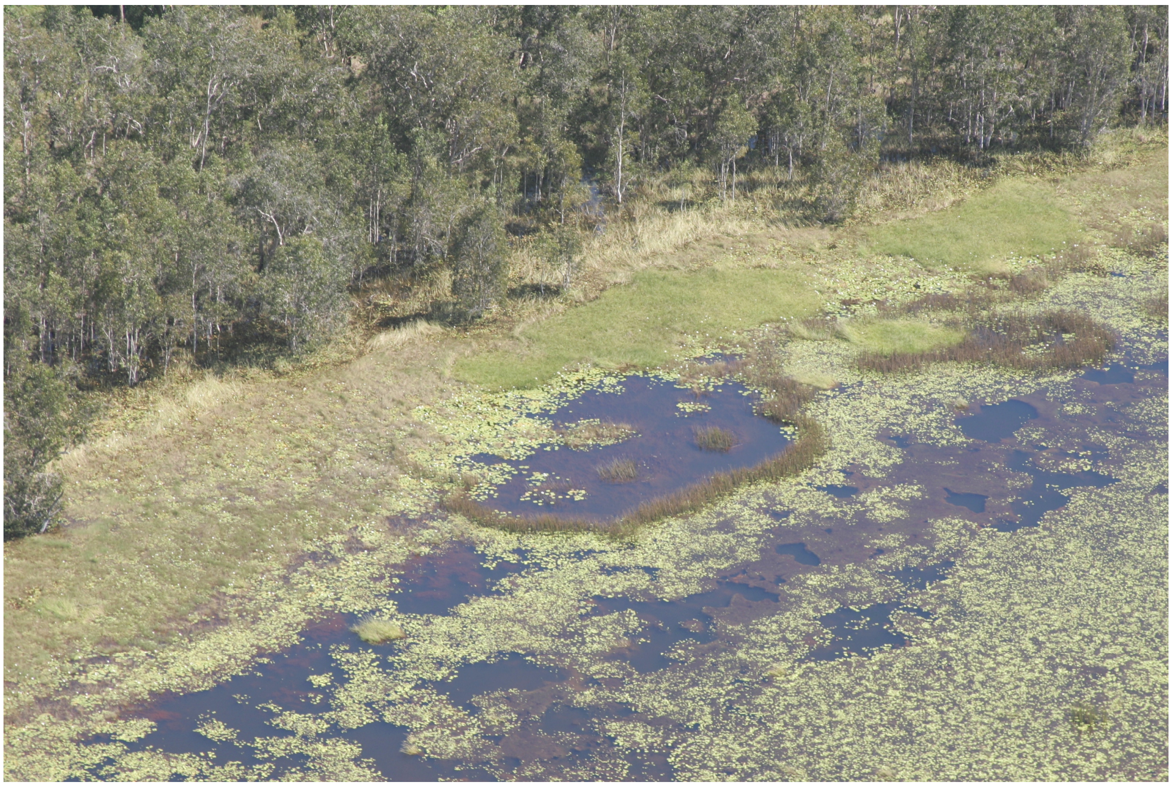
DEPARTMENT OF LAND RESOURCE MANAGEMENT

MACROPHYTE VEGETATION OF SIX LAGOONS IN THE DARWIN REGION, NT



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Title photos:

Herbert Lagoon, April 2008

Nymphoides subacuta, Knuckey Lagoon; *Nymphaea violacea*, Korebum Lagoon; Herbert Lagoon April 2008; *Utricularia leptoplectra,* Girraween Lagoon

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1. SUMMARY

The macrophytes of six lagoons in the Darwin region were recorded over a period of approximately one year. Results showed a large variety of plant species per lagoon and a strong individuality of lagoon plant lists. A total of 160 plants was recorded, 49 of which were aquatic or aquatic/terrestrial. Only six species were found in all six lagoons. The group of introduced plants totalled 26.

The general paucity of information on wetland plants in lagoons and billabongs in the Top End was pointed out.

Water quality parameters were measured during the plant surveys. No relation between plant species composition and water quality were found. Neither was a relation between land use in the lagoon catchment and plant species composition observed.

A wetland health indicator based on plant species richness and the presence of declared weeds was calculated. Two of the lagoons reached the highest score being classed as 'largely unmodified'. Three lagoons ranked as 'slightly modified' and one lagoon 'moderately modified'. These scores were based on data collected during one wet season. More data would be needed to assess the validity and suitability of the indicator and its weighting of the components of species richness and weeds.

It is assessed that the current macrophyte indicator is not ideal due to the high variability in data collection and the large effort required in the field. Suggestions are made to trial weeds or vegetation cover as indicators for wetland health.

The appendix includes photos of 54 of the 160 taxa recorded.

2. INTRODUCTION

The wet-dry tropics of the Northern Territory of Australia are home to a large amount of wetlands (Lowry & Finlayson 2004). The wetlands are assumed to be in good condition due to the low population density and relatively minor and localised impact through horti-/agriculture and mining (Finlayson et al. 2006). The plant communities of the wetlands of the dry-wet part of the Northern Territory (NT) of Australia and their ecology are well known (Finlayson 2005, Cowie et al. 2000). However, detailed studies on ecological aspects of the wetlands have mainly been limited to Kakadu National Park and the broader Alligator Rivers Region due to the uranium mining activities taking place (Finlayson 2005, Finlayson et al. 2006).

The lagoons in the Darwin region were only recently investigated more closely with respect to their water quality (Schult & Welch 2006) and trials on wetland health indicators (Lamche 2008). A large amount of knowledge exists on the flora of the Darwin lagoons (Cowie et al. 2000); however, this was the first study on the plant species richness of individual lagoons.

Species richness can be used as one biological parameter to assess the health status of a wetland. The macrophyte data collected at six lagoons in the outer Darwin area for this report were part of the national trials of indicators for wetland health, funded through the National Land and Water Resources Audit. The scope of the data collection was to create a biological indicator for wetland health based on species richness of macrophytes (Lamche et al. 2008).

At the same time the macrophyte data collected provide the first data on species richness of the six lagoons, which allows for analysis of this baseline information.

Water quality data were collected during the macrophyte surveys as other studies revealed links between environmental factors and macrophyte richness (Rolon & Maltchick 2006). The water quality data and land use data from the catchment of five of the six lagoons collected in an earlier study (Lamche 2008) were analysed in relation to the macrophyte data as a link between land use and macrophyte richness had been found in temperate wetlands (Lougheed et al. 2001).

Finally the macrophyte and weed wetland health indicators were calculated as described in Lamche et al. 2008 and discussed.

3. THE LAGOONS OF THE DARWIN REGION

Freshwater lagoons are a feature of the greater Darwin region. There are over 100 such lagoons in the area. The water quality of the lagoons is characterised by their very fresh waters and low buffering capacity but few studies have attempted to assess the lagoon vegetation (Lamche et al. 2008, Schult & Welch 2006, Schult 2004, Lloyd 1999). Six lagoons were studied during this project, Girraween (1), Herbert2 (2), Knuckey North East (3), McMinns (4), Waterlily (5) and Woodford Lagoon (6) (see Figure 1). All of these lagoons are located in the outer Darwin area that is mainly zoned for rural residential living. It is generally thought that the lagoons are in good environmental health, although there are impacts through introduced plants, some of these invasive, as well as feral animals. The lagoons serve as important habitats for many birds, amphibians and reptiles, especially at the end of the dry season when other water sources become sparse (Cowie et al. 2000b).

Girraween Lagoon is the largest of the lagoons studied with a size of 48 ha. It has a large permanent open water body and there is a considerable amount of recreational use of the lagoon for boating, fishing and speed boating. Some areas that regularly dry out are popular dirt and quad bike tracks. The area is known to be subject to illegal dumping (Metcalfe 2009). Weeds are partly managed by a local Landcare group.

Herbert 2 Lagoon, also known as Benjamin Lagoon, is a small lagoon in the rural area of Darwin. The lagoon receives drainage from surrounding rural residential developments and can dry out completely during the dry season. To our knowledge there has been no previous systematic data collection on plant diversity from this lagoon.

Knuckey Lagoons consist of four water bodies, which are joined into one large wetland complex of 1.158 km^2 during the wet season. All of the four water bodies can dry out by the end of the dry season. The north eastern lagoon was part of this study. Knuckey Lagoons are situated in the outer suburbs of Darwin and most of the surrounding native vegetation has been cleared, partly for mango orchards. The lagoons are the interest of a local Landcare group.

McMinns Lagoon is also a permanent water body, although this appears to be the result of historical dredging to deepen one section of the lagoon. In some years the lagoon might nearly dry out. The wetland is 38 ha in size. The lagoon is used as a local conservation reserve and is managed by a Landcare group. There is recreational use at two picnic areas and several walkways. Some rural residential blocks border the water body.

Waterlily Lagoon is 15 ha in size. It is surrounded by a rural residential estate and used for recreational purposes by residents.

Woodford lagoon measures approximately 28 ha and is situated on private land. Despite the land holder's efforts the lagoon is often used by "hoons" that created vehicle tracks around its perimeter in the dry season as well as by people hunting feral pigs.

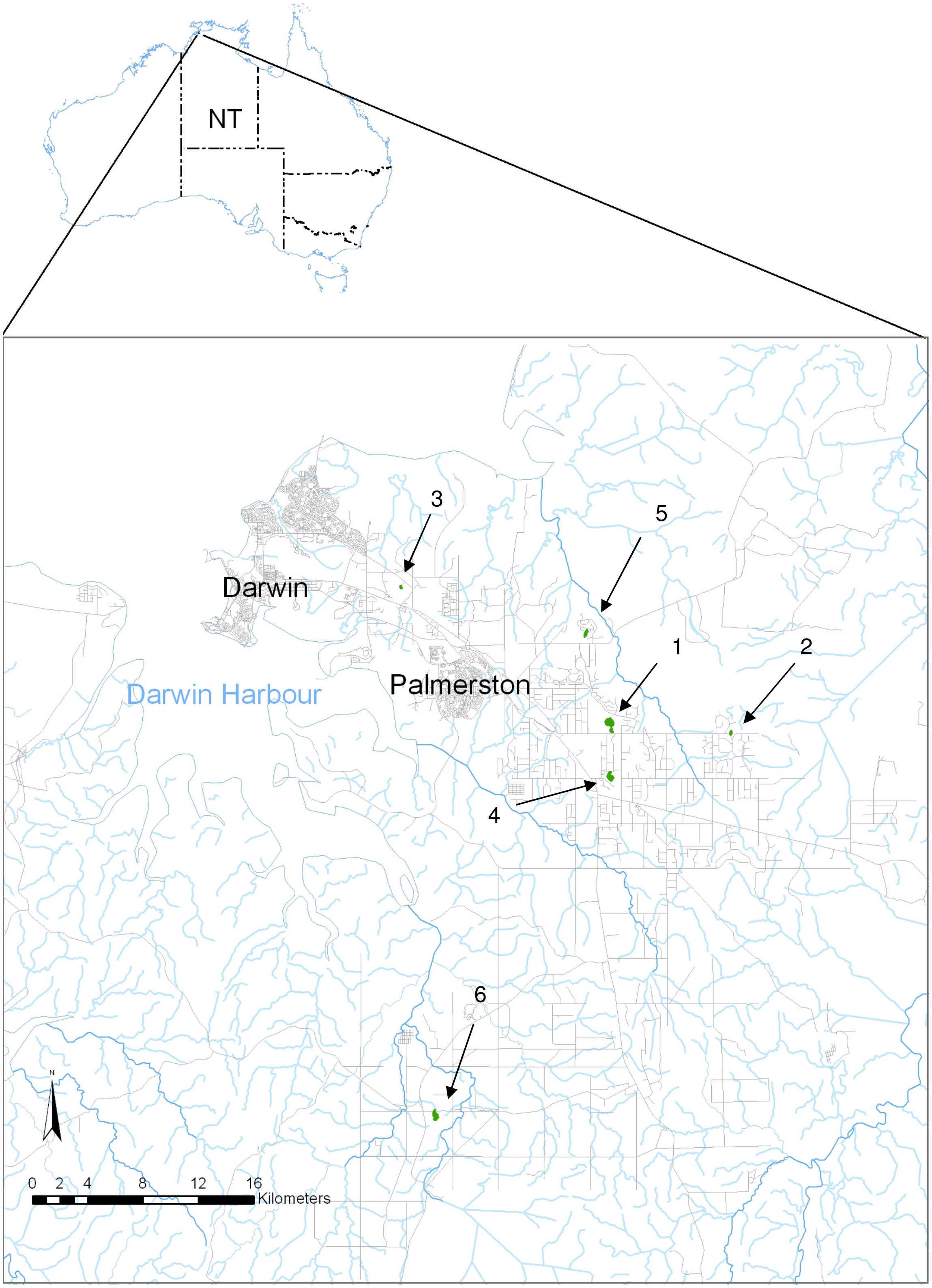

Figure 1: Location of lagoons studied (green).

4. MATERIAL AND METHODS

4.1 Macrophyte field data collection

The objective of the field component was to generate comprehensive species lists for each of the six lagoons for comparison to existing records or to be used to determine a reference condition.

Two transects were established at right angles to each other at each lagoon during the wet season when water levels were near their maximum. The starting points of the transects were located on the water's edge. Transects ran from this point towards the centre of the open water area of the lagoon (see Figure 2).

Hence, the lengths of the transects remained approximately the same for each wetland throughout the year, but individual wetlands had different transect lengths depending on their size and shape. The effort was designed to capture maximum species richness per wetland as opposed to a measure of species density obtained through an equal sampling effort in each wetland.

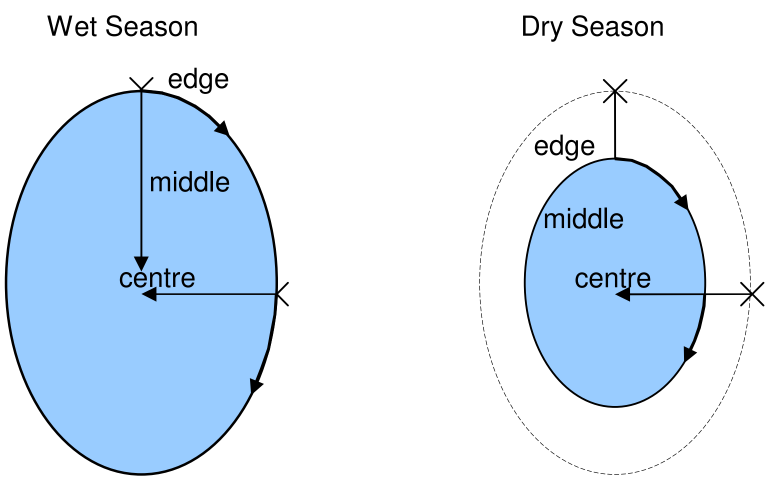

Figure 2: Location of transects for vegetation surveys during the wet and dry seasons. Edge, middle and centre refer to water quality collection points.

All emergent and submerged plant species within 2 m of each side of a transect were recorded. From the point where visual determination of species on the bottom was impossible, the lagoon bottom was sampled using a four-pronged hook attached to a rope. Every 10 to 20 m the tool was dragged along the bottom to recover submerged plant material. This method was effective where the submerged vegetation was present in a "tangled mass" but may have missed smaller submerged aquatic plants.

A tape measure was laid out along the water's edge for 50 m in a clockwise direction from the transect starting point. Sampling was conducted by wading along the edge at a depth of approximately 30 cm.

All plant species, including trees that were in contact with the water were recorded, regardless of their aquatic or terrestrial nature. The broad definition of macrophyte was used, including submerged, floating and emergent plants (herbs, shrubs, trees) and covered a wide taxonomic range (pteridophytes and spermatophytes) (Rolon et al 2008). Macroalgae were collected occasionally, but not systematically and were therefore excluded from this report.

The change in water level over the year posed a challenge in establishing where the edge of the lagoon was located. For our purposes, all plants growing on areas that were submerged at any time during the year were associated with the wetland and recorded during surveys. Since the first plant surveys were conducted after major wet season rainfalls, this included a number of species on the fringe of the lagoon that were not usually associated with waterlogged areas.

Subsequent surveys started from the same points. During the drier time of the year, transects originate in dry areas and cross the water's edge further along the transect (Figure 2). Edge vegetation was sampled wherever the water's edge was located at the time of sampling.

Plants were identified in the field and/or, where field identification was not possible; a specimen was collected for identification by NT Herbarium staff.

Four field surveys were carried out in February/March 2008, May 2008, October 2008 and April 2009.

4.2 Optimising sampling effort

To determine how many transects were required to collect a complete or near complete species list, two additional transects were sampled at four of the lagoons.

Although by far the most species were recorded from the first transect, additional transects led to the detection of several more species (Figure 3). There was no obvious "flattening" of the curve with more additional transects, indicating that at least four transects are required to detect close to all species present.

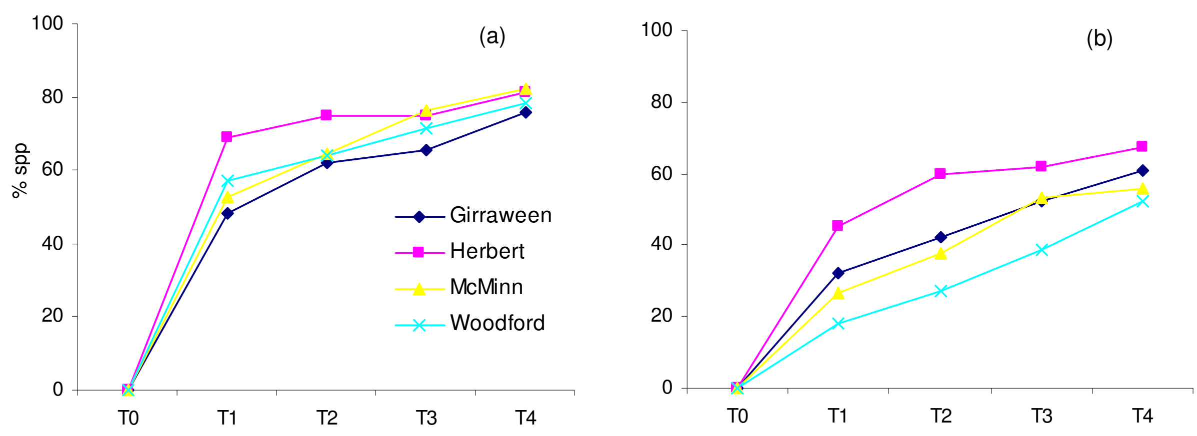

Figure 3: Percentage of total species recorded with each additional transect. Data shown are for the sampling date when most species were recorded, i.e. May 2008 for aquatic species (a) and February 2008 for terrestrial and aquatic species combined (b).

