Appendix C: Vegetation Diversity

1 Introduction

The wetlands of the lower Gwydir valley support a number of floristically and functionally diverse vegetation communities. The distribution of the flood dependent communities is determined by differences in landform, substrate and flooding frequency and duration. These vegetation communities are both state and federally listed as threatened ecological communities and include; flood dependent woodlands: supporting ecological vegetation communities with dominant tree species such as coolibah (*Eucalyptus coolabah*) and black box (*E. largiflorens*); floodplain wetland communities: supporting river red gum (*E. camaldulensis*), coolabah woodlands and river cooba (*Acacia stenophylla*) and lignum (*Duma florulenta*) shrubland species; and semi-permanent wetlands: supporting species such as water couch (*Paspalum distichum*), marsh club-rush (*Bolboschoenus fluviatilis*), spike rush (*Eleocharis* spp.*)*, tussock rush (*Juncus aridicola*), various sedge species and cumbungi (*Typha domingensis*) (Bowen and Simpson 2010).

The area occupied by these communities has declined since river regulation due to both restricted flows and clearing for agriculture (Wilson *et al.* 2009, Bowen and Simpson 2010). Maintaining the current extent and improving the condition of these communities is a target for environmental water management in the Gwydir catchment (DECC 2011, Commonwealth of Australia 2014a). Two specific questions were addressed through the monitoring of vegetation diversity in the 2019-20 water year in the Gwydir River Selected Area (Gwydir Selected Area, Selected Area):

- What did Commonwealth environmental water contribute to vegetation species diversity?
- What did Commonwealth environmental water contribute to vegetation community diversity?

2 Previous monitoring

Vegetation monitoring for the LTIM project was undertaken from December 2014 to March 2019 by Eco Logical Australia and NSW Office of Environment and Heritage (currently Department of Planning, Industry and Environment – Environment, Energy and Science (DPIE-EES)) within the Gingham, Lower Gwydir and Mallowa wetlands (Commonwealth of Australia 2019). Vegetation community condition and plant diversity of the Gwydir wetlands was shown to be driven by patterns of inundation. The highest species richness and cover recorded in the Gingham and Lower Gwydir wetlands was recorded in the 2014-15 water year, following a large release of environmental water in early spring 2014. Environmental water delivered to the Mallowa wetlands in the 2018-19 summer period also elicited a positive vegetation response. Inundation was also shown to be a practical management technique for the control of widespread weed species lippia (*Phyla canescens*), with inundation benefitting native wetland species such as water couch, helping them to outcompete lippia, reducing its cover. Tree recruitment was sporadic with no clear links to inundation, highlighting the importance of other key factors, such as grazing pressure that are likely to play a role within the lifecycle of wetland species of the Gwydir wetlands.

3 Methods

3.1 2019-20 water year

Monitoring throughout the Lower Gwydir, Gingham and Mallowa wetlands was undertaken in spring 2019 and autumn 2020 (Table 1, Figure 1-Figure 3). Due to restricted site access in the Gingham watercourse, a reduced total of 13 of the original 20 vegetation plots at five locations were surveyed during both spring 2019 and autumn 2020 sampling (Table 2, Figure 1). In addition, 17 plots within the Lower Gwydir and seven plots within the Mallowa wetlands were monitored (Table 2, Figure 2-Figure 3). All 37 plots were in one of four broad wetland vegetation communities and experienced a range of inundation conditions (Table 1). Vegetation surveys were completed in conjunction with NSW DPIE-EES staff, following MER Standard Methods and NSW DPIE-EES data collection protocols (Commonwealth of Australia 2014b). In addition to vegetation parameters, environmental variables including the degree of inundation and grazing impact were noted. Also noted was the impact of a wildfire that burnt 1,300 ha of the Gingham wetland in September 2019 around Bunnor, Goddards Lease and Westholme. Sites were classed as 'inundated' if there was standing water present at the time of survey, 'wet' if there was surface soil moisture present at the time of survey and 'dry' if there was no sign of inundation or surface soil moisture.

Species richness and vegetation cover were analysed using a Poisson regression on count data that investigated the influence of inundation, survey time (spring 2019, autumn 2020), Wetland (Gingham, Lower Gwydir, Mallowa) and vegetation community. Vegetation cover for each plot was calculated by adding together the cover of lower and mid strata types. Therefore, it was possible to get >100% cover. Both native and exotic species were included in this analysis.

To further explain changes in diversity, individual species were grouped into the following four functional groups (Brock and Casanova 1997, Hale *et al.* 2014):

- Amphibious responders (AmR) – plants that change their growth form in response to flooding and drying cycle, including morphologically plastic (ARp) and floating/stranded (ARf) groups;
- Amphibious tolerators (AmT) – plants that tolerate flooding patterns without changing their growth form, including low growing (Atl) and woody growth form (Atw).
- Terrestrial damp plants (Tda) – plants that are terrestrial species but tend to grow close to the water margin on damp soils; and
- Terrestrial dry plants (Tdr) - plants that are terrestrial species which don't normally grow in wetlands but may encroach into the area due to prolonged drying.

Changes in these functional groups were compared between the spring 2019 and autumn 2020 using a Poisson regression model on count data to test for differences.

To further understand the relationship between inundation and plant response, time since last inundation at each site was determined using satellite imagery (Appendix A: Gwydir River Hydrology) for each survey event. These data were then used to develop four categories of inundation (Inundation Period):

- Currently wet – site was inundated at the time of survey;
- Recently wet – 1 – 90 days since site was last inundated;
- Medium-term dry – 91 – 365 days since site was last inundated and;
- Long-term dry – > 365 days since site was last inundated.

Additionally, the cover data of two key species, water couch and lippia were analysed using a Poisson regression model on count data to assess the influence of inundation, survey time, wetland and vegetation community.

Changes in vegetation community composition data were investigated using multivariate nMDS plots with differences between survey time, wetland and vegetation community assessed using PERMANOVA in Primer 6. SIMPER analysis was used to identify the species that were most responsible for driving patterns in the data and follow up descriptive univariate analysis of these species were then undertaken.

Table 1 Sites surveyed in spring 2019 and autumn 2020 for vegetation diversity. Map projection GDA94 Zone 55. Sites that had standing water ('inundated') or exhibited surface moisture ('wet') at the time of sampling are shaded blue and those that were not are shaded yellow ('dry').

Wetland	Vegetation Communities	Sites	Northing	Easting	Spring 2019	Autumn 2020
Gingham	Water couch marsh grassland	Bunnor_1_1	6760771	728826	Dry	Wet
Gingham	Water couch marsh grassland	Bunnor_1_2	6760658	728917	Dry	Inundated
Gingham	Water couch marsh grassland	Bunnor_1_3	6760630	728812	Dry	Inundated
Gingham	Water couch marsh grassland	Goddard_1_1	6760882	731652	Dry	Inundated
Gingham	Water couch marsh grassland	Goddard_1_2	6760784	731738	Dry	Inundated
Gingham	Water couch marsh grassland	Goddard_1_3	6760678	731749	Dry	Wet
Gingham	Water couch marsh grassland	Munwonga_1_1	6764005	722759	Dry	Inundated
Gingham	Water couch marsh grassland	Munwonga_1_2	6763930	722771	Dry	Inundated
Gingham	Water couch marsh grassland	Munwonga_1_3	6764083	722726	Dry	Wet
Gingham	Water couch marsh grassland	Westholme_1_1	6759094	733487	Dry	Wet
Gingham	Water couch marsh grassland	Westholme_1_2	6759189	733523	Dry	Inundated
Gingham	Water couch marsh grassland	Westholme_1_3	6759157	733591	Dry	Wet
Gingham	Coolabah Woodland - wet understorey	Westholme_Coolibah_1	6764083	722726	Dry	Dry
Lower Gwydir	Marsh Club-rush tall sedgeland	Old Dromana Bolboschoenus_1_1	6751998	723274	Dry	Inundated
Lower Gwydir	Marsh Club-rush tall sedgeland	Old Dromana Bolboschoenus_1_2	6752001	723230	Dry	Inundated
Lower Gwydir	Water couch marsh grassland	Old_Dromana_Elders_1_1	6752745	723443	Dry	Dry
Lower Gwydir	Water couch marsh grassland	Old_Dromana_Elders_1_2	6752603	723435	Dry	Dry
Lower Gwydir	Water couch marsh grassland	Old_Dromana_Elders_1_3	6752706	723395	Dry	Dry

Wetland	Vegetation Communities	Sites	Northing	Easting	Spring 2019	Autumn 2020
Lower Gwydir	Coolabah Woodland - wet understorey	Old_Dromana_Elders_1_4	6752918	723552	Dry	Dry
Lower Gwydir	Coolabah Woodland - wet understorey	Old_Dromana_Nursery_1	6751431	726197	Dry	Dry
Lower Gwydir	Coolabah Woodland - wet understorey	Old_Dromana_Nursery_2	6751888	724473	Dry	Dry
Lower Gwydir	Eleocharis tall sedgelands	Old_Dromana_Ramsar_1_1	6750977	727152	Dry	Inundated
Lower Gwydir	Eleocharis tall sedgelands	Old_Dromana_Ramsar_1_2	6750992	727184	Dry	Inundated
Lower Gwydir	Eleocharis tall sedgelands	Old_Dromana_Ramsar_1_3	6751075	727098	Dry	Inundated
Lower Gwydir	Coolabah Woodland - wet understorey	Old_Dromana_Ramsar_2_1	6751800	726701	Dry	Wet
Lower Gwydir	Coolabah Woodland - wet understorey	Old_Dromana_Ramsar_2_2	6751789	726747	Dry	Dry
Lower Gwydir	Coolabah Woodland - wet understorey	Old_Dromana_Ramsar_2_3	6751833	726810	Dry	Dry
Lower Gwydir	Water couch marsh grassland	Old_Dromana_Ramsar_3_1	6751426	726741	Dry	Inundated
Lower Gwydir	Water couch marsh grassland	Old_Dromana_Ramsar_3_2	6751456	726641	Dry	Inundated
Lower Gwydir	Water couch marsh grassland	Old_Dromana_Ramsar_3_3	6751515	726746	Dry	Inundated
Mallowa	River Cooba - Lignum	Bungunya_1_1	6723793	709823	Dry	Dry
Mallowa	River Cooba - Lignum	Bungunya_1_2	6723336	710098	Dry	Dry
Mallowa	River Cooba - Lignum	Coombah_1_1	6722614	723649	Dry	Dry
Mallowa	River Cooba - Lignum	Coombah_1_2	6722491	723849	Wet	Dry
Mallowa	River Cooba - Lignum	Valetta_1_1	6723629	716519	Dry	Inundated
Mallowa	River Cooba - Lignum	Valetta_1_2	6723681	716970	Dry	Dry
Mallowa	River Cooba - Lignum	Valetta_2_1	6725026	716262	Dry	Wet

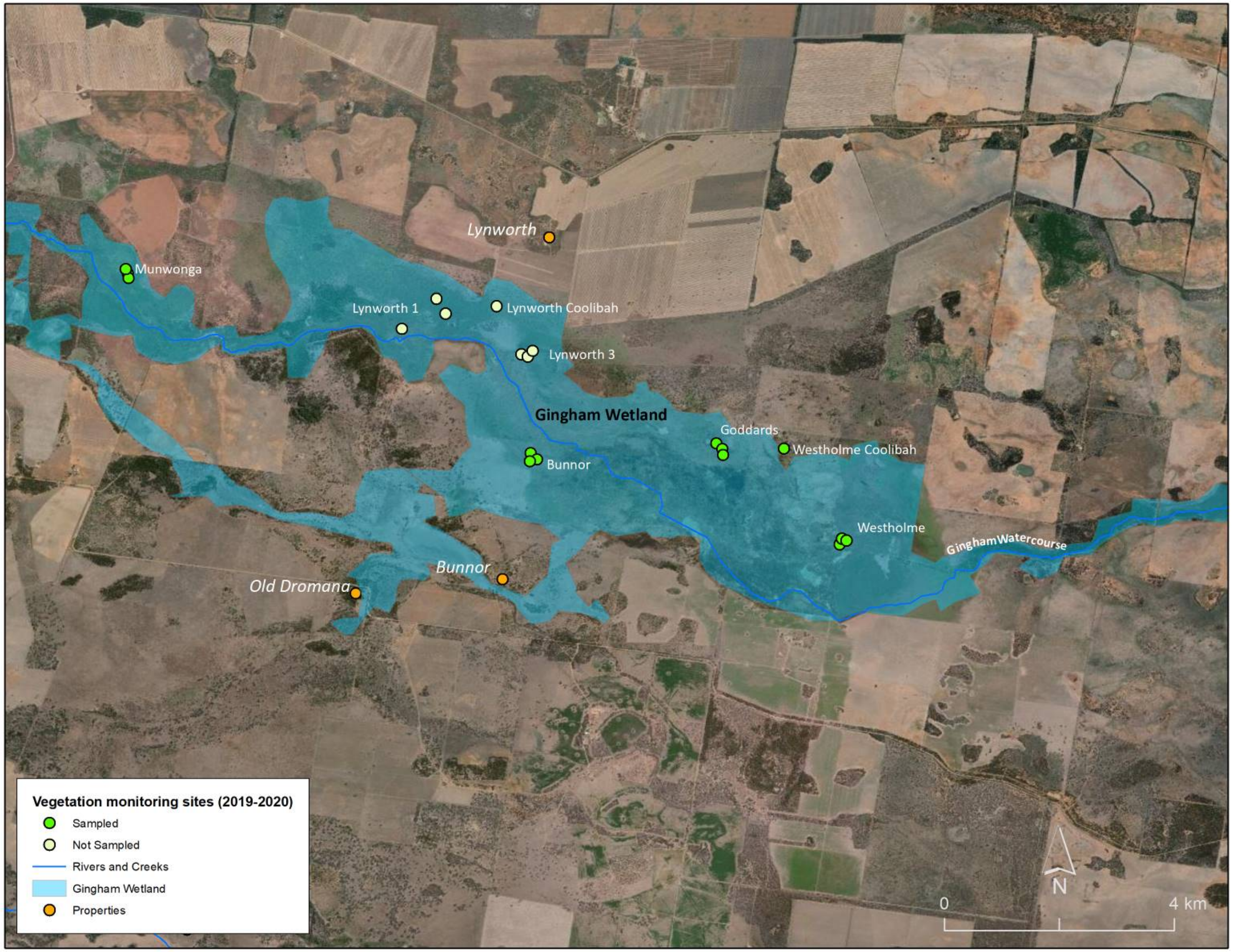

Figure 1 Location of the 2019-20 MER vegetation monitoring sites within the Gingham Wetlands.

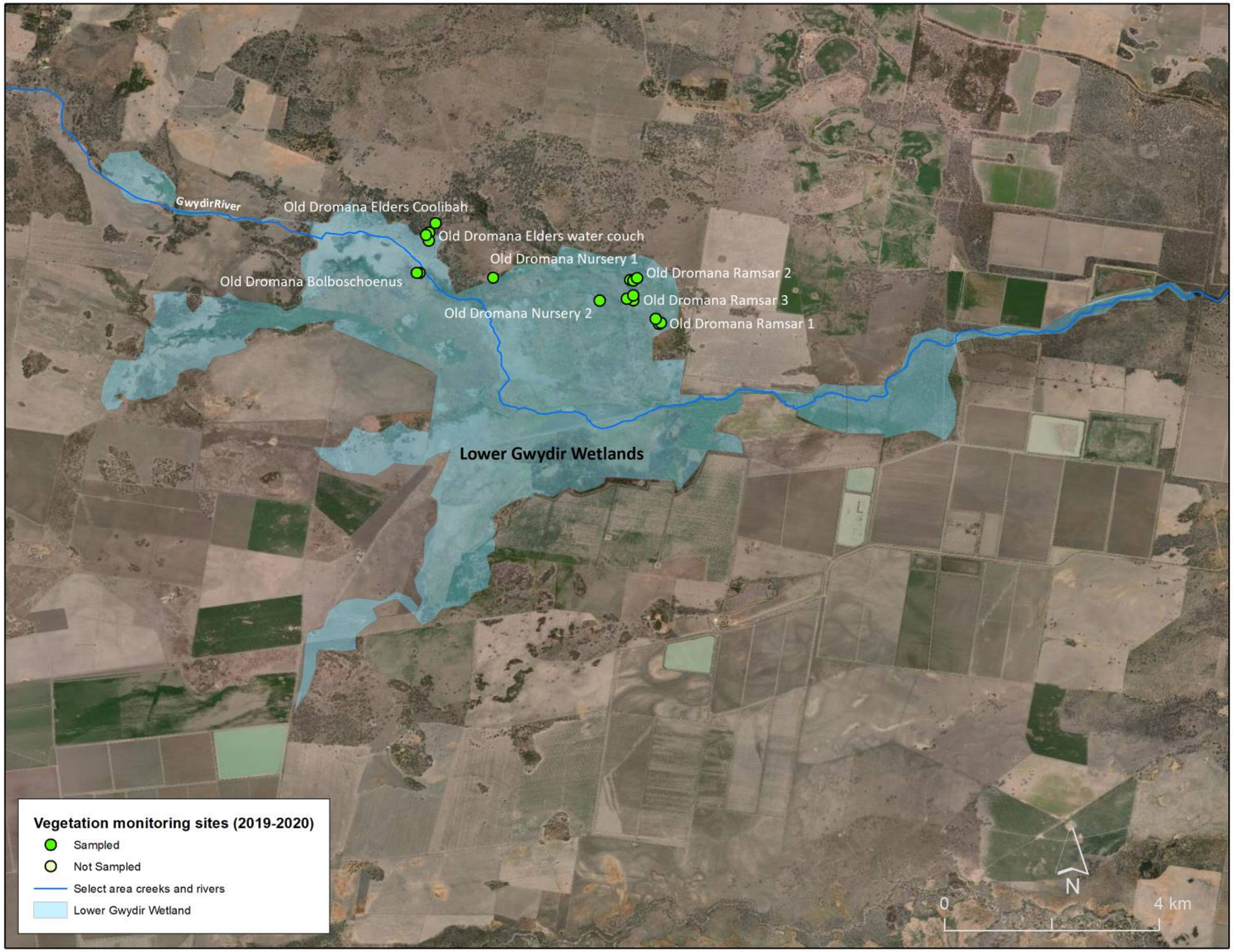

Figure 2 Location of the 2019-20 MER vegetation monitoring sites within the lower Gwydir Wetlands.

Figure 3 Location of the 2019-20 MER vegetation monitoring sites within the Mallowa Wetlands.

3.2 Multi-year comparison

To assess longer term trends in vegetation species richness and vegetation cover, a Poisson regression model on count data was used to investigate the influence of inundation, survey time (12 times from spring 2014 to autumn 2020, Table 2), wetland and vegetation community. Changes in the cover of key species (water couch and lippia) were assessed using a Poisson regression model on count data with the influence of inundation, survey time, wetland and vegetation community. Changes in community composition were investigated using multivariate nMDS plots with differences between inundation status, survey time, wetland and vegetation community assessed using PERMANOVA in Primer 6. For nMDS analyses that had large numbers of data points, the 'distance among centroids' function was used to group the data by the appropriate factor to aid interpretation of the nMDS plots. This was done for all multi-year nMDS comparisons.

Table 2 Timing of vegetation diversity survey events during the LTIM and MER projects.

Survey Event	Date	Plots surveyed	Inundated sites		
			Gingham	Lower Gwydir	Mallowa*
Spring 2014	18 - 21 November 2014	32	0	7	-
Autumn 2015	10 – 13 March 2015	33	18	1	-
Spring 2015	12 – 16 October, 11 December 2015	40	19	0	0
Autumn 2016	13 – 16 March 2016	40	0	0	5
Spring 2016	26 – 30 October 2016	40	19	8	2
Autumn 2017	6 – 9 March 2017	33	8	8	4
Spring 2017	4 – 6 October 2017, 13 November 2017	26	3	1	1
Autumn 2018	12 – 22 March 2018	40	0	0	0
Spring 2018	19 - 21 October 2018, 29 - 30 November 2018, 7 December 2018	32	5	2	0
Autumn 2019	11 -13 March 2019	31	0	0	0
Spring 2019	18-21 November 2019	37	0	0	1
Autumn 2020	23-27 March 2020, 21-22 April 2020, 15 May 2020	37	6	8	2

* The Mallowa was an addition to the Monitoring and Evaluation plan in 2015-16 therefore sites in the Mallowa were not monitored during the 2014-15 water year.

4 Results

4.1 2019-20 water year

4.1.1 Vegetation species richness

A total of 158 species from 47 families were recorded from within all vegetation plots across both the spring 2019 (68 species from 26 families) and the autumn 2020 (150 species from 45 families) vegetation surveys.

