis	February 2007 (Post-watering)	0.0148
*Abutilon theophrasti**	February 2007 (Post-watering)	0.041
Lachnagrostis filiformis	February 2007 (Post-watering)	0.048
Alternanthera denticulata	February 2007 (Post-watering)	NS Uncommon
Ammania multiflora	February 2007 (Post-watering)	NS Uncommon
Centipeda minima	February 2007 (Post-watering)	NS Uncommon
Glinus lotoides	February 2007 (Post-watering)	NS Uncommon
Mimulus repens	February 2007 (Post-watering)	NS Uncommon
Bare Soil	February 2008 (Post-watering)	<0.001
Glycyrrhiza acanthocarpa	February 2008 (Post-watering)	NS Uncommon
Sclerolaena brachyptera	February 2008 (Post-watering)	NS Widespread
Sclerolaena divaricata	February 2008 (Post-watering)	NS Widespread

3.12. Punkah Creek Flood Runner

Punkah Creek Flood Runner was watered twice during the study period and one pre and two post-watering surveys were undertaken (Table 1). The plant community changed in response to watering and was significantly different each survey (PERMANOVA *Pseudo* $F_{2,8}$=2.14, P=0.008; NMS ordination, Figure 15).

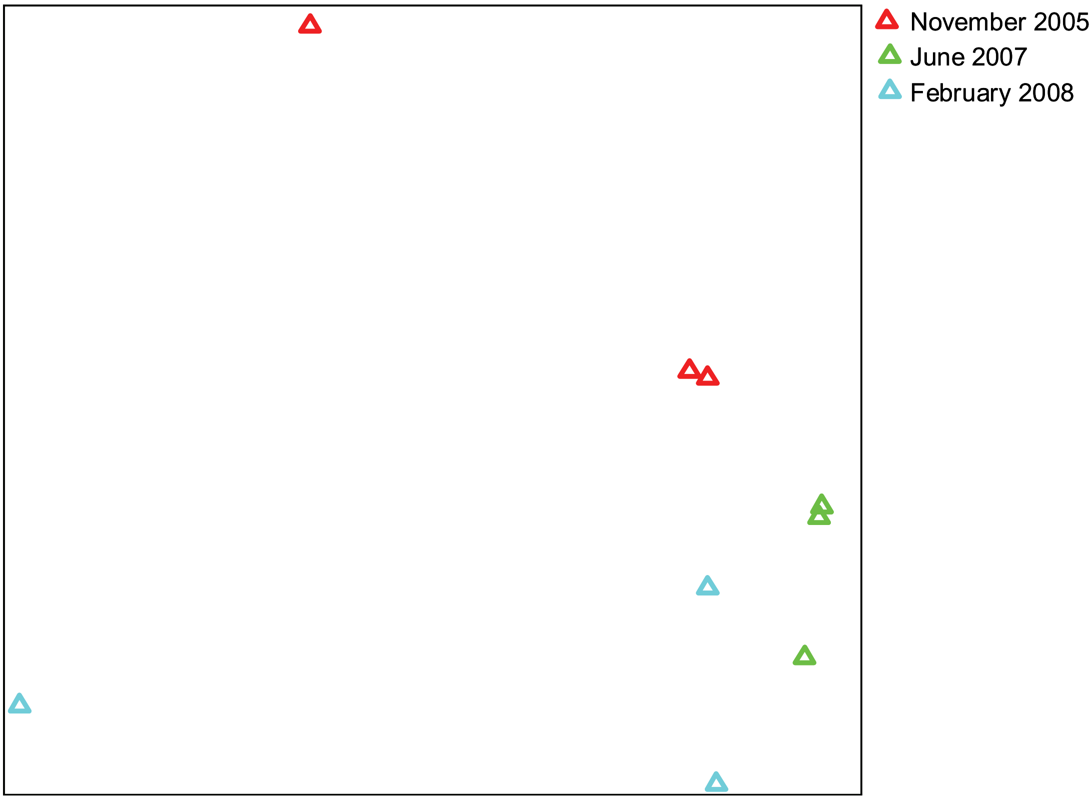


Figure 15: NMS ordination comparing the November 2005, June 2007 and February 2008 surveys for Punkah Flood Runner (stress=0.08).

Before Punkah Creek Flood Runner was watered the plant community was dominated by terrestrial and desiccation tolerant flood dependent species and after watering a diverse community of flood dependent and amphibious species was present (Table 18). However, by February 2008 most of the flood dependent and amphibious species had died and the wetland was dominated by bare soil (Table 18).

Table 18: Species list and Indicator Species Analysis results comparing the floristic composition between the November 2005, June 2007 and February 2008 surveys for Punkah Creek Flood Runner (*denotes exotic species ; NS=not significant).

Taxon	Survey Date	*Monte Carlo P*
Craspedia chrysantha	November 2005 (Pre-watering)	NS Widespread
Eleocharis acuta	June 2007 (Post-watering)	0.0314
Tetragonia tetragonoides	June 2007 (Post-watering)	0.0372
Marsilea angustifolia	June 2007 (Post-watering)	0.042
Centipeda minima	June 2007 (Post-watering)	NS Uncommon
Chenopodium pumilio	June 2007 (Post-watering)	NS Uncommon
Euphorbia drummondii	June 2007 (Post-watering)	NS Uncommon
Haloragis aspera	June 2007 (Post-watering)	NS Uncommon
Lachnagrostis filiformis	June 2007 (Post-watering)	NS Uncommon
Limosella australis	June 2007 (Post-watering)	NS Uncommon
Mollugo cerviana	June 2007 (Post-watering)	NS Uncommon
Muehlenbeckia florulenta	June 2007 (Post-watering)	NS Uncommon
Psuedognaphalium luteo-album	June 2007 (Post-watering)	NS Uncommon
Scleroblitum atriplinicum	June 2007 (Post-watering)	NS Uncommon
Sclerolaena divaricata	June 2007 (Post-watering)	NS Uncommon
Senecio cunninghamii	June 2007 (Post-watering)	NS Uncommon
Trachymene cyanopetula	June 2007 (Post-watering)	NS Uncommon
Carpobrotus rossii	June 2007 (Post-watering)	NS Widespread
Cyperus gymnocaulos	June 2007 (Post-watering)	NS Widespread
Sclerolaena brachyptera	June 2007 (Post-watering)	NS Widespread
Sporobolus mitchelli	June 2007 (Post-watering)	NS Widespread
Bare Soil	February 2008 (Post-watering)	0.031
Epaltes australis	February 2008 (Post-watering)	NS Uncommon
Atriplex spp.	February 2008 (Post-watering)	NS Widespread

3.13. Punkah Island Horseshoes

Punkah Island Horseshoes was watered twice during the study period and pre and post-watering surveys were undertaken (Table 1). Site1 and site 2 were analysed separately because site 1 dried earlier than site 2.

Site 1

Two pre and two post-watering surveys were undertaken at site 1 in Punkah Island Horseshoes and the response of the plant community over the study period was similar at each elevation (although the species driving the changes were different) (Table 19; NMS Ordination, Figure 16). The plant community did not change significantly between November 2004 and January 2005, after watering there was a significant change in floristic composition; however, it had changed back by February 2008 (November 2004=January 2005=February 2008≠June 2006).

Table 19: PERMANOVA *Pseudo-F* statistics comparing the change in floristic composition through time for each elevation at site 1 in Punkah Island Horseshoes.

Elevation	*df*	*Pseudo-F*	*P*
0 cm	3,11	20.24	0.016
+30 cm	3,23	4.32	<0.001
+60 cm	3,23	4.57	<0.001

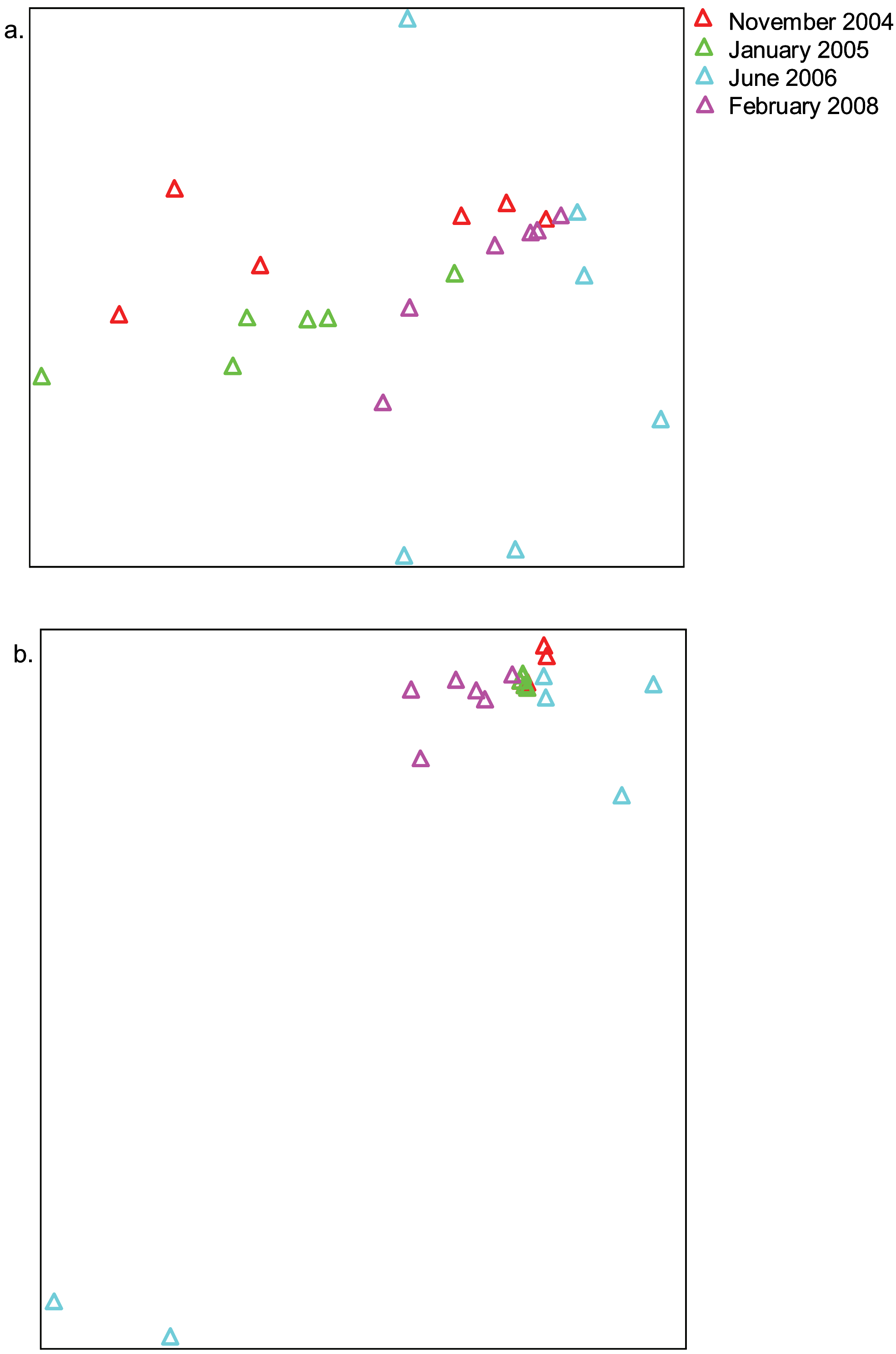


Figure 16: NMS ordination comparing the November 2004, January 2005, June 2006 and February 2008 surveys for Punkah Island Horseshoe Site 1 a. +30 cm (stress=0.152) and b. +60 cm (stress=0.116).