4.3 Wetland Plant classification

There is no generally accepted definition of whether a plant is aquatic or terrestrial. Different authors have used different definitions and it took a considerable effort and discussion time to decide on an appropriate classification for this project. Especially plants that grow in areas under water during the wet, which are dry later in the year are not considered truly aquatic but referred to as 'floodplain flora'. However, as these plants were associated with the wetland in its wet state, they were classed as aquatic in this study.

The assessment whether a plant was aquatic, aquatic/terrestrial or terrestrial was based on literature on the local floodplain flora of the Darwin region (Cowie et al. 2000) and the Alligator Rivers Region (Brennan 1996, Finlayson et al. 1989) as well as the National Vegetation Information System (NVIS) classification (ESCAVI 2003). These were also used to associate the species with their life strategy and growth forms.

The classification used here defines a number of species that are commonly associated with the fringes of wetlands and streams as terrestrial and these plants are therefore not included when "aquatic" plants only are discussed. Further work may be required to assess whether they should be included in future analyses of wetland vegetation.

4.4 Environmental Parameters

4.4.1 Water quality

4.4.1.1 Water quality sampling

Water quality was measured during each of the lagoon surveys at the edge, the middle of each transect into the lagoon and in the centre of the lagoon (see Figure 2). Water quality was not measured at the three intermittent lagoons Herbert 2, Knuckey NE and Waterlily in October, as water levels were very low or no pools found any more.

The following parameters were measured *in situ* using a Hydrolab Quanta multi-parameter probe (Hach P/L): temperature, pH, dissolved oxygen (DO), and electrical conductivity (EC). Turbidity was measured using a portable turbidity meter (Hach P/L). Water samples were kept on ice, stored in the refrigerator and submitted for analysis by an accredited chemistry laboratory. Chlorophyll samples were filtered onto a glass microfiber filter and then analysed by an accredited chemistry laboratory.

Water samples were analysed for nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), filterable reactive phosphorus (FRP), total nitrogen (TN), total phosphorus (TP), Alkalinity (mg $CaCO_3$/L) and Chlorophyll a.

4.4.1.2 Data analysis

A signed rank test was used to determine whether there were differences between the data collected from the edge, middle and centre of each transect when grouping the lagoon data for each date (Sigmaplot 8.0, Systat Software Inc). Significant differences were only found for Chlorophyll a values, some of which were very high. This could happen when a piece of alga had entered the water sample. These few extreme high values were excluded from further analysis. This exclusion rendered the chlorophyll data not significantly different for samples from the edge, the middle or the centre. The data from the edge, middle and centre of each transect were thus averaged for further analysis.

4.4.2 Catchment land use

The catchment area and land use in the catchment had been determined previously by Lamche (2008) for five of the lagoons, i.e. not for Woodford Lagoon, during the wetland health indicator trials and the methods used are described there. Land use was classified in the groups 'conservation and natural environments', 'production from relatively natural environments', 'production from dry land agriculture and plantations', 'production from irrigated agriculture and plantations', and 'intensive uses'.

Additionally the parameter 'cleared vegetation' in a 100 m zone around the wetland border was used, the data for which were gathered in the same project (Lamche 2008).

4.4.3 Relation of macrophyte data and environmental parameters

4.4.3.1 Relation between macrophyte richness and single environmental parameters

Correlations between single environmental parameters and macrophyte richness were calculated using Sigmaplot 8.0 (Systat Software Inc).

4.4.3.2 Multivariate analyses

Further analysis of the macrophyte data in relation to environmental parameters was carried out using the software program Primer 6 (Primer-E Ptd). First the resemblance of macrophyte data was calculated using Bray-Curtis similarity measure. Non-metric multi-dimensional scaling (MDS) was performed on the resemblance matrix.

Draftsmen's Plots were used to choose individual water quality parameters for transformation. Temperature, electrical conductivity, turbidity and nitrate were log transformed before all data were normalised. A resemblance matrix was then calculated using Euclidean Distance followed by MDS. A Principal Component Analysis (PCA) was calculated to demonstrate which water quality parameters determine the placement of lagoons in the ordination.

The BEST routine was performed between the macrophyte taxa list and the water quality data. This analysis finds the 'best' match between the multivariate among-sample macrophyte data patterns and that of the water quality data patterns.

For the analysis of macrophyte and land use data the same routines were performed as described above for water quality. The calculations for the macrophyte taxa lists were repeated as land use data for only five lagoons, excluding Woodford Lagoon, were available.

4.5 Wetland Health Macrophyte Indicator calculation

4.5.1 Background

The data reported on here were collected as part of the wetland health indicator trials for the Australian Framework for the Assessment of River and Wetland Health (FARWH, Norris et al 2007). This framework was created to measure the health of individual wetlands and streams using six broad indicator themes: *Catchment Disturbance, Physical Form, Hydrology, Fringing Zone, Water Quality* and *Biota* (Conrick et al. 2007). Macrophyte species richness and nativeness were trialled as indicators under the Biota theme for the Darwin region lagoons, but data collections were still underway during reporting (Lamche et al. 2008). The indicators were recalculated after the macrophyte data collection was completed and results are provided in this report.

The indicator system is based on a reference condition against which the current condition is compared. According to the FARWH, all indices are calculated to generate values between 1 and 0, with 1 standing for reference condition. Scores are grouped into bands of different colour to show the degree of modification of a wetland (Table 1).

Table 1: Indicator scores and banding system (Norris et al. 2007)

Band	Indicator score	Description
A	0.8 - 1	Largely unmodified
B	0.6 – <0.8	Slightly modified
C	0.4 – <0.6	Moderately modified
D	0.2 – <0.4	Substantially modified
E	0 – <0.2	Severely modified

4.5.2 The Macrophyte indicator

The Macrophyte indicator consisted of three sub-indices (Lamche et al. 2008):

- Native Species Richness
- Exotic Species and
- Declared Weeds.

For each of these sub-indices, a score was calculated and they were then integrated to a single “Macrophyte” score.

4.5.2.1 Reference condition and scoring

Species richness

The data available for the establishment of the reference conditions for the species richness indicator are presented in detail in section 5.1.4 including taxa recorded in studies outside the one presented here, which were available for Girraween and Knuckey Lagoons. Although it would be desirable to base the reference condition on an extensive data base, the amount of data available has considerably improved since the first macrophyte indicator trials (Lamche et al. 2008).

For the four lagoons for which no previous data were available, the number of native taxa found during this study was considered to be equal to the reference condition (Table 2). It is likely that this number will change, when more surveys are carried out. For the two lagoons for which additional data were available, the total number of native taxa recorded from these locations was used to determine the reference condition.

Table 2: Plant taxa reference condition for six lagoons in the Darwin region

Lagoon name	Reference condition (number of plant taxa)	Maximum number of species recorded in one survey	Wetland Complex Size (ha)
Girraween Lagoon	107	39	48.5
Herbert 2 Lagoon	55	34	8.5
Knuckey NE Lagoon	70	35	115.8
McMinns Lagoon	45	37	38.0
Waterlily Lagoon	45	30	15.3
Woodford Lagoon	44	27	13.4

The reference condition was defined newly for each lagoon based on the recent data collection covering approximately one year. The reference condition was defined as the maximum number of species recorded in one survey (Lamche et al. 2008).

The highest score was set according to the maximum number of species recorded in one survey and scores reduced as the number of recorded species declined (Table 3).

Table 3: Calculation of scores for plant species richness. 100% scores are based on the maximum number of species recorded in a single survey.

	100%	95%	90%	85%	80%
Girraween Lagoon	39	37	35	33	31
Herbert 2 lagoon	34	32	31	29	27
Knuckey NE Lagoon	35	33	32	30	28
McMinns Lagoon	37	35	33	31	30
Waterlily Lagoon	30	29	27	26	24
Woodford Lagoon	27	26	24	23	22
Score	1	0.75	0.5	0.25	0

Exotic Species

The presence of introduced species indicated disturbance of the wetland. The number of exotic species present was used as described in Lamche et al. (2008) as a measure and wetland health scores were reduced as the number of exotic species increased (Table 4).

Table 4: Scores for introduced plants.

No. of exotic species	0	1-2	3-4	5-6	>7
Score	1	0.75	0.5	0.25	0

Declared Weeds

Lamche et al. (2008) had decided to treat declared weeds of national significance separately from exotic species that are not declared weeds. During the field data collection it also became clear that terrestrial and aquatic weeds need to be treated differently for this measure. The presence of declared aquatic weeds, such as *Cabomba caroliniana* and *Salvinia molesta*, with the potential to significantly alter the structure and composition of the wetland vegetation should reduce scores to 0, while the presence of declared terrestrial weeds on the edges of the wetland was unlikely to have the same impact.

The scores were therefore chosen as listed in Table 5 after Lamche et al. (2008).

Table 5: Scores for declared weeds.

Presence of declared weeds	None	Terrestrial only	Aquatic weeds present
Score	1	0.5	0

4.5.3 Calculation of macrophyte index score

The Exotic Species and the Declared Weeds sub-scores measured very similar effects on the lagoon. The “Exotic Species” measure in fact included declared weeds as well as other introduced plants. The weighting for the three measures reflected this. Species richness was weighted at 0.5, while the two exotic species measures had a weight of 0.25 each. The macrophyte index score was calculated as:

Macrophyte index score = (species richness sub-score * 0.5) + (exotic species sub-score * 0.25) + (declared weeds sub-score * 0.25)

5. RESULTS AND DISCUSSION

5.1 Species richness

5.1.1 Wetland vegetation

Table 6 provides the plant species list for the six lagoons from all four data collections. The taxa list comprised 160 taxa, with only five of these not identifiable to species level. For each of the taxa, environmental preference as aquatic or terrestrial as well as the life strategy, annual or perennial, was listed as well as information on the growth form. Introduced species were marked and so were declared weeds (information from NT Herbarium).

Table 6: Taxa list for all six lagoons by environmental preference

Species	Family	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]	emergent, submerged or floating[e]	Girraween Lagoon	Herbert 2 Lagoon	Knuckey Lagoon	McMinns Lagoon	Waterlily Lagoon	Woodford Lagoon
Aeschynomene indica	Fabaceae	a	a	s		e			x			
Azolla pinnata	Azollaceae	a	p	f		ff	x				x	
Blyxa aubertii	Hydrocharitaceae	a	a	h		s	x	x	x		x	x
Caldesia oligococca	Alismataceae	a	ap	h		ff		x	x		x	x
Chrysopogon oliganthus	Poaceae	a	p	g		e	x	x		x	x	x
Cyperus platystylis	Cyperaceae	a	p	se		e	x		x			
Eleocharis dulcis	Cyperaceae	a	ap	se		e						x
Eriocaulon setaceum	Eriocaulaceae	a	a	h		s	x	x	x	x	x	x
Ischaemum australe	Poaceae	a	p	g		e	x					
Isoetes coromandelina	Isoetaceae	a	a	f		s			x	x	x	x
Leersia hexandra	Poaceae	a	p	g		e, ff	x					
Lepironia articulata	Cyperaceae	a	p	se		e	x					
Limnophila aromatica	Scrophulariaceae	a	a	h		e			x			
Maidenia rubra	Hydrocharitaceae	a	a	h		s			x			
Myriophyllum trachycarpum	Haloragaceae	a	a	h		e			x			
Najas sp.	Najadaceae	a	ap	h		s, fs	x	x	x	x	x	x
Nymphaea hastifolia	Nymphaeaceae	a	p	h		fs	x		x		x	
Nymphaea violacea	Nymphaeaceae	a	p	h		fs	x	x	x	x	x	x
Nymphoides aurantiaca	Menyanthaceae	a	ap	h		f	x				x	
Nymphoides crenata	Menyanthaceae	a	ap	h		f	x					
Nymphoides minima	Menyanthaceae	a	a	h		f			x			
Nymphoides parvifolia	Menyanthaceae	a	a	h		f			x			
Nymphoides spongiosa	Menyanthaceae	a	a	h		f			x			
Nymphoides subacuta	Menyanthaceae	a	ap	h		f			x		x	
Oryza rufipogon	Poaceae	a	ap	g		e				x		
Salvinia molesta	Salviniaceae	a	p	f	w	ff	x					

Species	Family	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]	emergent, submerged or floating[e]	Girraween Lagoon	Herbert 2 Lagoon	Knuckey Lagoon	McMinns Lagoon	Waterlily Lagoon	Woodford Lagoon
Scleria poaeformis	Cyperaceae	a	p	se		e	x					
Sesbania cannabina var. sericea	Fabaceae	a	a	s		e				x		
Triglochin dubium	Juncaginaceae	a	ap	h		s			x			
Utricularia aurea	Lentibulariaceae	a	ap	h		fs		x				
Utricularia gibba	Lentibulariaceae	a	ap	h		s	x	x		x	x	x
Utricularia muelleri	Lentibulariaceae	a	a	h		fs	x		x	x	x	x
Vallisneria annua	Hydrocharitaceae	a	a	h		s				x		
Websteria confervoides	Cyperaceae	a	p	se		e	x					
Eleocharis sundaica	Cyperaceae	at	p	se		e	x			x	x	x
Hymenachne acutigluma	Poaceae	at	p	g		e					x	
Limnophila chinensis	Scrophulariaceae	at	a	h		e	x					
Limnophila fragrans	Scrophulariaceae	at	a	h		e	x	x	x	x	x	
Ludwigia adscendens	Onagraceae	at	p	h		ef					x	
Melaleuca cajuputi	Myrtaceae	at	p	t		e	x					
Melaleuca leucadendra	Myrtaceae	at	p	t		e	x					
Melaleuca nervosa	Myrtaceae	at	p	t		e						x
Melaleuca viridiflora	Myrtaceae	at	p	t		e	x	x	x	x	x	
Nymphoides indica	Menyanthaceae	at	ap	h		f	x	x	x	x	x	x
Paspalum scrobiculatum	Poaceae	at	p	g		e	x	x	x	x		
Persicaria attenuata	Polygonaceae	at	p	h		e			x		x	
Philydrum lanuginosum	Philydraceae	at	p	h		e	x		x			
Pseudoraphis spinescens	Poaceae	at	p	g		e	x	x	x	x	x	x
Stylosanthes hamata	Fabaceae	at	p	h	i	e			x			
Acacia auriculiformis	Mimosaceae	t	p	t						x	x	
Acacia holosericea	Mimosaceae	t	p	st						x		
Alternanthera denticulata	Amaranthaceae	t	a	s					x			
Alysicarpus ovalifolius	Fabaceae	t	a	h	i			x				
Andropogon gayanus	Poaceae	t	p	g	w		x					
Antidesma ghaesambilla	Euphorbiaceae	t	p	st								x
Asteromyrtus symphyocarpa	Myrtaceae	t	p	t			x		x	x	x	
Bacopa floribunda	Scrophulariaceae	t	ap	h				x				
Brachiaria (Urochloa) humidicola	Poaceae	t	p	g	i		x					
Calopogonium mucunoides	Fabaceae	t	ap	v	i			x				
Cassytha filiformis	Lauraceae	t	p	v						x		
Cayratia maritima	Vitaceae	t	p	v								x
Chamaecrista mimosoides	Caesalpiniaceae	t	a	sh			x					
Chamaecrista rotundifolia	Caesalpiniaceae	t	a	h	i		x					
Chrysopogon latifolius	Poaceae	t	p	g						x		
Coldenia procumbens	Boraginaceae	t	a	h								x
Commelina ensifolia	Commelinaceae	t	a	h							x	
Corymbia bella	Myrtaceae	t	p	t			x					
Corymbia polycarpa	Myrtaceae	t	p	t								x
Crotalaria goreensis	Fabaceae	t	a	h	i		x					

Species	Family	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]	emergent, submerged or floating[e]	Girraween Lagoon	Herbert 2 Lagoon	Knuckey Lagoon	McMinns Lagoon	Waterlily Lagoon	Woodford Lagoon
Cyanotis axillaris	Commelinaceae	t	a	h							x	
Cyclosorus interruptus	Thelypteridaceae	t	p	f			x					
Cynanchum liebianum	Asclepiadaceae	t	?	h							x	
Cyperus angustatus	Cyperaceae	t	a	se			x					
Cyperus aquatilis	Cyperaceae	t	a	se				x	x			
Cyperus compressus	Cyperaceae	t	a	se	i				x			
Cyperus digitatus	Cyperaceae	t	ap	se							x	
Cyperus haspan	Cyperaceae	t	p	se			x	x				
Cyperus holoschoenus	Cyperaceae	t	a	se			x					
Cyperus scariosus	Cyperaceae	t	p	se					x			
Cyperus javanicus	Cyperaceae	t	p	se			x					
Cyperus polystachyos	Cyperaceae	t	a	se						x		
Cyperus serotinus	Cyperaceae	t	a	se			x	x	x			
Cyperus sphacelatus	Cyperaceae	t	a	se	i				x			
Dentella dioeca	Rubiaceae	t	a	h				x	x			x
Dentella repens	Rubiaceae	t	ap	h							x	
Desmodium muelleri	Fabaceae	t	a	h					x			
Desmodium pullenii	Fabaceae	t	?	h				x				
Desmodium pycnotrichum	Fabaceae	t	a	h						x		
Desmodium trichostachyum	Fabaceae	t	a	h				x				
Drosera petiolaris	Droseraceae	t	p	h			x					x
Eclipta prostrata	Asteraceae	t	a	h					x	x		
Ectrosia leporina	Poaceae	t	a	g				x	x			
Eleocharis ochrostachys	Cyperaceae	t	ap	se			x					
Emilia sonchifolia	Asteraceae	t	a	h	i					x		
Eragrostis sp.	Poaceae	t	ap	g				x	x			
Eriachne burkittii	Poaceae	t	ap	g			x		x			
Eriachne triseta	Poaceae	t	p	g				x				x
Eriocaulon cinereum	Eriocaulaceae	t	a	h				x			x	
Eriocaulon depressum	Eriocaulaceae	t	a	h			x			x	x	x
Eriocaulon nematophyllum	Eriocaulaceae	t	a	h						x		
Euphorbia vachellii	Euphorbiaceae	t	ap	h								x
Evolvulus alsinoides var. indeterminate	Convolvulaceae	t	a	h								x
Evolvulus nummularis	Convolvulaceae	t	p	h	i							x
Fimbristylis acicularis	Cyperaceae	t	a	se				x				
Fimbristylis dichotoma	Cyperaceae	t	p	se						x		
Fimbristylis littoralis	Cyperaceae	t	a	se				x			x	
Fimbristylis pauciflora	Cyperaceae	t	ap	se			x	x	x	x	x	x
Fuirena ciliaris	Cyperaceae	t	a	se			x	x				
Glinus oppositifolius	Molluginaceae	t	a	h								x
Goodenia kakadu	Goodeniaceae	t	a	h			x					x
Goodenia purpurascens	Goodeniaceae	t	ap	h					x			
Grevillea pteridifolia	Proteaceae	t	p	t						x		
Heliotropium indicum	Boraginaceae	t	a	h				x	x	x	x	x