Mean species richness across all sites and both survey periods (spring 2019 and autumn 2020) was 15.0 ± 9.94 (SD) species, similar to that recorded during the 2015-16 (14.2 ± 5.5 species) and 2016-17 (16 ± 7.76 species) water years. Species richness during the 2019-20 water year ranged from 1 (Old Dromana *Bolboschoenus* 1 in spring, 2019) to 41 species (Old Dromana Elders 1-4 in autumn 2020, Figure 4). Impacted by severe drought and fire at several sites, the spring 2019 survey recorded the lowest mean species richness values in the six years of the LTIM/MER projects (7.7 ± 3.3 species). The autumn 2020 survey occurred following widespread inundation and rainfall across the region and recorded a significantly higher mean species richness of 22.4 ± 8.9 species ($F=110.62$, $p<0.001$, Figure 4).

Vegetation community was found to significantly influence species richness ($F=6.63$ $p<0.001$) with the more naturally speciose communities of Coolabah Woodland Wetland (22.7 ± 14.2 species) and River Cooba-Lignum Shrubland (22.0 ± 11.4 species) having a significantly higher mean species richness than the single species dominated Marsh Club-Rush Sedgeland community (2.3 ± 1.1 species, Figure 5). Water Couch Marsh Grassland and Eleocharis Tall Sedgeland recorded mean species richness values of 13.5 ± 7.2 species and 10.0 ± 5.2 species, respectively. The effect of survey time on the species richness of vegetation community was also significant ($F=264.94$, $p<0.0001$), with all five vegetation communities increasing in mean species richness between the two sampling seasons, with Coolabah Woodland Wetland increasing by 25 species (71%), River Cooba–Lignum by 21 species (64%), Water Couch Marsh Grassland by 13 species (63%), Eleocharis Tall Sedgeland 7 species (54%), and Marsh Club-Rush Tall Sedgeland 2 species (50%, Figure 5).

In the 2019-20 water year the Mallowa recorded a significantly higher mean species richness (22.1 ± 11.5 species) than both the Gingham (14.5 ± 9 species) and Lower Gwydir (14.4 ± 10.5 species; $F=4.25$ $p<0.01$; Figure 6). A significant interaction between season and wetland was found, with all three wetlands increasing in mean species richness between spring 2019 and autumn 2020; Mallowa increased by 20 species (63%), Gingham by 15 species (67%), and Lower Gwydir by 13 species (62%, $F=42.55$, $p<0.001$, Figure 6).

While all but one of the sites were dry during the spring 2019 surveys, 22 of the 37 sites were either wet or inundated during the autumn 2020 surveys (Table 1). When sites were grouped by inundation category, wet sites supported significantly higher mean species richness (23.4 ± 7.7 species) than sites that were inundated (14.1 ± 6.2 species) and sites that were dry (12.3 ± 7.7 species, $F=7.81$, $p<0.0001$, Figure 7).

The Water Couch Marsh Grassland vegetation community, which occurs in both the Gingham and Lower Gwydir wetlands, responded differently to inundation, with the Gingham sites recording higher mean species richness (18 ± 4.9 species) than in the Lower Gwydir (13 ± 3.5 species, Figure 8). This may be a reflection of terrestrial species quickly recolonising fire and drought impacted sites in the Gingham. Water Couch Marsh

Grassland sites in the Gingham and Lower Gwydir wetlands that were either wet or remained dry recorded similar mean species richness (Figure 8).

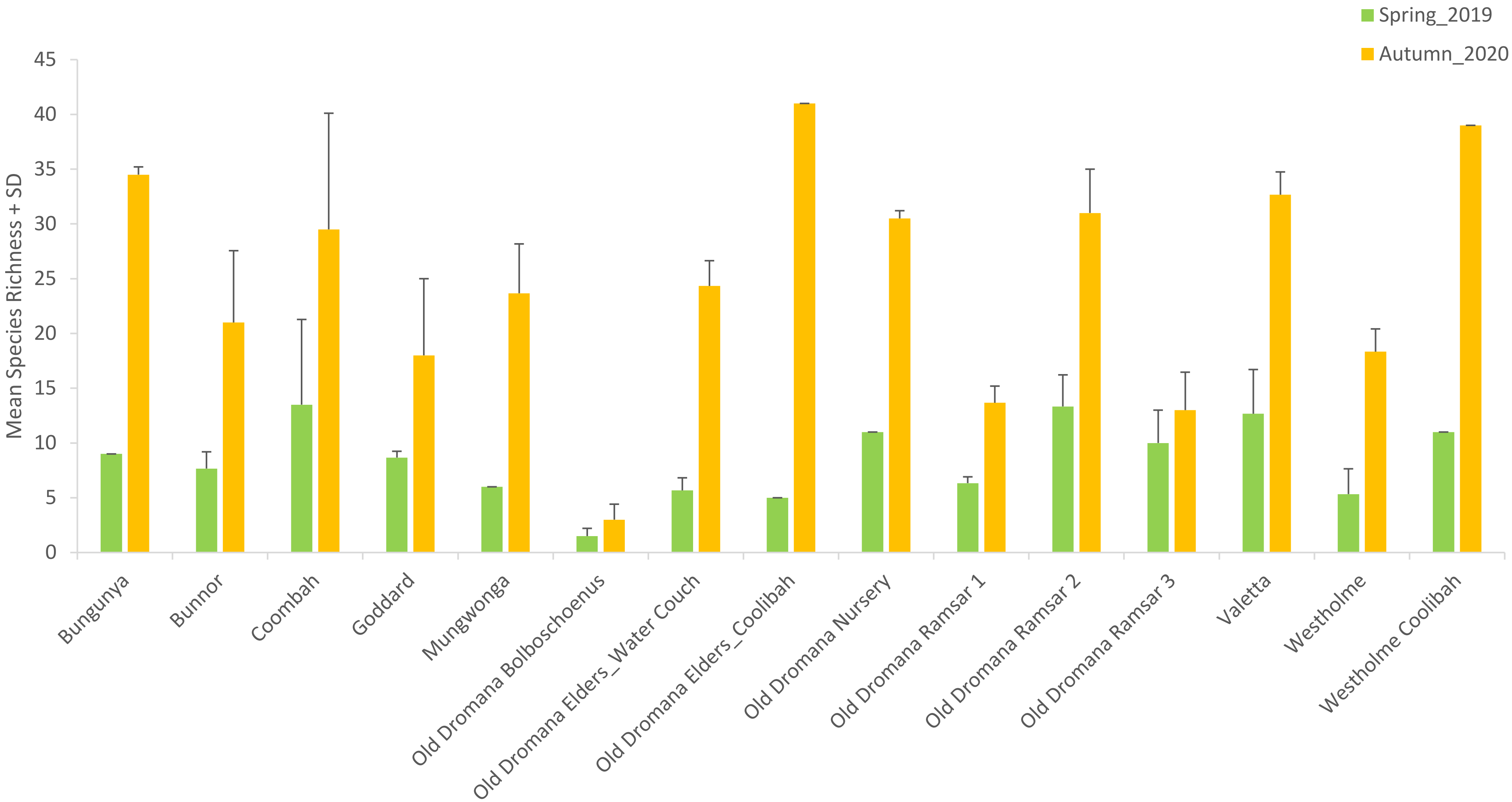

Figure 4 Mean species richness recorded at each of the 15 monitoring locations (37 sites) during the 2019-20 vegetation surveys.

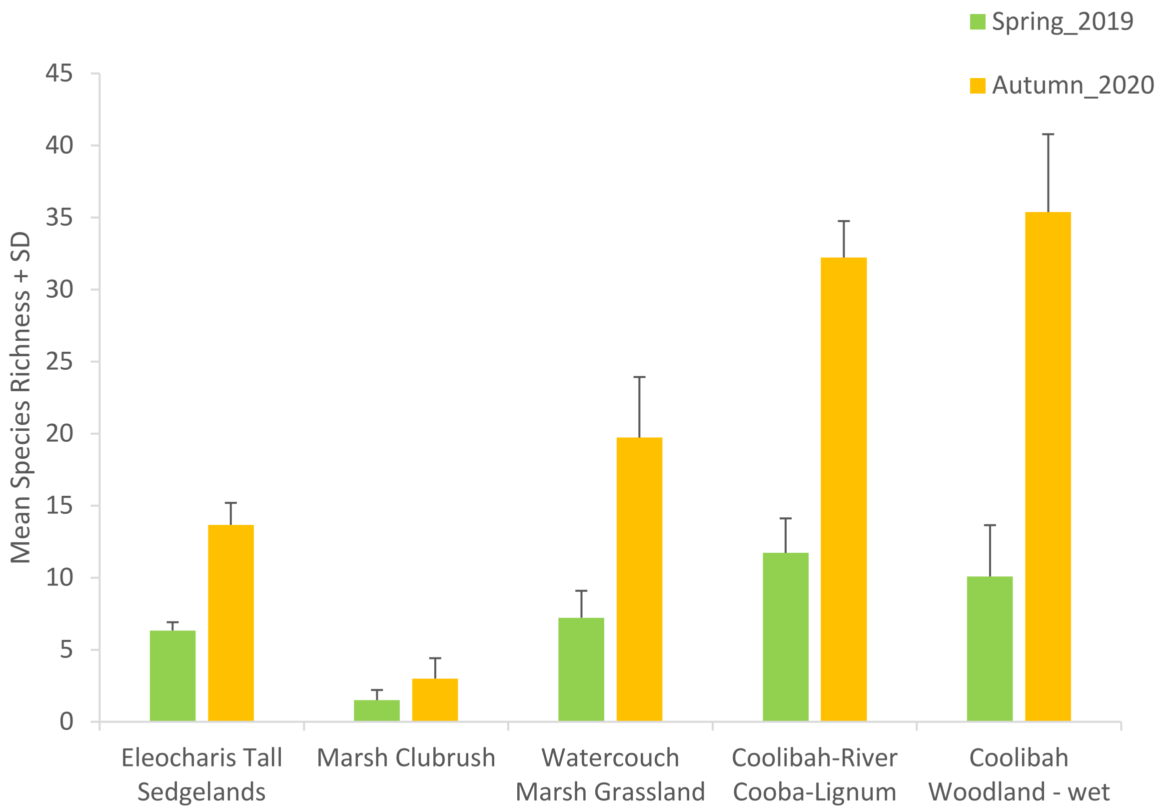

Figure 5 Mean species richness recorded at each of the five vegetation communities during the 2019-20 vegetation surveys.

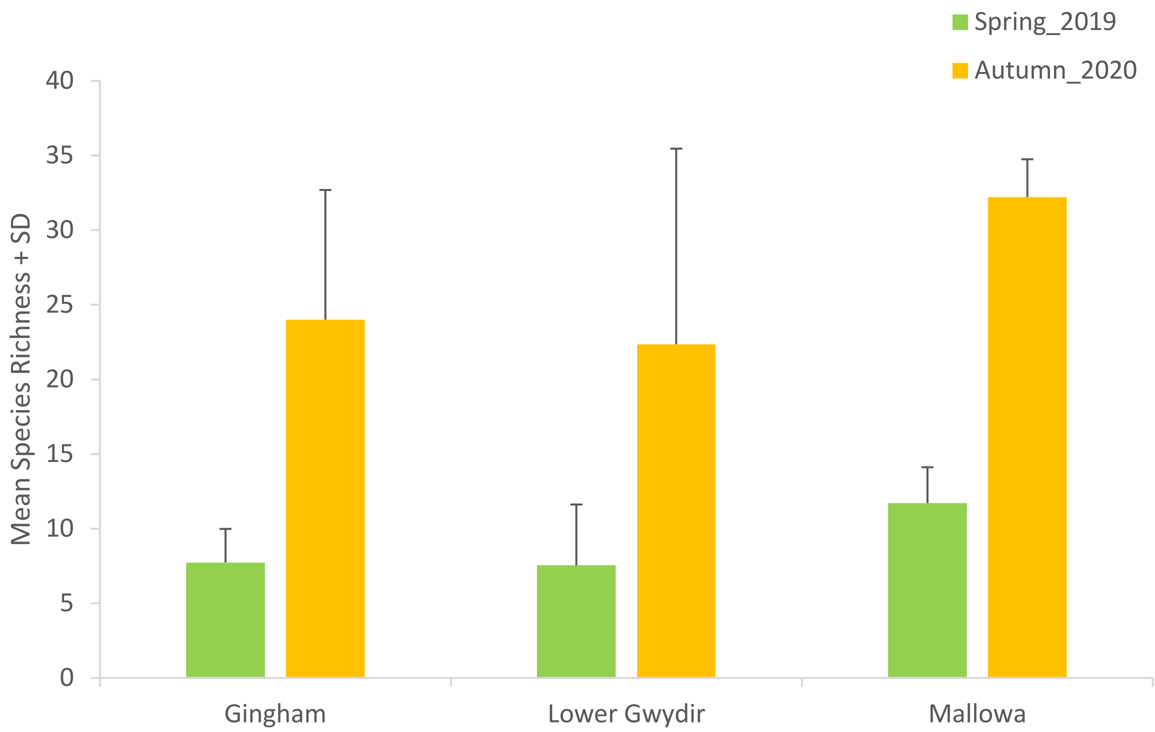

Figure 6 Mean species richness recorded at each of the three wetlands surveyed during the 2019-20 vegetation surveys.

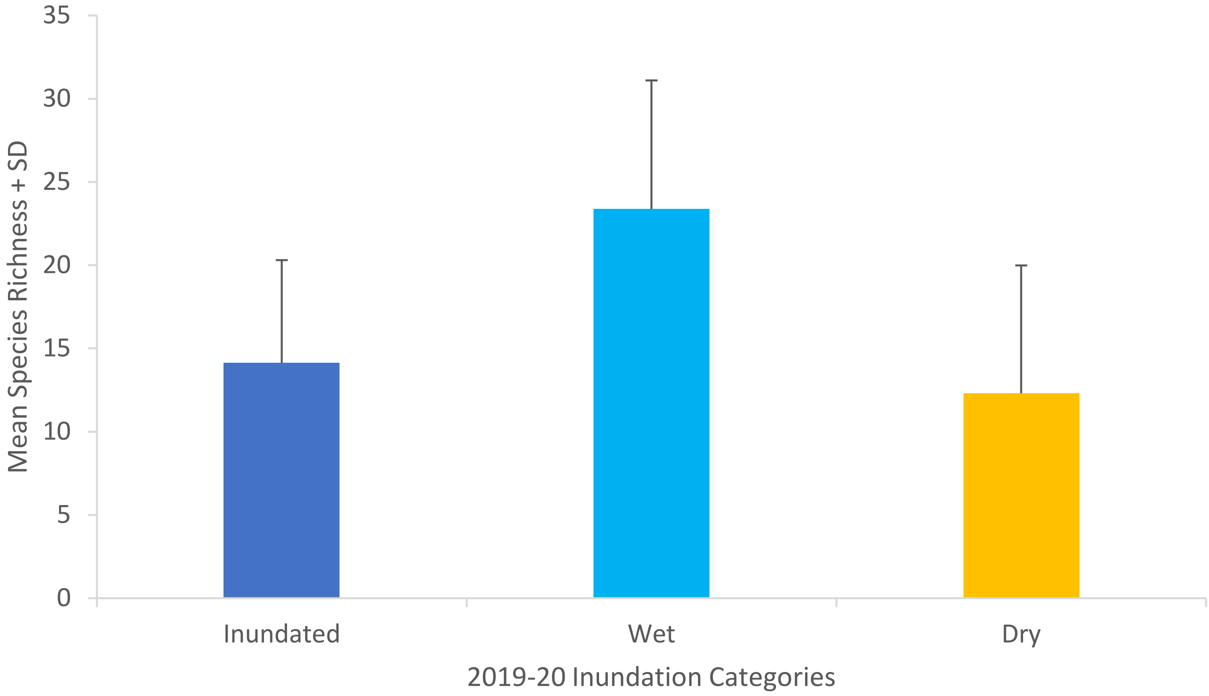

Figure 7 Mean number of species recorded across all 37 Selected Area vegetation monitoring sites by each of the three inundation categories encountered during the 2019-20 water year.

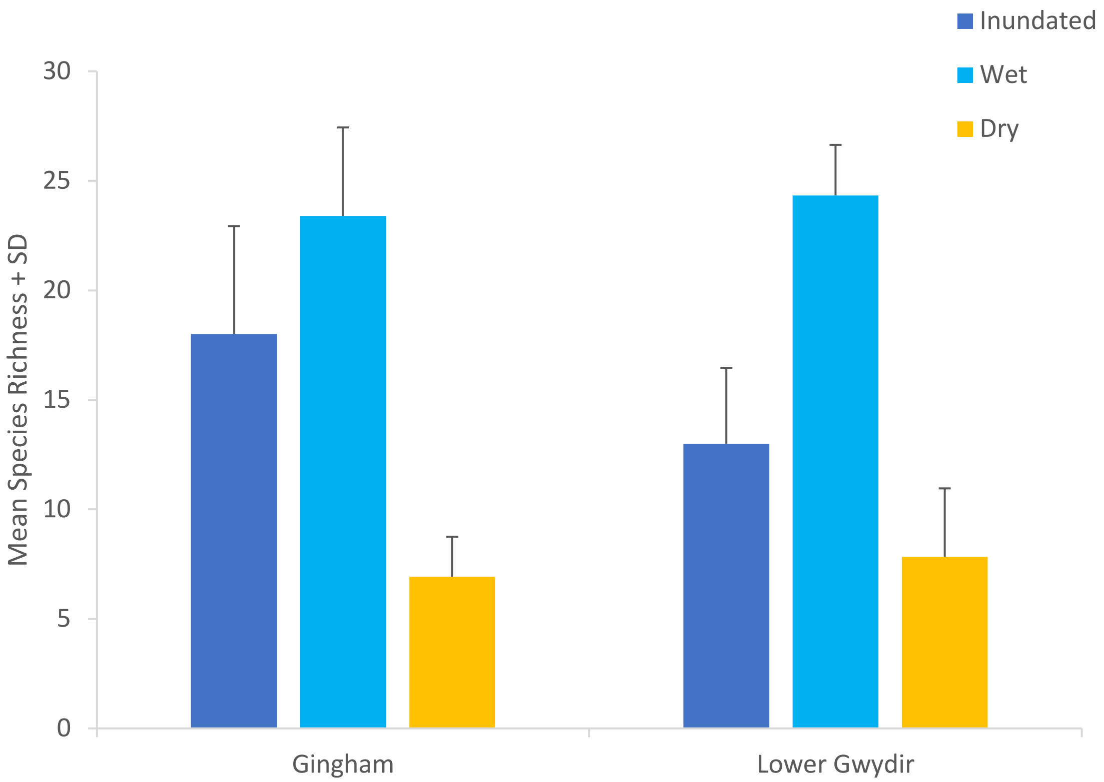

Figure 8 Mean number of species found in Water Couch Marsh Grasslands of the Gingham and Lower Gwydir wetlands, split by 2019-20 inundation categories.

Over the 2019-20 water year a greater number of total species were observed in the two terrestrial functional groups compared with the two amphibious groups, with Tdr the most speciose group (72 species), followed by Tda (50 species), AmT (26 species) and the AmR group (10 species, Table 3). Across both 2019-20 sampling seasons mean species richness at the site level was significantly higher in Tda (5 ± 3.9 species), Tdr (4.6 ± 6 species) and AmT (3.6 ± 2 species) groups than in the AmR functional group (1.7 ± 1.5 species), with the Tda group also significantly higher than the AmT functional group ($F=24.04$, $p<0.0001$, Figure 9).

All four functional groups were significantly more speciose in autumn 2020 than in spring 2019 ($F=131.89$, $p<0.0001$, Figure 9). A significant interaction between season and functional group was observed for species richness, which suggests that each functional group responded differently to changes between seasons. While mean species richness increased in all four functional groups between sampling times, the two terrestrial functional groups (Tda and Tdr) exhibited proportionally higher increases in mean species richness (76% ± 4%) than the two amphibious groups during the same time period (44% ± 13%, $F=6.84$, $p<0.001$, Figure 9).

Forbs were the most speciose growth form across both sampling periods, accounting for 43% (29 species) of all species in spring 2019 and 55% (82 species) of all species in autumn 2020 (Figure 10). Excluding mistletoes, increases were reported for all growth forms between spring 2019 and autumn 2020, with forbs (53 species) and the second most speciose growth form, grasses (13 species), increasing by 65% between sampling times (Figure 10).