At the 0 cm elevation at site 1 *Sporobolus mitchellii* was the dominant species before and after watering; however, *Marsilea angustifolia* was significantly more abundant in June 2006 (Table 20a). The significantly different plant community in June 2006 was due to higher abundance of *Marsilea angustifolia*.

At +30 cm terrestrial species and *Sporobolus mitchellii* were dominant in November 2004, January 2005 and February 2008; however, by June 2006 a diverse community of flood dependent and amphibious species was present (Table 20b).

At +60 cm terrestrial species and *Sporobolus mitchellii* were the dominant species in November 2004, January2005 and February 2008 but a diverse community of flood dependent and amphibious species was present in June 2006 (Table 20c). However, *Senecio runcifolius, Morgania floribunda* and *Epaltes australis* (flood dependent species) were significantly more abundant in February 2008 (Table 20c).

Arctotheca calendula was the only exotic species that significantly increased in abundance due to watering (Table 20b).

Table 20: Species list and Indicator Species Analysis results comparing the floristic composition between the November 2004, January 2005, June 2006 and February 2008 surveys for Punkah Island Horseshoe Site 1 a. 0 cm, b. +30 cm and c. +60 cm (*denotes exotic species; NS=not significant).

a.

Taxon	**Survey Date**	***Monte Carlo P***
Sporobolus mitchellii	November 2004 (Pre-watering)	NS Widespread
Marsilea angustifolia	June 2006 (Post-watering)	0.0196
Bare Soil	June 2006 (Post-watering)	NS Uncommon
Glinus lotoides	June 2006 (Post-watering)	NS Uncommon
Mimulus repens	June 2006 (Post-watering)	NS Widespread

b.

Taxon	**Survey Date**	***Monte Carlo P***
*Mesembryanthemum crystallinum**	November 2004 (Pre-watering)	0.0068
Maireana microcarpa	November 2004 (Pre-watering)	NS Uncommon
Carpobrotus rossii	November 2004 (Pre-watering)	NS Widespread
Sclerolaena brachyptera	November 2004 (Pre-watering)	NS Widespread
Enchylaena tomentosa	January 2005 (Pre-watering)	0.0004
Atriplex spp.	January 2005 (Pre-watering)	0.0356
Halosarcia pergranulata ssp. *pergranulata*	January 2005 (Pre-watering)	NS Uncommon
Senecio cunninghamii	June 2006 (Post-watering)	0.0038
Centipeda minima	June 2006 (Post-watering)	0.0066
Limosella australis	June 2006 (Post-watering)	0.0362
Marsilea angustifolia	June 2006 (Post-watering)	0.039
*Arctotheca calendula**	June 2006 (Post-watering)	0.041
Chenopodium pumilio	June 2006 (Post-watering)	0.041
Epaltes australis	June 2006 (Post-watering)	0.041
*Atriplex prostrata**	June 2006 (Post-watering)	NS Uncommon
*Carrichtera annua**	June 2006 (Post-watering)	NS Uncommon
*Heliotropium amplexicaule**	June 2006 (Post-watering)	NS Uncommon
*Picris hieracoides**	June 2006 (Post-watering)	NS Uncommon
Rhagodia spinescens	June 2006 (Post-watering)	NS Uncommon
Rumex bidens	June 2006 (Post-watering)	NS Uncommon
Euphorbia drummondii	June 2006 (Post-watering)	NS Widespread
*Heliotropium curassivicum**	June 2006 (Post-watering)	NS Widespread
Mimulus repens	June 2006 (Post-watering)	NS Widespread
Sclerolaena divaricata	February 2008 (Post-watering)	0.0076
Alternanthera denticulata	February 2008 (Post-watering)	NS Widespread
Sporobolus mitchellii	February 2008 (Post-watering)	NS Widespread

c.

Taxon	Survey Date	*Monte Carlo P*
Sclerolaena brachyptera	November 2004 (Pre-watering)	0.0172
Atriplex spp.	November 2004 (Pre-watering)	NS Uncommon
Enchylaena tomentosa	November 2004 (Pre-watering)	NS Uncommon
*Mesembryanthemum crystallinum**	November 2004 (Pre-watering)	NS Uncommon
Sporobolus mitchelli	November 2004 (Pre-watering)	NS Widespread
Marsilea angustifolia	June 2006 (Post-watering)	0.0048
Senecio cunninghamii	June 2006 (Post-watering)	0.0156
Centipeda minima	June 2006 (Post-watering)	0.017
Euphorbia drummondii	June 2006 (Post-watering)	0.032
Alternanthera denticulata	June 2006 (Post-watering)	NS Uncommon
*Aster subulatus**	June 2006 (Post-watering)	NS Uncommon
Dissocarpus paradoxus	June 2006 (Post-watering)	NS Uncommon
Halosarcia pergranulata ssp. *pergranulata*	June 2006 (Post-watering)	NS Uncommon
*Heliotropium curassivicum**	June 2006 (Post-watering)	NS Uncommon
*Hypochoeris radicata**	June 2006 (Post-watering)	NS Uncommon
Isolepis hookeriana	June 2006 (Post-watering)	NS Uncommon
Phyla canescens	June 2006 (Post-watering)	NS Uncommon
Polygonum plebium	June 2006 (Post-watering)	NS Uncommon
Psuedognaphalium luteo-album	June 2006 (Post-watering)	NS Uncommon
Sclerolaena divaricata	June 2006 (Post-watering)	NS Uncommon
*Sonchus oleraceus**	June 2006 (Post-watering)	NS Uncommon
Carpobrotus rossii	June 2006 (Post-watering)	NS Widespread
Senecio runcinifolius	February 2008 (Post-watering)	0.0014
Morgania floribunda	February 2008 (Post-watering)	0.0102
Epaltes australis	February 2008 (Post-watering)	0.0142
Chenopodium pumilio	February 2008 (Post-watering)	NS Widespread

Site 2

Two pre and one post-watering surveys were undertaken at site 2 in Punkah Island Horseshoes (site 2 was at a lower elevation than site 1 and retained water for longer than site 1) and the response of the plant community to watering was not consistent between elevations. The plant community changed significantly over the study period (Table 21; NMS Ordination, Figure 17); at 0 and +60 cm the plant community was significantly different for each survey; however, at +30 cm the November 2004 and January 2005 surveys were not significantly different but the February 2008 survey was significantly different from the two previous surveys (November 2004=January 2005≠February 2008).

Table 21: PERMANOVA *Pseudo-F* statistics comparing the change in floristic composition through time for each elevation at site 2 in Punkah Island Horseshoes.

Elevation	***df***	***Pseudo-F***	***P***
0 cm	3,11	10.41	0.004
+30 cm	3,23	4.43	<0.001
+60 cm	3,23	5.59	<0.001

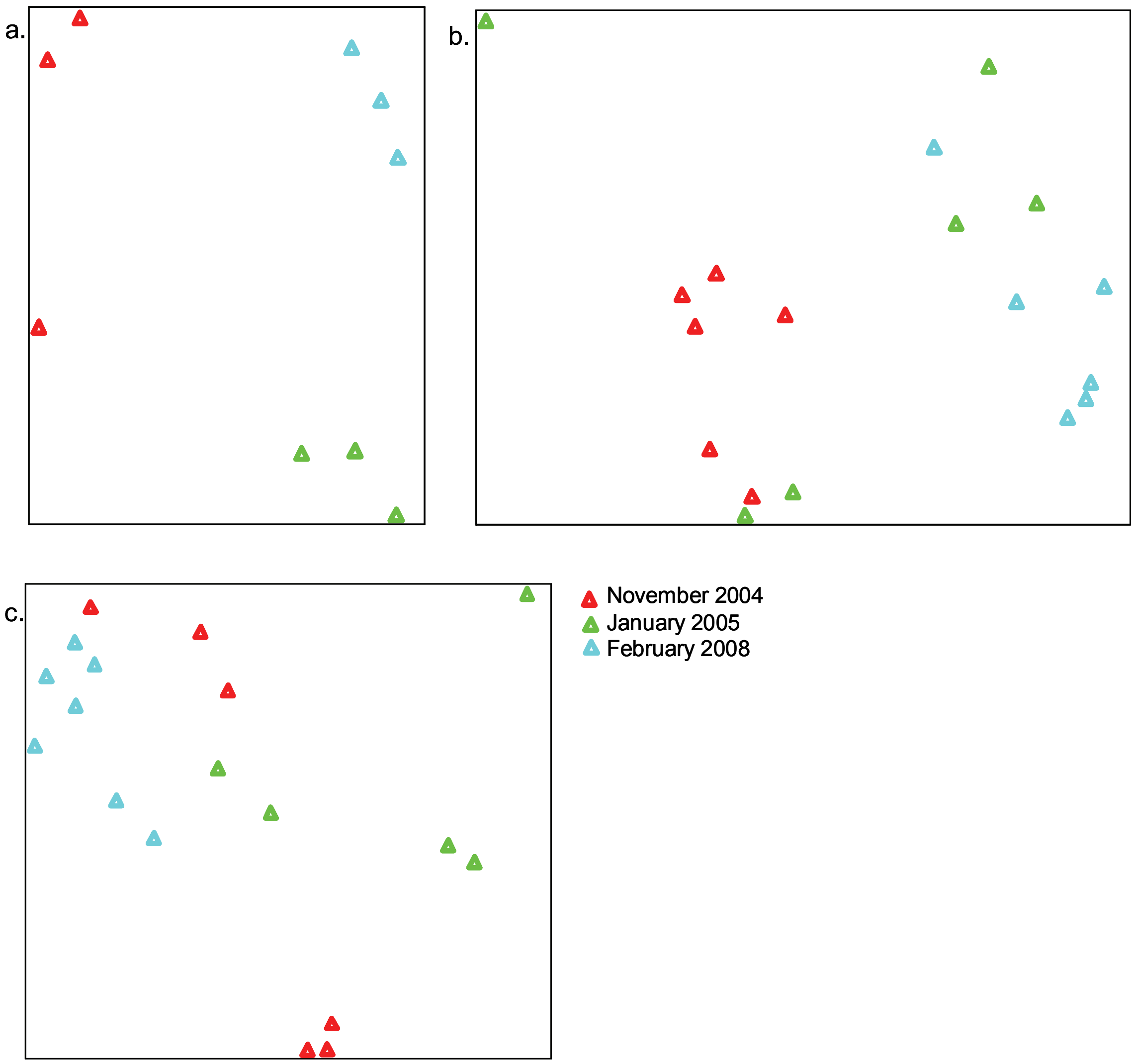


Figure 17: NMS ordination comparing the November 2004, January 2005 and February 2008 surveys for Punkah Island Horseshoe Site 2 a. 0 cm (stress=0.1), b. +30 cm (stress=0.124) and c. +60 cm (stress=0.098).