Species	Family	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]	emergent, submerged or floating[e]	Girraween Lagoon	Herbert 2 Lagoon	Knuckey Lagoon	McMinns Lagoon	Waterlily Lagoon	Woodford Lagoon
Heliotropium ventricosum	Boraginaceae	t	a	h					x			
Hibiscus meraukensis	Malvaceae	t	a	s								x
Hybanthus enneaspermus	Violaceae	t	a	sh			x					
Hyptis suaveolens	Lamiaceae	t	a	h	w			x				
Indigofera hirsuta	Fabaceae	t	a	h								x
Lindernia sp.	Scrophulariaceae	t	ap	h			x		x			
Livistona humilis	Arecaceae	t	p	p								x
Lophostemon grandiflorus	Myrtaceae	t	p	t				x				
Lophostemon lactifluus	Myrtaceae	t	p	t			x	x		x		x
Ludwigia hyssopifolia	Onagraceae	t	a	h					x			
Ludwigia octovalvis	Onagraceae	t	a	sh				x	x			
Macroptilium lathyroides	Fabaceae	t	a	h	i			x				x
Malachra capitata	Malvaceae	t	a	s	i			x				
Melinis repens	Poaceae	t	p	g	i		x					
Melochia corchorifolia	Sterculiaceae	t	a	sh				x	x	x	x	x
Microcarpaea minima	Scrophulariaceae	t	ap	h			x		x			x
Mimulus uvedaliae	Scrophulariaceae	t	a	h			x					
Murdannia nudiflora	Commelinaceae	t	p	h	i					x		
Oldenlandia galioides	Rubiaceae	t	a	h					x	x		
Oldenlandia tenuifolia	Rubiaceae	t	a	h							x	x
Pandanus spiralis	Pandanaceae	t	p	p			x					x
Passiflora foetida	Passifloraceae	t	p	v	i			x		x	x	x
Pennisetum polystachion	Poaceae	t	p	g	w		x	x				x
Phyllanthus sulcatus	Euphorbiaceae	t	a	h					x			
Planchonia careya	Lecythidaceae	t	p	st			x					
Polygala sp.	Polygalaceae	t	a	h				x				
Richardia braziliensis	Araceae	t	a	h	w				x			
Rhynchospora exserta	Cyperaceae	t	a	se				x				
Rhynchospora submarginata	Cyperaceae	t	?	se			x					
Rhynchospora wightiana	Cyperaceae	t	a	se				x				
Sacciolepis indica	Poaceae	t	ap	g			x					
Scoparia dulcis	Scrophulariaceae	t	a	h	i			x		x		
Sorghum intrans	Poaceae	t	a	g					x	x		x
Sorghum timorense	Poaceae	t	a	g			x					
Spermacoce articularis	Rubiaceae	t	a	h	i		x					
Spermacoce leptoloba	Rubiaceae	t	a	h				x		x		
Stachytarpheta cayennensis	Verbenaceae	t	p	sh	w					x		
Stylidium sp.	Stylidiaceae	t	a	h			x				x	
Stylosanthes guianensis	Fabaceae	t	a	h	i		x	x				
Stylosanthes humilis	Fabaceae	t	a	h	i		x	x	x		x	
Terminalia sp.	Combretaceae	t	p	t							x	
Tricostularia undulata	Cyperaceae	t	p	se			x					
Utricularia hamiltonii	Lentibulariaceae	t	a	h					x			
Utricularia leptoplectra	Lentibulariaceae	t	a	h			x			x		

Species	Family	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]	emergent, submerged or floating[e]	Girraween Lagoon	Herbert 2 Lagoon	Knuckey Lagoon	McMinns Lagoon	Waterlily Lagoon	Woodford Lagoon
Vigna lanceolata var. filiformis	Fabaceae	t	p	v				x				
Xyris complanata	Xyridaceae	t	p	h			x			x	x	x
Xyris indica	Xyridaceae	t	a	h			x			x	x	X
Total (species and genera)	**160**				**26**		**68**	**48**	**54**	**43**	**41**	**43**

[a]: Environmental preference is aquatic (a), terrestrial (t) or can be both (at).

[b]: Life strategy is annual (a), perennial (p) or can be both (ap).

[c]: Growth form: f=fern or related, g=grass, h=herb, forb, p=palm, s=shrub, se= sedge, t=tree, v=vine.

[d]: alien to the area: plant is introduced (i), a declared weed (w).

[e]: Details of environmental preference for aquatic plants: e=emergent, f=floating-leaved, ff= free-floating, fs= free-floating, submerged, s= submerged-rooted.

A large number of species was recorded as occurring at one lagoon only and not any of the five others (Figure 4). With further data collection, this number is likely to be reduced. However, at this stage it appears rather surprising that all of the six lagoons reveal such different species compositions. Only six species were found in all of the six lagoons: *Eriocaulon setaceum*, *Fimbristylis pauciflora*, *Najas sp*., *Nymphaea violacea*, *Nymphoides indica* and *Pseudoraphis spinescens,* with only one of these, *F. pauciflora* being terrestrial. *Blyxa aubertii, Chrysopogon oliganthus, Heliotropium indicum, Limnophila fragrans, Melaleuca viridiflora, Melochia corchorifolia, Utricularia gibba and U. muelleri* were recorded in five lagoons. Of these eight species only *H. indicum* and *M. corchorifolia* are terrestrial.

Of the 160 taxa recorded, 49 were aquatic and 15 of those could also grow terrestrial (Table 7).

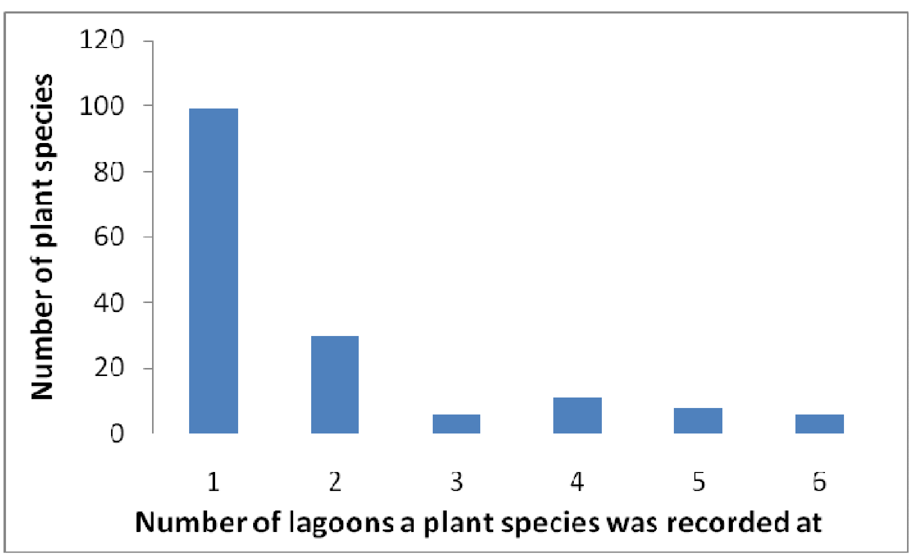

Figure 4: Frequency distribution: Number of lagoons a species was recorded at

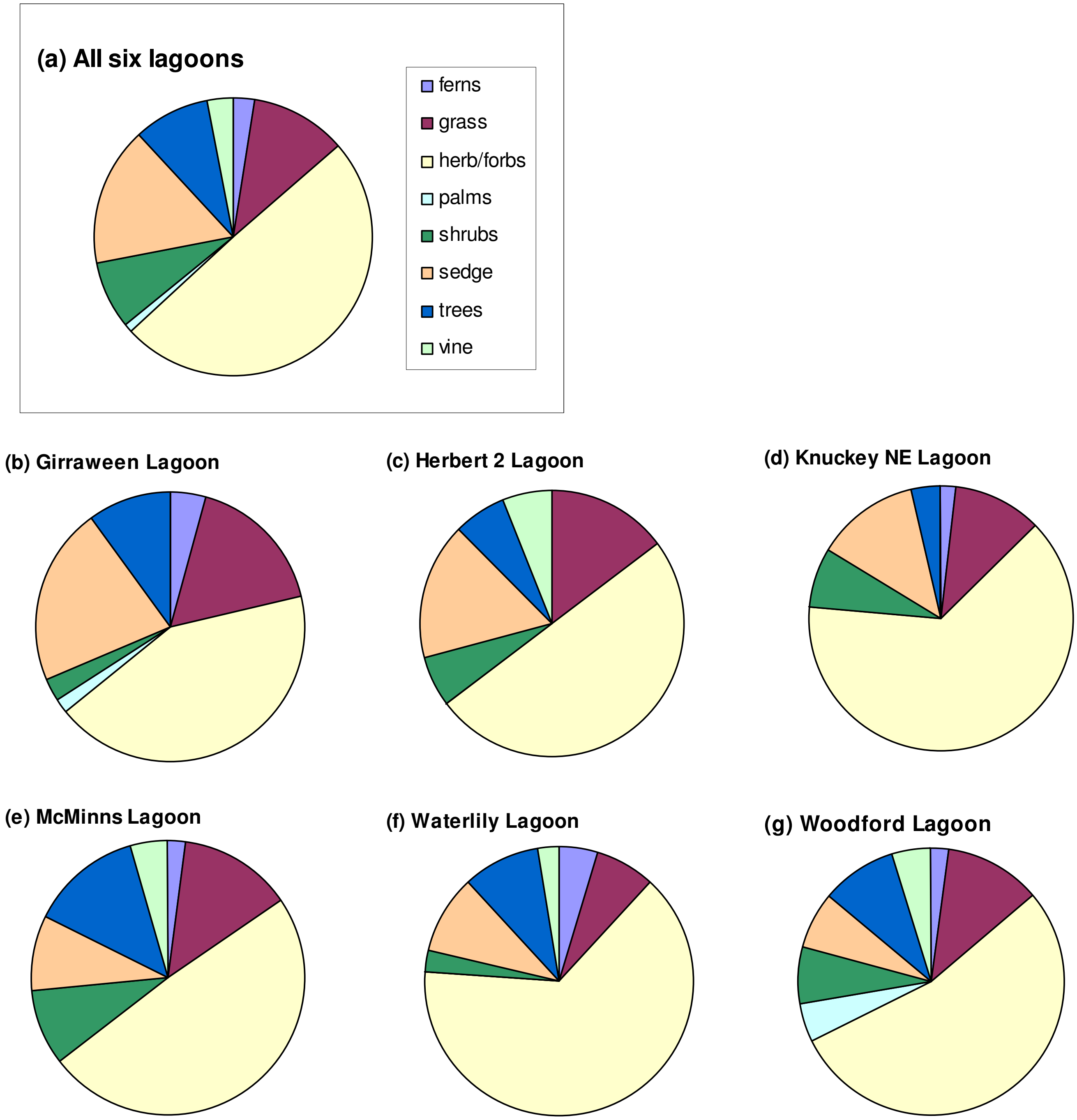

Figure 5: Macrophyte species composition by growth forms for (a) all lagoons and (b)-(g) each individual lagoon.

74 taxa were annuals, 57 perennials and 24 were reported as both, equating to 50-73% of species in each lagoon being annuals (Table 7). This is comparable to the description in Cowie et al. (2000) summarizing that many of the floodplain communities have a high proportion of annual plants. Finlayson et al. (1990) reported 72% annuals on seasonally inundated parts of the Magela floodplain and Taylor & Dunlop (1985) found 64-80% annuals for herbaceous

floodplains in the Alligator Rivers Region (cited in Cowie (2003)). Finlayson et al. (1994) reported between 43 and 55% annuals in five billabongs in the Magela Creek floodplain.

An overview of the composition of life forms of all six lagoons and per individual lagoon is provided in Figure 5. When looking at all six lagoons, the herb/forb group is making up half of all life forms with 83 species in this group. There were 27 types of sedge and 19 grasses. 15 taxa grow as trees and 13 as shrubs, although some grow as both. There were 5 vines, 4 ferns or related and 2 palms. Only Woodford Lagoon had all 8 life forms present, the other lagoons display 6 or 7 only.

Girraween Lagoon had the smallest fraction of herb/forbs, but a proportionally large fraction of sedge and grass species.

Table 7: Summary of macrophyte richness in six lagoons

		Girraween Lagoon	**Herbert 2 Lagoon**	**Knuckey Lagoon**	**McMinns Lagoon**	**Waterlily Lagoon**	**Woodford Lagoon**	**Total**
Hydrology	Permanent/seasonal	p	s	s	p	s	p	
Environmental Preference	aquatic	18	8	18	10	13	10	34
	aquatic/terrestrial	10	5	8	6	8	4	15
	terrestrial	40	35	28	27	20	29	111
	% aquatic species	41.2	27.1	48.2	37.2	51.2	32.6	30.6
Exotic Species	Introduced	10	10	5	5	2	4	25
	Declared weeds	3	2	1	1	0	1	6
	Aquatic weeds	1	0	0	0	0	0	1
Life form	Annual	23	26	32	20	16	18	76
	Perennial	34	13	11	18	15	17	57
	Annual/perennial	11	9	11	5	9	8	24
	% annual species							
Total		**68**	**48**	**54**	**43**	**41**	**43**	**160**

5.1.2 Seasonal changes

Data collections occurred in February/March 2008, May 2008, October 2008 and April 2009. Although it was planned to have the 4th collection in January 2009, there were access problems and the field work was delayed until April.

As to be expected, most of the taxa were recorded at the time of flooding, February/March, when 106 species of 160 were recorded. Eighty-three taxa were recorded in May, 69 in October and 59 in April 2009. It has to be mentioned that more taxa were recorded per collection, but identification to species level was not always possible. For example, the trees are present throughout the year, but flowers or seeds are only present at some times, so that identification was at other times only possible to genus level, i.e. *Melaleuca*. Only in locations where only one species of a genus was present, the species could then be accurately recorded. Many herbs, grasses, sedges are only identifiable to species level when in flower or presenting seeds.

Eighty-one of the 160 species were only recorded during one collection, which happened for all four collection times, but mainly in February/March. Twenty four species were recorded on all four occasions with the majority of these, 14, being aquatic or aquatic/terrestrial plants.

With the objective to obtain comprehensive species lists per lagoon, it appears therefore necessary to carry out field work in all seasons.

With respect to the growth forms, there was no considerable change of the growth form composition of the taxa over the seasons (data not shown).

There was a considerable seasonal shift in the life strategy of taxa recorded with 48.6 % annuals present in February/March and 40.7 % in May, which was reduced to 29 % annuals in October. It is to be expected that many annual plants thrive in the wet season. However, a percentage of 33.9 % annuals recorded in April 2009 does not quite agree with this explanation.

5.1.3 Aquatic macrophytes

The data collection method produced a large list of taxa as described above (section 5.1.1). In order to put our data in perspective and compare with other wetlands, the following discussion refers to all plants with aquatic life forms, i.e. aquatic macrophytes as defined in section 4.3.

A list of 49 aquatic macrophytes was obtained, 15 of these grow also under terrestrial conditions.

Girraween Lagoon and Knuckey Lagoon revealed the largest number of aquatic macrophytes with 28 and 26, respectively. In Waterlily Lagoon 21 aquatic macrophytes were recorded, whereas the three other lagoons recorded lower numbers of 13 to 16 aquatics. Girraween Lagoon is the largest permanent water body, leading to favourable conditions for aquatics all year round, which is one possible explanation for the high number of aquatic species. The relatively high taxa richness of Knuckey Lagoon could be due to the fact that Knuckey NE lagoon is part of a four lagoons wetland complex. These four lagoons merge into one water body during the wet season. However, all of these dry out in most dry seasons.

Finlayson et al. (1994) found between 22 and 30 aquatic macrophyte species in five Magela Creek Billabongs, which is comparable to the numbers found in our study for the larger lagoons. In a study on southern Brazilian wetlands Rolon et al. (2008) found between 9 and 57 aquatic macrophytes in 15 wetlands investigated with the larger number recorded in the large wetlands.

Figure 6 shows the frequency of occurrence of each aquatic macrophyte species in any of the six lagoons. A large number of taxa, 27, was only found in one lagoon. Five of the aquatic species were found in all lagoons: *Eriocaulon setaceum*, *Najas sp.*, *Nymphaea violacea*, *Nymphoides indica* and *Pseudoraphis spinescens*.

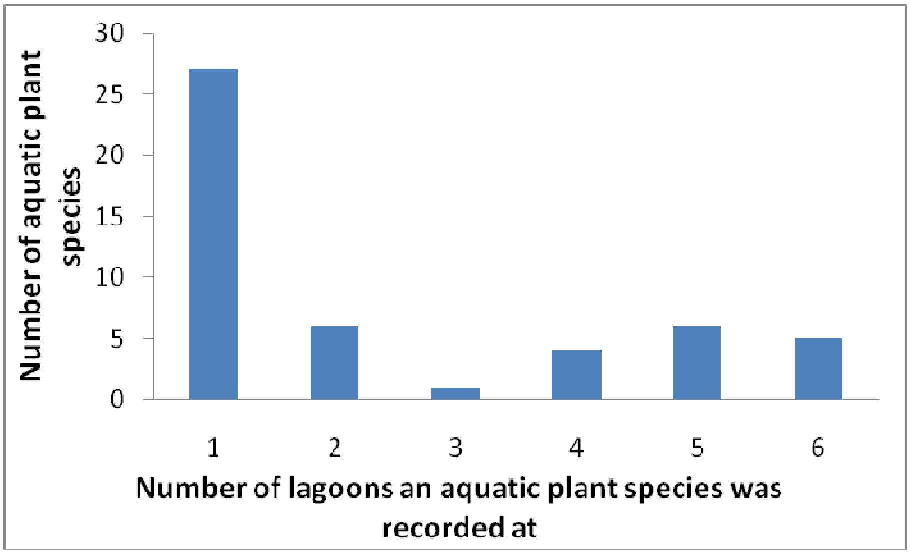

Figure 6: Frequency distribution of the 49 aquatic macrophytes.