*Table 3 Species counts and common species for each of the four functional groups recorded during the 2019-20 Water Year. *indicates exotic species.*

Functional Group	Species Count			Common species
	Spring 2019	Autumn 2020	Total	
AmR	4	10	10	*Marsilea drummondii, Ludwigia peploides, Paspalum distichum*, *Damasonium minus*, *Ludwigia peploides*
AmT	18	25	26	*Eleocharis* spp., *Typha domingensis*, *Ranunculus undosus, Cyperus difformis*, *Acacia stenophylla*
Tda	17	50	50	**Phyla canescens*, *Aeschynomene indica*, *Echinochloa colona*, *Alternanthera denticulate, Sesbania cannabina*
Tdr	29	65	72	**Xanthium occidentale*, **Medicago polymorpha, Vachellia farnesiana, Portulaca oleracea*, **Xanthum spinosum*

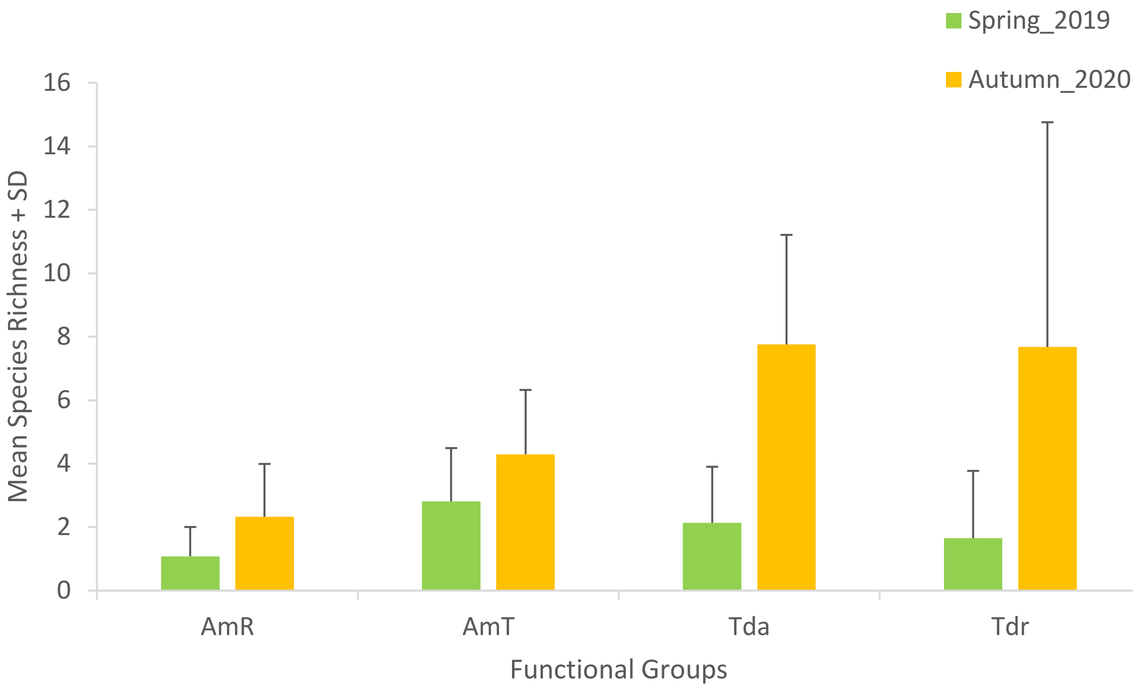

Figure 9 Mean species richness of functional groups across the two sampling periods over the course of the 2019-20 water year.

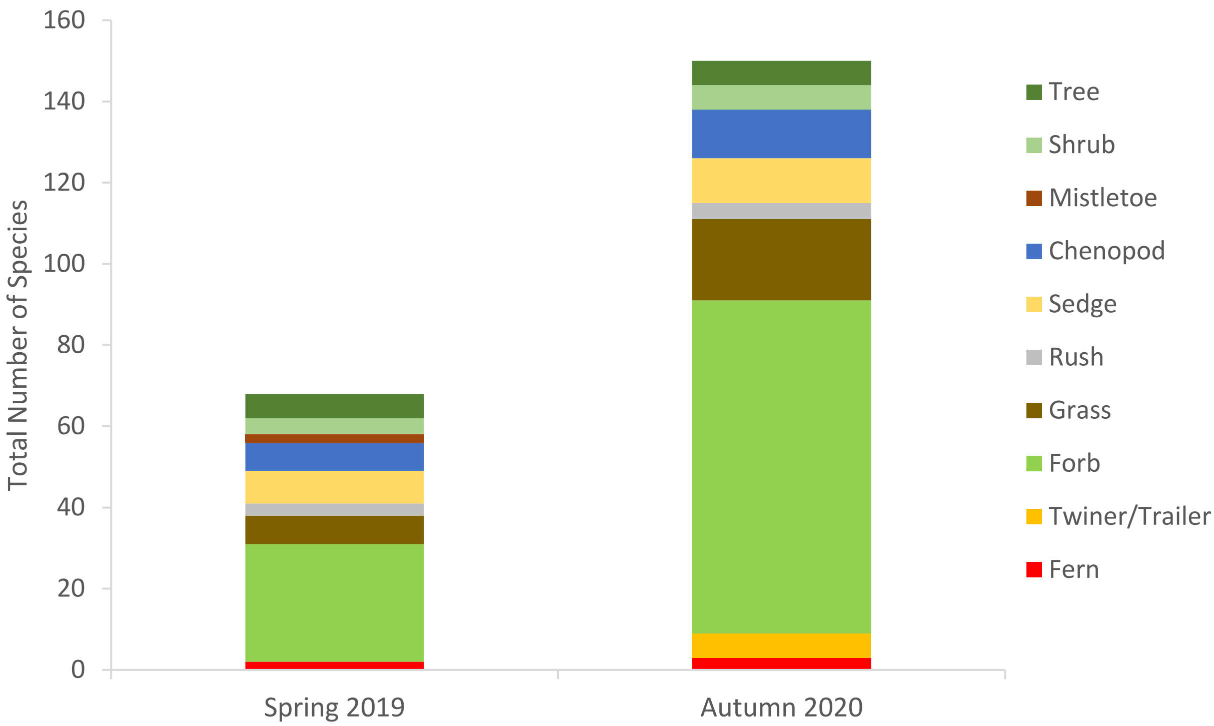

Figure 10 Total number of species per growth form recorded at vegetation monitoring sites in the 2019-20 water year.

4.1.2 Vegetation Cover

Mean cover was found to be significantly higher in autumn 2020 (83 ± 20%) compared to spring 2019 (39 ± 39%, $F=51.76$, $p<0.01$, Figure 11). Throughout the 2019-20 water year mean vegetation cover at the site level ranged from a minimum cover of 2 ± 0.3% at Bunnor in spring, to a mean total maximum cover of 116 ± 13% at Bungunyah in autumn (Figure 11).

Vegetation community type was found to significantly influence mean total vegetation cover with Marsh Club-Rush Sedgeland (103 ± 2%) and Eleocharis Tall Sedgeland (93 ± 6%) communities exhibiting greatest mean total vegetation cover, followed by River Cooba-Lignum (76 ± 44%), Water Couch Marsh Grassland (55 ± 40%) and Coolabah Woodland (55 ± 30%, $F=4.92$, $p<0.01$, Figure 12). A significant interaction between season and vegetation community was also evident ($F=2.71$, $p<0.05$), with the Water Couch Marsh Grassland (71%), Coolabah Woodland (52%) and River Cooba-Lignum (40%) communities showing significantly larger increases in cover between surveys compared to the Eleocharis Tall Sedgeland (8%) and Marsh Club-Rush Sedgeland (3%) communities (Figure 12).

Mean vegetation cover was significantly lower in the Gingham compared to the Lower Gwydir and Mallowa wetlands ($F=13.75$, $p<0.0001$, Figure 13). Vegetation cover increased across all wetlands between spring and autumn sampling times ($F=62.82$, $p<0.0001$, Figure 14). Despite recording the lowest cover observed across all three wetlands in spring 2019, vegetation cover in the Gingham wetland exhibited a significant cover increase of 90% between the spring and autumn sampling times, compared with a 49% increase in the Mallowa and a 32% increase in the Lower Gwydir wetlands ($F=9.63$, $p<0.001$, Figure 14).

Highest mean vegetation cover was observed in sites that were either inundated or wet (Figure 15). Cover at inundated sites was highest in the Mallowa wetland and similar for both the Lower Gwydir and Gingham wetlands. Wet sites recorded similar covers across all wetlands while Dry sites had highest cover values in both the Mallowa and Lower Gwydir wetlands and significantly lower cover values in the Gingham wetland (Figure 15).

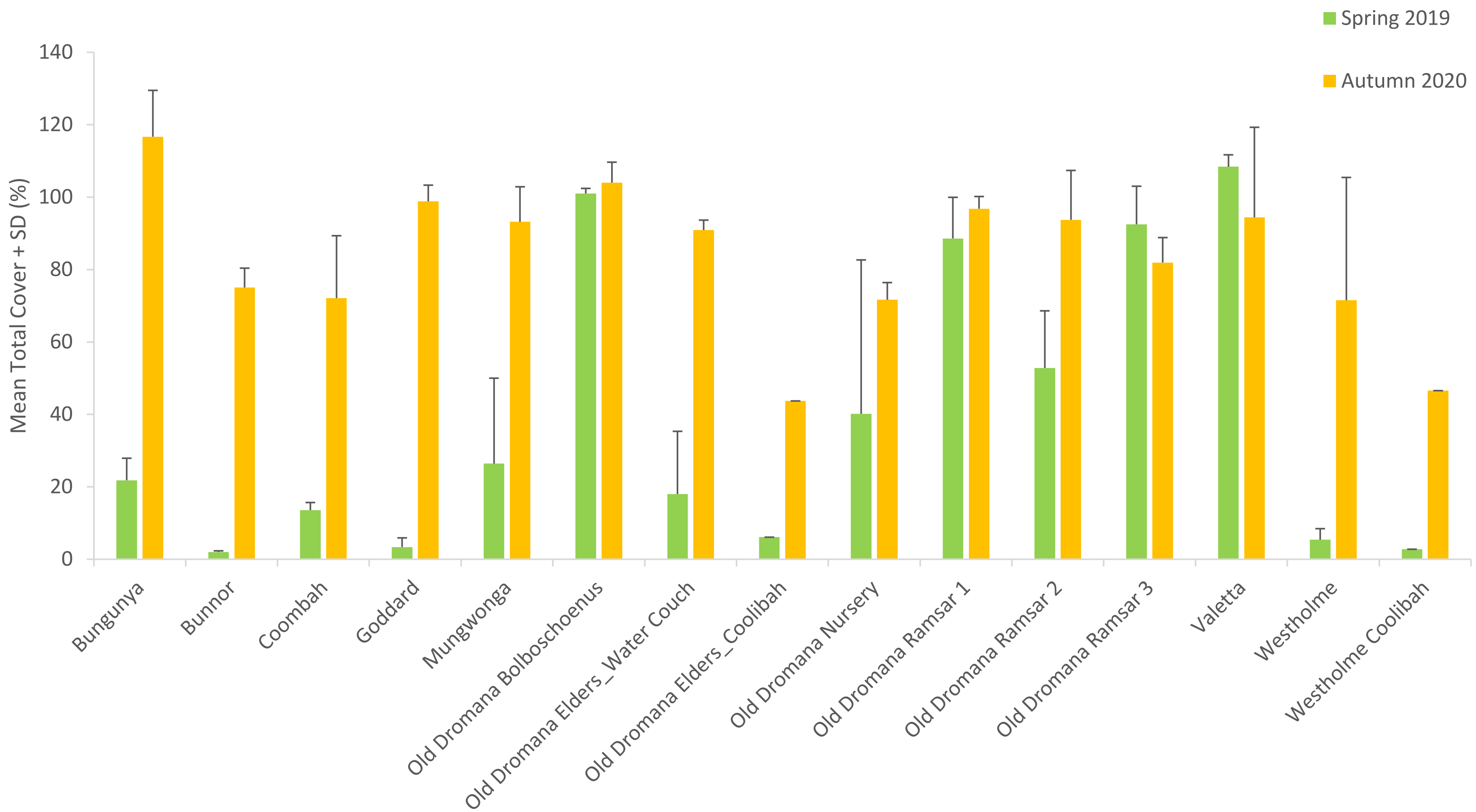

Figure 11 Mean vegetation cover recorded at each of the 15 monitoring locations (37 sites) during the spring 2019 and autumn 2020 vegetation surveys.

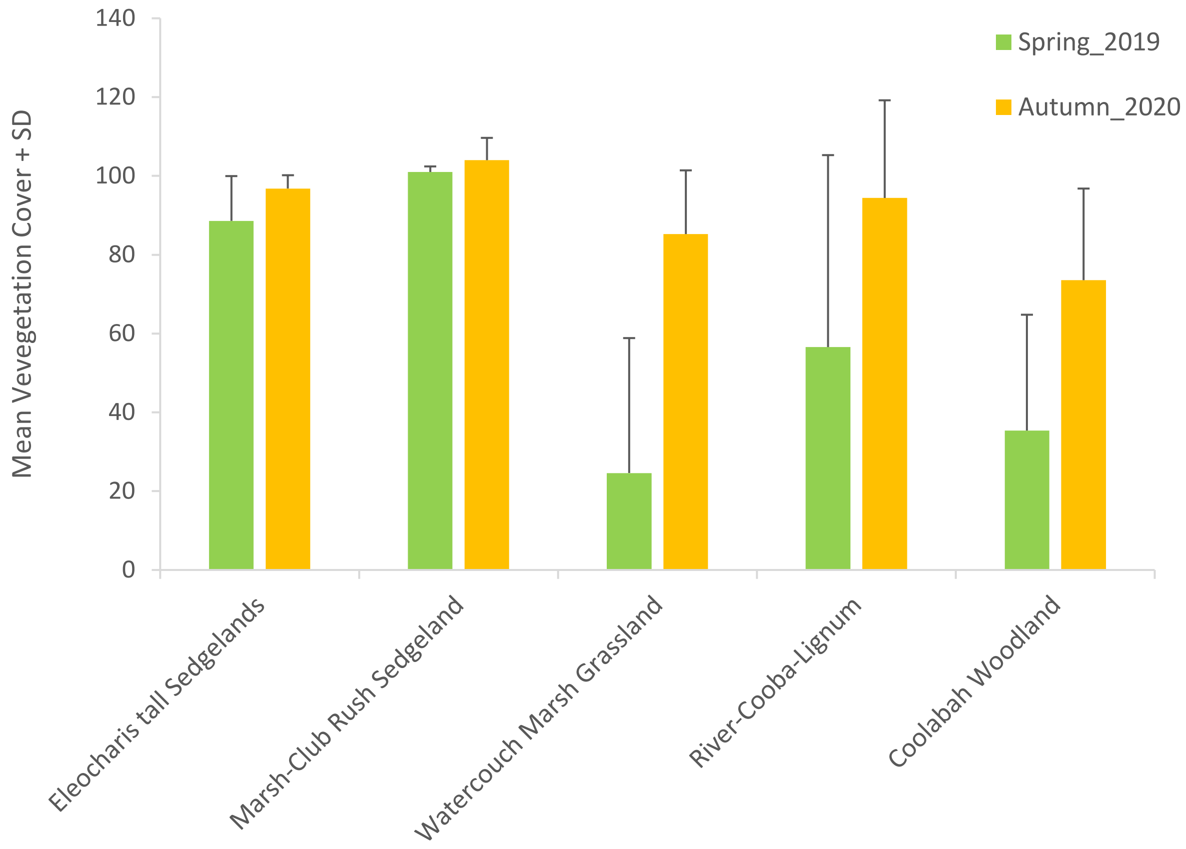

Figure 12 Mean vegetation cover at each of the five vegetation communities during the spring 2019 and autumn 2020 vegetation surveys.

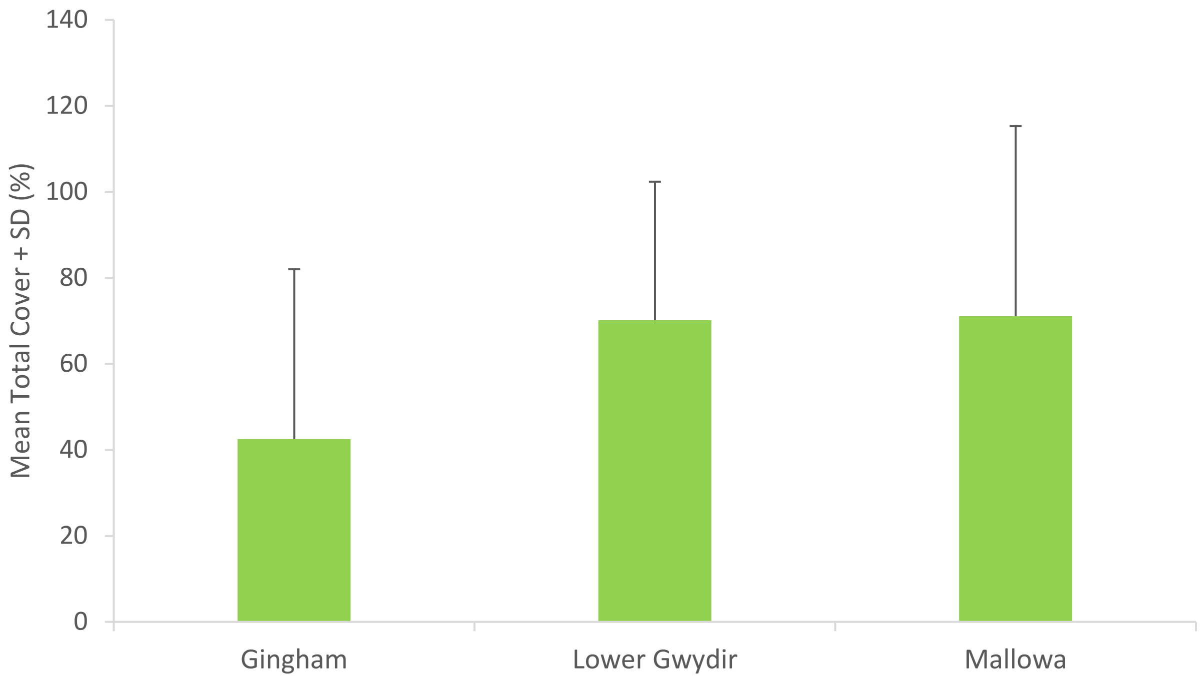

Figure 13 Mean total vegetation cover values recorded at each of the four vegetation communities across the 2019 water year.

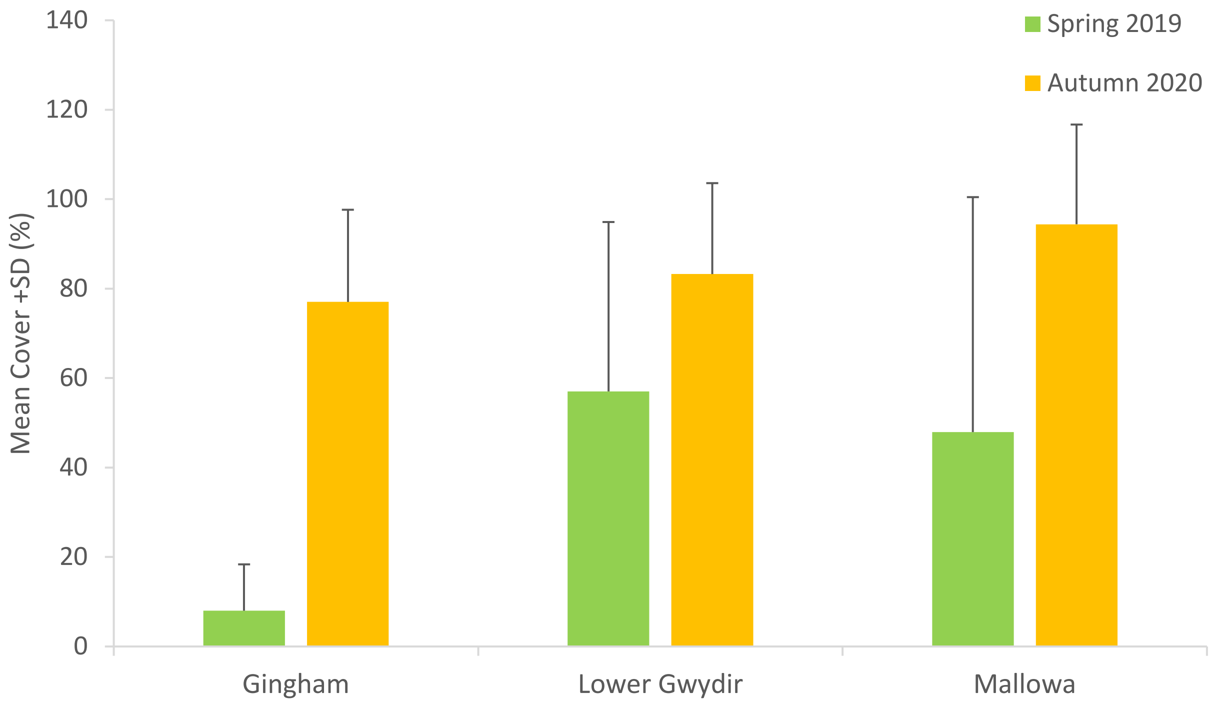

Figure 14 Mean vegetation cover at each of the three wetlands surveyed during the spring 2019 and autumn 2020 vegetation surveys.