At the 0 cm elevation at site 2 in November 2004 terrestrial species (*Atriplex* spp. and *Mesembryanthemum crystallinum*) were dominant but they declined in abundance and there were no significant indicators for the January 2005 survey (Table 22a). Post-watering (February 2008) flood dependent (*Glinus lotoides*) and amphibious (*Myriophyllum verrucosum*) species were significantly more abundant (Table 22a).

At +30 cm in November 2004 terrestrial species were dominant but declined in abundance and there were no significant indicators for the January 2005 survey (Table 22b). In February 2008 (post-watering) *Senecio cunninghamii, Chenopodium pumilio, Psuedognaphalium luteo-album* (flood dependent species) and *Mimulus repens* (amphibious species) were dominant (Table 22b). Furthermore, *Eucalyptus camaldulensis* seedlings and *Epaltes australis* were present post-watering but in low numbers (Table 22b).

At +60 cm in November 2004 the terrestrial species *Mesembryanthemum crystallinum* was dominant; however, *Atriplex* spp., *Enchylaena tomentosa* and *Sporobolus mitchelli* were also present (Table 22c). *Mesembryanthemum crystallinum* declined in abundance between November 2004 and January 2005 and post-watering a diverse flood dependent and amphibious community recruited, including *Eucalyptus camaldulensis* seedlings (Table 22c).

Heliotropium europaeaum and *Heliotropium curassivicum* were the only exotic species present in high numbers post-watering (Table 22).

Table 22: Species list and Indicator Species Analysis results comparing the floristic composition between the November 2004, January 2005 and February 2008 surveys for Punkah Island Horseshoe Site 2 a. 0 cm, b. +30 cm and c. +60 cm (*denotes exotic species; NS=not significant).

a.

Taxon	Survey Date	*Monte Carlo P*
Atriplex spp.	November 2004 (Pre-watering)	0.0368
*Mesembryanthemum crystallinum**	November 2004 (Pre-watering)	0.0368
Cyperus gymnocaulos	November 2004 (Pre-watering)	NS Widespread
*Heliotropium europaeaum**	January 2005 (Pre-watering)	NS Widespread
Mimulus repens	January 2005 (Pre-watering)	NS Widespread
*Heliotropium curassivicum**	January 2005 (Pre-watering)	NS Widespread
Glinus lotoides	February 2008 (Post-watering)	0.0358
Myriophyllum verucossum	February 2008 (Post-watering)	0.0412
Bare Soil	February 2008 (Post-watering)	NS Widespread

b.

Taxon	Survey Date	*Monte Carlo P*
Atriplex spp.	November 2004 (Pre-watering)	0.006
*Mesembryanthemum crystallinum**	November 2004 (Pre-watering)	0.0044
Sclerolaena brachyptera	November 2004 (Pre-watering)	0.0172
Cyperus gymnocaulos	November 2004 (Pre-watering)	NS Widespread
Carpobrotus rossii	January 2005 (Pre-watering)	NS Uncommon
Halosarcia pergranulata ssp. *pergranulata*	January 2005 (Pre-watering)	NS Uncommon
*Heliotropium europaeaum**	January 2005 (Pre-watering)	NS Uncommon
Bare Soil	January 2005 (Pre-watering)	NS Widespread
Sporobolus mitchelli	January 2005 (Pre-watering)	NS Widespread
Senecio cunninghamii	February 2008 (Post-watering)	0.0046
Chenopodium pumilio	February 2008 (Post-watering)	0.0152
Mimulus repens	February 2008 (Post-watering)	0.0292
Psuedognaphalium luteo-album	February 2008 (Post-watering)	0.0396
Epaltes australis	February 2008 (Post-watering)	NS Uncommon
Eucalyptus camaldulensis var. *camaldulensis*	February 2008 (Post-watering)	NS Uncommon
Pachycornia triandra	February 2008 (Post-watering)	NS Uncommon
Sclerolaena divaricata	February 2008 (Post-watering)	NS Uncommon

c.

Taxon	Survey Date	*Monte Carlo P*
*Mesembryanthemum crystallinum**	November 2004 (Pre-watering)	0.04
Carpobrotus rossii	November 2004 (Pre-watering)	NS Uncommon
Halosarcia pergranulata ssp. *pergranulata*	November 2004 (Pre-watering)	NS Uncommon
Enchylaena tomentosa	November 2004 (Pre-watering)	NS Widespread
Sporobolus mitchelli	November 2004 (Pre-watering)	NS Widespread
Bare Soil	November 2004 (Pre-watering)	NS Uncommon
Cyperus gymnocaulos	February 2008 (Post-watering)	0.0004
Epaltes australis	February 2008 (Post-watering)	0.0006
Senecio cunninghamii	February 2008 (Post-watering)	0.0188
Centipeda minima	February 2008 (Post-watering)	0.021
*Heliotropium europaeaum**	February 2008 (Post-watering)	0.0378
Iseotopsis graminifolia	February 2008 (Post-watering)	0.0378
Limosella australis	February 2008 (Post-watering)	0.0378
Glinus lotoides	February 2008 (Post-watering)	0.041
Chenopodium pumilio	February 2008 (Post-watering)	NS Uncommon
Eucalyptus camaldulensis var. *camaldulensis*	February 2008 (Post-watering)	NS Uncommon
Psuedognaphalium luteo-album	February 2008 (Post-watering)	NS Uncommon
Sclerolaena divaricata	February 2008 (Post-watering)	NS Uncommon
Atriplex spp.	February 2008 (Post-watering)	NS Widespread

3.14. Twin Creeks

Twin Creeks was watered twice during the study period and four post-watering surveys were undertaken (Table 1). The floristic composition changed significantly over the study period (PERMANOVA *Pseudo-*$F_{3,47}$=9.56, P<0.001; NMS Ordination Figure 18) and was significantly different for each survey.

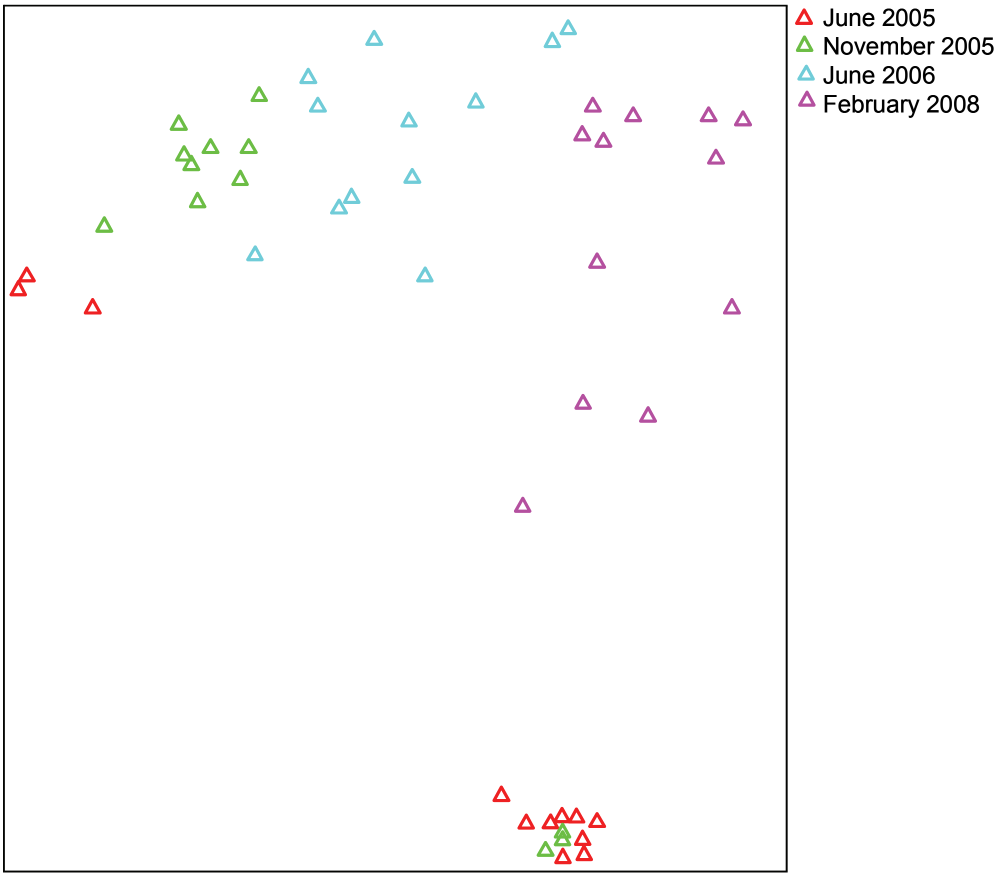


Figure 18: NMS ordination comparing the June 2005, November 2005, June 2006 and February 2008 surveys for Twin Creeks (stress=0.145).

Throughout the study period Twin Creeks has been dominated by flood dependent and amphibious species, except for the June 2005 survey when bare soil was dominant (although, several flood dependent species were present in low numbers in June 2005) (Table 23). Furthermore, *Eucalyptus camaldulensis, Acacia stenophylla* and *Muehlenbeckia florulenta* seedlings were present but several exotic taxa were also present (Table 23). However, *Xanthium occidentale, Hypochoeris radicata* and *Phyla canescens* (exotic species) were also abundant at times throughout the study period (Table 23).

Table 23: Species list and Indicator Species Analysis results comparing the floristic composition between the June 2005, November 2005, June 2006 and February 2008 surveys for Twin Creeks (*denotes exotic species ; NS=not significant).