5.1.4 Vegetation of individual lagoons

5.1.4.1 Girraween Lagoon

A total of 71 species, 29 of these aquatic, were recorded at Girraween Lagoon during the four surveys (Appendix 1, Table A1). 29 species were only recorded in Girraween Lagoon and not at any of the five other lagoons.

One species of conservation significance was recorded at Girraween Lagoon. The aquatic sedge *Websteria confervoides* is a data deficient plant (Short et al. 2011). Only four records of this plant are listed in the NT Herbarium database and 9 in the Australian Virtual Herbarium (AVH 2011).

Of the 71 taxa recorded, 11 were introduced with *Salvinia molesta* being the only aquatic weed. This species has the potential to spread rapidly and choke wetlands (e.g. Cowie 2003), however, it is currently limited to several small patches, probably due to the low nutrient levels of the lagoon (Schult & Welch 2006, Lamche et al. 2008). The area surrounding Girraween Lagoon is subject to a subdivision into rural blocks and there is a risk that an increase in nutrients following the subdivision may provide enough capacity for *S. molesta* to spread and change the ecology of Girraween Lagoon.

The flora of Girraween Lagoon has now been relatively well recorded. 36 species have previously been listed at the lagoon that were not collected during this study (Table 8). This brings the total taxa richness of Girraween Lagoon to 107, with 43 or 40% of these being aquatic.

Table 8: Additional species recorded at Girraween Lagoon during other surveys (NT Herbarium (cited in Staben & Forsyth 2002), Metcalfe 2009, Staben & Forsyth, 2002)

Species	Family	Environmental preference	Source
Aldrovanda vesiculosa	Droseraceae	a	NT Herbarium
Eleocharis dulcis	Cyperaceae	a	Metcalfe 2009
Limnophila australis	Scrophulariaceae	a	Metcalfe 2009
Myriophyllum trachycarpum	Haloragaceae	a	NT Herbarium
Nymphoides hydrocharoides	Menyanthaceae	a	Staben & Forsyth 2022
Nymphoides minima	Menyanthaceae	a	NT Herbarium
Nymphoides subacuta	Menyanthaceae	a	NT Herbarium
Actinoscirpus grossus	Cyperaceae	at	Staben & Forsyth 2002
Crinum angustifolium	Liliaceae	at	Metcalfe 2009
Crinum uniflorum	Liliaceae	at	NT Herbarium
Hymenachne acutigluma	Poaceae	at	Metcalfe 2009
Melaleuca nervosa	Myrtaceae	at	Metcalfe 2009
Melaleuca symphiocarpa	Myrtaceae	at	Staben & Forsyth 2002
Scleria poaeformis	Cyperaceae	at	Metcalfe 2009
Commelina ensifolia	Commelinaceae	t	Metcalfe 2009, Staben & Forsyth 2002
Corymbia polycarpa	Myrtaceae	t	Metcalfe 2009
Cyanotis axillaris	Commelinaceae	t	Metcalfe 2009
Drosera burmanni	Droseraceae	t	NT Herbarium
Eriocaulon cinereum	Eriocaulaceae	t	Metcalfe 2009, NT Herbarium
Eriocaulon tortuosum	Eriocaulaceae	t	NT Herbarium
Eriocaulon spectabile	Eriocaulaceae	t	NT Herbarium
Goodenia leiosperma	Goodeniaceae	t	Metcalfe 2009
Goodenia prob. pilosa(Calogyne)	Goodeniaceae	t	Metcalfe 2009, Staben & Forsyth 2002
Goodenia purpurascens	Goodeniaceae	t	NT Herbarium
Goodenia symonii	Goodeniaceae	t	NT Herbarium
Heliotropium ventricosum	Boraginaceae	t	NT Herbarium
Ipomoea macrantha	Convolvulaceae	t	NT Herbarium
Ludwigia octovalvis	Onagraceae	t	Metcalfe 2009
Lycopodiella cernua	Lycopodiaceae	t	Metcalfe 2009, NT Herbarium
Lygodium microphyllum	Lygodiaceae	t	Metcalfe 2009
Oldenlandia tenuifolia	Rubiaceae	t	NT Herbarium
Utricularia circumvoluta	Lentibulariaceae	t	NT Herbarium
Utricularia hamiltonii	Lentibulariaceae	t	NT Herbarium
Utricularia lasiocaulus	Lentibulariaceae	t	NT Herbarium
Utricularia limosa	Lentibulariaceae	t	NT Herbarium
Utricularia triflora	Lentibulariaceae	t	NT Herbarium

a = aquatic, t = terrestrial and at = can be both.

5.1.4.2 Herbert 2 Lagoon

Fifty-five species were recorded from Herbert 2 Lagoon, 16 of these were aquatic species (Appendix 1, Table A2). The highest number of taxa was recorded in the May survey in 2008 and the lowest number in October 2008, when the lagoon was nearly dry.

12 species were only recorded in Herbert 2 Lagoon and not at any of the five other lagoons.

There were 10 alien plants, with two of them, *Hyptis suaveolens* and *Pennisetum polystachion* (mission grass), being declared weeds.

5.1.4.3 Knuckey Lagoons

A total of 57 species was recorded from Knuckey NE Lagoon, 28 of which were aquatic. Appendix 1, Table A3 displays the aquatic macrophyte species recorded in Knuckey NE

Lagoon during the four surveys. 20 species were only recorded in Knuckey NE Lagoon and not at any of the five other lagoons studied.

Two species of conservation significance were recorded from Knuckey NE Lagoon: *Nymphoides subacuta* and *Utricularia hamiltonii*. Both are endemic to the NT and classed by the International Union for Conservation of Nature IUCN as 'near threatened' (Short et al. 2011, Holmes et al. 2005, Cowie 2003). *Nymphoides subacuta* was also found at Waterlily Lagoon.

Five alien plants were recorded, with one declared weed, *Richardia braziliensis,* being noted. Only one of the introduced plants, *Stylosanthes hamata*, was aquatic.

Historical data include 13 more species/genera for Knuckey including the other three lagoons of the complex that were not recorded during the current surveys (Table 9).

Table 9: Additional taxa recorded at Knuckey Lagoons during other surveys (NT Herbarium, Lloyd 1999)

Species	Family	Environmental preference	Source of record
Hymenachne sp.	Poaceae	a	*Lloyd 1999*
Najas malesiana	Najadaceae	a	*NT Herbarium*
Nymphoides aurantiaca	Menyanthaceae	a	*NT Herbarium*
Oryza sp.	Poaceae	a	*Lloyd 1999*
Utricularia gibba	Lentibulariaceae	a	*NT Herbarium*
Ludwigia adscendens	Onagraceae	at	*NT Herbarium*
Aniseia martinicensis	Convolvulaceae	t	*NT Herbarium*
Cynodon dactylon var. dactylon	Poaceae	t	*NT Herbarium*
Eleusine sp.	Poaceae	t	*Lloyd 1999*
Panicum paludosum	Poaceae	t	*NT Herbarium*
Polygola sp.	Polygalaceae	t	*Lloyd 1999*
Rhynchospora sp.	Cyperaceae	t	*Lloyd 1999*
Vetiveria sp.= Chrysopogon sp.	Poaceae	t	*Lloyd 1999*

with a = aquatic, t = terrestrial, at = could be both.

5.1.4.4 McMinns Lagoon

Table A4 in the appendix displays the macrophyte species recorded in McMinns Lagoon during the four surveys. Seventeen of the 45 plant species were aquatic.

The number of five alien plants and one declared weed, *Stachytarpheta cayennensis,* Snakeweed, is again relatively low.

Interestingly there were more species recorded in October than in May and April, although the by far largest taxa list was obtained in the wet season in February/March.

5.1.4.5 Waterlily Lagoon

Twenty-two of the 45 species recorded at Waterlily Lagoon were aquatic (Table A5, Appendix 1). Eight species were only found in Waterlily Lagoon and not any of the other lagoons studied. Among the recorded taxa were two species of conservation significance. The aquatic plant *Nymphoides subacuta*, also recorded at Knuckey NE Lagoon, is an NT endemic plant categorised as near threatened in IUCN classification (Short 2011 et al., Holmes et al. 2005, Cowie 2003, International Union for the Conservation of Nature IUCN: http://www.iucnredlist.org).

The terrestrial plant *Cynanchum liebianum,* a data deficient plant, is only known from few locations in the outer Darwin region (NT Herbarium, Figure 7). The species appears to be endemic to the Litchfield Shire (Holmes et al. 2005), but is certainly endemic to the Northern Territory (Short et al 2011).

Waterlily Lagoon displayed the lowest number of alien plants with only two species recorded, none of them a declared weed. However, Waterlily Lagoon also had a low taxa count of 45, similar to the permanent water bodies McMinns Lagoon and Woodford Lagoon, which had 44.

Figure 7: *Cynanchum liebianum*, a data deficient plant found at Waterlily Lagoon.

5.1.4.6 Woodford Lagoon

Forty-four species were recorded from Woodfords Lagoon, 14 of these aquatic (Table A6, Appendix 1). Woodford Lagoon ranks lowest of the six lagoons studied aquatic plant species. Thirteen species were only recorded in Woodford Lagoon and not at any of the five other lagoons studied. *Livistona humilis* is endemic to the NT (Short et al 2011).

The highest taxa number was recorded in October, and the lowest count obtained in April. Woodford Lagoon displayed four alien species, one of them, *Pennisetum polystachion*, a declared weed.

5.1.4.7 Discussion of individual lagoons

The seasonal overview of plant collections reveals that many of the aquatic plants are recorded all year round. In most occasions, the late wet season survey provided the largest taxa number, and would therefore be confirmed to be the best time for surveys. However, numerous plants were not detected or identifiable at this time of the year so that several surveys throughout the year are preferable.

In another study of vegetation richness of lagoons in the Top End, Finlayson et al. (1994) recorded total plant species counts of between 33 and 43 in five billabongs in Magela Creek. Taxa richness of the outer Darwin lagoons presented here is therefore slightly higher with counts between 41 and 68, although different survey effort or different definitions of lagoon size could explain to such findings.

With respect to aquatic species, the Magela Creek billabongs displayed between 22 and 30 species in the five apparently permanent water bodies (Finlayson et al. 1994). This is quite similar to the 13 to 28 aquatic macrophytes found in the Darwin region lagoons. The Magela Creek billabongs had a percentage of 57 to 73 % aquatic species. This was lower for Darwin region lagoons, which displayed 27 to 51%. It is possible that the surveyed Magela Creek billabongs display this higher number of aquatic species, because they are all permanent, providing a more stable environment for aquatics. The size of the water bodies might also be a factor.

The percentage of annual plants species ranged from 43 to 55 in the Magela Creek billabongs (Finlayson et al. 1994) which was higher in Darwin area lagoons with 50-80% annuals. This is possibly due to the seasonal nature of half of the Darwin lagoons as many of the species persist through the dry phase purely as seed (Cowie 2003).

Cowie et al. (2000) generally state that the plant communities of the floodplains are species-poor compared to neighbouring upland communities such as woodland and open forest. Within floodplain communities, species richness is lowest at wet and saline sites and highest at drier sites. For example, the more deeply flooded *Oryza* and *Eleocharis* dominated communities have significantly fewer species then the ‘drier’ *Fimbristylis* sedge land (Cowie et al. 2000).

5.2 Macrophyte richness and environmental parameters

5.2.1 Grouping of lagoons according to macrophyte richness

The macrophyte data as collected allowed for an assessment of resemblance based on presence/absence data, which is displayed as a dendrogram in Figure 8.

When presenting this information in an ordination after multi-dimensional scaling (MDS) analysis, McMinns Lagoon and Waterlily Lagoon plot very close together with the other lagoons being distributed relatively evenly in the ordination space (Figure 9). The degree of similarity between the six lagoons studied was relatively low, with the highest value of fifty (with 100 being identical, 0 being no similarity) between McMinns and Waterlily Lagoon. This was already noted from the results of Table 6 with 99 of 160 total taxa only recorded in one lagoon. It appears still somehow surprising given that the geographic distribution of the lagoons is very close, all within the Darwin Harbour catchment. They are all on the same altitude with similar soils (Kandosols) and comparable water quality parameters (please refer to section 5.2.2).

The five Magela Creek Billabongs studied by Finlayson et al (1994) revealed a quite similar pattern: of 104 plant species recorded in all billabongs, 52 were found in only one of the five. This points to the fact that there is a lack of information on macrophyte species richness of Top End lagoons and billabongs, as plant lists for very few water bodies are available. It can be speculated that macrophyte species lists become more similar between lagoons, the more data are available. On the basis of the current knowledge, it appears that the lagoons are unique due to the fact that macrophyte species composition is so dissimilar.

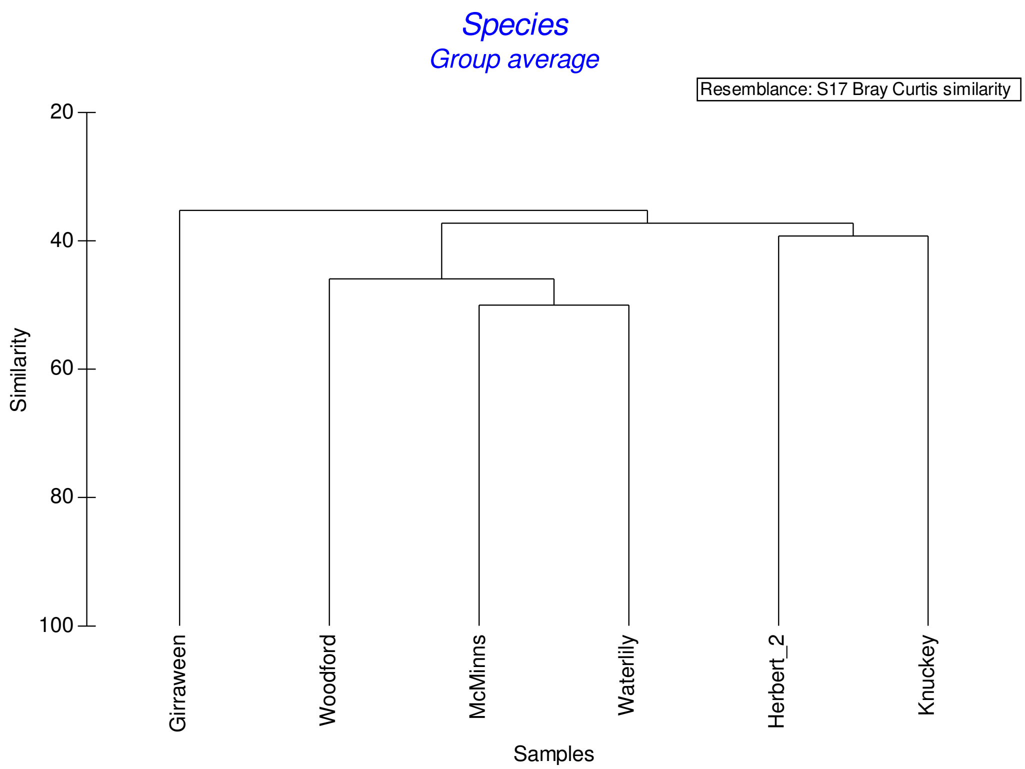

Figure 8: Cluster analysis of Lagoons based on resemblance of macrophyte taxa data

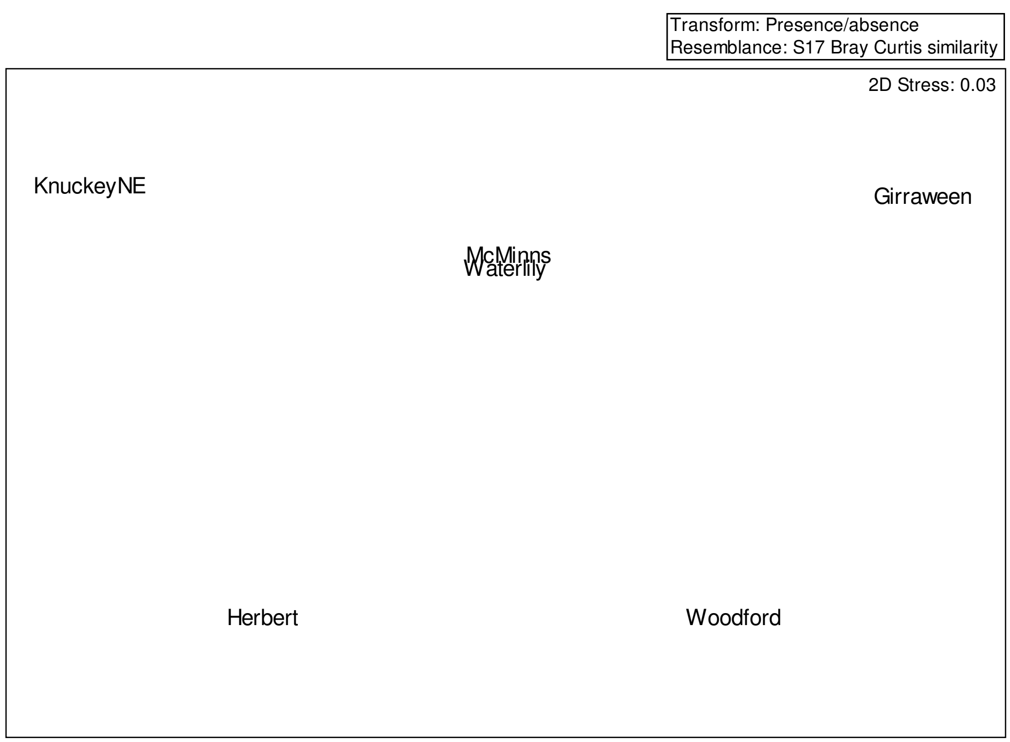

Figure 9: MDS ordination of the six lagoons based on macrophyte taxa data.

5.2.2 Water quality

The water quality of the lagoons did not vary largely with the seasons and is therefore presented as average of the four or three data collections for the seasonal lagoons (Table 10 and 11, Figure 10).