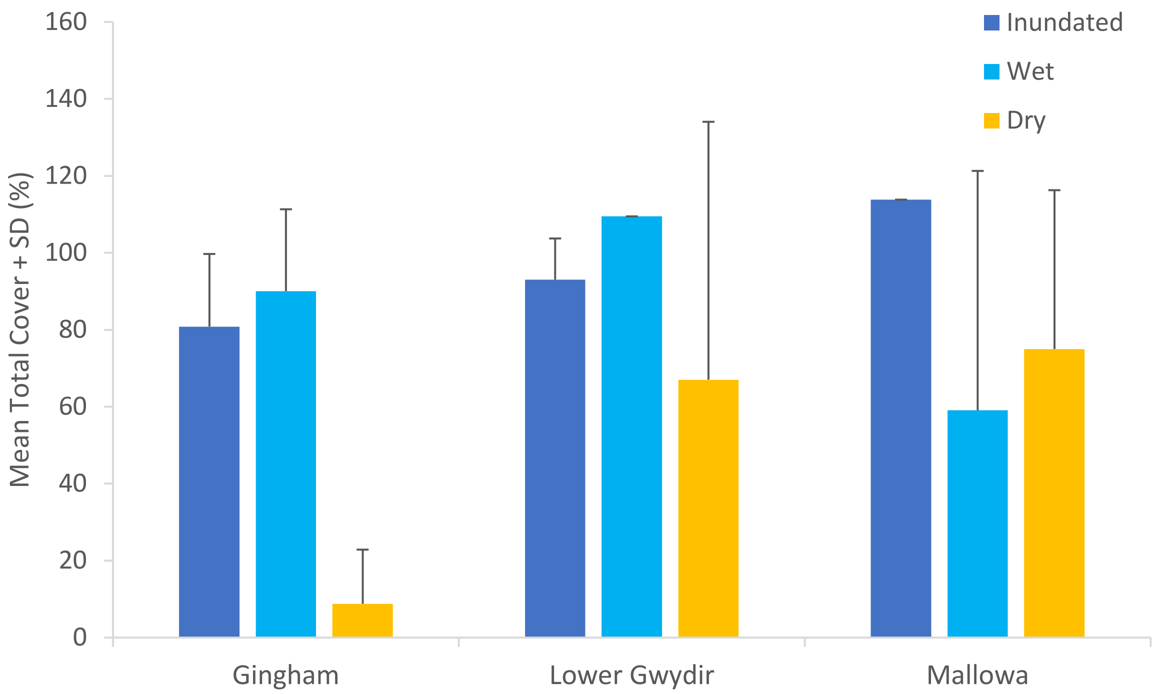

Figure 15 Mean vegetation cover of the three wetlands when grouped by inundation in the 2019-20 water year. The lack of standard deviations for Lower Gwydir 'wet' and Mallowa 'inundated' reflects only one site falling into each of these groupings.

Throughout the 2019-20 water year, the semi-permanent native perennial grass species, water couch, and the invasive perennial wetland herb species, lippia, were found at 49% and 73% of vegetation survey sites, respectively. Mean total cover for water couch remained low across both 2019-20 survey periods, with <0.5 ± 0.2% observed in the spring survey period and <1±2% observed in autumn (Figure 16). Lippia cover values were higher, with cover increasing between survey periods from 3 ± 1% in spring to 4 ± 8% in autumn (Figure 16).

Water couch cover was marginally greater at wet sites (2 ± 3%) than at both dry and inundated sites. A similar trend was observed for lippia which also recorded highest mean cover in wet sites (5 ± 11%) compared with those sites which were dry or inundated (Figure 17).

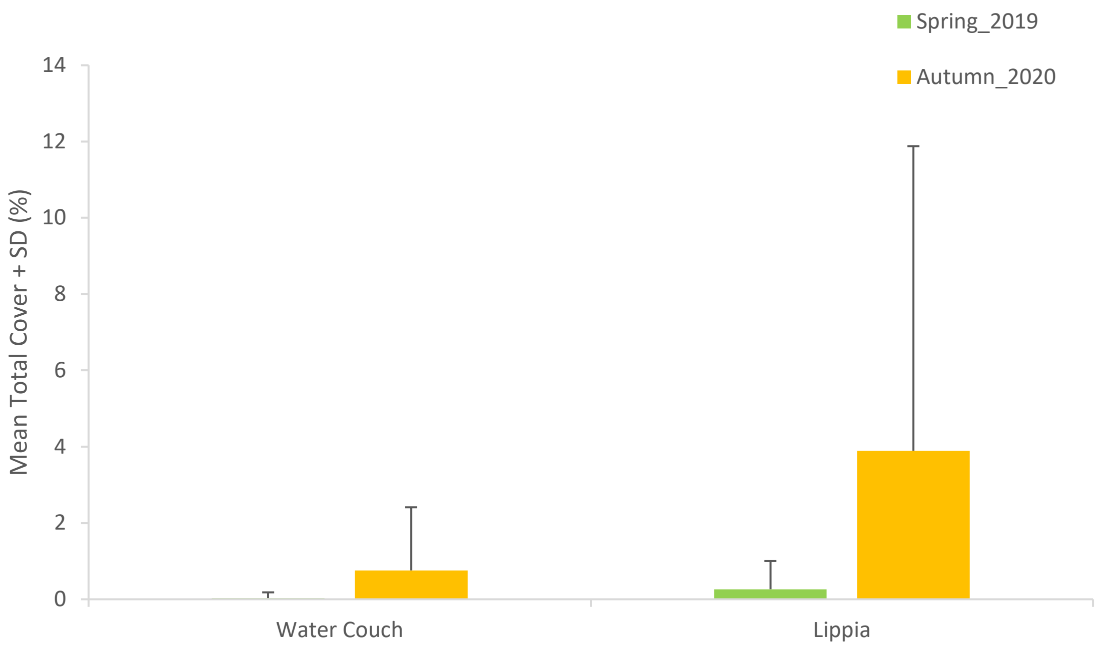

Figure 16 Mean cover of water couch and lippia across all sites during the spring 2019 and autumn 2020 vegetation surveys.

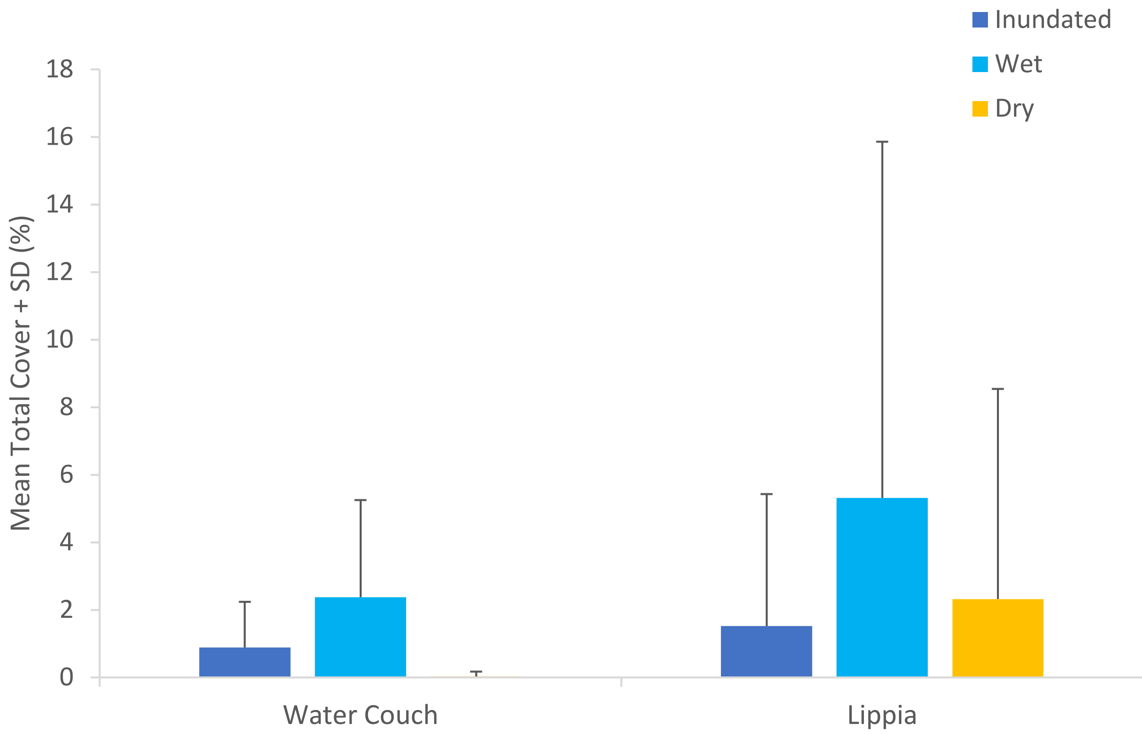

Figure 17 Mean total cover of water couch and lippia when grouped by inundation categories observed during the 2019-20 vegetation surveys.

4.1.3 Vegetation composition

Sampling time had the largest influence on observed patterns in the data (Pseudo-F = 8.54, $p<0.001$), then vegetation community (Pseudo-F = 8.21, $p<0.001$), wetland (Pseudo-F = 6.50, $p<0.001$) and to a lesser extent inundation status (Pseudo-F = 2.28, $p<0.005$, Figure 18). A significant interaction was observed between sampling time and wetland (Pseudo-F = 2.17, $p<0.005$), with all wetlands differing significantly between sample times. This result was driven by significant differences between sample times in River Cooba–Lignum, Water Couch Marsh Grassland and Coolabah Woodland communities ($p<0.005$). Wet sites tended to group closer together in ordination space compared to inundated and dry sites, suggesting more similar community composition in wet sites (Figure 19).

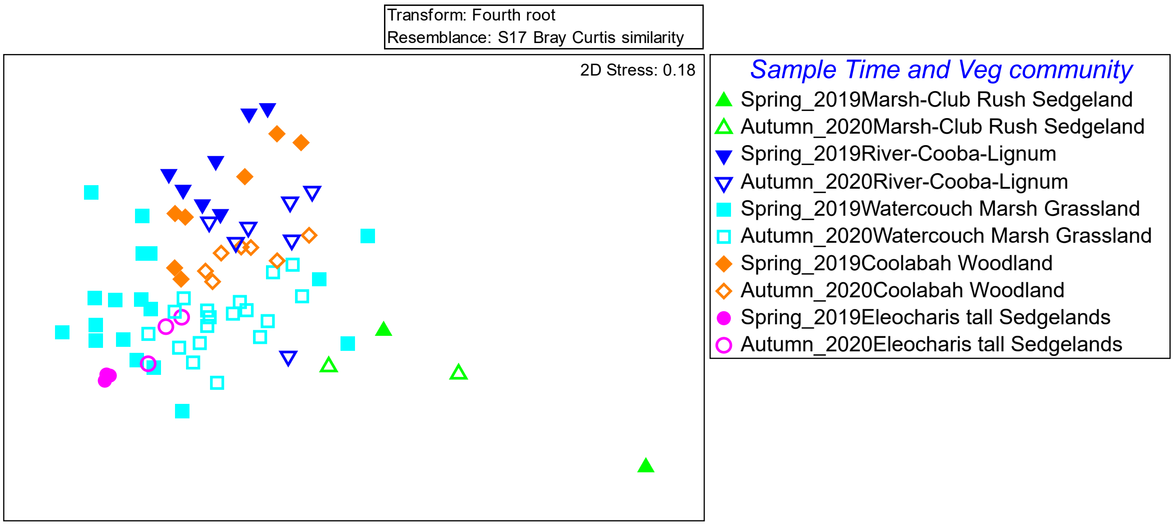

Figure 18 nMDS plot of community composition vegetation data collected during the 2019-2020 water year grouped by sample time and vegetation community.

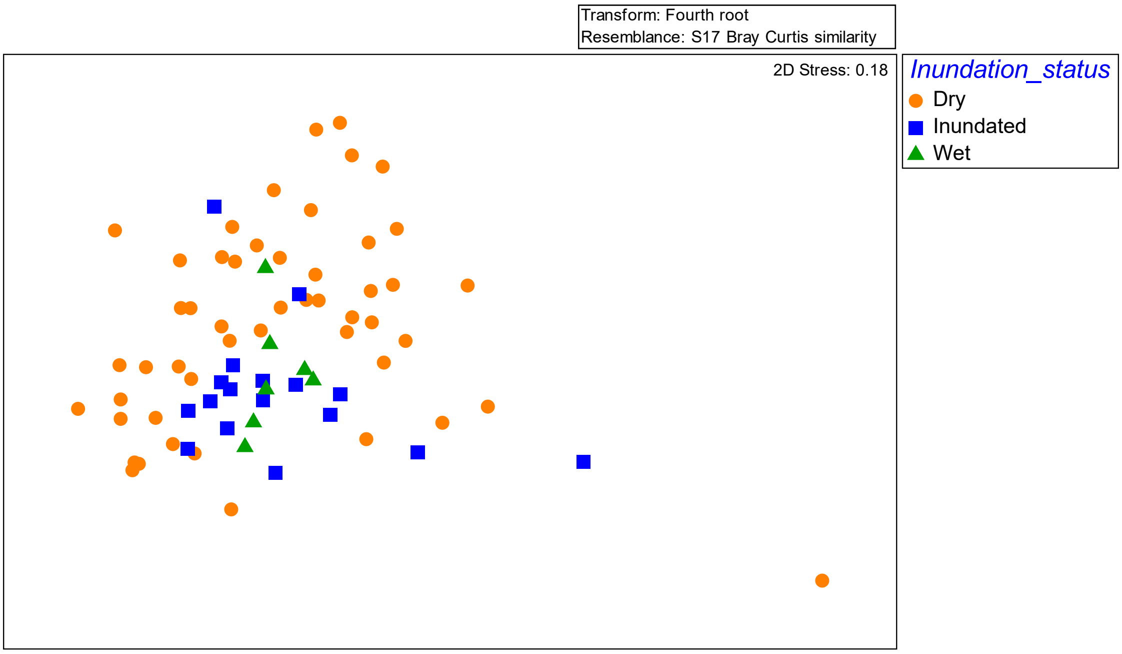

Figure 19 nMDS plot of community composition vegetation data grouped by the three inundation categories observed during the 2019-2020 water year.

SIMPER analysis indicated that flat spike-sedge (Eleocharis plana) cover influenced the dissimilarly between all groups based on survey time and inundation status (Table 4). In addition, narrow-leaved cumbungi (Typha domingensis, 19.33%) contributed the most to the spring 2019 grouping, while awnless barnyard grass (Echinochloa colona, 10.81%) was the second most influential species for the autumn 2020 grouping. For the inundation status groupings, flat spike-sedge (12.89%), narrow-leaved cumbungi (11.89%) and awnless barnyard grass (10.14%) contributed the most to the inundated grouping, dirty Dora (Cyperus difformis, 16.16%) and flat spike-sedge (12.69%) contributed to the wet grouping and again flat spike-sedge (12.87%), along with lippia 12.25%) and narrow-leaved cumbungi (12.10%) contributed to the dry grouping (Table 4).

Table 4 SIMPER results for the 19-20 vegetation community composition data grouped by sampling time and inundation status

Data grouping	Species (Functional group)	Average cover	Contribution (%)
Spring 2019	narrow-leaved cumbungi (AmT)	20.09	19.33
	flat spike-sedge (AmT)	13.86	13.30
	lippia (Tda)	0.31	11.63
	nardoo (AmR)	12.34	10.43
Autumn 2020	flat spike-sedge (AmT)	5.47	11.59
	awnless barnyard grass (Tda)	18.95	10.81
	budda pea (Tda)	5.74	9.14
	lippia (Tda)	3.10	5.88
Inundated	flat spike-sedge (AmT)	5.47	12.89
	narrow-leaved cumbungi (AmT)	20.71	11.89
	awnless barnyard grass (Tda)	18.95	10.14
	budda pea (Tda)	5.74	7.97
Wet	dirty dora (AmT)	7.25	16.16
	flat spike-sedge (AmT)	11.38	12.69
	water couch (AmR)	4.00	7.00
	water primrose (AmR)	4.00	6.87
Dry	flat spike-sedge (AmT)	8.93	12.87
	lippia (Tda)	8.88	12.25
	narrow-leaved cumbungi (AmT)	21.33	12.10
	nardoo (AmR)	0.248	9.48

4.2 Multi-year comparisons

4.2.1 Vegetation species richness

The inclusion of the 2019-20 MER vegetation data into the previous LTIM project dataset continued to show that mean species richness differs significantly over time ($F=16.62$, $p<0.0001$). This inclusion also set a new six-year mean species richness low of 7.7 ± 3.3 species recorded during severe drought conditions in spring 2019 (Figure 20). The subsequent declining trend in species richness observed during both 2019 surveys was reversed following inundation and rainfall in summer 2020, as indicated by the increased richness recorded in autumn 2020 (22.4 ± 8.9 species). This latter vegetation survey recorded the second highest species richness values for the Gwydir Selected Area since the first year of the monitoring program in spring 2014 (25 ± 7 species, Figure 20).

Coolabah Woodlands (19.6 ± 8.9 species) and River Cooba-Lignum Shrubland (19.3 ± 8.5 species) were significantly more speciose than the Water Couch Marsh Grasslands (14.3 ± 6.9 species) and Eleocharis Tall Sedgelands (14 ± 6.3 species), while all four of these vegetation communities supported greater mean species richness than the Marsh Club-Rush community (3 ± 1.3 species, $F=19.51$, $p<0.0001$). A significant interaction between vegetation community and time since inundation was observed ($F=2.05$, $p<0.05$). Eleocharis Tall Sedgelands and Coolibah Woodlands exhibited a decline in mean species richness whereas Water Couch Marsh Grassland and River Cooba-Lignum Shrubland communities showed an increase in richness as time since inundation increased (Figure 21). Marsh Club-Rush showed a mixed response with greatest mean species richness observed in the medium-term dry category and lowest richness observed in the long-term dry inundation category (Figure 21).

Mean species richness was significantly greater in long-term dry (17.4 ± 9.7 species) than both recently wet (16 ± 6.9 species) and currently wet (15.7 ± 8.5 species) inundation categories ($F=7.40$, $p<0.0001$), reflecting the inherently greater species diversity observed in terrestrial versus amphibious functional groups throughout the Selected Area. Each of the four functional groups exhibited significantly different species richness values, with the two terrestrial Tdr (5.6 ± 5 species) and Tda (5.6 ± 3.4 species) functional groups supporting greater species richness than the two amphibious AmT (4.5 ± 2.1 species) and Amr (2.7 ± 1.6 species) functional groups ($F=121.55$, $p<0.0001$, Figure 22). A significant interaction was also observed between functional groups and time since inundation ($F=5.44$, $p<0.0001$). The two amphibious functional groups both exhibited a decreasing trend in species richness with time since inundation (Figure 22). In contrast, the Tdr functional group displayed increasing trend in species richness with time since inundation and the Tda functional groups showed a variable response with respect to time since inundation.

Mean species richness was different among the three wetlands, with Mallowa (20 ± 9.1 species) supporting a significantly greater mean species richness than Gingham (14.1 ± 6.7 species), a finding which is reflective of the types of vegetation communities found within each of these systems ($F=13.69$, $P<0.0001$, Figure 23)

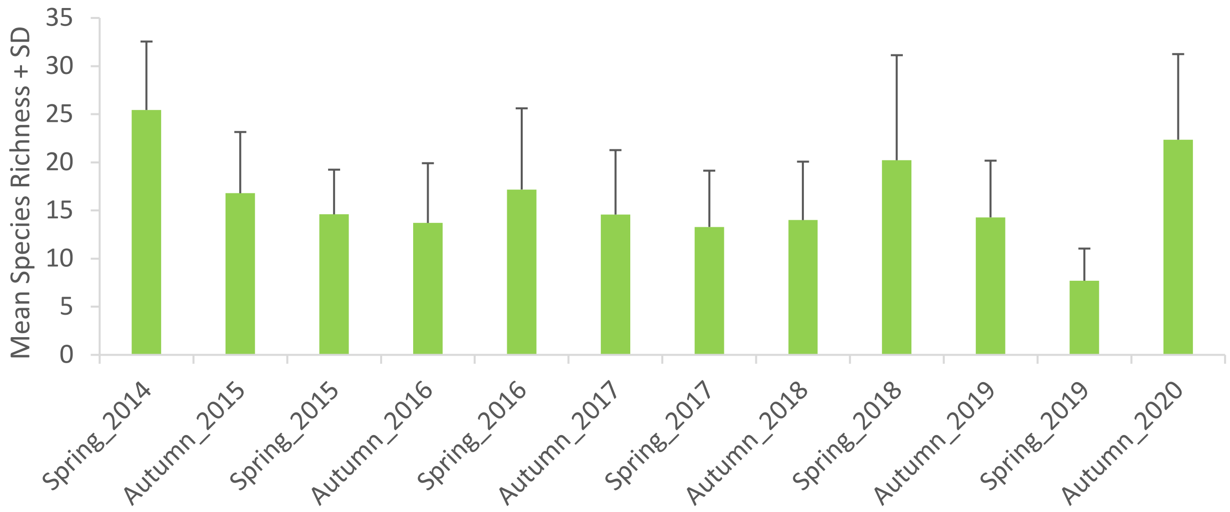

Figure 20 Mean total species richness as recorded throughout the LTIM and MER projects.