Taxon	**Survey Date**	***Monte Carlo P***
Bare Soil	June 2005	<0.001
Ammania multiflora	June 2005	NS Uncommon
Euphorbia drummondii	June 2005	NS Uncommon
Glinus lotoides	June 2005	NS Uncommon
*Heliotropium amplexicaule**	June 2005	NS Uncommon
Centipeda minima	November 2005	<0.001
Craspedia chrysantha	November 2005	<0.001
*Xanthium occidentale**	November 2005	<0.001
Psuedognaphalium luteo-album	November 2005	0.0044
Isolepis hookeriana	November 2005	0.0102
Alternanthera denticulata	November 2005	0.0156
Plantago turrifera	November 2005	0.0238
Polygonum plebium	November 2005	0.043
Senecio runcinifolius	November 2005	0.0474
Wahlenbergia fluminalis	November 2005	0.0491
Carpobrotus rossii	November 2005	NS Uncommon
Cyperus gymnocaulos	November 2005	NS Uncommon
*Hordeum vulgare**	November 2005	NS Uncommon
Iseotopsis graminifolia	November 2005	NS Uncommon
Lachnagrostis filiformis	November 2005	NS Uncommon
Limosella australis	November 2005	NS Uncommon
Marsilea angustifolia	November 2005	NS Uncommon
*Rorippa palustris**	November 2005	NS Uncommon
Epaltes australis	November 2005	NS Widespread
Eucalyptus camaldulensis var. *camaldulensis*	November 2005	NS Widespread
Brachycome basaltica	June 2006	0.0032
*Hypochoeris radicata**	June 2006	0.0038
Morgania floribunda	June 2006	0.004
Atriplex spp.	June 2006	0.0136
Tetragonia tetragonoides	June 2006	0.015
Sclerolaena divaricata	June 2006	0.0314
Muehlenbeckia florulenta	June 2006	0.0474
*Arctotheca calendula**	June 2006	NS Uncommon
Chenopodium pumilio	June 2006	NS Uncommon
*Conyza bonariensis**	June 2006	NS Uncommon
*Echium plantagineum**	June 2006	NS Uncommon
*Heliotropium europaeaum**	June 2006	NS Uncommon
Mollugo cerviana	June 2006	NS Uncommon
Rhodanthe pygmaeum	June 2006	NS Uncommon

Taxon	**Survey Date**	***Monte Carlo P***
Haloragis aspera	June 2006	NS Widespread
Senecio cunninghamii	June 2006	NS Widespread
Sporobolus mitchelli	February 2008	<0.001
Eragrostis australasica	February 2008	0.0018
Acacia stenophylla	February 2008	NS Uncommon
*Phyla canescens**	February 2008	NS Widespread
Sclerolaena brachyptera	February 2008	NS Widespread

3.15. Werta Wert Wetland

Werta Wert Wetland was watered twice during the study period and four post-watering surveys were undertaken. In each basin the plant community changed significantly through time and was significantly different for each survey (Table 24; NMS Ordination, Figure 19).

Table 24: PERMANOVA *Pseudo-F* statistics comparing the change in floristic composition through time for each basin of Werta Wert Wetland.

Basin	*df*	*Pseudo-F*	*P*
Central	3,35	19.42	<0.001
Northern	3,35	38.48	<0.001
Southern	3,35	14.92	<0.001

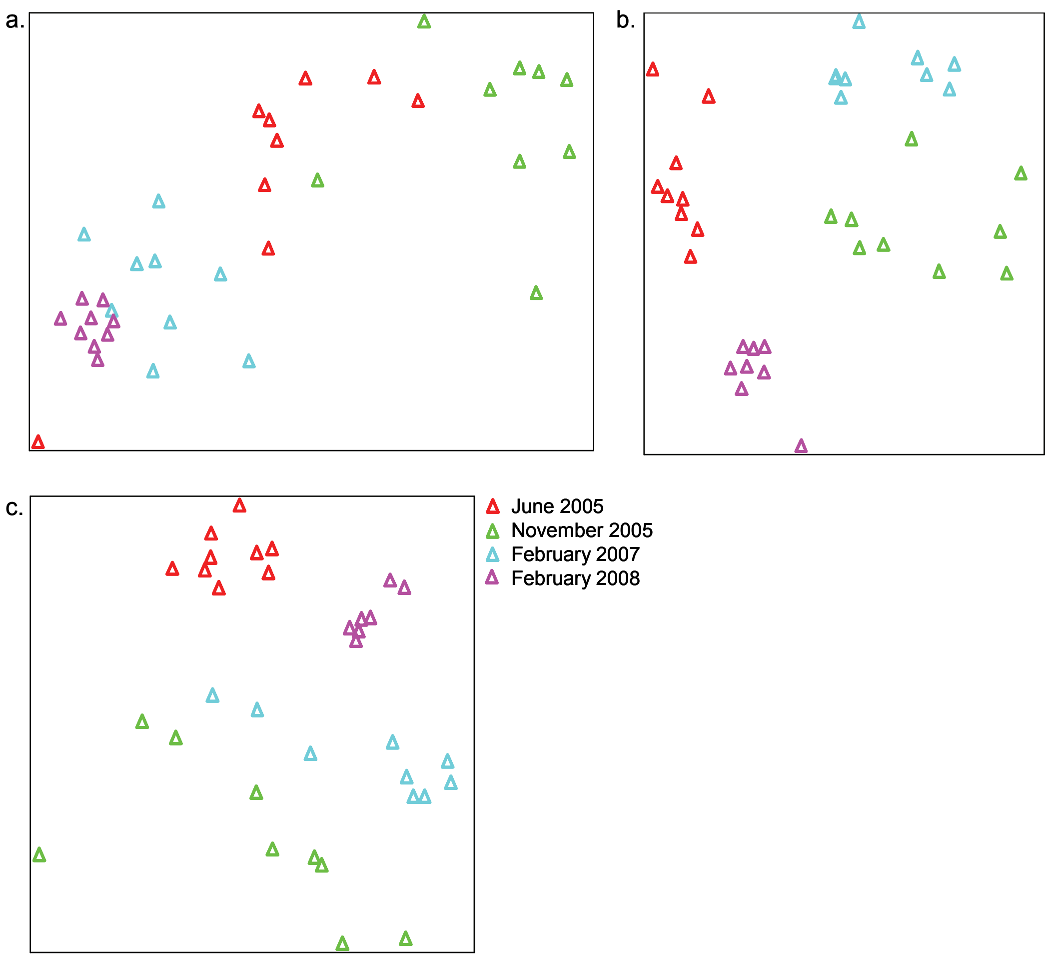


Figure 19: NMS ordination comparing the June 2005, November 2005, February 2007 and February 2008 surveys for a. the Central Basin (stress=0.176), b. the Northern Basin (stress=0.14) and c. the Southern Basin (stress=0.15) of Werta Wert Wetland.

From June 2005 to February 2007 all basins were generally dominated by flood dependent and amphibious species; however, by February 2008 terrestrial species had colonised the wetland and bare soil was also a significant indicator in the southern basin (Table 25). In addition, the exotic taxa *Heliotropium amplexicaule, Heliotropium europaeaum, Abutilon theophrasti, Xanthium occidentale, Medicago* spp., *Trifolium* spp. and *Cuscuta campestris* were common throughout the study period. The *Eucalyptus camaldulensis* individuals present in the southern and central basins were adult trees or saplings (at least 5 years old) and had not recruited in response to watering.

Table 25: Species list and Indicator Species Analysis results comparing the floristic composition between the June 2005, November 2005, February 2007 and February 2008 surveys for a. the Central Basin, b. the Northern Basin and c. the Southern Basin of Werta Wert Wetland (*denotes exotic species; NS=not significant).

a.

Taxon	Survey Date	*Monte Carlo P*
Glinus lotoides	June 2005	0.0028
Glycyrrhiza acanthocarpa	June 2005	NS Uncommon
Medicago spp.*	June 2005	NS Uncommon
Eucalyptus camaldulensis var. *camaldulensis*	June 2005	NS Widespread
Myriophyllum verucossum	November 2005	<0.001
Polygonum plebium	November 2005	<0.001
Brachycome basaltica	November 2005	<0.001
Centipeda minima	November 2005	<0.001
*Abutilon theophrasti**	November 2005	0.0012
Chenopodium pumilio	November 2005	0.0012
Psuedognaphalium luteo-album	November 2005	0.0018
*Heliotropium europaeaum**	November 2005	0.005
Craspedia chrysantha	November 2005	0.043
Mimulus repens	November 2005	0.048
Eragrostis dielsii	November 2005	NS Uncommon
Limosella australis	November 2005	NS Uncommon
Plantago turrifera	November 2005	NS Uncommon
Alternanthera denticulata	November 2005	NS Widespread
Epaltes australis	November 2005	NS Widespread
Isolepis hookeriana	November 2005	NS Widespread
Lachnagrostis filiformis	November 2005	NS Widespread
Sporobolus mitchelli	November 2005	NS Widespread
*Heliotropium amplexicaule**	February 2007	NS Widespread
Bare Soil	February 2008	NS Uncommon
Atriplex spp.	February 2008	NS Widespread

b.

Taxon	Survey Date	*Monte Carlo P*
Glinus lotoides	June 2005	<0.001
*Heliotropium europaeaum**	June 2005	<0.001
Myriophyllum verucossum	June 2005	<0.001
Chenopodium pumilio	June 2005	0.016
*Malva parviflora**	June 2005	NS Uncommon
Mimulus repens	June 2005	NS Uncommon
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	0.01
Alternanthera denticulata	November 2005	0.0114
Tetragonia tetragonoides	November 2005	0.05
*Bromus rubens**	November 2005	NS Uncommon
*Centaurea calcitrapa**	November 2005	NS Uncommon
Muehlenbeckia florulenta	November 2005	NS Uncommon
Polygonum aviculare	November 2005	NS Uncommon
Psuedognaphalium luteo-album	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
Sclerolaena divaricata	November 2005	NS Widespread
Marsilea angustifolia	February 2007	<0.001
Polygonum plebium	February 2007	<0.001
*Polypogon monspeliensis**	February 2007	<0.001
Rumex bidens	February 2007	<0.001
Isolepis hookeriana	February 2007	0.044
Trifolium spp.*	February 2007	0.044
*Atriplex prostrata**	February 2007	NS Uncommon
Brachycome basaltica	February 2007	NS Uncommon
Cyperus gymnocaulos	February 2007	NS Uncommon
Rorippa islandica	February 2007	NS Uncommon
Trachymene cyanopetula	February 2007	NS Uncommon
*Abutilon theophrasti**	February 2007	NS Widespread
Medicago spp.*	February 2007	NS Widespread
Enchylaena tomentosa	February 2008	0.0074
Atriplex spp.	February 2008	NS Widespread
Bare Soil	February 2008	NS Widespread

c.

Taxon	Survey Date	*Monte Carlo P*
*Heliotropium europaeaum**	June 2005	<0.001
Centipeda minima	June 2005	0.0036
Myriophyllum verucossum	June 2005	NS Uncommon
Rumex bidens	November 2005	<0.001
Craspedia chrysantha	November 2005	<0.001
Lachnagrostis filiformis	November 2005	0.002
Polygonum plebium	November 2005	0.0026
*Heliotropium amplexicaule**	November 2005	0.003
Medicago spp.*	November 2005	0.0094
Alternanthera denticulata	November 2005	0.0462
*Aster subulatus**	November 2005	NS Uncommon
Eragrostis dielsii	November 2005	NS Uncommon
*Malva parviflora**	November 2005	NS Uncommon
Stipa sp.	November 2005	NS Uncommon
Wahlenbergia fluminalis	November 2005	NS Uncommon
*Cuscuta campestris**	November 2005	NS Widespread
Glycyrrhiza acanthocarpa	November 2005	NS Widespread
Chenopodium pumilio	February 2007	0.0076
Eucalyptus camaldulensis var. *camaldulensis*	February 2007	NS Uncommon
Sclerolaena divaricata	February 2007	NS Uncommon
Brachycome basaltica	February 2007	NS Widespread
Glinus lotoides	February 2007	NS Widespread
Mollugo cerviana	February 2007	NS Widespread
Sporobolus mitchelli	February 2007	NS Widespread
Bare Soil	February 2008	0.0412
Enchylaena tomentosa	February 2008	NS Uncommon
Atriplex spp.	February 2008	NS Widespread

3.16. Woolshed Creek

Woolshed Creek was watered twice during the study period and two pre and one post watering surveys were undertaken (Table 1). The plant community changed significantly through time at all elevations (Table 26; NMS Ordination, Figure 20) and the change though time was consistent between elevations. There was no significant difference in floristic composition between November 2004 and January 2005 (pre-watering surveys) but the plant community changed significantly between January 2005 and February 2008 (post-watering) (November 2004=January 2005≠February 2008).