As found in previous studies, the water quality of the lagoons was very good, characterized through high clarity and low conductivity (Lamche 2008, Schult & Welch 2005).

Table 10: Physico-chemical water quality parameters of six Darwin region lagoons. Average, minimum and maximum values of water quality parameters measured during the three (*) or four sampling occasions

Lagoon		Temp (˚C)	pH	DO (mg/L)	EC (µS/cm)	Turbidity (NTU)
Girraween Lagoon	Mean	30.4	6.08	7.02	16	2.1
N=15	Min	28.3	5.1	4.8	11	0.9
	Max	32.2	7.4	8.3	25	10
Herbert 2 Lagoon*	Mean	28.0	5.4	7.7	20	3.1
n=11	Min	27.2	5.0	2.7	12	1.4
	Max	31.6	6.0	15.5	27	7.8
Knuckey (NE) Lagoon*	Mean	30.4	5.8	5.4	16	2.1
N=11	Min	27.1	5.4	3.2	12	1.0
	Max	31.5	6.7	7.9	20	7.9
McMinns Lagoon	Mean	29.6	6.4	7.3	19	2.7
N=14	Min	23.8	5.5	3.4	11	1.3
	Max	35.0	8.7	12.4	43	5.5
Waterlily Lagoon*	Mean	28.0	5.7	4.0	25	2.5
N=11	Min	24.7	5.2	2.2	20	1.1
	Max	30.2	7.8	5.9	34	4.4
Woodford Lagoon	Mean	28.1	6.4	6.1	13	2.7)
N=12	Min	24.5	5.2	2.9	7.8	0.6
	Max	31.3	8.2	9.3	18	4.9

Table 11: Nutrient, alkalinity and chlorophyll a values from six Darwin region lagoons.

Lagoon		NO_2_N (µg/L)	NO_3_N (µg/L)	FRP (µg/L)	TN (µg/L)	TP (µg/L)	Alk $CaCO_3$ (mg/L)	Chl a (µg/L)
Girraween Lagoon	Mean	<1	4	2	520	10	4.1	4.5
N=15	Min	<1	1	<1	190	2.5	3.8	1.0
	Max	2	9	3	650	30	5.3	9.0
Herbert 2 Lagoon*	Mean	<1	7	1	340	16	4.4	8.7
N=11	Min	<1	<1	<1	100	2.5	3.5	1.0
	Max	2	27	2	730	35	5.6	14
Knuckey (NE) Lagoon*	Mean	1	2	2	730	20	4.6	5.5
N=11	Min	0.5	<1	<1	310	2.5	3.3	1.0
	Max	2	8	3	1200	55	5.8	9
McMinns Lagoon	Mean	<1	4	2	920	10	5.2	5.0
N=19	Min	<1	<1	<1	260	5	2.7	2.0
	Max	1	14	4	1700	25	11	10
Waterlily Lagoon*	Mean	1.5	2	2	910	30	5.3	7.6
N=11	Min	1	<1	1	300	5	4.3	1.5
	Max	2	7	5	1500	135	6.8	15
Woodford Lagoon	Mean	<1	2	1	450	10	5.6	5.3
N=12	Min	<1	<1	<1	220	2.5	3.6	1.0
	Max	2	7	3	570	15	9.5	11

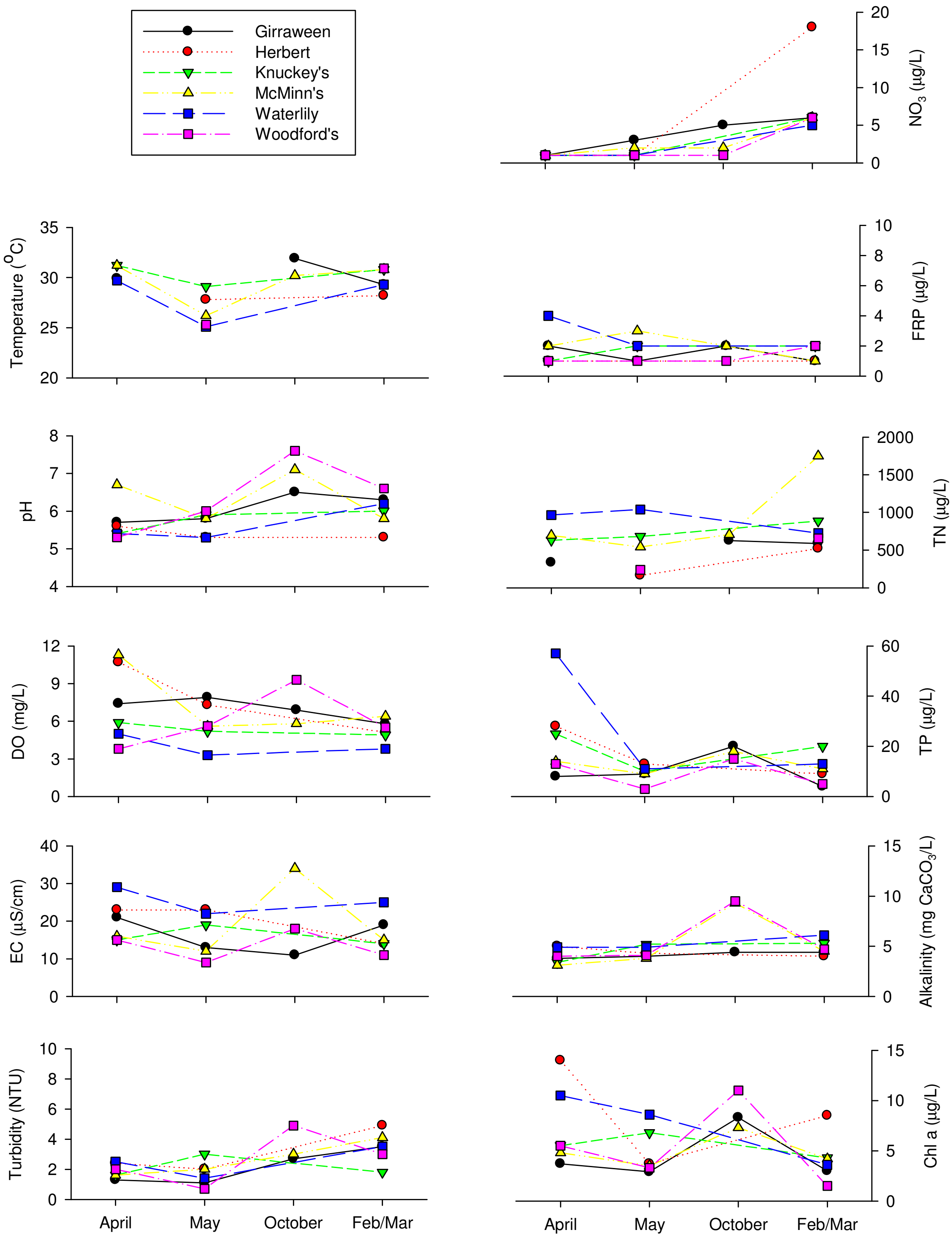

Figure 10: Seasonal changes in water quality for six lagoons in 2008/09.

The dendrogram based on resemblance calculated using Euclidean distance shows that all the lagoons are quite similar in their water quality (0 means similar, indefinite means dissimilar) (Figure 11).

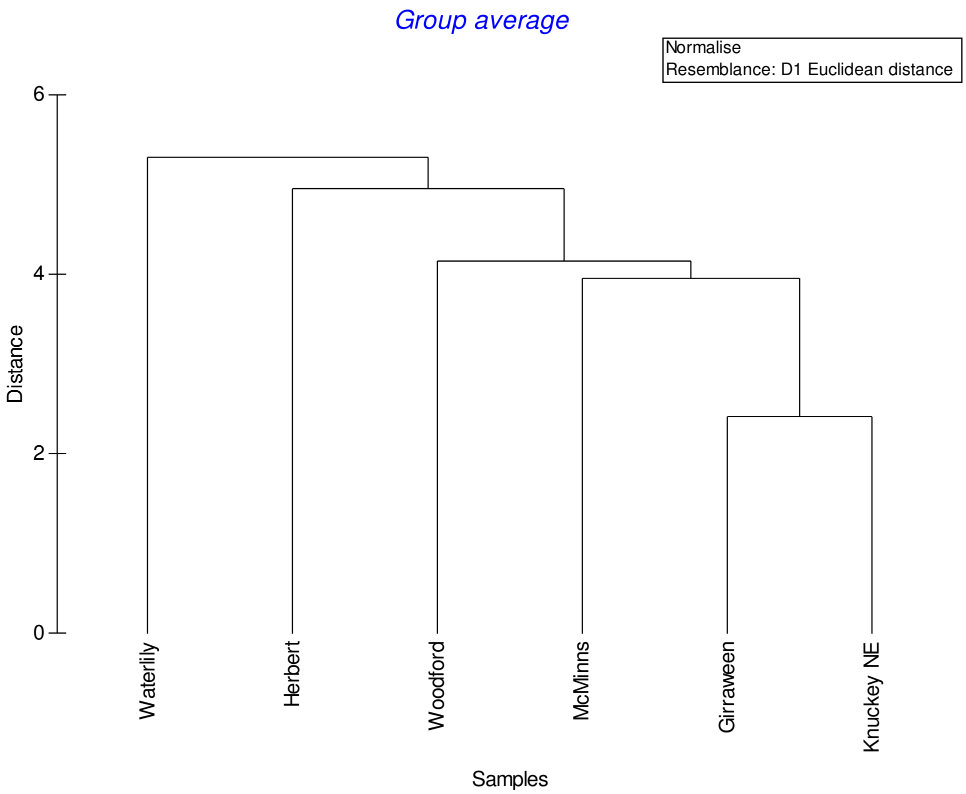

Figure 11: Dendrogram of lagoon's similarity using Euclidean distance based on average water quality data.

The MDS ordination based on water quality as shown in Figure 12 plotted the lagoons in a spatial pattern very different to the one shown in Figure 9 based on the macrophyte presence/absence data. This suggests that the macrophyte data of the lagoons cannot be explained through the water quality of the lagoons.

The BEST analysis was carried out in order to find which of the water quality parameters might explain the species composition of the lagoons. The best result with a correlation coefficient rho of 0.593 was found between the macrophyte data and the parameters (log) turbidity and alkalinity. This relation was not very strong, which was also due to the fact that the analysis was based on data from six lagoons only.

There are only few studies, where macrophyte richness was attempted to be related to water quality parameters and the results are ambivalent. Rolon et al. (2008) found a weak relationship between aquatic macrophyte richness and soluble reactive phosphorus and discuss several studies where macrophyte richness was explained through nitrate and phosphorus in ponds (Jones et al. 2003, James et al. 2005) or no relationship was found (Rolon & Maltchick 2006, Murphy et al. 2003). Mäkelä et al. (2004) found a positive relationship between species richness and conductivity. Akasaka et al (2010) report on a negative relationship between macrophyte richness and turbidity as well as nutrient concentration. Michalska-Hejduk et al (2009) found no relationship between macrophyte distribution and environmental parameters. Only the studies by Rolon et al. (2008), Rolon & Maltchick (2006) and Murphy et al. (2003) were carried out in tropical areas of southern Brazil and might therefore be more comparable than the other studies carried out in northern hemisphere temperate climates.

In a study on streams in the Wet Tropics in Queensland, Australia, Mackay et al. (2010) found that macrophyte metrics including species richness were not strongly influenced by water quality or the types of land use. However, although carried out in relatively similar climate, macrophyte species composition in streams cannot easily be compared to data from wetlands.

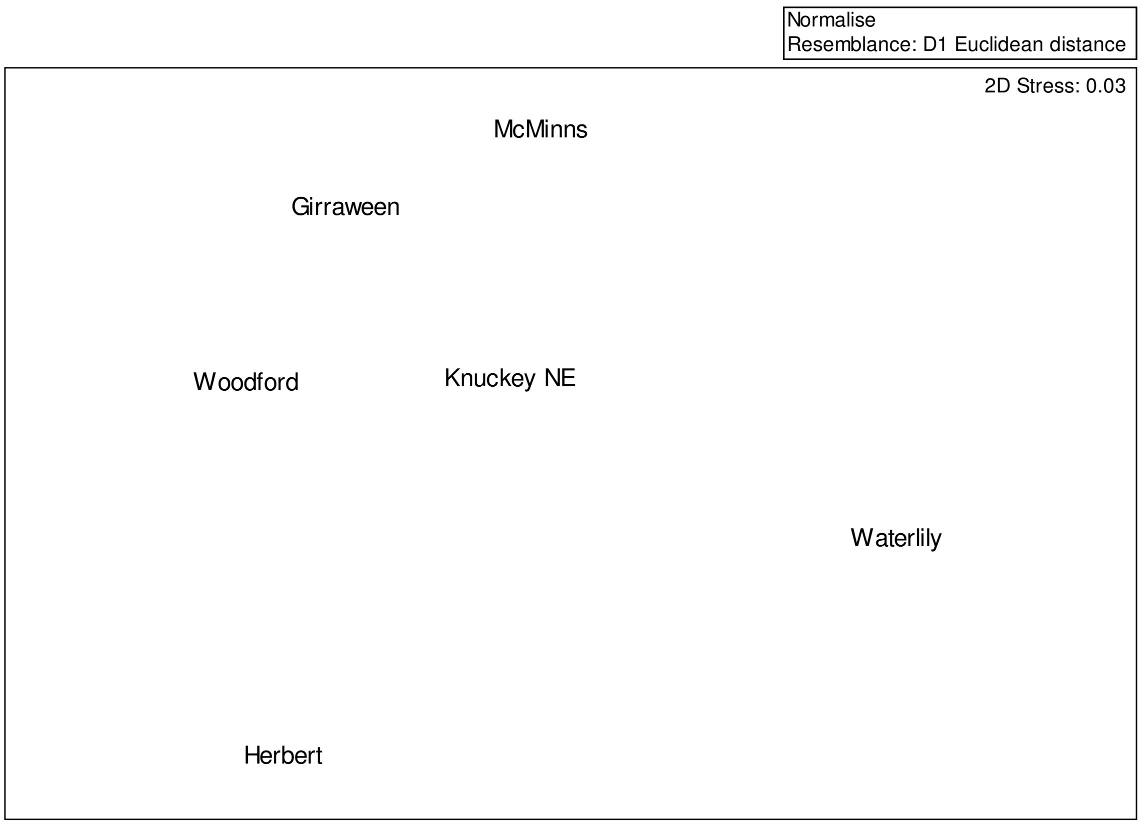

Figure 12: MDS ordination of the six lagoons based on water quality data.

5.2.3 Land use

Land use data were available for five of the six lagoons, excluding Woodford Lagoon, from the project on wetland health indicators and are summarised in Table 12 (Lamche 2008). The land use pattern in the catchment of the five lagoons varies largely.

The area surrounding the wetland complex is called the fringing zone. The amount of remnant native vegetation in a 100 m wide fringing zone, called FZ100, was also investigated as a potential relation to the macrophyte species richness.

The macrophyte richness was positively related to the amount of remnant native vegetation in the fringing zone (R^2=0.60, p=0.12). This regression is statistically not significant, however, the power of this relation might be increased if data for a larger number of lagoons would be available.

Table 12: Summary of land use parameters in the catchment (from Lamche 2008)

Lagoon	Size wetland complex (ha)	Total catchment area (ha)	Conservation and Natural Environments (%)	Production from Relatively Natural Environments (%)	Production from Dry land Agriculture and Plantations (%)	Production from Irrigated Agriculture and Plantations (%)	Intensive Uses (%)	Cleared area (%)	Area FZ100* (ha)	Remnant native vegetation in FZ100* (%)
Girraween Lagoon	49	706	59	6	4.3	3.0	27	44	36	90
Herbert_2 Lagoon	8.5	158	52	14	22	0	12	28	15	62
Knuckey NE Lagoon	116	210	20	0	1.9	4.0	74	95	67	6.1
McMinns Lagoon	62	520	30	8.5	15	5.6	41	77	41	5.2
Waterlily Lagoon	15	84	58	0.02	8.9	3.0	30	57	19	23

*FZ100: Fringing zone 100 m around the wetland complex area.

The Principal Component Analysis PCA displayed in Figure 13 places Girraween Lagoon and Waterlily Lagoon closer together due to the large percentage of conservation land use in the catchment and remnant native vegetation in the fringing zone. Knuckey NE Lagoon is clearly separate from all other lagoons due to the large cleared area and production from irrigated agriculture and plantations as well as intensive land use in the catchment.

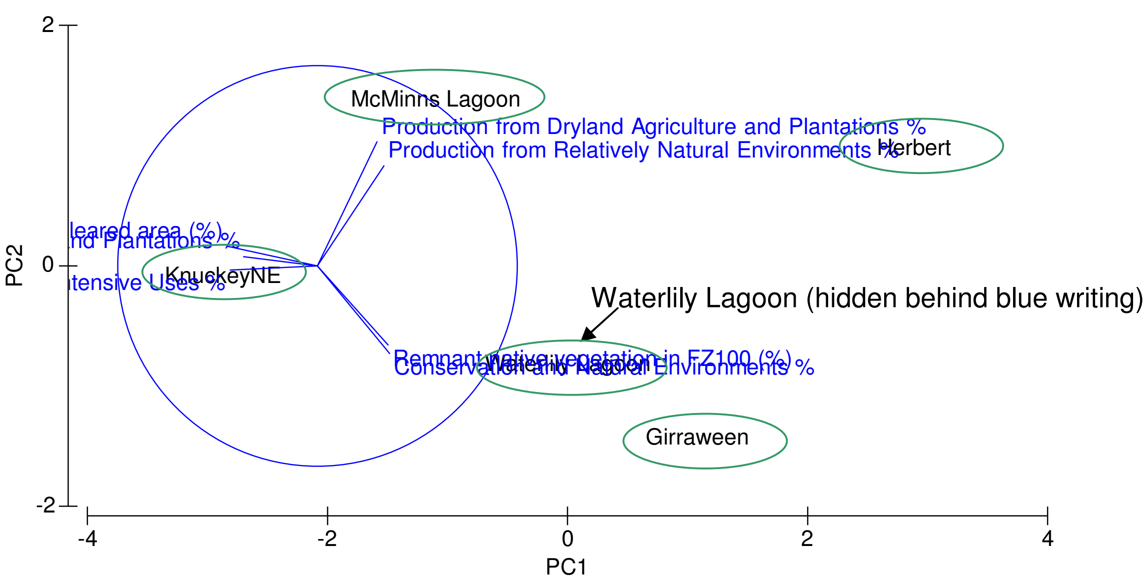

Figure 13: Principal Component Analysis of land use data in the catchment (in %).