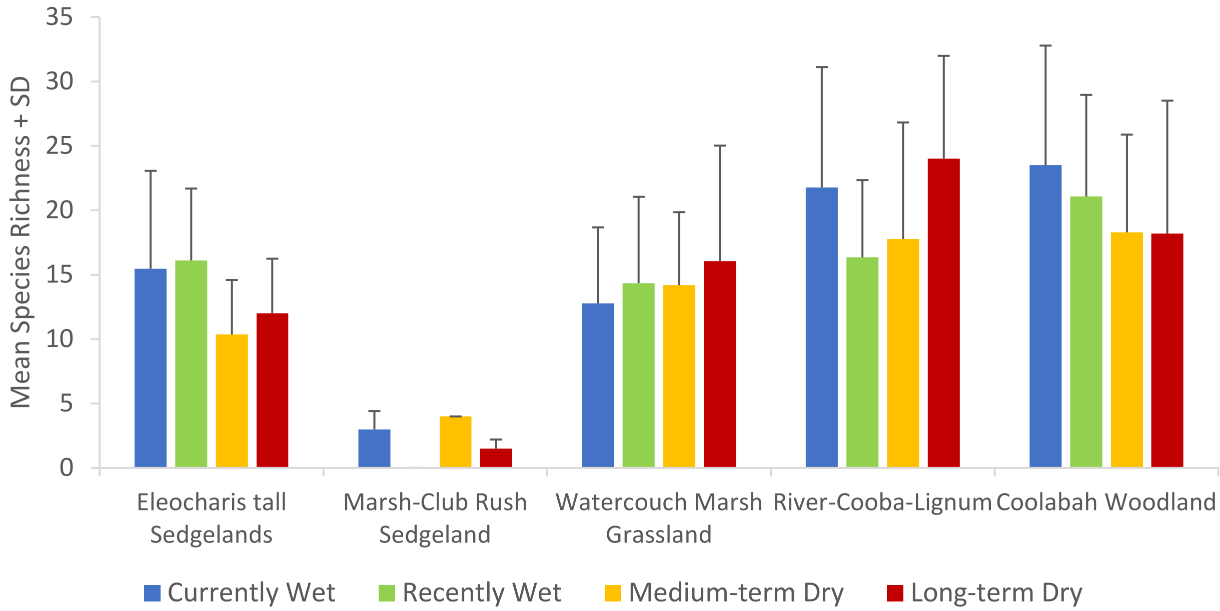

Figure 21 Mean species richness of the four vegetation communities split by inundation status across all years of LTIM/MER project.

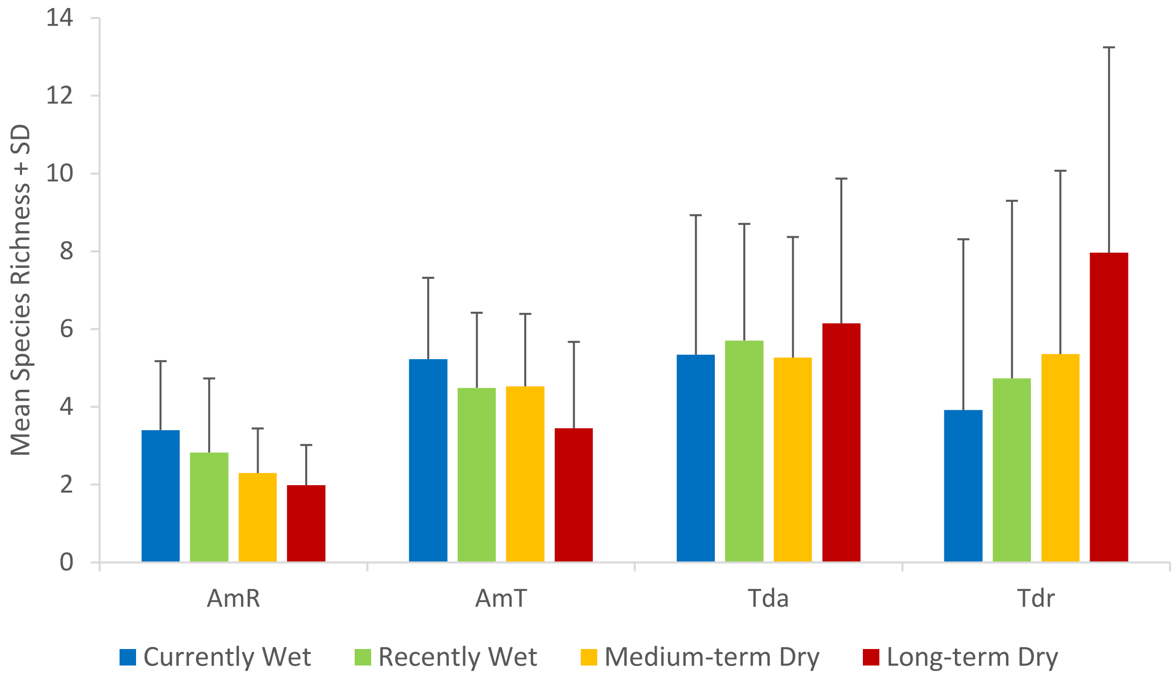

Figure 22 Mean species richness of the four functional groups split by inundation status across all years of LTIM/MER project.

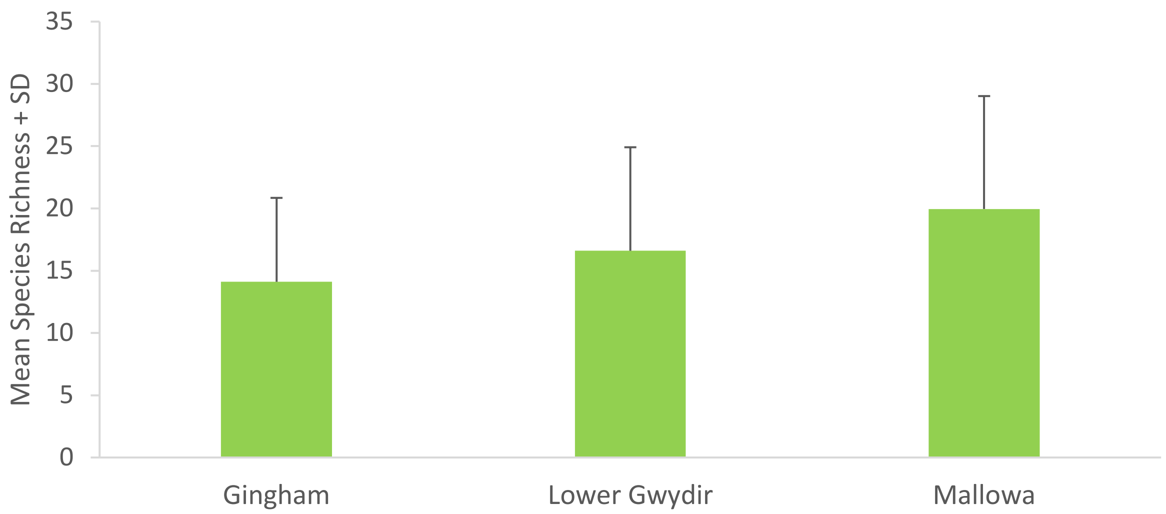

Figure 23 Mean species richness at each of the three wetlands across all years of LTIM/MER project.

4.2.2 Vegetation cover

Mean vegetation cover was significantly lower in spring 2019 than during any other year of the LTIM/MER project (42 ± 42%, F=9.51, p<0.0001, Figure 24). No long-term cover difference was detected between vegetation communities (Figure 25).

While cover values were similar across sites that were either currently wet (88 ± 20%) and recently wet (80 ± 33%), or currently wet and medium-term dry (73 ± 32%), all three inundation categories supported significantly greater vegetation cover values than those sites that were long-term dry (58 ± 37%, F=22.2, p<0.0001, Figure 26).

A significant interaction between functional group and inundation category was detected for mean vegetation cover where, as time since inundation increased, amphibious groups decreased in cover while terrestrial groups showed a stable or slightly increasing trend (F=20.81 p<0.0001; Figure 26). Greatest covers were observed in the two amphibious functional groups AmT (34 ± 32%) and AmR (29 ± 32%), compared with the two terrestrial groups, Tda (14 ± 17%) and Tdr (7 ± 14%, F=76.8, p<0.0001, Figure 26).

Vegetation cover varied significantly across wetlands with the Gingham (64 ± 44%) and Lower Gwydir (63 ± 39%) having significantly greater cover than the Mallowa (53 ± 40%) (F=6.09, p<0.01, Figure 27).

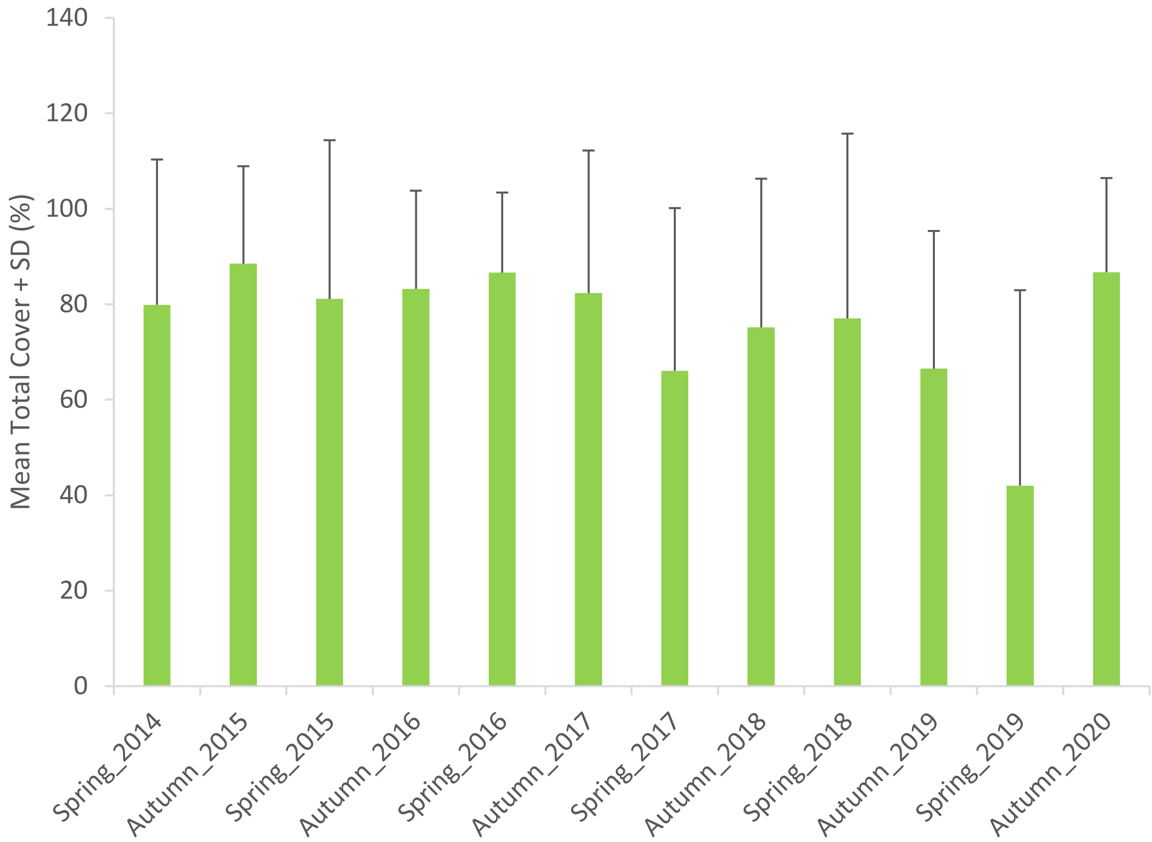

Figure 24 Mean vegetation cover across all years of LTIM/MER project.

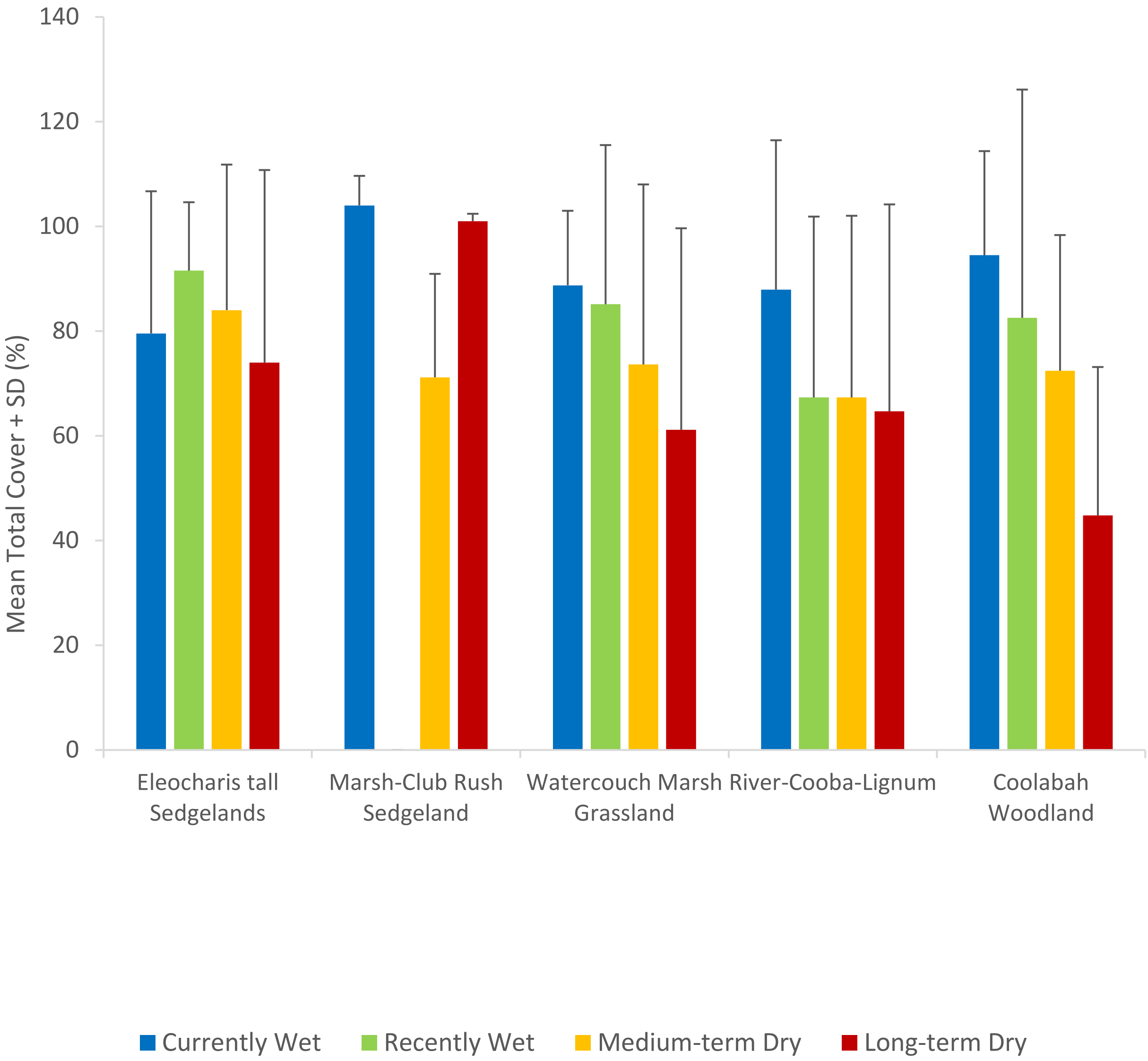

Figure 25 Mean vegetation cover from the five different vegetation communities when grouped by inundation across all years of LTIM/MER project.

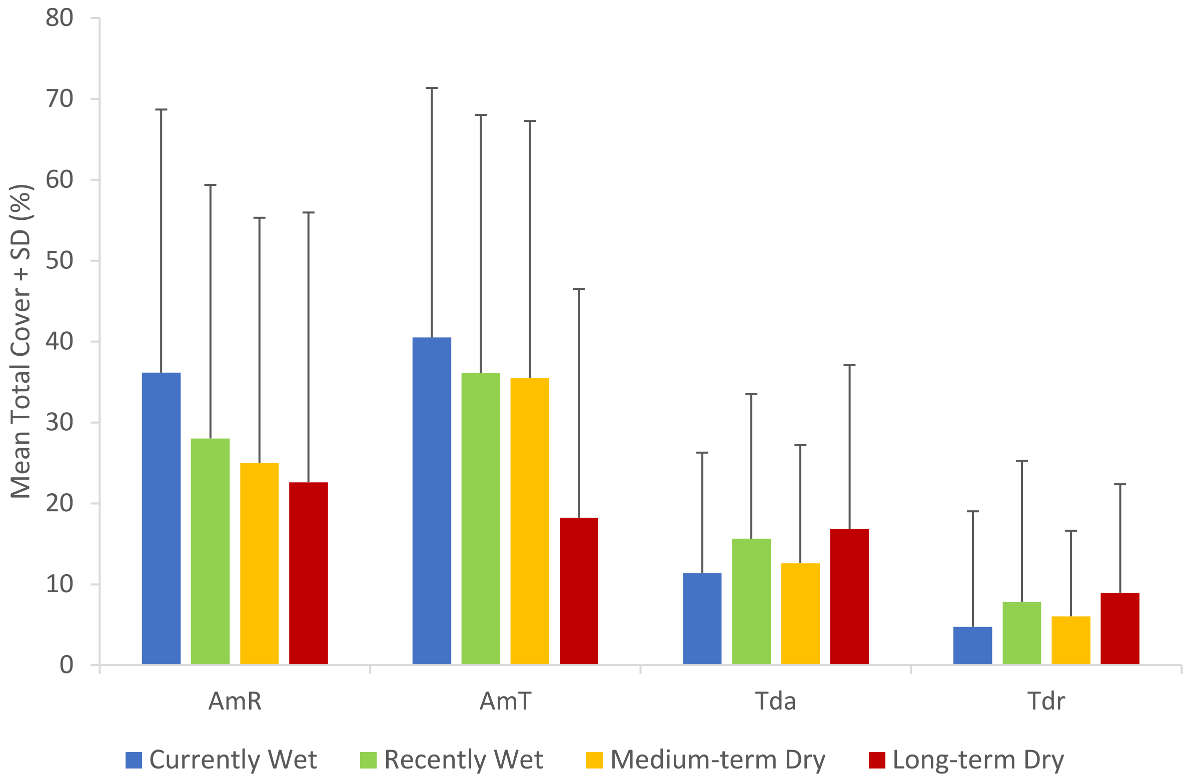

Figure 26 Mean vegetation cover of the four functional groups split by inundation categories across all years of LTIM/MER project.