Table 26: PERMANOVA *Pseudo-F* statistics comparing the change in floristic composition through time for each elevation in Woolshed Creek.

Elevation	*df*	*Pseudo-F*	*P*
0 cm	2,17	4.47	<0.001
+30 cm	2,35	10.74	<0.001
+60 cm	2,35	9.78	<0.001

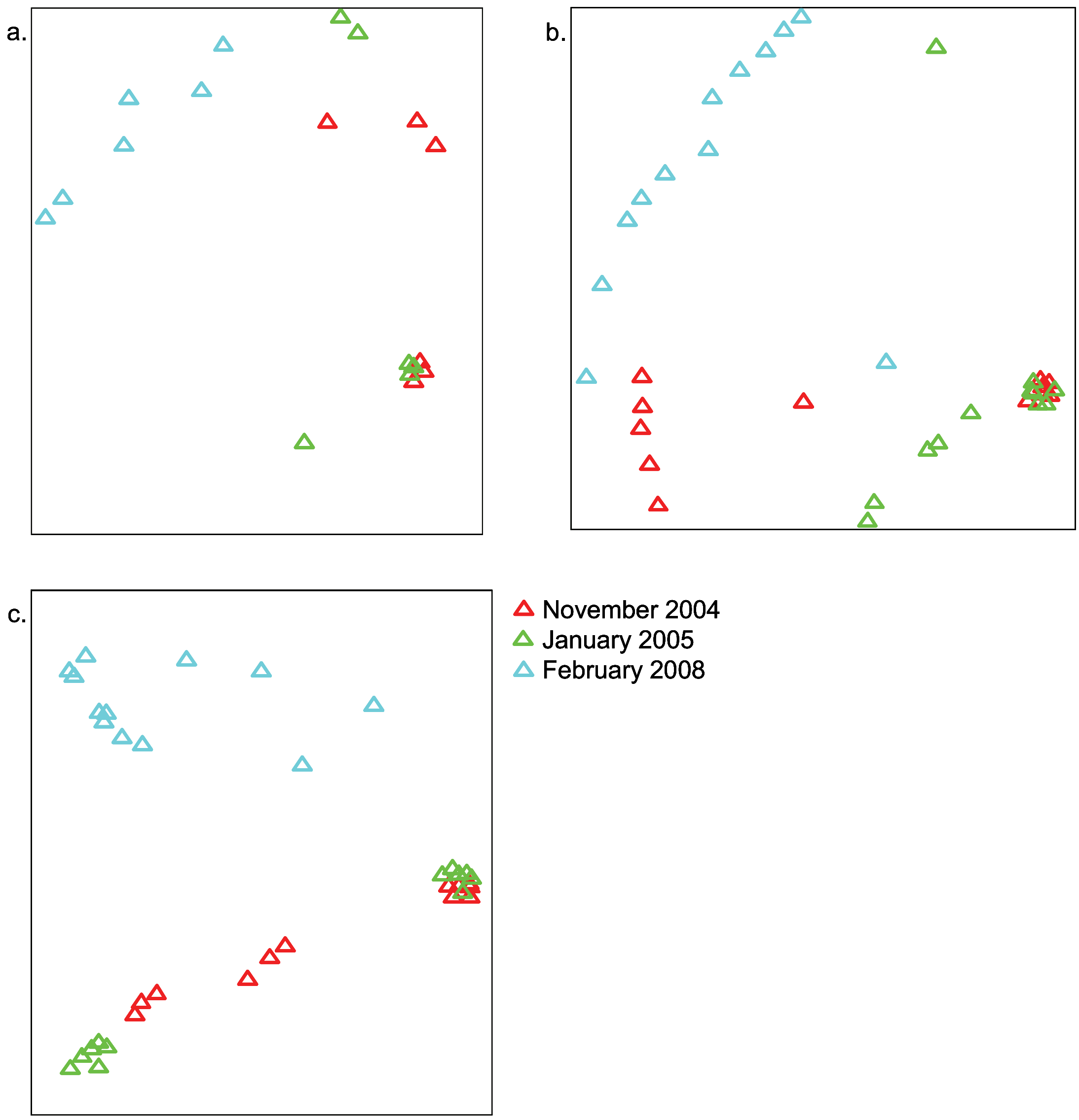


Figure 20: NMS ordination comparing the November 2004, January 2005 and February 2008 surveys for Woolshed Creek a. 0 cm (stress=0.112), b. +30 cm (stress=0.15) and c. +60 cm (stress=0.12).

Pre-watering the plant community at all elevations was dominated by bare soil and terrestrial taxa and post-watering a diverse community dominated by flood dependent and amphibious species was present (Table 27). The +30 and +60 cm elevations had a larger number of flood dependent and amphibious species post-watering than the 0 cm elevation (Table 27). Furthermore, *Eucalyptus camaldulensis* seedlings were present post-watering at all elevations (and were significant indicators of the February 2008 survey at the +30 and +60 cm elevations) and *Acacia stenophylla* seedlings were present at the 0 cm elevation (Table 27). *Heliotropium curassivicum* and *Heliotropium europaeaum* were the only exotic species present in high numbers post-watering (Table 27).

Table 27: Species list and Indicator Species Analysis results comparing the floristic composition between the November 2004, January 2005 and February 2008 surveys for Woolshed Creek a. 0 cm, b. +30 cm and c. +60 cm (*denotes exotic species; NS=not significant).

a.

Taxon	**Survey Date**	***Monte Carlo P***
Bare Soil	January 2005 (Pre-watering)	0.0252
Sclerolaena brachyptera	January 2005 (Pre-watering)	0.0498
*Mesembryanthemum crystallinum**	January 2005 (Pre-watering)	NS Uncommon
Psuedognaphalium luteo-album	January 2005 (Pre-watering)	NS Uncommon
*Spergularia marina**	January 2005 (Pre-watering)	NS Uncommon
Atriplex spp.	January 2005 (Pre-watering)	NS Widespread
Sporobolus mitchelli	January 2005 (Pre-watering)	NS Widespread
Glinus lotoides	February 2008 (Post-watering)	0.0044
*Heliotropium europaeaum**	February 2008 (Post-watering)	0.0044
Chenopodium pumilio	February 2008 (Post-watering)	0.0398
Senecio cunninghamii	February 2008 (Post-watering)	0.0398
Acacia stenophylla	February 2008 (Post-watering)	NS Uncommon
Alternanthera denticulata	February 2008 (Post-watering)	NS Uncommon
Ammania multiflora	February 2008 (Post-watering)	NS Uncommon
Centipeda minima	February 2008 (Post-watering)	NS Uncommon
Cyperus gymnocaulos	February 2008 (Post-watering)	NS Uncommon
Epaltes australis	February 2008 (Post-watering)	NS Uncommon
Eucalyptus camaldulensis var. *camaldulensis*	February 2008 (Post-watering)	NS Uncommon
*Heliotropium amplexicaule**	February 2008 (Post-watering)	NS Uncommon
*Heliotropium curassivicum**	February 2008 (Post-watering)	NS Uncommon
Medicago spp.*	February 2008 (Post-watering)	NS Uncommon
Morgania floribunda	February 2008 (Post-watering)	NS Uncommon
Polygonum plebium	February 2008 (Post-watering)	NS Uncommon

b.

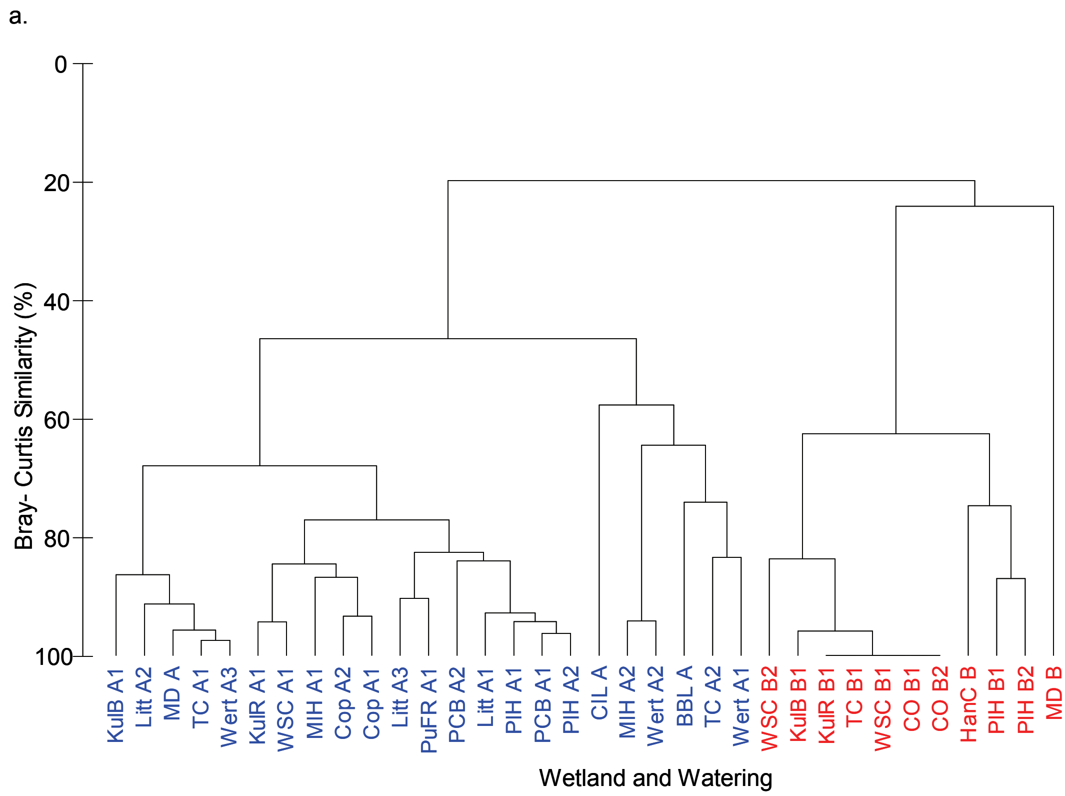
Taxon	**Survey Date**	***Monte Carlo P***
Sclerolaena brachyptera	November 2004 (Pre-watering)	0.0022
*Mesembryanthemum crystallinum**	November 2004 (Pre-watering)	0.0046
Atriplex spp.	November 2004 (Pre-watering)	0.0188
*Spergularia marina**	November 2004 (Pre-watering)	NS Uncommon
Carpobrotus rossii	November 2004 (Pre-watering)	NS Uncommon
*Rorippa palustris**	November 2004 (Pre-watering)	NS Uncommon
Wahlenbergia fluminalis	November 2004 (Pre-watering)	NS Uncommon
Cyperus gymnocaulos	November 2004 (Pre-watering)	NS Uncommon
Euphorbia drummondii	November 2004 (Pre-watering)	NS Uncommon
Sclerolaena divaricata	November 2004 (Pre-watering)	NS Uncommon
Bare Soil	January 2005 (Pre-watering)	<0.001
Enchylaena tomentosa	January 2005 (Pre-watering)	NS Widespread
Chenopodium pumilio	February 2008 (Post-watering)	<0.001
Epaltes australis	February 2008 (Post-watering)	<0.001
Glinus lotoides	February 2008 (Post-watering)	<0.001
*Heliotropium curassivicum**	February 2008 (Post-watering)	<0.001
*Heliotropium europaeaum**	February 2008 (Post-watering)	<0.001
Alternanthera denticulata	February 2008 (Post-watering)	<0.001
Centipeda minima	February 2008 (Post-watering)	<0.001
Senecio cunninghamii	February 2008 (Post-watering)	0.0098
Eucalyptus camaldulensis var. *camaldulensis*	February 2008 (Post-watering)	0.013
Sporobolus mitchelli	February 2008 (Post-watering)	0.018
Polygonum plebium	February 2008 (Post-watering)	0.0422
Glycyrrhiza acanthocarpa	February 2008 (Post-watering)	NS Uncommon
*Heliotropium amplexicaule**	February 2008 (Post-watering)	NS Uncommon
Senecio runcinifolius	February 2008 (Post-watering)	NS Uncommon
Ammania multiflora	February 2008 (Post-watering)	NS Uncommon
Cyperus exaltatus	February 2008 (Post-watering)	NS Uncommon
Morgania floribunda	February 2008 (Post-watering)	NS Uncommon