MDS ordination was recalculated on the macrophyte data for the five lagoons for which land use data were available and MDS ordination was also calculated based on the land use data. Again there was no good spatial match between the lagoons in the ordination based on macrophyte data versus land use data (data not shown).

The BEST routine was carried out in order to find the 'best' match between the multivariate among-sample patterns of the macrophyte assemblage and that from the associated land use variables. In other words, a subset of abiotic variables was searched that 'explains' the biotic pattern. The BEST routine performed for the five lagoons revealed a weak relation between the macrophyte taxa data and the land use parameters '% production from dry land agriculture and plantations', '% intensive uses in catchment', '% remnant vegetation in the fringing zone' (rho=0.794, p=0.14). Again, due to the small amount of data (five lagoons), the power of this calculation is poor and the relation not statistically significant.

In other studies, Akasaka et al (2010) found a negative relationship between the proportion of urban area and the diversity of macrophytes, confirming our findings. Lougheed et al. (2001) found that the proportion of agricultural and urban land in wetland catchments was a highly significant predictor of water quality. Declining water quality was shown to lead to reduced submerged macrophyte biodiversity. James et al (2005) stated that freshwater lakes in Poland with less intensely farmed catchments had greater macrophyte species richness then those in the U.K., which again supports the results presented in this study.

5.3 Wetland health indicator

5.3.1 Measure: Species richness

Due to the lack of baseline information on species richness in the Darwin region lagoons, all the lagoons achieved the highest score because the reference condition was established from the current data collection (Table 13).

It is unlikely that all species present in the wetland are detected during a single survey. It may not be sufficient nor meaningful to carry out a single survey to detect change in the wetland and only repeated surveys can establish whether species numbers have really changed. It was concluded that four transects per lagoon were acceptable to pick up many of the species present. The best time for surveys was still the late wet season, although the October collection (late dry season) produced the largest species count for Woodford Lagoon.

Further discussion is required to establish whether the choice to use data from one survey only to calculate the indicator is meaningful. This decision was made in order to keep the field effort reasonable and allow for possible inclusion of a larger number of lagoons/sites as well as repetition of the survey in several years time.

However, bearing in mind that especially for Girraween Lagoon, where several studies have been carried out, a taxa richness is now 107, but with only 39 taxa recorded during one survey, this appears to underestimate the number of taxa considerably.

Table 13: Macrophyte species richness sub-score for six selected lagoons

Lagoon name	No. of species recorded in one survey	Score	Band
Girraween Lagoon	39	1	A
Herbert 2 lagoon	34	1	A
Knuckey Lagoon	35	1	A
McMinns Lagoon	37	1	A
Waterlily Lagoon	30	1	A
Woodford's Lagoon	27	1	A

5.3.2 Measure: Introduced species

All scores except the highest score were represented by the six lagoons in the trials (Table 14). None of the lagoons were free of exotic species and the scores seem to reflect the condition of the lagoons. The six lagoons in the trial are all located within residential areas and are regularly accessed by people and vehicles for recreational purposes. The introduced plants were mostly found near heavily accessed areas such as roads and picnic areas. If such areas are within the lagoon complex, one of the survey transects should be located in a way that they are included in the survey.

Table 14: Exotic species indicator sub-score for six selected lagoons detected in late wet season

Lagoon name	Survey date	No. of exotic species	Score	Band
Girraween Lagoon	Feb-08	7	0	E
Herbert 2 Lagoon	Feb-08	5	0.25	D
Knuckey Lagoon	Feb-08	5	0.25	D
McMinns Lagoon	Feb-08	4	0.5	C
Waterlily Lagoon	Feb-08	2	0.75	B
Woodford's Lagoon	Feb-08	1	0.75	B

When comparing the scores based on one survey to the ones based on all four surveys (Table 15), it is not surprising that three of the six lagoons received lower scores when using more data as more alien species were recorded. Again further discussion is required to establish which of the scores is more meaningful and if this result justifies the larger field effort of repeated surveying.

Table 15: Exotic species indicator sub-score for six selected lagoons detected during all four surveys

Lagoon name	No. of exotic species	Score	Band
Girraween Lagoon	11	0	E
Herbert 2 Lagoon	10	0	E
Knuckey Lagoon	5	0.25	D
McMinns Lagoon	5	0.25	D
Waterlily Lagoon	2	0.75	B
Woodford's Lagoon	4	0.5	C

During vegetation surveys of five billabongs in Magela Creek, between one and three alien plant species were found (Finlayson et al. 1994). This lower number of alien plants could be due to the remoteness of the billabongs studied as opposed to the frequently visited lagoons in the Darwin rural area. A contributing factor could be that the data collected in Magela Creek stem from the late 1980ies and an increase of alien plants might be recorded in new data collections.

In a study of alien plants in the Alligator Rivers Region, Cowie et al. (1988) focused on disturbed sites, ten of which were associated with rivers or wetland fringes. At these sites they report between 2 and 24 alien species. The relative large numbers recorded at some sites are likely associated with the selection of disturbed sites, which are prone to be open to alien plants for establishment plus the disturbance itself bringing in seeds from alien plants.

5.3.3 Measure: Declared weeds

Only four of the six trial lagoons contained declared Northern Territory Weeds (NT Herbarium), and only Girraween Lagoon contained a declared aquatic weed species, the floating fern *Salvinia molesta* (Figure 14). The scores reflect the status of the lagoons well (Table 16).

Figure 14: An infestation of *Salvinia molesta* at Girraween Lagoon.

Table 16: Declared weeds indicator sub-score for six selected lagoons using late wet season survey

Lagoon name	Survey date	Terrestrial	Aquatic	Score	Band
Girraween Lagoon	Feb-08	No	Yes	0	E
Herbert 2 Lagoon	Feb-08	Yes	No	0.5	C
Knuckey Lagoon	Feb-08	Yes	No	0.5	C
McMinns Lagoon	Feb-08	Yes	No	0.5	C
Waterlily Lagoon	Feb-08	No	No	1	A
Woodford Lagoon	Feb-08	No	No	1	A

This indicator was also calculated using the data from all four surveys and one lagoon, Woodford, received a lower score (Table 17).

Table 17: Declared weeds indicator sub-score for six selected lagoons using all 4 surveys

Lagoon name	Terrestrial	Aquatic	Score	Band
Girraween Lagoon	Yes	Yes	0	E
Herbert 2 Lagoon	Yes	No	0.5	C
Knuckey Lagoon	Yes	No	0.5	C
McMinns Lagoon	Yes	No	0.5	C
Waterlily Lagoon	No	No	1	A
Woodford Lagoon	Yes	No	0.5	C

5.3.4 Integrated Macrophyte indicator score

The Exotic Species and the Declared Weeds sub-scores measure very similar effects on the lagoon. The “Exotic Species” measure in fact includes declared weeds as well as other introduced plants. When integrating the three indicator scores to the macrophyte indicator score, the weighting introduced in section 4.5.3 reflects this. The integrated macrophyte scores are shown in Table 18 for the late wet season survey in February 2007 and in Table 19 based on all four surveys. The scores distinguish the six lagoons into three bands. Girraween Lagoon, the largest water body with the highest species richness ranks the lowest, which is due to the presence of the aquatic weed *Salvinia*. It is debatable whether the indicator should be re-weighted in order to possibly give larger credit to high species diversity.

Table 18: Macrophyte integrated score based on one wet season survey

	Measure				
Lagoon name	Species richness	Exotic species	Declared weeds	Integrated Macrophyte Indicator Score	Band
Weight	0.5	0.25	0.25		
Girraween Lagoon	1	0	0	0.5	C
Herbert 2 Lagoon	1	0.25	0.5	0.6875	B
Knuckey Lagoon	1	0.25	0.5	0.6875	B
McMinns Lagoon	1	0.5	0.5	0.75	B
Waterlily Lagoon	1	0.75	1	0.9375	A
Woodford's Lagoon	1	0.75	1	0.9375	A

Table 19: Macrophyte integrated score based on all four surveys

	Measure				
Lagoon name	Species richness	Exotic species	Declared weeds	Integrated Macrophyte Indicator Score	Band
Weight	0.5	0.25	0.25		
Girraween Lagoon	1	0	0	0.5	C
Herbert 2 Lagoon	1	0	0.5	0.625	B
Knuckey Lagoon	1	0.25	0.5	0.6875	B
McMinns Lagoon	1	0.25	0.5	0.6875	B
Waterlily Lagoon	1	0.75	1	0.9375	A
Woodford's Lagoon	1	0.5	0.5	0.75	B

Data collection for macrophyte species diversity also provides data on exotic species and declared weeds in the wetlands. These indicators provide a useful assessment of the degree of disturbance of the lagoons and their vulnerability to weed infestation. A number of aquatic weeds are present in the Northern Territory, including *Cabomba caroliniana, Echinochloa polystachya, Hymenachne amplexicaulis, Mimosa pigra, Salvinia molesta and Urochloa mutica* (Cowie 2003). One of these is found at one of the trial lagoons (Girraween Lagoon). These aquatic weeds have the potential to invade and "choke" wetlands, reducing species diversity and the area of open water (see also section 4.5.2).

However, Girraween Lagoon obtained the lowest overall score for the macrophyte index, although it does not appear to be less healthy, but in better condition than some of the other lagoons. The low score is obtained due to the presence of the aquatic weed *Salvinia*, which covers a very small proportion of the lagoon but has the potential to be detrimental. It is therefore important to decide whether the indicator should reflect the current situation or assumptions for the future. At this stage the indicator was meant to describe the current state of health. Therefore the weighting of the subindices needs adjustment to place greater value on the nativeness of the index. However, a broader data base covering a large number of lagoons would be essential to modify the weighting and obtain index scores that reflect the current situation better.

One other way of combining native and introduced species numbers is by using the percentage of weeds per total species number (Wray & Bayley 2006).

It is important to bear in mind that the biota index is only one of six indices used to assess wetland health, and a minimum of three indices are required to calculate an overall health index for a wetland or a region under the national system (Norris et al. 2007). Each of the indices can be a combination of several measures. Therefore the outcome that the trialled macrophyte indicator is not considered ideal means, that other measures in the biota theme can be used instead, i.e. based on fish species, amphibians, macroinvertebrates, water birds, algae. The general finding is that it is very time consuming to gather information for the biota index so that this theme is often not chosen to be one of the three minimally required indices.

Croft & Chow-Fraser (2007) developed a macrophyte index to assess the health of the wetlands in the Great Lakes region in North America. The index was based on data from 127 wetlands, occasionally collected for more than one year. The index gives each individual plant species a value for tolerance to degradation and one to indicate the niche breadth. They measured a range of water quality parameters and could relate the outcome of their macrophyte index to the water quality and/or human induced disturbance. They also had access to 30 years worth of historical data at two regions that allowed for validation of the index. This study demonstrates that with the adequate amount of resources to widely gather data and access expert knowledge, a very meaningful wetland indicator can be developed using macrophytes.

Macrophyte indicators used in Europe are based on indicator values for individual plant species (Schneider 2007), an approach that is desirable for the NT floodplain flora, but at present no resources would be available.

5.3.5 Perspective

When the Australian Framework for River and Wetland Health FARWH (Norris et al. 2007) was developed, several trials were carried out throughout Australia. The FARWH trials on wetland health from New South Wales (NSW) did not choose to use the biota indicator, as the assessment size was based on surface water management areas, the scale Australian wide comparison is aimed at. The NSW study concluded that there was not enough information to calculate a biota index, but provided the outlook that macroinvertebrate and frog data would be collected and/or collated in future assessments (Turak et al. 2011).

Other results on the FARWH trials are based on river health only (Dixon et al. 2011, NWC 2011, Senior et al. 2011, Storer et al. 2011).

5.3.6 Conclusion

In the following the important points with regards to the macrophyte wetland health indicator are summarised:

Best time for sampling: it is best to sample 4 or at least 2 times in a year as annual plants are not present throughout the year. If only one survey is possible, it has to be in the late wet season.

Number of transects: It was shown that the first transect captures the largest number of species, but that every additional transect up to four increased the species number without plateauing. In this study 2 transects were surveyed towards the centre of the lagoon plus two along the edge of the water. This was found suitable, but more transects would certainly be better.

Usefulness of indicator: Although the number of plant species per wetland is meaningful when assessing wetland health, the use of species number as indicator appears debatable for the following reasons:

- The variability in species number per survey was high.
- A great proportion of species was not being picked up in a single survey. How can thus the manifestation of a change in species number be demonstrated ?
- How can the non-detection of a rare or threatened species be interpreted when it is not being picked up in a survey or over several consecutive years: is it not there and the habitat quality has declined or was it simply not recorded and there was no change in wetland health ?
- The data collection on macrophytes is time consuming and is based on the individual wetland. Reducing the variability in the data can be reduced by increasing the survey effort, but this is not considered feasible as the effort is already considerably large.
- The definition of the reference condition as number of species recorded in one survey for each of the wetlands studied is also debatable. Ideally the reference condition should be a predictable number based on either a species list per wetland or a number that can e.g. be extrapolated from wetland size and local knowledge.
- Although not discussed in this report, there is a great grey area as to which plant species are associated with a wetland - be it aquatic or floodplain flora – and what terrestrial plants to include or not. Until there is a strict definition, this will contribute to the variability of the use of species number as indicator as different surveyors use varying approaches.
- The use of weeds as part of the overall macrophyte indicator is still assessed as meaningful. However, the use of weed species number presents similar problems as discussed for the native macrophyte species index. Still, the survey for weeds can be designed by looking at frequently visited and disturbed areas, which are more likely to have weeds, rather than random transects designed to capture native macrophytes.
- Non-detection of a formerly present weed during a survey leads to the question whether the species is absent or not detected. Especially if there would be a management plan implemented in order to eliminate the weed from the wetland, the knowledge of its presence is essential. However, if it is not detected, at least it has not spread widely.

- With respect to comparisons of the scores of wetlands on a higher level, i.e. integration of the score to wetlands of surface water management area for nationwide analysis, this indicator is not practical as it is based on the individual wetland.

However, macrophytes live in a location over extended periods and therefore offer themselves as indicators for the health of the wetland. They are sampled easily without the requirement of special or costly equipment as they are sessile and identified relatively quickly.

The macrophyte cover of wetlands, i.e. a semi-quantitative approach might be more useful than species richness as indicator. Instead of collecting data from the ground it could be worthwhile assessing aerial photography or photos collected by a remote controlled ‘toy’ helicopter mounted with a camera.

It would be worthy to look at an indicator where data can be collected by remote sensing.

It is concluded that macrophyte species richness as used in this report is not a useful indicator for the biota index.

Recommendations for future surveys: As it was stated above that the indicator as applied here is not practical and useful, it is recommended to change methodology and trial macrophyte cover as indicator and/or establish remote data collection methodology.

In general the collection of macrophyte data of the Darwin area lagoons should be repeated in five or ten years time in order to broaden the knowledge and baseline information. It would be best to include more lagoons. It will be very interesting to see whether the species composition will remain as unique for individual lagoons or whether the increased data set would show larger overlap in species lists between lagoons.

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7. APPENDIX 1: MACROPHYTE LISTS FOR INDIVIDUAL LAGOONS

Table A1: Macrophyte vegetation of Girraween Lagoon during four surveys

Species[#]	Family	Feb 08[¤]	May 08	Oct 08	Apr 09	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]
Andropogon gayanus	Poaceae		1			t	p	g	w
Asteromyrtus symphyocarpa	Myrtaceae		1			t	p	t	
Azolla pinnata	Azollaceae	1	2			a	p	f	
Blyxa aubertii	Hydrocharitaceae				1	a	a	h	
Brachiaria (Urochloa) humidicola	Poaceae		1			t	p	g	i
Calopogonium/Cajanus mucunoides	Fabaceae		1			t	ap	v	i
Chamaecrista mimosoides	Caesalpiniaceae		1			t	a	sh	
Chamaecrista rotundifolia	Caesalpiniaceae	1				t	a	h	i
Chrysopogon oliganthus	Poaceae	3	4	1	2	a	p	g	
Corymbia bella	Myrtaceae			1		t	p	t	
Corymbia polycarpa?	Myrtaceae			1		t	p	t	
Crotalaria goreensis	Fabaceae	1				t	a	h	i
Cyclosorus interruptus	Thelypteridaceae			1		t	p	f	
Cyperus angustatus	Cyperaceae	1				t	a	se	
Cyperus haspan	Cyperaceae		1		1	t	p	se	
Cyperus holoschoenus	Cyperaceae	1				t	a	se	
Cyperus javanicus	Cyperaceae	1				t	p	se	
Cyperus platystylis	Cyperaceae			1	2	a	p	se	
Cyperus serotinus	Cyperaceae	1				t	a	se	
Drosera petiolaris s. l.	Droseraceae	1				t	p	h	
Eleocharis ochrostachys	Cyperaceae			1		t	ap	se	
Eleocharis sundaica	Cyperaceae		3	1	1	at	p	se	
Eriachne burkittii	Poaceae				1	t	ap	g	
Eriocaulon depressum	Eriocaulaceae				1	t	a	h	
Eriocaulon setaceum	Eriocaulaceae	1	3		2	a	a	h	
Fimbristylis pauciflora	Cyperaceae	2	1	1	2	t	ap	se	
Fuirena ciliaris	Cyperaceae		1			t	a	se	
Goodenia kakadu	Goodeniaceae	2	1	1	2	t	a	h	
Hybanthus enneaspermus	Violaceae	1				t	a	sh	
Ischaemum australe	Poaceae	3		1		a	p	g	
Isoetes coromandelina?	Isoetaceae		1			a	a	f	
Leersia hexandra	Poaceae	1	2			a	p	g	
Lepironia articulata	Cyperaceae		4	1	2	a	p	se	
Limnophila chinensis	Scrophulariaceae	2	2	1	2	at	a	h	
Limnophila fragrans	Scrophulariaceae		2			at	a	h	
Lindernia sp.	Scrophulariaceae			1		t	ap	h	
Lophostemon lactifluus	Myrtaceae			1		t	p	t	
Melaleuca cajuputi	Myrtaceae		4			at	p	t	
Melaleuca leucadendra	Myrtaceae	1	3		2	at	p	t	
Melaleuca viridiflora	Myrtaceae	3				at	p	t	

Melinis repens	Poaceae	1				t	p	g	i
Microcarpaea minima	Scrophulariaceae		1			t	ap	h	
Mimulus uvedaliae	Scrophulariaceae	1	1	1	2	t	a	h	
Najas sp.	Najadaceae	3	3	1		a	ap	h	
Nymphaea hastifolia	Nymphaeaceae	1				a	p	h	
Nymphaea violacea	Nymphaeaceae	1	4	1	2	a	p	h	
Nymphoides aurantiaca	Menyanthaceae	1	1		1	a	ap	h	
Nymphoides crenata	Menyanthaceae		1			a	ap	h	
Nymphoides indica	Menyanthaceae	1		1	1	at	ap	h	
Pandanus spiralis	Pandanaceae	1	2	1		t	p	p	
Paspalum scrobiculatum	Poaceae	2			1	at	p	g	
Pennisetum polystachion	Poaceae		1			t	p	g	w
Philydrum lanuginosum	Philydraceae		1	1	1	at	p	h	
Planchonia careya	Lecythidaceae			1		t	p	st	
Pseudoraphis spinescens	Poaceae	2	4	1	1	at	p	g	
Rhynchospora submarginata	Cyperaceae	2				t	?	se	
Sacciolepis indica	Poaceae			1	2	t	ap	g	
Salvinia molesta	Salviniaceae	2	4	1	2	a	p	f	w
Scleria poaeformis	Cyperaceae		1	1	1	a	p	se	
Sorghum timorense	Poaceae	1				t	a	g	
Spermacoce articularis	Rubiaceae	1				t	a	h	i
Stylidium sp.	Stylidiaceae				1	t	a	h	
Stylosanthes guianensis	Fabaceae	1				t	a	h	i
Stylosanthes humilis	Fabaceae	1				t	a	h	i
Tricostularia undulata	Cyperaceae	1				t	p	se	
Utricularia gibba	Lentibulariaceae	2	4	1	1	a	ap	h	
Utricularia leptoplectra	Lentibulariaceae		1		3	t	a	h	
Utricularia muelleri	Lentibulariaceae	3	4	1	2	a	a	h	
Websteria confervoides	Cyperaceae	3	1	1	1	a	p	se	
Xyris complanata	Xyridaceae	2	1	1	2	t	p	h	
Xyris indica	Xyridaceae		1		2	t	a	h	
Count of presence	71*	39	38	29	30				11

[#]:The 29 species highlighted in green were only recorded in Girraween Lagoon and not at any of the five other lagoons.