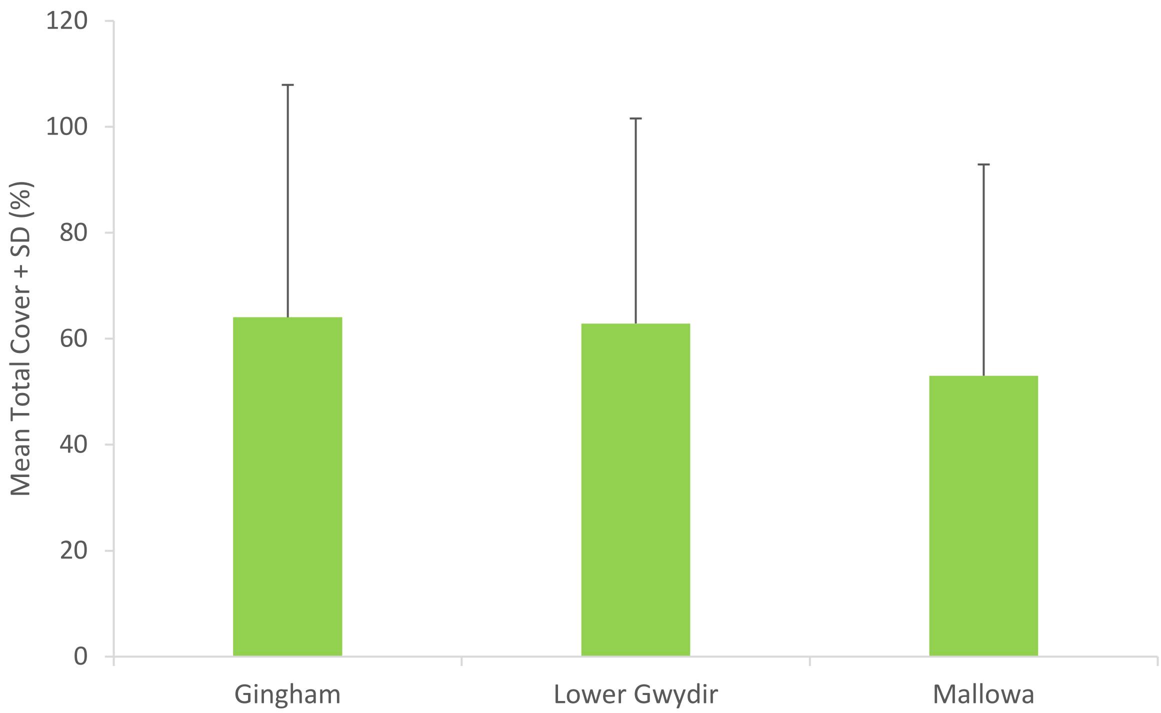

Figure 27 Mean vegetation cover of the three wetlands across all years of LTIM/MER project.

LTIM/MER survey times water couch mean cover was highest in autumn 2015 (56 ± 32%), while lippia was highest in autumn 2018 (19 ± 22%). However, lowest cover for both water couch and lippia (<1%) were observed during the spring 2019 survey period, with both species evidently affected by severe drought conditions (Figure 28). Water couch cover has been variable over the LTIM project but reduced considerable in 2019-20, while lippia has remained relatively stable across the six years of the LTIM/MER project (Figure 28). Notwithstanding the relatively large variation in the data, water couch recorded higher mean cover at wet sites (38 ± 33%) when compared to long-term dry sites (32 ± 14%), while lippia displayed the opposite pattern with mean cover highest in long-term dry sites (14 ± 18%) and lowest cover across inundated sites (6 ± 8%, Figure 29). All three wetlands supported similar mean cover of lippia (~10%), however, water couch had highest mean cover values in the Gingham wetlands (43 ± 32%) compared with the Lower Gwydir (19 ± 25%) and Mallowa (18 ± 30%, Figure 30).

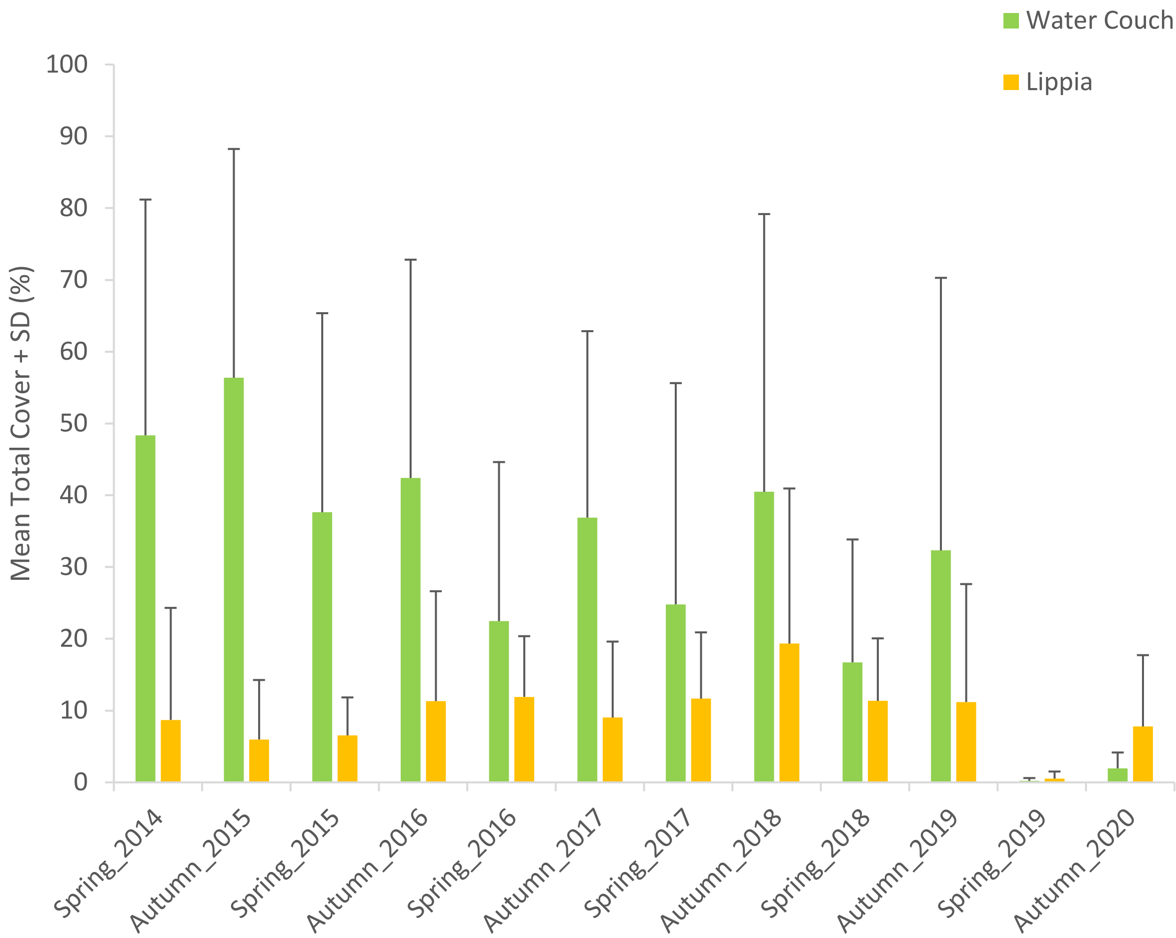

Figure 28 Mean cover of the native grass species, water couch, and the exotic invasive species lippia, across all years of the LTIM/MER project.

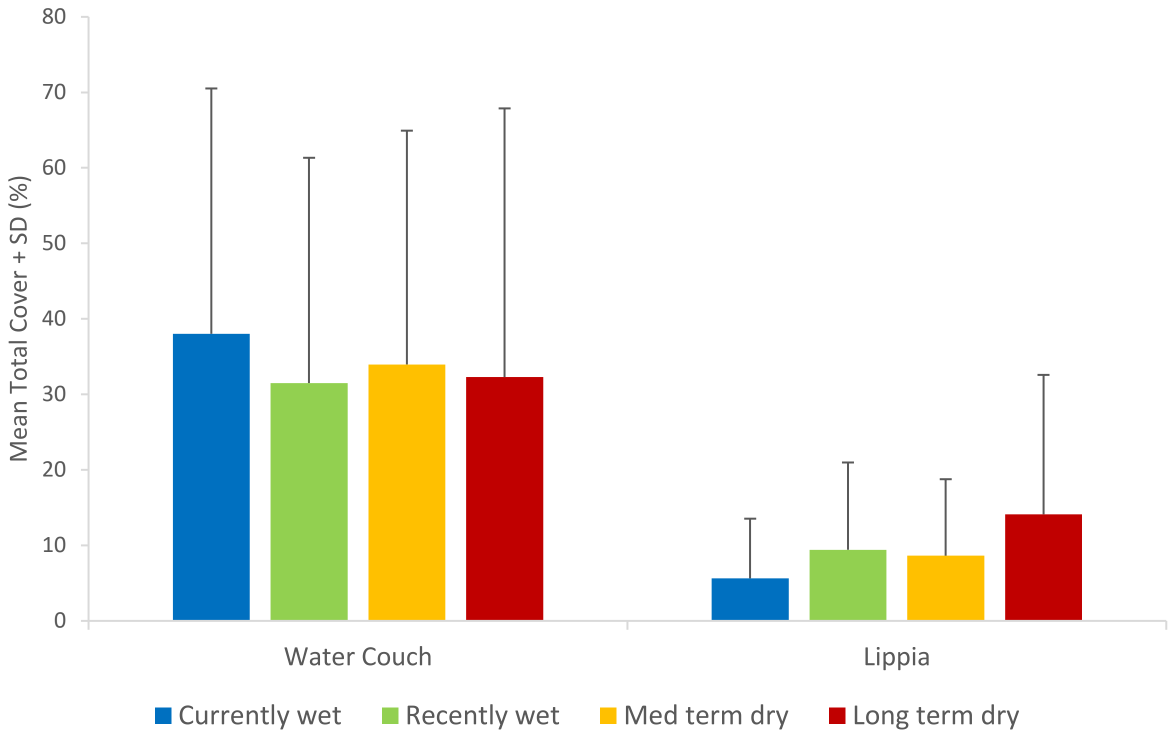

Figure 29 Mean cover of the native grass species water couch and the exotic invasive species lippia split by inundation categories across all years of the LTIM/MER project.

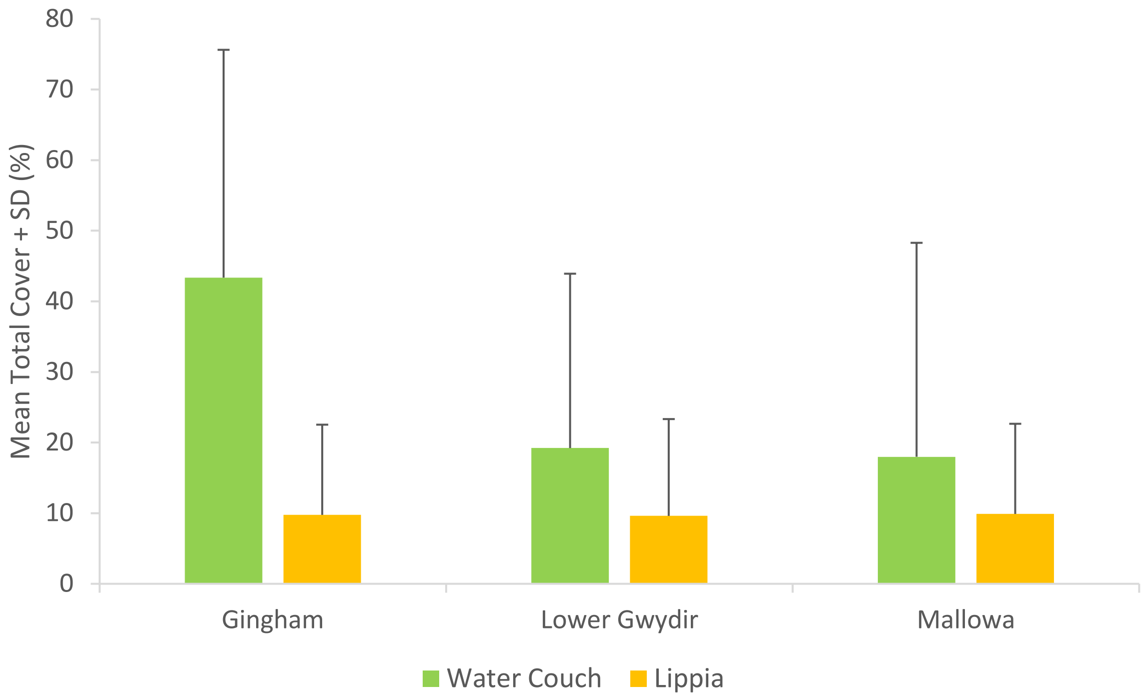

Figure 30 Mean cover of the native grass species water couch and the exotic invasive species lippia split by wetlands across all years of the LTIM/MER project.

4.2.3 Multi-year vegetation community composition

When data from all years of the LTIM and MER projects were compared, significant differences in the vegetation community composition was observed between wetlands (Pseudo-F = 38.24, p<0.001), vegetation communities (Pseudo-F = 25.30, p<0.001), Survey times (Pseudo-F = 6.90, p<0.001) and inundation categories (Pseudo-F = 7.31, p<0.001). Significant interactions were also detected between survey time and both wetland (Pseudo-F = 2.06, p0.001) and vegetation community (Pseudo-F = 1.40, p<0.001) and inundation category and both wetland (Pseudo-F=3.64, p<0.001) and vegetation community (Pseudo-F = 1.52, p<0.001).

Samples from the spring 2019 survey time showed the greatest spread in the data of all sampling times (Figure 31) consistent with the trend of increasing variability between sites over time noted in the LTIM data (Commonwealth of Australia 2019). However, sites in autumn 2020 grouped closer together suggesting a reduction in between site variability (Figure 31, Table 5) linked to increased inundation during the autumn 2020 survey period.

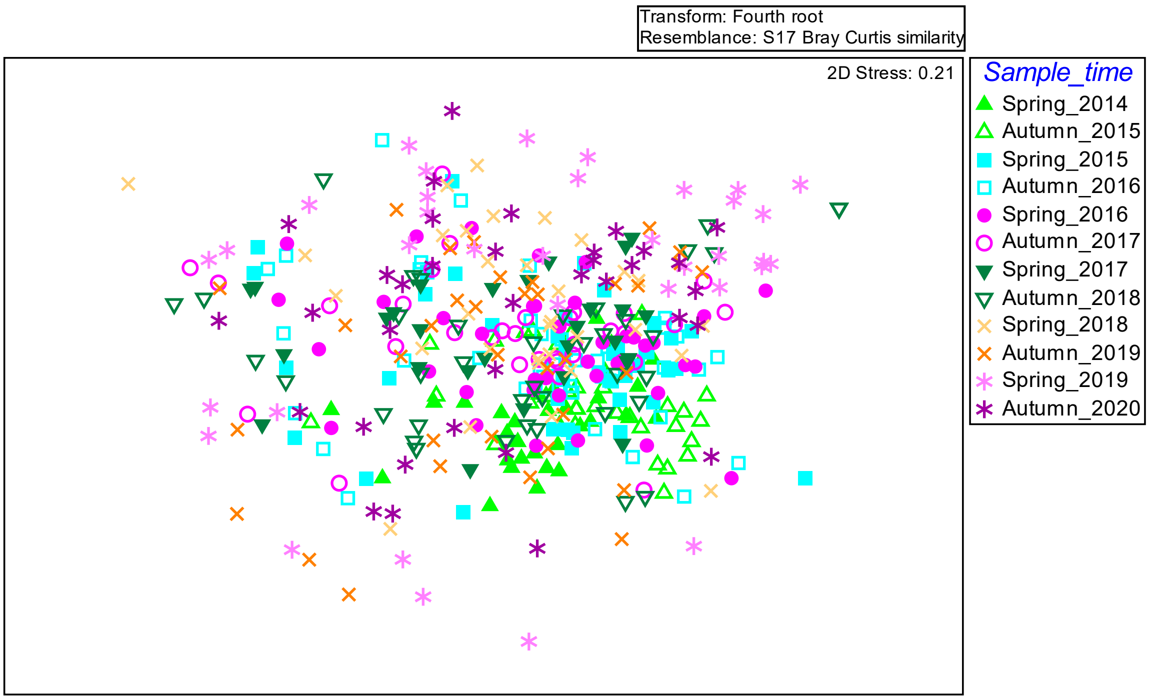

Figure 31 nMDS plot of all LTIM and MER project vegetation community composition data grouped by sampling time.

Table 5 Dispersion values of survey times.

Survey time	Dispersion value
Spring 2014	0.572
Autumn 2015	0.69
Spring 2015	0.957
Autumn 2016	0.988
Spring 2016	0.869
Autumn 2017	1.017
Spring 2017	0.985
Autumn 2018	1.14
Spring 2018	1.091
Autumn 2019	1.183
Spring 2019	1.366
Autumn 2020	1.062

Currently wet sites showed tighter clustering suggesting a more similar community composition than in other inundation categories (Figure 32). The degree of clustering increased with increasing dryness with the currently wet group having a dispersion value of 0.841, recently wet 0.977, med-term dry 1.039 and long-term dry a dispersion index of 1.232 (Table 5). While each inundation category was significantly different to one another overall ($p<0.05$), varying responses were observed for individual vegetation communities (Table 6). Sites within Water Couch Marsh Grassland communities showed the greatest difference between inundation classes, with significant differences between all classes. River Cooba – Lignum Shrubland sites showed significant differences between all classes except between the recently wet/medium term dry pairing ($p=0.109$). Coolibah Woodland sites showed significant differences between groupings apart from the recently wet/medium term dry, and currently wet/recently wet pairings. Only one pairing showed a significant difference in the Eleocharis Tall Sedgeland sites being the currently wet/medium term dry pairing ($p<0.05$, Table 6).

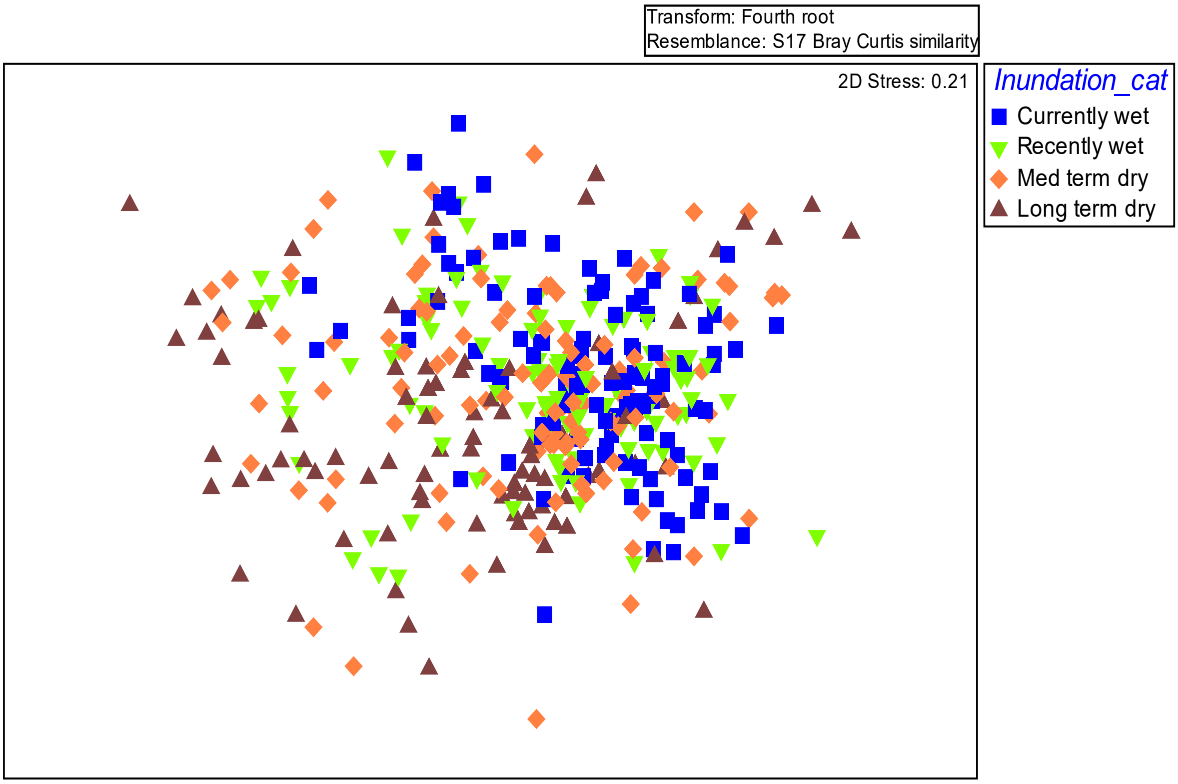

Figure 32 nMDS plot of species composition data from the whole LTIM and MER project grouped by inundation category.

Table 6 PERMANOVA results of comparison between inundation categories for each vegetation community. Shaded cells represent significant differences.

Water couch marsh grassland				
	Currently wet	Recently wet	Med-term dry	Long-term dry
Currently wet				
Recently wet	0.018			
Med-term dry	0.001	0.024		
Long-term dry	0.001	0.001	0.002	
River cooba-lignum shrubland				
	Currently wet	Recently wet	Med-term dry	Long-term dry
Currently wet				
Recently wet	0.043			
Med-term dry	0.001	0.109		
Long-term dry	0.001	0.001	0.003	
Eleocharis tall sedgeland				
	Currently wet	Recently wet	Med-term dry	Long-term dry
Currently wet				
Recently wet	0.261			
Med-term dry	0.03	0.129		
Long-term dry	0.192	0.144	0.643	
Coolabah woodland				
	Currently wet	Recently wet	Med-term dry	Long-term dry
Currently wet				
Recently wet	0.069			
Med-term dry	0.001	0.441		
Long-term dry	0.001	0.001	0.003	

SIMPER analysis noted variation in species contributions when grouped by inundation category. The contribution of water couch generally reduced across the categories with this species highest mean cover (29%) and contribution percentage (21.59%) occurring within Inundated sites (Table 7). Flat spike-sedge contributed the most to the recently wet category (16.76%), then reduced as sites dried. Lippia increased in both contribution percentage and mean cover as inundation categories became drier with long-term dry sites recording the highest contribution (19.06%) and mean cover (11%, Table 7).