c.

Taxon	Survey Date	*Monte Carlo P*
Carpobrotus rossii	November 2004 (Pre-watering)	0.0106
*Mesembryanthemum crystallinum**	November 2004 (Pre-watering)	0.013
Sclerolaena brachyptera	November 2004 (Pre-watering)	0.0302
Euphorbia drummondii	November 2004 (Pre-watering)	NS Uncommon
Muehlenbeckia florulenta	November 2004 (Pre-watering)	NS Uncommon
*Rorippa palustris**	November 2004 (Pre-watering)	NS Uncommon
*Solanum nigrum**	November 2004 (Pre-watering)	NS Widespread
Sporobolus mitchelli	November 2004 (Pre-watering)	NS Widespread
Bare Soil	January 2005 (Pre-watering)	0.0002
Atriplex spp.	January 2005 (Pre-watering)	0.024
Sclerolaena divaricata	January 2005 (Pre-watering)	NS Widespread
Epaltes australis	February 2008 (Post-watering)	<0.001
Eucalyptus camaldulensis var. *camaldulensis*	February 2008 (Post-watering)	<0.001
Centipeda minima	February 2008 (Post-watering)	<0.001
Senecio cunninghamii	February 2008 (Post-watering)	<0.001
Chenopodium pumilio	February 2008 (Post-watering)	<0.001
Glinus lotoides	February 2008 (Post-watering)	0.001
Polygonum plebium	February 2008 (Post-watering)	0.0014
Alternanthera denticulata	February 2008 (Post-watering)	0.0018
*Heliotropium curassivicum**	February 2008 (Post-watering)	0.0112
Morgania floribunda	February 2008 (Post-watering)	0.029
Cyperus gymnocaulos	February 2008 (Post-watering)	0.044
*Heliotropium europaeaum**	February 2008 (Post-watering)	0.049
Senecio runcinifolius	February 2008 (Post-watering)	0.05
*Atriplex prostrata**	February 2008 (Post-watering)	NS Uncommon
Brachycome basaltica	February 2008 (Post-watering)	NS Uncommon
*Conyza bonariensis**	February 2008 (Post-watering)	NS Uncommon
Cyperus exaltatus	February 2008 (Post-watering)	NS Uncommon
Eragrostis dielsii	February 2008 (Post-watering)	NS Uncommon
Glycyrrhiza acanthocarpa	February 2008 (Post-watering)	NS Uncommon
Isolepis hookeriana	February 2008 (Post-watering)	NS Uncommon
Lachnagrostis filiformis	February 2008 (Post-watering)	NS Uncommon
Ludwigia peploides ssp. *montevidensis*	February 2008 (Post-watering)	NS Uncommon
Persicaria lapathifolium	February 2008 (Post-watering)	NS Uncommon
Psuedognaphalium luteo-album	February 2008 (Post-watering)	NS Uncommon
Wahlenbergia fluminalis	February 2008 (Post-watering)	NS Uncommon
*Xanthium occidentale**	February 2008 (Post-watering)	NS Uncommon

3.17. Changes in functional group abundance in response to watering

The changes in the abundance of functional groups across multiple sites show very clear patterns before and after watering. At a similarity of 20% cluster analysis (based on the abundance of functional groups) identifies two significantly different groups that correspond to before (red labels) and after watering (blue labels) (Figure 21a). Indicator species analysis showed that the cluster containing the pre-watering surveys was dominated by bare soil and the terrestrial functional group and the cluster containing the post-watering surveys was dominated by the amphibious and flood dependent functional groups. In contrast, cluster analysis shows four groups at a similarity of 20% comparing the floristic composition of the same wetlands, with no clear groups separating pre and post-watering (Figure 21b).



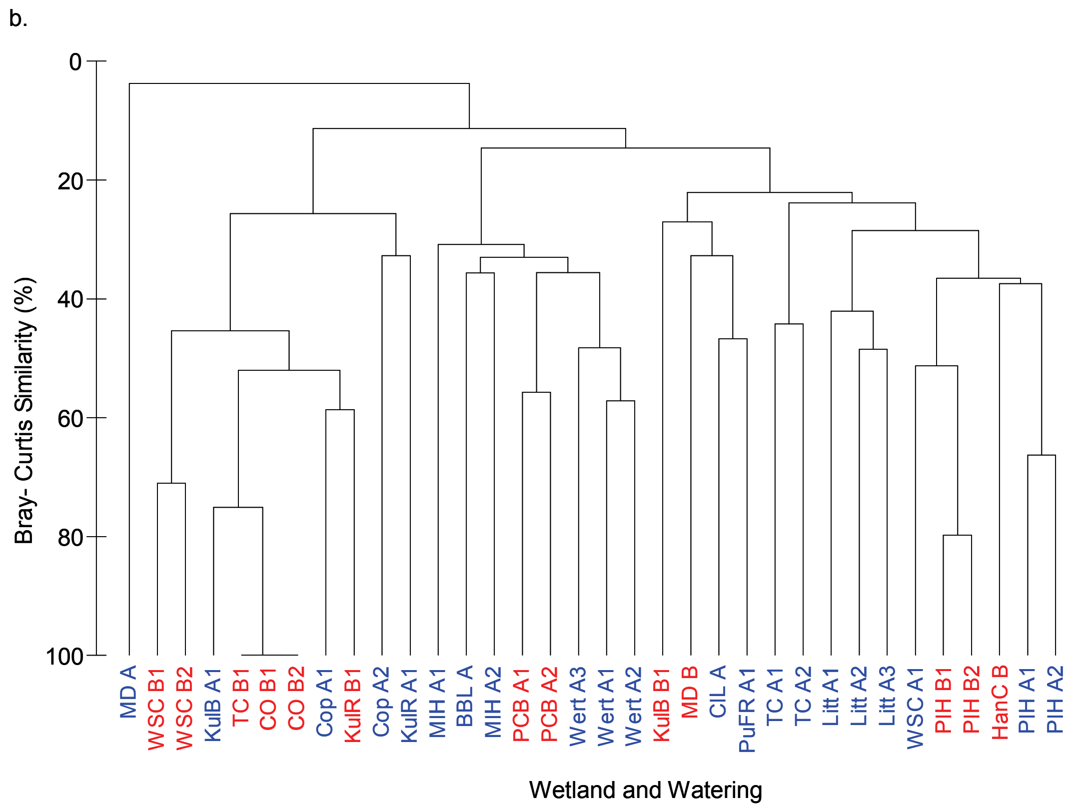


Figure 21: Group average cluster analysis comparing a. the abundance of functional groups and b. the floristic composition before and after watering.

Table 28: 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**
Brandy Bottle Lagoon	Yes	No	Yes	Yes	Despite no significant increase in the abundance of flood dependent species or grazing sensitive species, there were several recorded in low numbers exclusively in the post watering survey. There was no significant increase in abundance of pest plants species and no overstorey seedlings were observed (Table 4).
Chowilla Island Loop	Yes	Yes	Yes	Yes	No pre-watering survey was undertaken but several flood dependent species (most of which are sensitive to grazing) were present post-watering and large numbers of *Eucalyptus camaldulensis* seedlings were present post-watering. Eight exotic taxa were present but were in low numbers (Table 5).
Chowilla Island Oxbow	Yes	Yes	Yes	No	Several flood dependent species (some of which were sensitive to grazing) increased in abundance due to watering; *Eucalyptus camaldulensis* seedlings were also present (in large numbers) post-watering but the abundance of four exotics increased significantly in response to watering (Table 7).
Coppermine Waterhole	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* seedlings were present in high numbers and *Acacia stenophylla* and *Muehlenbeckia florulenta* seedlings were also present. However, five exotic species were abundant over the study period (Table 9).
Kulcurna Black Box	Yes	No	Yes	Yes	The only species that increased in abundance in response to watering was *Wahlenbergia fluminalis* (flood dependent, gazing sensitive species). No overstorey seedlings were observed but there was no increase in the abundance of exotic taxa (Table 10).
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. *Heliotropium europaeaum* was the only exotic species present in high numbers; however, it was abundant throughout the study period (Table 11).
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 were present in high numbers (although they were not present in any of the quadrats, they were abundant around the edge of the lake) and *Muehlenbeckia florulenta* seedlings were also present but not in any of the survey quadrats. *Medicago* spp. was abundant in November 2005 after the first watering but was the only exotic present in large numbers (Table 12).
Monoman Depression	Yes	No	Yes	Yes	*Glinus lotoides* abundance increased significantly and several terrestrial species decreased in abundance in response to watering (although the response was short-lived with bare soil increasing significantly in abundance between February 2007 and February 2008 in the absence of further watering). No overstorey seedlings were observed and there was no increase in the abundance of pest plants (Table 13).
Monoman Island Horseshoe	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. *Medicago* spp. was the only exotic present in large numbers (Table 15).
Pipeclay Creek Billabong	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; however, the entire flood dependent and amphibious understorey community except *Sporobolus mitchellii, Senecio cunninghamii* and *Brachycome basaltica* had died by February 2008. *Eucalyptus camaldulensis* seedlings were present in high numbers. The only exotic species present in large numbers was *Heliotropium europaeaum* (Table 16).