[¤]: The number displays on how many of the four transects the species was recorded.

[a]: Environmental preference is aquatic (a), terrestrial (t) and can be both (at).

[b]: Life strategy is annual (a), perennial (p) and can be both (ap).

[c]: Growth form: f=fern or related, g=grass, h=herb, forb, p=palm, s=shrub, se= sedge, t=tree, v=vine.

[d]: alien to the area: plant is introduced (i), a declared weed (w).

*: the total number of taxa is higher than in the overview table 8 in section 4.1.1 as some plants identified to genus level only or with a question mark at species level are included in this table.

Table A2: Macrophyte vegetation of Herbert 2 Lagoon during four surveys

Species[#]	Family	Feb/Mar 08[a]	May 08	Oct 08	Apr 09	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]
Alysicarpus ovalifolius	Fabaceae	1				t	a	h	i
Bacopa floribunda	Scrophulariaceae		1			t	ap	h	
Blyxa aubertii	Hydrocharitaceae	1	1			a	a	h	
Caldesia oligococca	Alismataceae		1			a	ap	h	
Calopogonium mucunoides	Fabaceae	1	2		1	t	ap	v	i
Cassytha sp.	Lauraceae		1			t	p	v	
Chrysopogon oliganthus	Poaceae	3	2	1	1	a	p	g	
Cyperus aquatilis	Cyperaceae		1			t	a	se	
Cyperus haspan	Cyperaceae	1	1		1	t	p	se	
Cyperus serotinus	Cyperaceae	1				t	a	se	
Dentella dioecea	Rubiaceae	1	1			t	a	h	
Desmodium pullenii	Fabaceae		1			t	?	h	
Desmodium trichostachyum	Fabaceae		1			t	a	h	
Ectrosia leporina	Poaceae		1			t	a	g	
Eleocharis sp.	Cyperaceae	2	2	1	2	at	ap	se	
Eragrostis sp.	Poaceae				1	t	ap	g	
Eriachne triseta	Poaceae		1			t	p	g	
Eriocaulon cinereum	Eriocaulaceae		1			t	a	h	
Eriocaulon setaceum	Eriocaulaceae		1			a	a	h	
Fimbristylis acicularis	Cyperaceae	1				t	a	se	
Fimbristylis littoralis	Cyperaceae		1			t	a	se	
Fimbristylis pauciflora	Cyperaceae	2	1	1		t	ap	se	
Fuirena ciliaris	Cyperaceae		1			t	a	se	
Heliotropium indicum	Boraginaceae			1		t	a	h	
Hyptis suaveolens	Lamiaceae	1				t	a	h	w
Limnophila fragrans	Scrophulariaceae	2	2			at	a	h	
Lophostemon grandiflorus	Myrtaceae				1	t	p	t	
Lophostemon lactifluus	Myrtaceae			1		t	p	t	
Ludwigia ?hyssopifolia	Onagraceae				1	t	a	h	
Ludwigia octovalvis	Onagraceae		1			t	a	sh	
Macroptilium lathyroides	Fabaceae			1		t	a	h	i
Malachra capitata	Malvaceae			1		t	a	s	i
Melaleuca viridiflora	Myrtaceae	1	2		1	at	p	t	
Melochia corchorifolia	Sterculiaceae	2	1			t	a	sh	
Najas sp.	Najadaceae					a	ap	h	
Nymphaea hastifolia?	Nymphaeaceae	1				a	p	h	
Nymphaea violacea	Nymphaeaceae	3	1		1	a	p	h	
Nymphoides indica	Menyanthaceae	4	1	1	2	at	ap	h	
Oldenlandia sp.	Rubiaceae	3				t	a	h	
Oryza meridionalis/rufipogon	Poaceae		1		1	a	ap	g	
Paspalum scrobiculatum	Poaceae	2	1		1	at	p	g	
Passiflora foetida	Passifloraceae		1			t	p	v	i
Pennisetum polystachion	Poaceae		1			t	p	g	w
Polygala sp.	Polygalaceae	1				t	a	h	

Pseudoraphis spinescens	Poaceae	6	1	1	1	at	p	g	
Rhynchospora exserta	Cyperaceae	1				t	a	se	
Rynchospora wightiana	Cyperaceae		1			t	a	se	
Scoparia dulcis	Scrophulariaceae	1				t	a	h	i
Spermacoce leptoloba	Rubiaceae	1				t	a	h	
Stylosanthes guianensis	Fabaceae	1				t	a	h	i
Stylosanthes humilis	Fabaceae				1	t	a	h	i
Utricularia aurea	Lentibulariaceae	8	1	1	1	a	ap	h	
Utricularia gibba	Lentibulariaceae	2	1		1	a	ap	h	
Vigna lanceolata var. filiformis	Fabaceae				1	t	p	v	
Xyris sp.	Xyridaceae		1			t	ap	h	
Count of presence	55*	27	34	10	17				10

#: The 12 species highlighted in green were only recorded in Herbert 2 Lagoon and not at any of the five other lagoons.

¤: The number displays on how many of the four transects the species was recorded.

a: Environmental preference is aquatic (a), terrestrial (t) and can be both (at).

b: Life strategy is annual (a), perennial (p) and can be both (ap).

c: Growth form: f=fern or related, g=grass, h=herb, forb, p=palm, s=shrub, se= sedge, t=tree, v=vine.

d: alien to the area: plant is introduced (i), a declared weed (w).

*: the total number of taxa is higher than in the overview table 8 in section 4.1.1 as some plants identified to genus level only or with a question mark at species level are included in this table.

Table A3: Macrophyte vegetation of Knuckey NE Lagoon during four surveys

Species[#]	Family	Feb 08[¤]	May 08	Oct 08	Apr 09	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]
Aeschynomene indica	Fabaceae	1	1			a	a	s	
Alternanthera denticulata	Amaranthaceae	2				t	a	s	
Asteromyrtus symphyocarpa	Myrtaceae	2	1	1		t	p	t	
Blyxa aubertii	Hydrocharitaceae	1				a	a	h	
Caldesia oligococca	Alismataceae		1		1	a	ap	h	
Coldenia procumbens	Boraginaceae			1		t	a	h	
Cyperus aquatilis	Cyperaceae		1			t	a	se	
Cyperus compressus	Cyperaceae	1				t	a	se	i
Cyperus platystylis	Cyperaceae			1		a	p	se	
Cyperus scariosus	Cyperaceae	1				t	p	se	
Cyperus serotinus	Cyperaceae	1				t	a	se	
Cyperus sphacelatus	Cyperaceae	1				t	a	se	i
Dentella dioeca	Rubiaceae	1	1	1		t	a	h	
Desmodium muelleri	Fabaceae	2	1			t	a	h	
Eclipta prostrata	Asteraceae			2		t	a	h	
Ectrosia leporina	Poaceae	1				t	a	g	
Eleocharis sp.	Cyperaceae		3	1	1	at	ap	se	
Eragrostis sp.	Poaceae	2				t	ap	g	
Eriachne burkittii	Poaceae		1	1		t	ap	g	
Eriocaulon setaceum	Eriocaulaceae	1	1		1	a	a	h	
Fimbristylis pauciflora	Cyperaceae	4	1	1	1	t	ap	se	
Goodenia purpurascens	Goodeniaceae	1	1		1	t	ap	h	
Heliotropium indicum	Boraginaceae			1		t	a	h	
Heliotropium ventricosum	Boraginaceae			1		t	a	h	
Isoetes coromandelina subsp. macrotuberculata	Isoetaceae	1			2	a	a	f	
Limnophila aromatica	Scrophulariaceae		1			a	a	h	
Limnophila fragrans	Scrophulariaceae	1	1	1		at	a	h	
Lindernia sp.	Scrophulariaceae	1				t	ap	h	
Ludwigia hyssopifolia	Onagraceae	1	1		1	t	a	h	
Ludwigia octovalvis	Onagraceae			1		t	a	sh	
Maidenia rubra	Hydrocharitaceae		1			a	a	h	
Melaleuca viridiflora	Myrtaceae	1	2	1	2	at	p	t	
Melochia corchorifolia	Sterculiaceae	3	3			t	a	sh	
Microcarpaea minima	Scrophulariaceae	1	1	1	1	t	ap	h	
Myriophyllum trachycarpum	Haloragaceae		1		3	a	a	h	
Najas sp.	Najadaceae	3	1		1	a	ap	h	
Nymphaea hastifolia	Nymphaeaceae	1				a	p	h	
Nymphaea violacea	Nymphaeaceae		1		2	a	p	h	
Nymphoides indica	Menyanthaceae				2	at	ap	h	
Nymphoides minima	Menyanthaceae				1	a	a	h	
Nymphoides parvifolia	Menyanthaceae				1	a	a	h	
Nymphoides spongiosa	Menyanthaceae		1			a	a	h	
Nymphoides subacuta	Menyanthaceae		1	1	1	a	ap	h	

Oldenlandia galioides	Rubiaceae	8	1			t	a	h	
Paspalum scrobiculatum	Poaceae	6				at	p	g	
Persicaria attenuata	Polygonaceae	2	1	1	1	at	p	h	
Philydrum lanuginosum	Philydraceae		1			at	p	h	
Phyllanthus sulcatus	Euphorbiaceae	1				t	a	h	
Pseudoraphis spinescens	Poaceae	9	1	1	2	at	p	g	
Richardia braziliensis	Araceae	1				t	a	h	w
Sorghum intrans	Poaceae	2	1		1	t	a	g	
Stylosanthes hamata	Fabaceae	1				at	p	h	i
Stylosanthes humilis	Fabaceae	2				t	a	h	i
Triglochin dubium	Juncaginaceae	1				a	ap	h	
Utricularia aurea?	Lentibulariaceae	2	1			a	ap	h	
Utricularia hamiltonii	Lentibulariaceae		1			t	a	h	
Utricularia muelleri	Lentibulariaceae		1		2	a	a	h	
Count of presence	57*	35	31	17	20				5

[#]: The 20 species highlighted in green were only recorded in Knuckey NE Lagoon and not at any of the five other lagoons studied.

[¤]: The number displays on how many of the four transects the species was recorded.

[a]: Environmental preference is aquatic (a), terrestrial (t) and can be both (at).

[b]: Life strategy is annual (a), perennial (p) and can be both (ap).

[c]: Growth form: f=fern or related, g=grass, h=herb, forb, p=palm, s=shrub, se= sedge, t=tree, v=vine.

[d]: alien to the area: plant is introduced (i), a declared weed (w).

*: the total number of taxa is higher than in the overview table section 4.1.1 as some plants identified to genus level only or with a question mark at species level are included in this table.

Table A4: Macrophyte vegetation of McMinns Lagoon during four surveys

Species[#]	Family	Feb/Mar 08[¤]	May 08	Oct 08	Apr 09	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]
Acacia auriculiformis	Mimosaceae	2	2	1		t	p	t	
Acacia holosericea	Mimosaceae	1		1		t	p	st	
Asteromyrtus symphyocarpa	Myrtaceae	1		1		t	p	t	
Blyxa aubertii	Hydrocharitaceae	1				a	a	h	
Cassytha filiformis	Lauraceae	1		1		t	p	v	
Chrysopogon latifolius	Poaceae	1				t	p	g	
Chrysopogon oliganthus	Poaceae	1	3	1	2	a	p	g	
Cyperus polystachyos	Cyperaceae	2				t	a	se	
Desmodium pullenii	Fabaceae	1				t	?	h	
Desmodium pycnotrichum	Fabaceae	1				t	a	h	
Eclipta prostrata	Asteraceae	1				t	a	h	
Eleocharis sundaica	Cyperaceae	2	1	1	1	at	p	se	
Emilia sonchifolia	Asteraceae	1				t	a	h	i
Eriocaulon depressum	Eriocaulaceae				1	t	a	h	
Eriocaulon nematophyllum	Eriocaulaceae		1			t	a	h	
Eriocaulon setaceum	Eriocaulaceae	2	3		1	a	a	h	
Fimbristylis dichotoma	Cyperaceae	1				t	p	se	
Fimbristylis pauciflora	Cyperaceae		3	1	1	t	ap	se	
Grevillea pteridifolia	Proteaceae	1		1		t	p	t	
Heliotropium indicum	Boraginaceae			1		t	a	h	
Isoetes coromandelina	Isoetaceae		2			a	a	f	
Limnophila fragrans	Scrophulariaceae	1	1			at	a	h	
Lophostemon lactifluus	Myrtaceae	3		1		t	p	t	
Melaleuca viridiflora	Myrtaceae	2	2	1	2	at	p	t	
Melochia corchorifolia	Sterculiaceae	2			1	t	a	sh	
Murdannia nudiflora	Commelinaceae	1				t	p	h	i
Najas sp.	Najadaceae	2	3	1	1	a	ap	h	
Nymphaea violacea	Nymphaeaceae	2	5	1	2	a	p	h	
Nymphoides indica	Menyanthaceae	2	4	1	1	at	ap	h	
Oldenlandia galioides	Rubiaceae	1			1	t	a	h	
Oryza rufipogon	Poaceae		2	1	1	a	ap	g	
Paspalum scrobiculatum	Poaceae	1				at	p	g	
Passiflora foetida	Passifloraceae			1		t	p	v	i
Pseudoraphis spinescens	Poaceae	3	3	1	2	at	p	g	
Scoparia dulcis	Scrophulariaceae	1				t	a	h	i
Sesbania cannabina var. sericea	Fabaceae	1	1	1		a	a	s	
Sorghum intrans	Poaceae	3			1	t	a	g	
Spermacoce leptoloba	Rubiaceae	2				t	a	h	
Stachytarpheta cayennensis	Verbenaceae	2				t	p	sh	w
Utricularia gibba	Lentibulariaceae	3	3	1	1	a	ap	h	
Utricularia leptoplectra	Lentibulariaceae		1		1	t	a	h	
Utricularia muelleri	Lentibulariaceae	1	2	1	2	a	a	h	
Vallisneria annua	Hydrocharitaceae	1		1	1	a	a	h	
Xyris complanata	Xyridaceae	1		1		t	p	h	

Xyris indica	Xyridaceae	1	1			t	a	h	
Total (species and genera)	45*	37	19	22	18				5

[#]: The 13 species highlighted in green were only recorded in McMinns Lagoon and not at any of the five other lagoons studied.

[¤]: The number displays on how many of the four transects the species was recorded.

[a]: Environmental preference is aquatic (a), terrestrial (t) and can be both (at).

[b]: Life strategy is annual (a), perennial (p) and can be both (ap).

[c]: Growth form: f=fern or related, g=grass, h=herb, forb, p=palm, s=shrub, se= sedge, t=tree, v=vine.

[d]: alien to the area: plant is introduced (i), a declared weed (w).

*: the total number of taxa is higher than in the overview table section 4.1.1 as some plants identified to genus level only or with a question mark at species level are included in this table.