The small fluctuations in mean cover and contribution indicate the dominance and resilience of amphibious functional species in the Gwydir wetlands, highlighting the ability of water couch, flat-spike sedge and to a lesser extent, narrow-leaved cumbungi, to rapidly respond to inundation, persist into drying conditions and bounce back following extended dry periods (Table 7).

Table 7 Contribution and mean cover (%) of the top four lower and mid-story species recorded across each Inundation categories

Inundation Category	Species (Functional group)	Mean Cover (%)	Contribution (%)
Currently wet	water couch (AmR)	28.76	21.59
	flat spike-sedge (AmT)	12.06	15.06
	swamp buttercup (AmT)	1.82	7.09
	narrow-leaved cumbungi (AmT)	9.99	6.81
Recently wet	flat spike-sedge (AmT)	12.77	16.76
	water couch (AmR)	19.01	14.26
	lippia (Tda)	5.77	9.20
	tussock rush (AmT)	1.06	5.93
Medium-term dry	flat spike-sedge (AmT)	13.41	16.36
	water couch (AmR)	20.15	14.38
	lippia (Tda)	6.00	12.73
	narrow-leaved cumbungi (AmT)	8.31	7.95
Long-term dry	lippia (Tda)	10.62	19.06
	water couch (AmR)	16.31	9.35
	flat spike-sedge (AmT)	5.23	8.54
	wild aster (Tda)	0.31	6.11

4.3 Tree Recruitment

Average tree recruitment was calculated for three separate age classes across all survey periods for river cooba and coolibah within the River Cooba-lignum and Coolabah Wetland Woodland vegetation communities respectively (Figure 33-Figure 36). Despite severe drought conditions and increased grazing pressure experienced throughout 2019, coolibah seedling and sapling numbers in all three size classes at Old Dromana Nursery 2-1 remained relatively stable in the period since autumn 2019 (Figure 33). However, survivorship decreased at Old Dromana Ramsar 2-1 during the same period, with only the 1.3-3 m sapling class persisting into spring 2019, and no surviving seedlings or saplings present in autumn 2020 (Figure 34). Despite the observation of several relatively small coolibah recruitment events, including autumn 2016 and autumn 2017, survivorship into larger sapling classes appears to be limited and may be dependent upon localised factors.

All 18 river cooba saplings in the 1.3-5 m size class at Coombah 1-1 had been intentionally felled in the time between the autumn and spring 2019 surveys. Despite the complete removal of this class, a small number of river-cooba seedlings were observed during the spring 2019 survey (Figure 35). Despite no river cooba seedlings or saplings being recorded at Valetta 1-1 in autumn 2019, three saplings were observed in the 1.3-3 m size in the spring 2019 survey, however, these individuals did not appear to survive through to the following autumn 2020 survey (Figure 36). The relatively large number of river cooba seedlings that came up in the spring 2015 pulse did not persist into spring 2017. Similarly, to the low survivorship observed in seedlings, river-cooba saplings in the 0.5-1.3 m size class appear to remain susceptible to pressures such as floods, drought and grazing, however, those saplings that reach the 1.3-3 m size class may be more stable and have a higher likelihood of withstanding these pressures.

While fluctuations in seedling and sapling numbers have been observed it is important to point out that there may be unavoidable count discrepancies between sampling times. Such discrepancies are a likely combination of the effects of drought and grazing, which can reduce seedling and sapling heights and lead to the loss of leaves, which can subsequently result in the temporary reduction in plant numbers when individuals are missed or assessed as dead between survey periods.

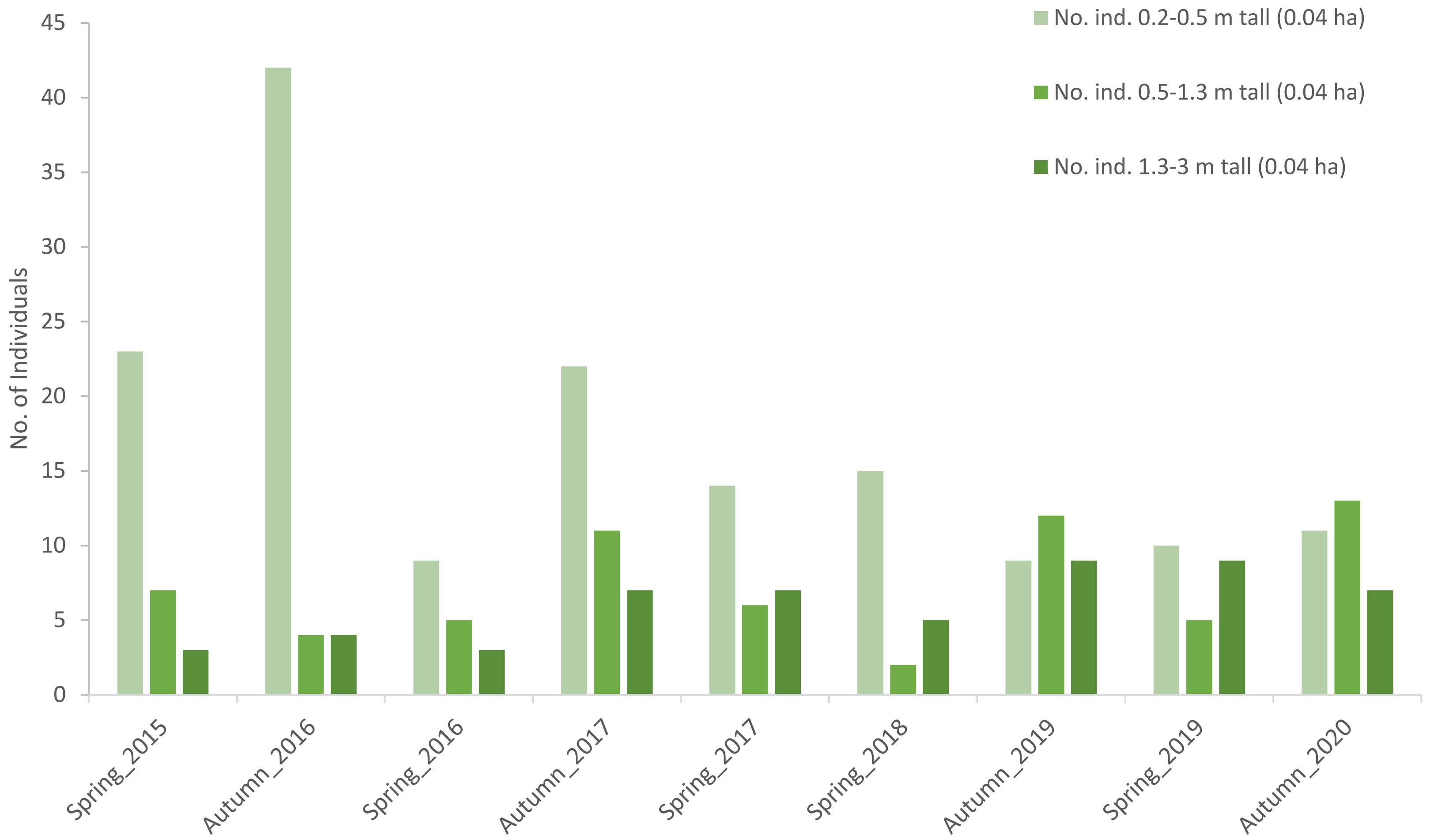

Figure 33 Number of coolibah seedlings recorded at Old Dromana Nursery 2 across all LTIM/MER sample times.

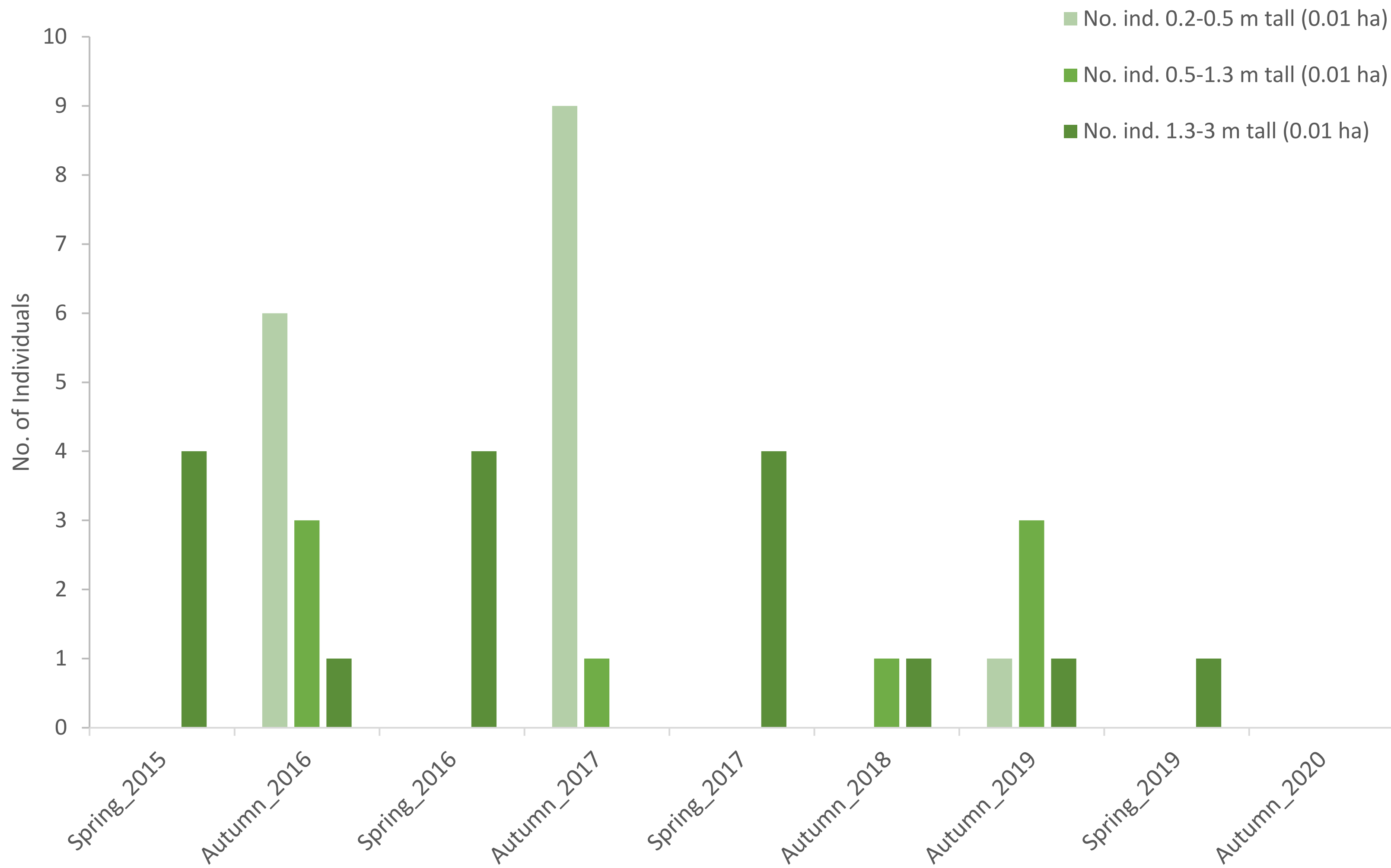

Figure 34 Number of coolibah seedlings recorded at Old Dromana Ramsar 2-1 across all LTIM/MER sample times.

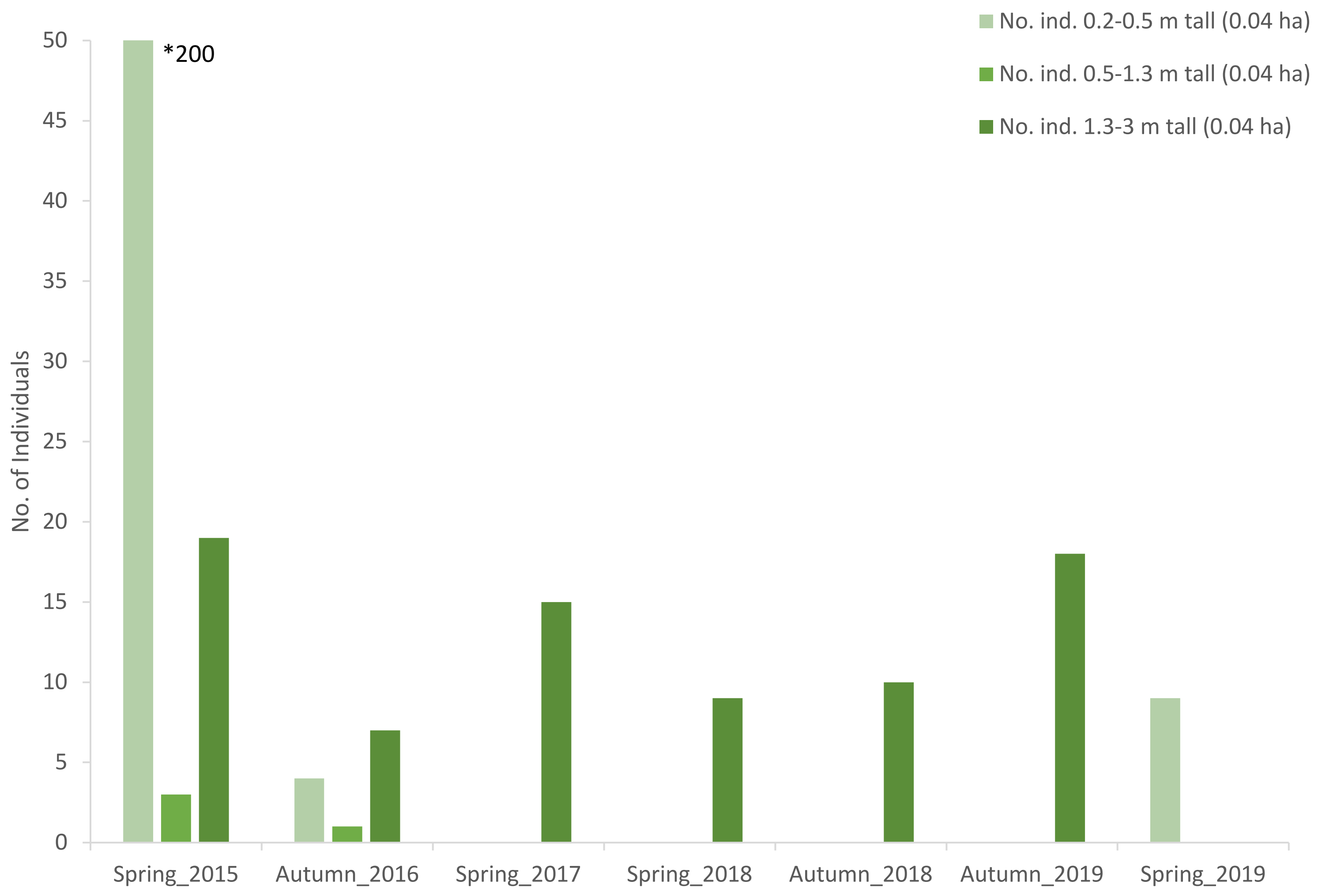

Figure 35 Number of river cooba seedlings recorded at Coombah 1-1 across all LTIM/MER sample times. Note that the autumn 2020 survey did not record river-cooba seedling and sapling numbers at this site.

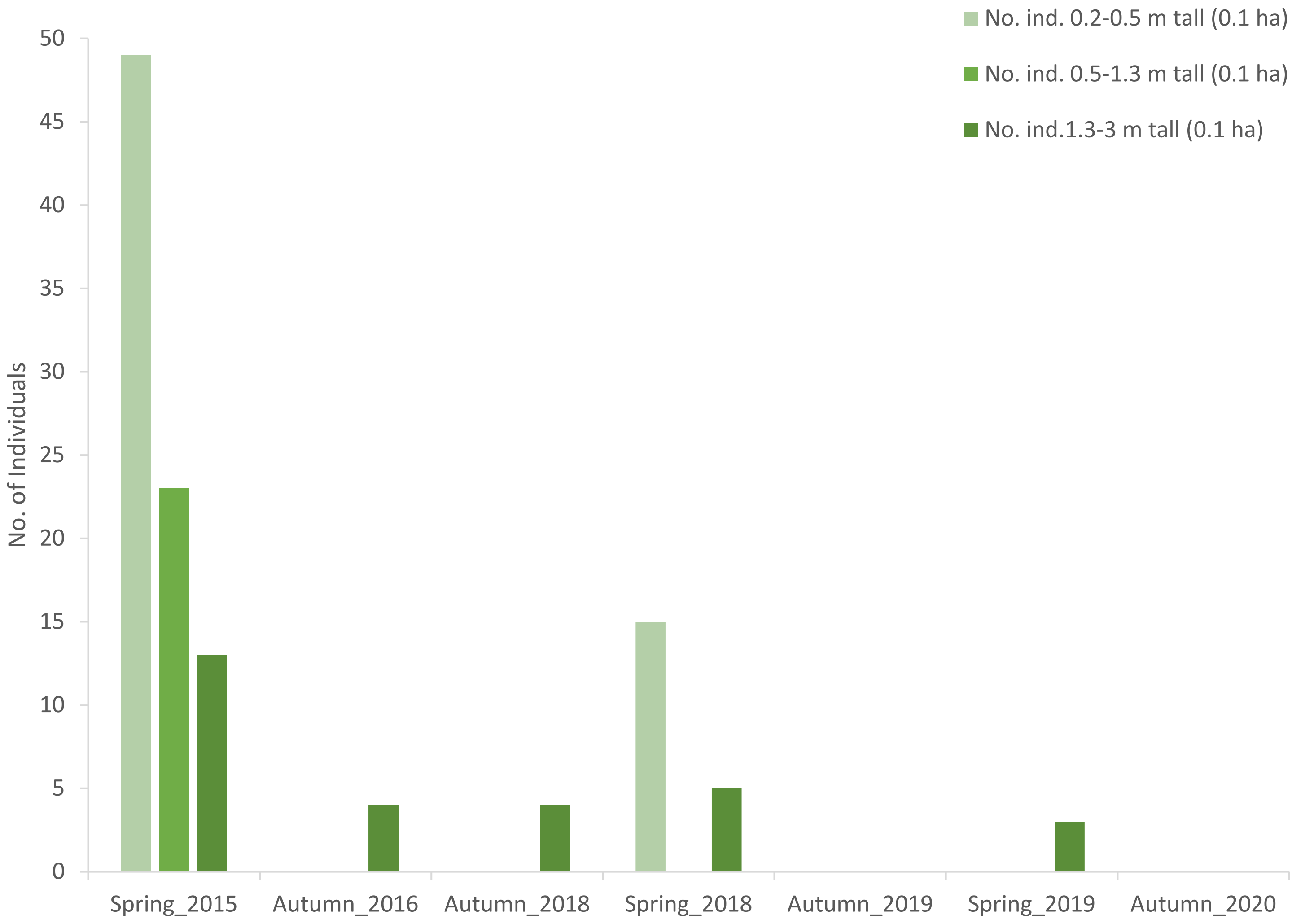

Figure 36 Number of river cooba seedlings recorded at Valetta 1-1 across all LTIM/MER sample times.

5 Discussion

Spring 2019 recorded the lowest mean species richness values in the six years of LTIM/MER project monitoring within the Selected Area, highlighting the severity and intensity of the drought conditions experienced during 2019. However, following inundation and above average rainfall, less than five months later the lower Gwydir wetlands recorded very high vegetation cover along with the second highest species richness observed across all years of the project (Figure 37).

Figure 37 Drought conditions observed in spring 2019 (top) and following autumn inundation (bottom) at both Goddards Lease Ramsar (top and bottom left) and Old Dromana Elders (top and bottom right) vegetation monitoring sites in the lower Gwydir Wetlands

Wilson *et al.* (2009) reported the high level of resilience exhibited by lower Gwydir wetland vegetation communities to a variable water regime. The high species richness observed during the autumn survey is not only a demonstration of this resilience, but it may also be related to reduced competition as indicated by low vegetation cover during spring. The September 2019 wildfire that burnt 1,300 ha in the Gingham wetland, including nine LTIM/MER survey plots, explains the cover differences observed among wetlands in the spring sampling period. Wildfire and prescribed burns have previously burnt large areas of the Gingham and lower Gwydir wetlands, however, the long-term effects of fire on these wetland systems is poorly understood. Potential long-term impacts across each of the vegetation communities affected by the Gingham fire and the role of inundation in ameliorating impacts and expediting recovery will be investigated through the MER project.