	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**
Punkah Creek Depression	Yes	No	Yes	No	Significant increase in *Myriophyllum verrucosum, Lachnagrostis filiformis* and *Typha domingensis* abundance post-watering (and several flood dependent grazing sensitive species were also present in low numbers) but there was also a significant increase in the exotic species *Abutilon theophrasti* and *Heliotropium europaeaum*. The response to watering was short-lived with all flood dependent and amphibious species (except *Glycyrrhiza acanthocarpa*) dying and a significant increase in bare soil by February 2008. No overstorey seedlings were observed (Table 17).
Punkah Creek Flood Runner	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) recruited in response to watering; however, the entire flood dependent and amphibious understorey community except *Sporobolus mitchellii* and *Cyperus gymnocaulos* had died and bare soil was dominant by February 2008. *Muehlenbeckia florulenta* seedlings were observed on the edge of the wetland (Table 18).
Punkah Island Horseshoes	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* seedlings were observed around the edges of the eastern horseshoe. *Heliotropium curassivicum* and *Heliotropium europaeaum* were the only exotic species present; however, they did recruit in response to watering and were present in large numbers (Table 20, Table 22).
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, Acacia stenophylla* and *Muehlenbeckia florulenta* seedlings were also observed. However, *Xanthium occidentale, Hypochoeris radicata* and *Phyla canescens* were present in high numbers at times (Table 23).
Werta Wert Wetland	Yes	No	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. However, no overstorey seedlings were present and *Abutilon theophrasti, Heliotropium europaeaum, Heliotropium amplexicaule, Sonchus oleraceus, Xanthium occidentale, Polypogon monspeliensis* and *Medicago* spp. were present in large numbers at times (Table 25).
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* seedlings were observed throughout the wetland. However, *Heliotropium europaeaum* and *Heliotropium curassivicum* also increased in abundance in response to watering (Table 27).

4. Discussion, Management Implications and Further Studies

In all wetlands where pre and post-watering surveys were undertaken (except Brandy Bottle Lagoon) 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 an increase in the abundance of flood dependent and amphibious taxa (Figure 21a, Table 28). Furthermore, sites where only post-watering surveys were undertaken were dominated by amphibious and flood dependent taxa within 12 months of watering (Table 28). The plant community in Brandy Bottle Lagoon was dominated by terrestrial taxa pre-watering and flood dependent taxa post-watering but was spatially variable. Therefore, lack of statistical power was probably the reason a significant difference was not detected (only three quadrats were surveyed in Brandy Bottle Lagoon). An increase in the number of replicates in Brandy Bottle Lagoon (and other sites where only three replicates have been established) for future surveys will give greater statistical power to detect differences (Quin and Keogh 2002).

The plant community that developed in response to watering varied between sites (Figure 21b) 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 drawdown (Britton and Brock 1994), rate of draw down (Nicol *et al.* 2003; Nicol 2004), soil texture (Nicol 2004), 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. Nevertheless, the response of the plant community in relation to water regime functional groups was very consistent between sites regardless of the aforementioned factors (Figure 21a). These results provide justification of the functional approach used to determine TLM understorey targets (Murray Darling Freshwater Research Centre 2010) and can be used to assess TLM targets. Furthermore, there is potential to use water regime functional groups to assess the impacts of flooding (regulated and natural) at the whole of floodplain scale and compare the impact of management actions between systems and across different spatial and temporal scales.

Results from Coppermine Waterhole, Woolshed Creek and Punkah Island Horseshoes and observations in Lake Littra and Kulcurna Red Gum flood runner show that the greatest understorey diversity is located at the edge of the wetland. Therefore, for future monitoring, quadrats will be established around the edges of all wetlands (at the maximum water level) to gain a better indication of how the plant community has changed in response to watering and report on TLM targets. A review of the environmental watering and floodplain vegetation condition monitoring programs needs to be undertaken to consolidate both monitoring programs and ensure that an effective monitoring program to assess the impact of the Chowilla Creek regulator is established before construction is completed.

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 28). These results (and results from the condition monitoring program (Gehrig *et al.* 2010) show that the understorey community is resilient and there is potential for flood dependent and amphibious species to recolonise areas of floodplain that have not been inundated for over five years. However, overstorey (*Eucalyptus camaldulensis, Muehlenbeckia florulenta* and *Acacia stenophylla*) seedlings were only recorded in 11 of the 16 wetlands surveyed (*Eucalyptus largiflorens* seedlings were not recorded or observed in any watered wetlands despite being present along the edges of both sites in Kulcurna and adjacent to Lake Littra). *Eucalyptus camaldulensis, Eucalyptus largiflorens* (Nicol 2004) and *Muehlenbeckia florulenta* (Chong and Walker 2005) do not form long-lived soil seed banks and must rely on dispersal into an area for colonisation. Nevertheless, it is unclear why overstorey recruitment was patchy especially in wetlands such as Werta Wert Wetland where there was no overstorey recruitment despite large numbers of overstorey plants, which are a potential seed source.

In the absence of natural or regulated flooding, watering temporary wetlands is an appropriate interim management action to meet TLM targets. The area of flood dependent herbs and grasses, grazing sensitive species was improved and conditions for regeneration of all targets were met at some sites. The spatial extent of these improvements is limited (approximately 5% of the floodplain); nevertheless, these areas may be important refugia for amphibious and floodplain species and may play an important role in recolonisation following natural or regulated flooding. The only TLM target that is not met by watering is to limit the extent of invasive species including weeds; however, the same invasive species will recruit in response to natural flooding (Nicol 2007).

The majority of species that recruited in response to watering were native (a total of 55 native species recruited in response to watering); however, 28 exotic taxa (Table 3) have been recorded or observed in wetlands that were watered. All of the exotic species will recruit in response to falling water levels (Cunningham *et al.* 1981; Nicol 2004) in wetlands that have been watered. Table 29 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 29: List of exotic taxa 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, Punkah Creek Depression
Arctotheca calendula	Coppermine Waterhole, Kulcurna Black Box, Punkah Island Horseshoes, Twin Creeks
Aster subulatus	Coppermine Waterhole, Werta Wert Wetland
Bromus rubens	Kulcurna Black Box, Lake Littra, Punkah Creek Depression, Werta Wert Wetland
Carrichtera annua	Coppermine Waterhole
Conyza bonariensis	Chowilla Oxbow, Twin Creeks
*Cuscuta campestris#**	Coppermine Waterhole, Werta Wert Wetland
*Echium plantagineum#**	Coppermine Waterhole, Twin Creeks
*Heliotropium amplexicaule**	Coppermine Waterhole, Werta Wert Wetland
*Heliotropium curassivicum**	Chowilla Oxbow, Kulcurna Red Gum, Lake Littra, Punkah Island Horseshoes, Woolshed Creek
*Heliotropium europaeum**	Chowilla Oxbow, Coppermine Waterhole, Kulcurna Black Box, Pipeclay Creek Billabong, Punkah Island Horseshoes, Punkah Creek Depression, Werta Wert Wetland, Woolshed Creek
*Hypochoeris radicata**	Chowilla Island Horseshoe, Coppermine Waterhole, Kulcurna Black Box, Twin Creeks, Werta Wert Wetland
Lactuca saligna	Coppermine Waterhole
Medicago spp.*	Brandy Bottle Lagoon, Coppermine Waterhole, Punkah Creek Depression, Lake Littra, Monoman Island Horseshoe, Werta Wert Wetland
Mesembryanthemum crystallinum	Chowilla Island Horseshoe, Lake Littra, Monoman Depression, Punkah Island Horseshoes, Punkah Creek Depression, Punkah Creek Flood Runner, Woolshed Creek
*Phyla canescens**	Twin Creeks, Punkah Island Horseshoes
*Polygonum aviculare**	Chowilla Oxbow, Werta Wert Wetland
Polypogon monspeliensis	Werta Wert Wetland
Rorippa palustris	Chowilla Island Horseshoe, Monoman Depression, Pipeclay Creek Billabong, Twin Creeks, Woolshed Creek
*Solanum nigrum**	Woolshed Creek
Sonchus oleraceus	Coppermine, Kulcurna Black Box, Monoman Depression, Punkah Island Horseshoes, Punkah Creek Depression, Twin Creeks, Werta Wert Wetland
Spergularia marina	Kulcurna Black Box
Trifolium spp.*	Werta Wert Wetland
*Xanthium occidentale#**	Coppermine, Kulcurna Black Box, Twin Creeks, Werta Wert Wetland

Results from this monitoring program, the floodplain condition monitoring program (Gehrig *et al.* 2010) 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 Murray Darling Basin such as the Menindee Lakes (Nicol 2004) and Markaranka (Marsland and Nicol 2008; Marsland and Nicol 2009), where 12 months after flooding (with no follow up 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*). In wetlands that were flooded more frequently flood dependent and amphibious species are able to regenerate more often (or persist); therefore, are present for longer periods (Nicol *et al.* 2010). 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), often have large persistent seed banks and are able to colonise areas rapidly (Nicol 2004).

The frequency and duration of watering to maximise the benefit of environmental watering to both the overstorey and understorey 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. Another approach is to monitor the understorey 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 understorey is resilient and able to colonise areas that have not been flooded for at least five years and more suitable triggers for rewatering (to make best use of limited environmental water) may be the onset of decline in overstorey condition or salt tolerant species replacing terrestrial species in the understorey (*sensu* Nicol *et al.* 2010).

The seed bank is an important component of floodplain understorey 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 understorey 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 understorey probably contributes more to the terrestrial food web than the riverine food web. Nevertheless, understorey vegetation probably contributes significantly to floodplain soil carbon and when flooded probably contributes to the riverine food web.

The influence of watering on understorey vegetation has given an insight into how the plant community may respond to the Chowilla Creek regulator. Results suggest that there will be a shift in the abundance of functional groups from dominance by terrestrial taxa to flood dependent and amphibious taxa for up to 12 months after regulated flooding, after which terrestrial species become dominant. The change in abundance of functional groups will be uniform across the floodplain but the distribution and abundance of different species will be spatially variable depending on the floristic composition of the seed bank, soil texture, soil salinity and water regime.

5. References

Anderson, M.J. (2001). A new method for non-parametric analysis of variance. *Austral Ecology* **26:** 32-46.

Anderson, M.J. and Ter Braak, C.J.F. (2003). Permutation tests for multi-factorial analysis of variance. Journal of Statistical Computation and Simulation 73: 85-113.

Australian Bureau of Meteorology (2006). Climate averages for Renmark. http://www.bom.gov.au/climate/averages/tables/cw_024016.shtml.

Australian Nature Conservation Agency (1996). A Directory of Important Wetlands in Australia. Australian Nature Conservation Agency, Canberra.

Barker, W.R., Barker, R.M., Jessop, J.P. and Vonow, H.P. (2005). Census of South Australian Vascular Plants (5th edn). (Botanic Gardens of Adelaide and State Herbarium: Adelaide: Adelaide).