Table A5: Macrophyte vegetation of Waterlily Lagoon during four surveys

Species[#]	Family	Feb 08[¤]	May 08	Oct 08	Apr 09	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]
Acacia auriculiformis	Mimosaceae	1	1	1	2	t	p	t	
Asteromyrtus symphyocarpa	Myrtaceae	1	1			t	p	t	
Azolla pinnata	Azollaceae		1		1	a	p	f	
Blyxa aubertii	Hydrocharitaceae	3			1	a	a	h	
Caldesia oligococca	Alismataceae	2	1		1	a	ap	h	
Chrysopogon oliganthus	Poaceae	1	2	1	2	a	p	g	
Commelina ensifolia	Commelinaceae	1				t	a	h	
Cyanotis axillaris	Commelinaceae	1				t	a	h	
Cynanchum liebianum	Asclepiadaceae	1				t	?	h	
Cyperus digitatus	Cyperaceae	2		1		t	ap	se	
Dentella repens	Rubiaceae			1		t	ap	h	
Desmodium muelleri	Fabaceae	1				t	a	h	
Eleocharis sundaica	Cyperaceae	1	1	1	2	at	p	se	
Eriocaulon cinereum	Eriocaulaceae				1	t	a	h	
Eriocaulon depressum	Eriocaulaceae				1	t	a	h	
Eriocaulon setaceum	Eriocaulaceae	1			1	a	a	h	
Fimbristylis littoralis	Cyperaceae		1			t	a	se	
Fimbristylis pauciflora	Cyperaceae	1				t	ap	se	
Heliotropium indicum	Boraginaceae			1		t	a	h	
Hymenachne acutigluma	Poaceae	1		1	1	at	p	g	
Isoetes coromandelina	Isoetaceae				2	a	a	f	
Limnophila fragrans	Scrophulariaceae	1				at	a	h	
Ludwigia adscendens	Onagraceae	1	1	1	1	at	p	h	
Melaleuca viridiflora	Myrtaceae		1	1	1	at	p	t	
Melochia corchorifolia	Sterculiaceae	1				t	a	sh	
Najas sp.	Najadaceae	3	1		1	a	ap	h	
Nymphaea hastifolia	Nymphaeaceae	2				a	p	h	
Nymphaea violacea	Nymphaeaceae	1	1		2	a	p	h	
Nymphoides aurantiaca	Menyanthaceae		1			a	ap	h	
Nymphoides indica	Menyanthaceae		1		1	at	ap	h	
Nymphoides subacuta	Menyanthaceae				2	a	ap	h	
Oldenlandia tenuifolia	Rubiaceae	1		1		t	a	h	
Oryza sp.	Poaceae				2	a	ap	g	
Passiflora foetida	Passifloraceae	1				t	p	v	i
Persicaria attenuata	Polygonaceae	1	1	1	2	at	p	h	
Pseudoraphis spinescens	Poaceae	1	1	1	2	at	p	g	
Rhynchospora sp.	Cyperaceae	1				t	a	se	
Sorghum sp.	Poaceae	1			2	t	a	g	
Stylidium sp.	Stylidiaceae			1		t	a	h	
Stylosanthes humilis	Fabaceae	1				t	a	h	i
Terminalia sp.	Combretaceae	1				t	p	t	
Utricularia gibba	Lentibulariaceae		2			a	ap	h	
Utricularia muelleri	Lentibulariaceae	2	1		1	a	a	h	
Xyris complanata	Xyridaceae	2			1	t	p	h	

Xyris indica	Xyridaceae				1	t	a	h	
Total (species and genera)	45*	30	17	13	24				2

[#]: The 8 species highlighted in green were only recorded in Waterlily Lagoon and not at any of the five other lagoons studied.

[¤]: The number displays on how many of the four transects the species was recorded.

[a]: Environmental preference is aquatic (a), terrestrial (t) and can be both (at).

[b]: Life strategy is annual (a), perennial (p) and can be both (ap).

[c]: Growth form: f=fern or related, g=grass, h=herb, forb, p=palm, s=shrub, se= sedge, t=tree, v=vine.

[d]: alien to the area: plant is introduced (i), a declared weed (w).

*: the total number of taxa is higher than in the overview table section 4.1.1 as some plants identified to genus level only or with a question mark at species level are included in this table.

Table A6: Macrophyte vegetation of Woodford Lagoon during four surveys

Species[#]	Family	Mar 08 [a]	May 08	Oct 08	Apr 09	Environmental preference[a]	Life strategy[b]	Growth form[c]	Alien to the area[d]
Antidesma ghaesambilla	Euphorbiaceae			1		t	p	st	
Blyxa aubertii	Hydrocharitaceae	1	3		1	a	a	h	
Caldesia oligococca	Alismataceae	1		1	1	a	ap	h	
Cayratia maritima	Vitaceae	1		1		t	p	v	
Chrysopogon oliganthus	Poaceae			1		a	p	g	
Coldenia procumbens	Boraginaceae			1		t	a	h	
Corymbia polycarpa	Myrtaceae			1		t	p	t	
Dentella dioeca	Rubiaceae			1		t	a	h	
Desmodium ? campylocaulon	Fabaceae				1	t	a	h	
Drosera petiolaris	Droseraceae			1		t	p	h	
Eleocharis dulcis	Cyperaceae		1			a	ap	se	
Eleocharis sundaica	Cyperaceae		1	1		at	p	se	
Eriachne triseta	Poaceae			1		t	p	g	
Eriocaulon depressum	Eriocaulaceae				1	t	a	h	
Eriocaulon setaceum	Eriocaulaceae	1			1	a	a	h	
Euphorbia vachellii	Euphorbiaceae			1		t	ap	h	
Evolvulus alsinoides var. indeterminate	Convolvulaceae		1			t	a	h	
Evolvulus nummularis	Convolvulaceae			1		t	p	h	i
Fimbristylis pauciflora	Cyperaceae	1	1	1		t	ap	se	
Glinus oppositifolius	Molluginaceae			1		t	a	h	
Goodenia kakadu	Goodeniaceae		1			t	a	h	
Heliotropium indicum	Boraginaceae			1		t	a	h	
Hibiscus meraukensis	Malvaceae	1				t	a	s	
Indigofera hirsuta	Fabaceae	2				t	a	h	
Isoetes coromandelina	Isoetaceae		2		1	a	a	f	
Livistona humilis	Arecaceae	1		1		t	p	p	
Lophostemon lactifluus	Myrtaceae	1	6	1	1	t	p	t	
Macroptilium lathyroides	Fabaceae			1		t	a	h	i
Melaleuca nervosa	Myrtaceae	1	1	1		at	p	t	
Melochia corchorifolia	Sterculiaceae	1				t	a	sh	
Microcarpaea minima	Scrophulariaceae		1			t	ap	h	
Najas sp.	Najadaceae	2	5	1	2	a	ap	h	
Nymphaea violacea	Nymphaeaceae	2	6	1	1	a	p	h	
Nymphoides indica	Menyanthaceae	1	1	1	1	at	ap	h	
Oldenlandia tenuifolia	Rubiaceae	1		1		t	a	h	
Pandanus spiralis	Pandanaceae	1				t	p	p	
Passiflora foetida	Passifloraceae	1		1		t	p	v	i
Pennisetum polystachion	Poaceae		1			t	p	g	w
Pseudoraphis spinescens	Poaceae	1	3	1	1	at	p	g	
Sorghum intrans	Poaceae	3	4		1	t	a	g	
Utricularia gibba	Lentibulariaceae	3	6	1	1	a	ap	h	
Utricularia muelleri	Lentibulariaceae	2	5		1	a	a	h	
Xyris complanata	Xyridaceae	2				t	p	h	

Xyris indica	Xyridaceae			1		t	a	h	
Total (species and genera)	44*	22	18	27	14				4

[#]: Thirteen species highlighted in green were only recorded in Woodford Lagoon and not at any of the five other lagoons studied.

[¤]: The number displays on how many of the four transects the species was recorded.

[a]: Environmental preference is aquatic (a), terrestrial (t) and can be both (at).

[b]: Life strategy is annual (a), perennial (p) and can be both (ap).

[c]: Growth form: f=fern or related, g=grass, h=herb, forb, p=palm, s=shrub, se= sedge, t=tree, v=vine.

[d]: alien to the area: plant is introduced (i), a declared weed (w).

*: the total number of taxa is higher than in the overview table section 4.1.1 as some plants identified to genus level only or with a question mark at species level are included in this table.

8. APPENDIX 2: WETLAND PLANTS PHOTOS

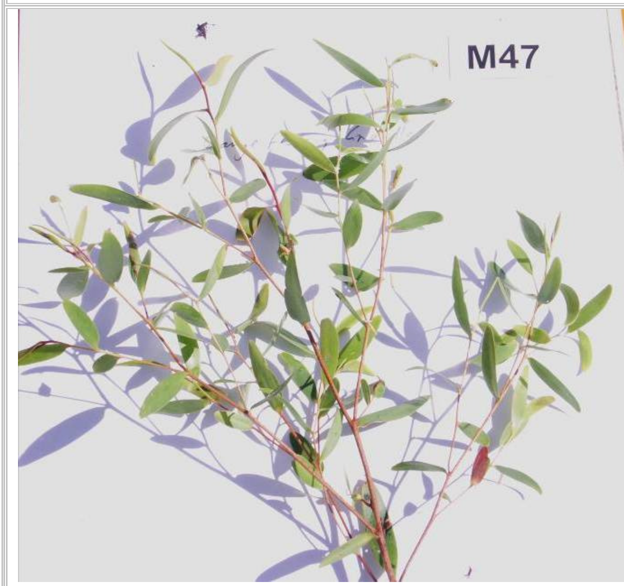
A large number of photos was taken from many plants during the field work. As to be expected, not all photos are worthwhile reproducing due to inadequate light and focus and the ones that were selected to be presented are still not always in perfect quality. However, it was felt worthwhile to depict the photos taken during this project as they are not only displaying pretty plants, but can also be helpful for identification in further studies.

Not all of the plants are presented, the images display 54 of the 160 taxa recorded.

Most of the photos were taken by Dave Wilson, who was contracted for field work assistance.

Plants are labelled (a) for aquatic and (at) for aquatic/terrestrial environmental preference. No label means that the plant is terrestrial.

	Acacia auriculiformis Mimosaceae McMinns Lagoon 7/3/2008
	Acacia holosericea Mimosaceae McMinns Lagoon 7/3/2008

	Asteromyrtus symphyocarpa Myrtaceae Waterlily Lagoon 28/2/2008
	Asteromyrtus symphyocarpa Myrtaceae McMinns Lagoon 7/3/2008
	Asteromyrtus symphyocarpa Myrtaceae McMinns Lagoon 7/3/2008

Azolla pinnata (a)
Azollaceae

Waterlily Lagoon

17/4/2009

Blyxa aubertii (a)
Hydrocharitaceae

Waterlily Lagoon

28/2/2008

Caldesia oligococca (a)
Alismataceae

Waterlily Lagoon

17/4/2009

	Caldesia oligococca (a) Alismataceae Waterlily Lagoon 28/2/2008
	Calopogonium mucunoides Fabaceae Introduced Herbert 2 Lagoon 27/4/2009
	Chrysopogon oliganthus (a) Poaceae Girraween Lagoon 21/2/2008

		Commelina ensifolia Commelinaceae Waterlily Lagoon 28/2/2008 and 17/4/2009
		Cyanotis axillaris Commelinaceae Waterlily Lagoon 28/2/2008 and 18/3/2009
		Cynanchum liebianum Asclepiadaceae Waterlily Lagoon 28/2/2008

	Cynanchum liebianum Asclepiadaceae Waterlily Lagoon 30/11/2007
	Cyperus angustatus Cyperaceae Girraween Lagoon 22/2/2008

	Cyperus angustatus Cyperaceae Girraween Lagoon 22/2/2008
	Cyperus haspan Cyperaceae Herbert 2 Lagoon 27/4/2009
	Cyperus javanicus Cyperaceae Girraween Lagoon 21/2/2008

	Cyperus platystylis (a) Cyperaceae Girraween Lagoon 30/4/2009
	Cyperus platystylis (a) Cyperaceae Girraween Lagoon 30/4/2009
	Drosera petiolaris Droseraceae Girraween Lagoon 22/2/2008

		Eleocharis possibly sundaica (at) Poaceae Waterlily Lagoon 21/5/2008
 		Eragrostis sp. Poaceae Herbert 2 Lagoon 27/4/2009
		Eriocaulon setaceum (a) Eriocaulaceae Waterlily Lagoon 17/4/2008

	Eriocaulon setaceum (a) Eriocaulaceae Girraween Lagoon 30/4/2009
	Fimbristylus dichotoma Cyperaceae McMinns Lagoon 7/3/2008
	Fimbristylus pauciflora Cyperaceae Girraween Lagoon 21/2/2008

	Grevillea pteridifolia Proteaceae McMinns Lagoon 7/3/2008
	Grevillea pteridifolia Proteaceae McMinns Lagoon 29/2/2008

	Hybanthus enneaspermus Violaceae Girraween Lagoon 21/2/2008
	Hymenachne acutigluma (at) Poaceae Waterlily Lagoon 28/2/2008
	Hymenachne acutigluma Poaceae Waterlily Lagoon 28/2/2008

		Ischaemum australe (a) Poaceae Girraween Lagoon 22/2/2008
		Lepironia articulata (a) Cyperaceae Girraween Lagoon 9/5/2008
		Lepironia articulata (a) Cyperaceae Girraween Lagoon 30/4/2009 and 9/5/2008

	Lophostemon lactifluus Myrtaceae McMinns Lagoon 7/3/2008
	Lophostemon lactifluus Myrtaceae Woodford Lagoon 6/3/2008
	Ludwigia adscendens (at) Onagraceae Waterlily Lagoon 28/2/2008

		Melaleuca viridiflora (at) Myrtaceae Herbert Lagoon 7/3/2008
		Melaleuca viridiflora (at) Myrtaceae Herbert Lagoon 7/3/2008
		Melinis repens Poaceae Girraween Lagoon 21/2/2008
		Melochia corchorifolia Sterculiaceae 28/2/2008 Waterlily Lagoon

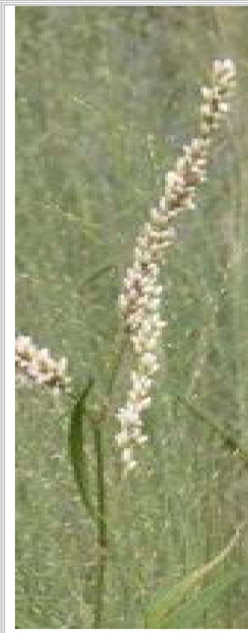
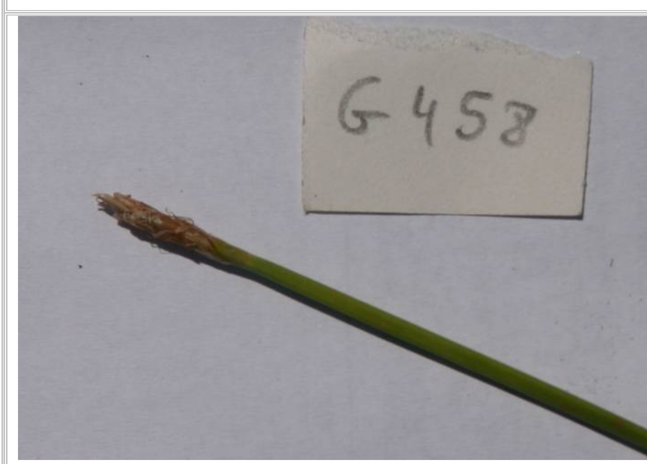
	Melochia corchorifolia Sterculiaceae 28/2/2008 Waterlily Lagoon
	Najas sp. (a) Najadaceae Waterlily Lagoon 28/2/2008
	Nymphaea hastifolia (a) Nymphaeaceae Girraween Lagoon 22/2/2008

	Nymphaea hastifolia (a) Nymphaeaceae Girraween Lagoon 22/2/2008
	Nymphaea violacea (a) Nymphaeaceae Knuckey Lagoon 1/5/2008
	Nymphaea violacea (a) Nymphaeaceae Knuckey Lagoon 1/5/2008

	Nymphoides indica (at) Menyanthaceae Herbert 2 Lagoon 14/2/2008
	Nymphoides indica (at) Menyanthaceae Herbert 2 Lagoon 14/2/2008
	Nymphoides spongiosa (a) Menyanthaceae Knuckey Lagoon 1/5/2008

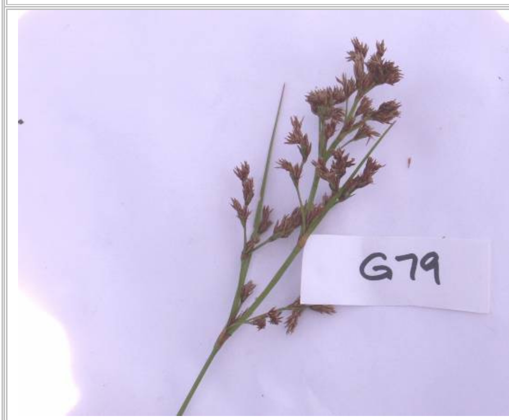
	Nymphoides subacute (a) Menyanthaceae Knuckey Lagoon 1/5/2008
	Nymphoides subacute (a) Menyanthaceae Knuckey Lagoon 1/5/2008
	Oldenlandia galioides Rubiaceae McMinns Lagoon 29/2/2008

	Pandanus spiralis Pandanaceae Girraween Lagoon 22/2/2008
	Paspalum scrobiolatum (at) Poaceae Girraween Lagoon 30/4/2009
	Paspalum scrobiolatum (at) Poaceae Girraween Lagoon 22/2/2008

 	Persicaria attenuata (at) Polygonaceae Waterlily Lagoon 28/2/2008
	Persicaria attenuata (at) Polygonaceae Waterlily Lagoon 28/2/2008
	Sacciolepis indica Poaceae Girraween Lagoon 30/4/2009

		Salvinia molesta (a) Salviniaceae Declared weed Girraween Lagoon 30/4/2009
		Sesbania cannabina var. sericea (a) Fabaceae McMinns Lagoon 29/2/2008
		Sesbania cannabina var. sericea (a) Fabaceae McMinns Lagoon 3/3/2008
		Sorghum intrans Poaceae McMinns Lagoon 3/3/2008

	Sorghum timorense Poaceae Girraween Lagoon 21/2/2008
	Spermococe leptoloba Rubiaceae McMinns Lagoon 29/2/2008
	Stachytarpheta cayennensis Verbenaceae Weed (declared) McMinns Lagoon 29/2/2008

	Terminalia sp. Combretaceae Waterlily Lagoon 28/2/2008
	Tricostularia undulata Cyperaceae Girraween Lagoon 22/2/2008
	Tricostularia undulata Cyperaceae Girraween Lagoon 22/2/2008

		Utricularia aurea (a) Lentibulariaceae Herbert 2 Lagoon 14/2/2008
		Utricularia leptoplectra Lentibulariaceae Girraween Lagoon 9/5/2008
		Utricularia muelleri (a) Lentibulariaceae Woodford Lagoon 6/3/2008 Waterlily Lagoon 17/4/2009

Utricularia muelleri (a)

Lentibulariaceae

Girraween Lagoon

21/2/2008 and

Woodford Lagoon

23/5/2008

Xyris complanata

Xyridaceae

Girraween Lagoon

30/4/2009

Xyris complanata

Xyridaceae

Girraween Lagoon

22/2/2008