Across all years, terrestrial vegetation communities that occur higher in the landscape such as Coolabah Woodland Wetland and River Cooba-Lignum Shrubland, have been found to be more speciose than the lower elevated amphibious wetland vegetation communities (Commonwealth of Australia 2019). While vegetation cover did not differ between vegetation communities across all years, it was significant in the 2019/20 water year, where the more speciose vegetation communities exhibited the lowest cover values, especially during drought conditions. The pattern of higher species richness and lower vegetation cover in Coolabah Woodland Wetland and River Cooba-Lignum Shrubland communities can be likely attributed to the mix of both amphibious and terrestrial species found within them. The inherent mix of species belonging to different functional groups which may be expressed at different times depending on water availability, allows these slightly more elevated 'low floodplain' communities increased flexibility to cope with greater environmental variability, such as longer drier periods, shorter inundation, increased bare ground and reduced competition, compared with lower elevated 'watercourse' communities supporting predominantly amphibious species. In the Gwydir wetlands it becomes apparent that greater tolerance for dry conditions translates to increased species richness. This partially explains the species richness differences observed between the three Gwydir wetlands; Mallowa>Gingham>Lower Gwydir, highlighting the differences in the dominant vegetation communities supported by each wetland and the disparity between numbers of vegetation survey plots between wetlands. However, it is also recognised that each of the three wetlands are inundated at different depths, during different years and at different frequencies - critical information to be considered in the future when teasing out the drivers of species richness and cover differences between each wetland system.

The abrupt decline in both water couch and lippia cover in spring 2019 is further testament to the severity of the drought conditions experience beforehand. The autumn 2020 survey highlights the resilience of lippia and its ability to persist during extreme dry and 'bounce-back' after wetting. McCosker (1994) notes that lippia cannot tolerate long periods of inundation at depths greater than 20 cm. This suggests that inundation depths were not sufficient to supress lippia, but instead may have enhanced its growth (McCosker *et al.* 1999). Water couch cover was the lowest recorded across the 6 years of LTIM/MER monitoring. Despite this, water couch is known to respond vigorously to inundation (Wilson *et al.* 2009), and so it is possible that following autumn inundation and winter rainfall during 2020, the spring 2020 survey may yield increased water couch cover. However, Wilson *et al.* (2009) found that while summer flows promoted amphibious species, autumn flows resulted in a greater number of Terrestrial damp functional species. This may help to explain why Gingham wetland sites, such as Bunnor and Goddards Lease, that have previously supported high cover levels of the amphibious water couch, were dominated in the autumn 2020 survey by the terrestrial awnless barnyard grass. Water couch prefers periods of long inundation following late spring or summer floods (Wilson *et al.* 2009) but can be sustained by overland flows and localised rainfall (Torrible *et al.* 2009). It is possible that previous high levels of water couch cover observed throughout earlier years of the LTIM/MER project will not return until such conditions allow.

Significant changes in the assemblage of species supported by each vegetation community was strongly linked to time since inundation. This suggests that each vegetation community supports a variety of both amphibious and terrestrial species but the degree to which these functional groups are expressed differs between each vegetation community in response to drying. The ability for vegetation communities to respond to both wetting and drying phases is likely an adaptive response to flow variability and natural boom-bust dynamics of floodplain biota. Despite this, across all years of the LTIM/MER project all four vegetation communities had different cover and species richness responses to time since inundation, suggesting that inundation requirements are different for each community. While seasonal delivery of environmental flows should be timed to match as closely as possible the unregulated hydrological record, there is limited knowledge on the ecological requirements of many wetland plant species (Roberts 2002, Wilson *et al.* 2009). This highlights the importance of long-term monitoring in furthering our understanding of species response to water delivery timing, frequency and flow variability.

While amphibious functional groups in the Gwydir wetlands supported fewer species than terrestrial groups, they exhibited higher cover. This was predominantly due to tall, long-lived species such as typha, eleocharis and to a lesser extent marsh club-rush, that were able to persist throughout dry periods while maintaining high cover as above ground dead vegetative material. Frequently flooded wetlands are typically characterised by typha and water couch (Thomas *et al*. 2011). However, while typha has been increasing in the Gwydir wetlands since 2017 (Commonwealth of Australia 2019) the observation has been coupled with the decrease in water couch, particularly in this most recent 2019-20 water year. Wilson *et al.* (2009) found that where grazing had occurred in the wetlands, water couch was the dominant species and that the removal of grazing resulted in the increase of other amphibious taxa, such as typha, which respond well to frequently inundated sites and shade-out prostrate species such as water couch. Both species are recognised as key wetland species, water couch for its provision of habitat and productive water bird feeding areas (Burns 2002, Bowen and Simpson 2009) and typha for its provision of habitat and ability to remove excess nutrients from eutrophic systems (Roberts and Klienert 2015). Whether these observations in water couch and typha are short-term fluctuations related to drought or long-term trends in response to changed land management practices and altered water regimes remains to be seen.

6 Conclusion

Severe drought followed by inundation and flooding which included a small portion of water for the environment highlight the ‘Boom and Bust’ nature of the Gwydir wetlands and its inherent resilience. The contraction of water couch, persistence of lippia and increasing dominance of typha are ongoing observations and management considerations in the Selected Area. Balancing the dry-wet inundation gradient that drives the dominance of these species has direct implications for the timing, frequency and extent of water delivery and is a challenge that continues to face water managers.

The delivery of water for the environment should aim to match natural flow regimes as much as possible. Timing these flows to coincide with optimal growing seasons in late spring and early summer, and/or coinciding managed releases on the back of natural events to maximise inundation, duration and extent can promote conditions that are favourable for the germination and establishment of key wetland taxa.

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8 Attachment 1: 2019/2020 species list

Family	Scientific Name	Common Name	Functional Group	Growth Habit	Exotic
Aizoaceae	*Glinus lotoides*	Hairy Carpet-weed	Tdr	Forb	No
Aizoaceae	*Tetragonia tetragonoides*	New Zealand Spinach	Tdr	Forb	No
Aizoaceae	*Trianthema triquetrum*	Small Hogweed	Tdr	Forb	No
Alismataceae	*Damasonium minus*	Starfruit	AmR	Forb	No
Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed	Tda	Forb	No
Amaranthaceae	*Amaranthus macrocarpus*	Dwarf Amaranth	Tdr	Forb	No
Amaryllidaceae	*Calostemma purpureum*	Garland lily	Tda	Forb	No
Amaryllidaceae	*Crinum flaccidum*	Darling Lily	Tda	Forb	No
Apiaceae	*Cyclospermum leptophyllum*	Slender Celery	Tda	Forb	Yes
Apiaceae	*Daucus glochidiatus*	Native Carrot	Tdr	Forb	No
Asphodelaceae	*Bulbine bulbosa*	Bulbine Lily	Tda	Forb	No
Asteraceae	*Asteraceae* sp.	a Daisy	Tdr	Forb	var
Asteraceae	*Brachyscome* sp.	a Daisy	Tda	Forb	No
Asteraceae	*Calotis hispidula*	Bogan Flea	Tdr	Forb	No
Asteraceae	*Calotis scapigera*	Tufted Burr-daisy	Tda	Forb	No
Asteraceae	*Calotis* sp.	a Burr-daisy	Tda	Forb	No
Asteraceae	*Centipeda minima*	Spreading Sneezeweed	Tda	Forb	No
Asteraceae	*Cirsium vulgare*	Spear Thistle	Tdr	Forb	Yes
Asteraceae	*Conyza* sp.	a Fleabane	Tdr	Forb	Yes
Asteraceae	*Eclipta platyglossa*	Yellow Twin-heads	Tda	Trailing	No
Asteraceae	*Senecio* sp.	a Groundsel	Tdr	Forb	No
Asteraceae	*Sonchus oleraceus*	Common Sow Thistle	Tdr	Forb	Yes
Asteraceae	*Symphyotrichum subulatum*	Wild Aster	Tda	Forb	Yes
Asteraceae	*Xanthium occidentale*	Noogoora Burr	Tdr	Forb	Yes
Asteraceae	*Xanthium spinosum*	Bathurst Burr	Tdr	Forb	Yes
Brassicaceae	*Brassicaceae*	a Brassica	Tdr	Forb	Yes

Brassicaceae	*Cardamine hirsuta*	Hairy Bittercress	AmT	Forb	Yes
Brassicaceae	*Rapistrum rugosum*	Turnip Weed	Tda	Forb	Yes
Brassicaceae	*Rorippa eustylis*	Dwarf Bittercress	Tdr	Forb	No
Brassicaceae	*Rorippa palustris*	Marsh Watercress	Tda	Forb	Yes
Brassicaceae	*Sisymbrium irio*	London Rocket	Tda	Forb	Yes
Cactaceae	*Opuntia* sp.	a Cactus	Tdr	Forb	Yes
Caryophyllaceae	*Stellaria angustifolia*	Swamp Starwort	Tda	Forb	No
Casuarinaceae	*Casuarina cristata*	Belah	Tda	Tree	No
Chenopodiaceae	*Atriplex* sp.	a Saltbush	Tdr	Chenopod	No
Chenopodiaceae	*Dysphania pumilio*	Small Crumbweed	Tdr	Chenopod	No
Chenopodiaceae	*Einadia nutans*	Nodding Saltbush	Tdr	Chenopod	No
Chenopodiaceae	*Einadia polygonoides*	Knotweed Goosefoot	Tdr	Chenopod	No
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush	Tdr	Chenopod	No
Chenopodiaceae	*Maireana enchylaenoides*	Wingless Fissure-weed	Tdr	Chenopod	No
Chenopodiaceae	*Maireana* sp.	a Cotton Bush	Tdr	Chenopod	No
Chenopodiaceae	*Rhagodia spinescens*	Thorny Saltbush	Tdr	Chenopod	No
Chenopodiaceae	*Salsola australis*	Buckbush	Tdr	Chenopod	No
Chenopodiaceae	*Sclerolaena bicornis*	Goathead Burr	Tdr	Chenopod	No
Chenopodiaceae	*Sclerolaena birchii*	Galvinized Burr	Tdr	Chenopod	No
Chenopodiaceae	*Sclerolaena muricata*	Black Rolypoly	Tdr	Chenopod	No
Chenopodiaceae	*Sclerolaena* sp.	a Copperburr	Tdr	Forb	No
Commelinaceae	*Commelina cyanea*	Scurvy Weed	Tda	Forb	No
Convolvulaceae	*Convolvulus erubescens*	Pink Bindweed	Tda	Trailing	No
Convolvulaceae	*Convolvulus graminetinus*	Bindweed	Tda	Trailing	No
Convolvulaceae	*Polymeria pusilla*	Bindweed	Tda	Trailing	No
Cucurbitaceae	*Cucumis melo*	Ulcardo Melon	Tdr	Trailing	No
Cucurbitaceae	*Cucumis myriocarpus*	Paddy Melon	Tdr	Trailing	Yes
Cyperaceae	*Bolboschoenus fluviatilis*	Marsh Club-rush	AmT	Sedge	No
Cyperaceae	*Carex appressa*	Tall Sedge	AmT	Sedge	No
Cyperaceae	*Carex inversa*	Knob Sedge	AmT	Sedge	No

Cyperaceae	*Cyperus bifax*	Downs Nutgrass	AmT	Sedge	No
Cyperaceae	*Cyperus difformis*	Dirty Dora	AmT	Sedge	No
Cyperaceae	*Cyperus* sp.	a Sedge	AmT	Sedge	No
Cyperaceae	*Eleocharis acuta*	Common Spike Rush	AmT	Sedge	No
Cyperaceae	*Eleocharis pallens*	Pale Spike-sedge	AmT	Sedge	No
Cyperaceae	*Eleocharis plana*	Flat Spike-sedge	AmT	Sedge	No
Cyperaceae	*Eleocharis pusilla*	Small Spike-rush	AmT	Sedge	No
Cyperaceae	*Eleocharis sphacelata*	Tall Spike-rush	AmT	Sedge	No
Euphorbiaceae	*Euphorbia dallachyana*	Mat Spurge	Unknown	Forb	No
Euphorbiaceae	*Euphorbia drummondii*	Caustic Weed	Tdr	Forb	No
Fabaceae (Faboideae)	*Aeschynomene indica*	Budda Pea	Tda	Shrub	No
Fabaceae (Faboideae)	*Cullen tenax*	Emu-foot	Tda	Forb	No
Fabaceae (Faboideae)	*Medicago polymorpha*	Burr Medic	Tdr	Forb	Yes
Fabaceae (Faboideae)	*Sesbania cannabina*	Sesbania Pea	Tda	Shrub	No
Fabaceae (Mimosoideae)	*Acacia stenophylla*	River Cooba	AmT	Tree	No
Fabaceae (Mimosoideae)	*Vachellia farnesiana*	Mimosa Bush	Tdr	Shrub	No
Geraniaceae	*Geranium solanderi*	Native Geranium	Tdr	Forb	No
Haloragaceae	*Haloragis glauca*	Haloragis	Unknown	Forb	No
Haloragaceae	*Myriophyllum crispatum*	Upright Water-milfoil	AmR	Forb	No
Haloragaceae	*Myriophyllum* sp.	a Water-milfoil	AmR	Forb	No
Hypericaceae	*Hypericum* sp.	a Hypericum	Unknown	Forb	var
Juncaceae	*Juncus aridicola*	Tussock Rush	AmT	Rush	No
Juncaceae	*Juncus* sp.	a Rush	AmT	Rush	No
Juncaceae	*Juncus usitatus*	Billabong Rush	AmT	Rush	No
Juncaginaceae	*Cycnogeton dubium*	Water Yam	AmT	Forb	No
Lemnaceae	*Lemna disperma*	Common Duckweed	AmR	Forb	No
Lobeliaceae	*Lobelia concolor*	Poison Pratia	Tdr	Forb	No
Loranthaceae	*Amyema cambagei*	Needle-leaf Mistletoe	Tdr	Mistletoe	No

Loranthaceae	*Amyema miquelii*	Box Mistletoe	Tdr	Mistletoe	No
Lythraceae	*Ammannia multiflora*	Jerry-jerry	Tda	Forb	No
Malvaceae	*Abutilon malvifolium*	Bastard Marshmallow	Tdr	Forb	No
Malvaceae	*Gossypium hirsutum*	Cotton	Tdr	Forb	Yes
Malvaceae	*Hibiscus trionum*	Flower-of-an-hour	Tda	Forb	No
malvaceae	*Hibiscus verdcourtii*	Wide Leaf Bladder Ketmia	Tda	Forb	No
Malvaceae	*Malva parviflora*	Small-flowered Mallow	Tdr	Forb	Yes
Malvaceae	*Malvastrum americanum*	Spiked Malvastrum	Tdr	Forb	Yes
Malvaceae	*Sida* sp.	a Sida	Tdr	Forb	No
Malvaceae	*Sida trichopoda*	High Sida	Tdr	Forb	No
Marsileaceae	*Marsilea drummondii*	Common Nardoo	AmR	Fern	No
Marsileaceae	*Marsilea hirsuta*	Small Nardoo	AmT	Fern	No
Marsileaceae	*Marsilea* sp.	a Nardoo	AmR	Fern	No
Myrtaceae	*Eucalyptus camaldulensis*	River Red Gum	AmT	Tree	No
Myrtaceae	*Eucalyptus coolabah*	Coolibah	Tda	Tree	No
Myrtaceae	*Eucalyptus populnea*	Bimble Box	Tdr	Tree	No
Nyctaginaceae	*Boerhavia dominii*	Tarvine	Tdr	Forb	No
Onagraceae	*Ludwigia octovalvis*	Willow Primrose	Tda	Forb	No
Onagraceae	*Ludwigia peploides*	Water Primrose	AmR	Forb	No
Oxalidaceae	*Oxalis chnoodes*	Shaddy Wood Sorrel	Tdr	Forb	No
Oxalidaceae	*Oxalis* sp.	a Wood Sorrel	Tda	Forb	No
Phrymaceae	*Glossostigma elatinoides*	Mudmat	AmR	Forb	No
Poaceae	*Aristida* sp.	a Three-awned Grass	Tdr	Grass	No
Poaceae	*Chloris truncata*	Windmill Grass	Tdr	Grass	No
Poaceae	*Cynodon dactylon*	Couch	Tdr	Grass	No
Poaceae	*Dactyloctenium radulans*	Button Grass	Tdr	Grass	No
Poaceae	*Diplachne fusca*	Brown Beetle Grass	Tda	Grass	No
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass	Tda	Grass	Unknown
Poaceae	*Echinochloa crus-galli*	Barnyard Grass	Tda	Grass	Yes

Poaceae	*Echinochloa crus-pavonis*	South American Barnyard Grass	Tda	Grass	Yes
Poaceae	*Echinochloa inundata*	Marsh Millet	Tda	Grass	No
Poaceae	*Eragrostis* sp.	a Lovegrass	Tdr	Grass	No
Poaceae	*Eriochloa crebra*	Tall Cupgrass	Tdr	Grass	No
Poaceae	*Lachnagrostis filiformis*	Blown-grass	Tda	Grass	No
Poaceae	*Panicum decompositum*	Hairy Panic	Tdr	Grass	No
Poaceae	*Panicum effusum*	Hairy Panic	Tdr	Grass	No
Poaceae	*Panicum* sp.	a Panic	Tdr	Grass	No
Poaceae	*Paspalidium aversum*	Paspalidium	Tdr	Grass	No
Poaceae	*Paspalidium jubiflorum*	Warrego Grass	Tda	Grass	No
Poaceae	*Paspalum distichum*	Water Couch	AmR	Grass	No
Poaceae	*Poa* sp.	a Tussock Grass	Tdr	Grass	No
Poaceae	*Sorghum halepense*	Johnson Grass	Tdr	Grass	Yes
Poaceae	*Sporobolus caroli*	Fairy Grass	Tdr	Grass	No
Polygonaceae	*Duma florulenta*	Tangled Lignum	AmT	Shrub	No
Polygonaceae	*Persicaria decipiens*	Slender Knotweed	AmT	Forb	No
Polygonaceae	*Persicaria hydropiper*	Water Pepper	AmT	Forb	No
Polygonaceae	*Persicaria lapathifolia*	Pale Knotweed	AmT	Forb	No
Polygonaceae	*Persicaria orientalis*	Princes Plume	AmT	Forb	No
Polygonaceae	*Persicaria* sp.	a Knotweed	Tda	Forb	No
Polygonaceae	*Rumex brownii*	Swamp Dock	Tda	Forb	No
Polygonaceae	*Rumex* sp.	a Dock	Tda	Forb	No
Polygonaceae	*Rumex tenax*	Shiny Dock	Tda	Forb	No
Pontederiaceae	*Eichhornia crassipes*	Water Hyacinth	AmR	Forb	Yes
Portulacaceae	*Portulaca oleracea*	Pigweed	Tdr	Forb	No
Ranunculaceae	*Ranunculus undosus*	Swamp Buttercup	AmT	Forb	No
Rubiaceae	*Galium aparine*	Cleavers	Tdr	Forb	Yes
Rubiaceae	*Galium* sp.	a Bedstraw	Tdr	Forb	No
Sapindaceae	*Alectryon oleifolius*	Western Rosewood	Tdr	Tree	No
Scrophulariaceae	*Eremophila debilis*	Amulla	Tdr	Forb	No

Scrophulariaceae	*Eremophila* sp.	an Emubush	Tdr	Shrub	No
Scrophulariaceae	*Mimulus gracilis*	Slender Monkey-flower	Tda	Forb	No
Solanaceae	*Lycium ferocissimum*	African Boxthorn	Tdr	Shrub	Yes
Solanaceae	*Physalis ixocarpa*	Ground Cherry	Tdr	Forb	Yes
Solanaceae	*Physalis lanceifolia*	Ground Cherry	Tda	Forb	Yes
Solanaceae	*Physalis minima*	Wild Gooseberry	Tda	Forb	Yes
Solanaceae	*Physalis peruviana*	Cape Goosberry	Tda	Forb	Yes
Solanaceae	*Physalis* sp.	a Ground Cherry	Tdr	Forb	Yes
Solanaceae	*Solanum esuriale*	Quena	Tda	Forb	No
Solanaceae	*Solanum nigrum*	Black-berry Nightshade	Tdr	Forb	Yes
Typhaceae	*Typha domingensis*	Narrow-leaved Cumbungi	AmT	Rush	No
Verbenaceae	*Phyla canescens*	Lippia	Tda	Forb	Yes
Zygophyllaceae	*Tribulus micrococcus*	Yellow vine	Tdr	Forb	No
Zygophyllaceae	*Tribulus terrestris*	Cat-head	Tdr	Forb	Yes