Boulton, A.J. and Lloyd, L.N. (1992). Flooding frequency and invertebrate emergence from dry floodplain sediments of the River Murray, Australia. *Regulated Rivers: Research and Management* **7**: 137-151.

Bray, J.R., Curtis, J.T. (1957). An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs* **27:** 325-349.

Britton, D.L. and Brock, M.A. (1994). Seasonal germination from wetland seed banks. *Australian Journal of Marine and Freshwater Research* **45:** 1445-1457.

Brock, M.A. and Britton, D.L. (1995). The role of seed banks in the revegetation of Australian temporary wetlands. In 'Restoration of Temperate Wetlands'. (John Wiley and Sons Ltd).

Casanova, M.T. and Brock, M.A. (2000). How do depth, duration and frequency of flooding influence the establishment of wetland plant communities? *Plant Ecology* **147:** 237-250.

Chong, C. and Walker, K.F. (2005). Does lignum rely on a soil seed bank? Germination andreproductive phenology of *Muehlenbeckia florulenta* (Polygonaceae). *Australian Journal of Botany* **53:** 407-415.

Clarke, K.R. and Gorley, R.N. (2006). PRIMER version 6.1.12. (PRIMER-E Ltd: Plymouth).

Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. and Leigh, J.H. (1981). Plants of Western New South Wales. (New South Wales Government Printing Office: Sydney).

Dashorst, G.R.M. and Jessop, J.P. (1998). Plants of the Adelaide Plains and Hills. (The Botanic Gardens of Adelaide and State Herbarium: Adelaide).

Dixon, M.D. (2003). Effects of flow pattern on riparian seedling recruitment on sandbars in the Wisconsin River, Wisconsin, USA. *Wetlands* **23:** 125-139.

Dufrene, M. and Legendre, P, (1997). Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs* **67:** 345-366.

Eldridge, S.R., Thorburn, P.J., McEwan, K.L. and Hatton, T.J. (1993). Health and structure of *Eucalyptus* communities on Chowilla and Monoman Island of the River Murray floodplain, South Australia. Australia Commonwealth Scientific and Industrial Research Organization Division of Water Resources, 93-3, Adelaide.

Gehrig, S.L., Marsland, K.B., Nicol, J.M. and Weedon, J.T. (2010). Chowilla Icon Site – Floodplain vegetation monitoring, 2010 interim report. South Australian Research and Development Institute (Aquatic Sciences), F2010/000279-1, Adelaide.

Gippel, C.J. and Blackham, D. (2002) Review of environmental impacts of flow regulation and other water resource developments in the River Murray and Lower Darling River system. Murray Darling Basin Commission, Canberra.

Grime, J.P. (1979). Plant Strategies and Vegetation Processes. (John Wiley and Sons Ltd: Chichester).

Hassam, M.G. (2007). Understorey vegetation response to artificial flooding frequencies with reference to environmental factors at temporary wetlands found in the Chowilla Floodplain. Honours thesis, Finders University of South Australia.

Jessop, J., Dashorst, G.R.M. and James, F.R. (2006). Grasses of South Australia. An illustrated guide to the native and naturalised species. (Wakefield Press: Adelaide).

Jessop, J.P. and Tolken, H.R. (1986). The Flora of South Australia. (Government of South Australia Printer: Adelaide).

Keddy, P.A. and Reznicek, A.A. (1982). The role of seed banks in the persistence of Ontario's coastal plain flora. *American Journal of Botany* **69:** 13-22.

Kingsford, R.T. (2000). Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia. *Austral Ecology* **25:** 109-127.

Leck, M.A. (1989). Wetland seed banks. In 'Ecology of Soil Seed Banks'. (Eds M.A. Leck, V.T. Parker and R.L. Simpson) pp. 283-308. (Academic Press: San Diego).

Leck, M.A. (2003). Seed-bank and vegetation development in a created tidal freshwater wetland on the Delaware River, Trenton, New Jersey, USA. *Wetlands* **23:** 310-343.

Marsland, K.B. and Nicol, J.M. (2008). Markaranka Flat Baseline Vegetation Survey. South Australian Research and Development Institute (Aquatic Sciences), SARDI Publication Number F2008/000059-1, Adelaide.

Marsland, K.B. and Nicol, J.M. (2009). Markaranka Flat floodplain vegetation monitoring-initial survey. South Australian Research and Development Institute (Aquatic Sciences), F2008/000059-2, Adelaide.

McCune. B. and Mefford, M.J. (2005). PC-ORD. Multivariate Analysis of Ecological Data, Version 5.0. (MjM Software Design: Glendon Beach, Oregon, USA).

McCune B., Grace, J.B. and Urban, D.L. (2002). Analysis of Ecological Communities. (MjM Software Design: Gleneden Beach, Oregon).

Murray Darling Basin Commission (2003). Preliminary investigations into observed river red gum decline along the River Murray below Euston. Murray Darling Basin Commission, Canberra.

Murray Darling Freshwater Research Centre (2010). The Living Murray: Condition Monitoring Program Design for Chowilla Floodplain and the Lindsay, Mulcra and Wallpolla Islands. A report prepared for MDBC by the MDFRC. Development Draft/2010.

Nicol, J.M. (2004). Vegetation Dynamics of the Menindee Lakes with Reference to the Seed Bank. PhD thesis, The University of Adelaide.

Nicol, J. (2007). 'Risk of pest plant recruitment as a result of the operation of Chowilla environmental regulator.' South Australian Research and Development Institute (Aquatic Sciences), SARDI Publication Number F2007/000253-1, Adelaide.

Nicol, J., Doody, T. and Overton, I. (2010). An evaluation of the Chowilla Creek environmental regulator on floodplain understorey vegetation. South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Nicol, J.M., Ganf. G.G. and Pelton, G.A. (2003). Seed banks of a southern Australian wetland: the influence of water regime on final species composition. *Plant Ecology* **168:** 191-205.

O'Malley, C. and Sheldon, F. (1990). Chowilla Floodplain biological study. Nature Conservation Society of South Australia, Adelaide.

Overton, I. and Jolly, I. (2004). Integrated studies of floodplain vegetation health, saline groundwater and flooding on the Chowilla Floodplain, South Australia. CSIRO Land and Water, 20/04, Adelaide.

Quinn, G.P. and Keogh, M.J. (2002). Experimental design and data analysis for biologists. (Cambridge University Press: Cambridge).

Roberts, J. and Marston, F. (2000). Water Regime of Wetland and Floodplain Plants in the Murray-Darling Basin. CSIRO Land and Water, 30-00, Canberra.

Romanowski, N. (1998). Aquatic and Wetland Plants. A Field Guide for Non-tropical Australia. (University of New South Wales Press: Sydney).

Sainty, G.R. and Jacobs, S.W.L. (1994). Waterplants in Australia. (Sainty and Associates: Darlinghurst, N.S.W., Australia).

Shafroth, P.B., Stromberg, J.C. and Patten, D.T. (2002). Riparian vegetation response to altered disturbance and stress regimes. *Ecological Applications* **12:** 107-123.

Sharley, T. and Huggan, C. (1995). Chowilla Resource Management Plan. Murray Darling Basin Commission, Canberra.

Stave, J., Oba, G. Nordal, I. and Stenseth, N.C. (2006). Seedling establishment of *Acacia tortilis* and *Hyphaene compressa* in the Turkwel riverine forest, Kenya. *African Journal of Ecology* **44:** 178-185.

Taylor, P.J., Walker, G.R., Hodgson, G., Hatton, T.J. and Correll, R.L. (1996). Testing of a GIS model of *Eucalyptus largiflorens* health on a semiarid, saline floodplain. *Environmental Management* **20:** 553-564.

Walker, G.R., Jolly, I.D. and Jarwal, S.D. (1996). Salt and water movement in the Chowilla Floodplain. CSIRO Division of Water Resources, 15, Canberra.

Weedon, J.T. and Nicol, J.M (2006) Chowilla Significant Ecological Asset – Floodplain Vegetation Monitoring Interim Report. South Australian Research and Development Institute (Aquatic Sciences), Adelaide, 17pp. SARDI Publication Number RD06/0334.

Zampatti, B., Nicol, J., Leigh, S. and Bice, C. (2006). 2005 progress report for the Chowilla fish and aquatic macrophyte project. SARDI Aquatic Sciences, Adelaide.

6. Appendices

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

Wetland (Location)	Site	Easting	Northing
Brandy Bottle Lagoon	Brandy Bottle	490728	6244838
Chowilla Island Loop	Chowilla Island Loop 1	487464	6236798
Chowilla Island Loop	Chowilla Island Loop 2	487239	6236425
Chowilla Oxbow	Chowilla Oxbow 1	487727	6239416
Chowilla Oxbow	Chowilla Oxbow 2	487804	6238952
Coppermine	Coppermine 1	485269	6240208
Coppermine	Coppermine 2	485568	6240091
Kulcurna B	Kulcurna B1	503657	6233898
Kulcurna B	Kulcurna B2	503667	6234131
Kulcurna RG	Kulcurna 1	504118	6234315
Kulcurna RG	Kulcurna 2	504251	6234648
Kulcurna RG	Kulcurna 3	503690	6235129
Lake Littra	Lake Littra 1	500081	6245421
Lake Littra	Lake Littra 2	500085	6245220
Lake Littra	Lake Littra 3	499963	6244601
Monoman Depression	Monoman Depression	488091	6240839
Monoman Island Horseshoe	Monoman Island Horseshoe 1	488421	6241327
Monoman Island Horseshoe	Monoman Island Horseshoe 2	488871	6241679
Pipe Clay Creek Backwater	Pipeclay Creek Backwater 1	493367	6242911
Pipe Clay Creek Backwater	Pipeclay Creek Backwater 2	493243	6242603
Punkah Island Horseshoes	Punkah Island Horseshoe 01	497476	6242482
Punkah Island Horseshoes	Punkah Island Horseshoe 02	497670	6241977
Punkah Depression	Punkah Depression 1	495965	6245906
Punkah Depression	Punkah Depression 2	495926	6245918
Punkah Flood runner	Punkah Flood runner 1	498520	6245503
Punkah Flood runner	Punkah Flood runner 2	498513	6245508
Twin Creeks	Twin Creeks 01	489592	6243306
Twin Creeks	Twin Creeks 02	489596	6243376
Twin Creeks	Twin Creeks 03	489077	6243258
Twin Creeks	Twin Creeks 04	488844	6243423
Woolshed Creek	Woolshed Creek 01	485587	6236197
Woolshed Creek	Woolshed Creek 02	485919	6237151
Werta Wert	Werta Wert Central 1	487722	6244850
Werta Wert	Werta Wert Central 2	487709	6244930
Werta Wert	Werta Wert Central 3	487627	6244854
Werta Wert	Werta Wert North 1	488041	6245182
Werta Wert	Werta Wert North 2	488191	6245206
Werta Wert	Werta Wert North 3	488288	6245341
Werta Wert	Werta Wert South 1	487611	6243827
Werta Wert	Werta Wert South 2	487698	6243755

Wetland (Location)	Site	Easting	Northing
Werta Wert	Werta Wert South 3	487905	6243689