

Restoring biodiversity in the Gwydir Wetlands through environmental flows

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ABSTRACT

As part of the Water Reforms process, environmental flow rules have been progressively implemented in New South Wales rivers. The Integrated Monitoring of Environmental Flows (IMEF) is a major project established to better understand how rivers and associated wetlands respond to environmental water allocations. The results presented here represent the vegetation data collected for the testing of the hypothesis that 'protecting or restoring a portion of freshes and high flows and otherwise maintaining natural flow variability will replenish anabranches and riverine wetlands, restoring their biodiversity'.

The study site is the Ramsar listed Gwydir Wetlands, located on the Gingham and Gwydir (Big Leather) Watercourses in the Lower Gwydir Valley, 100 kilometres west of Moree. The expansion of irrigated agriculture in the lower Gwydir valley has severely altered flow regimes in the wetlands.

The spread of the weed *Phyla canescens* (Lippia) is of major concern to landholders in the Gwydir Wetlands. Results indicate that *Paspalum distichum* (Water couch) and *Eleocharis plana* (Ribbed spike-rush) can maintain dominance over *Phyla canescens* if flooding occurs on a semi-regular basis. Conversely, *Eichhornia crassipes* (Water hyacinth) is a rampant noxious weed of open water in the Gwydir Wetlands, and has quickly spread in areas that are inundated for long periods. Management of this weed requires periodic drying of the wetlands to cause desiccation and death of the plants.

The flooding requirement of individual species and plant associations in the Gwydir Wetlands are currently not fully understood. By providing better information on the consequence of different flows, the IMEF project will help to develop better management strategies to shift the dominance from introduced species such as *P. canescens* and *E. crassipes* to more desirable native plant species.

KEYWORDS

Biodiversity, environmental flows, exotic plants, Gwydir Wetlands, Integrated Monitoring of Environmental Flows, long-term water regime.

INTRODUCTION

The Integrated Monitoring of Environmental Flows (IMEF) is a major scientific project established by the New South Wales (NSW) Department of Land and Water Conservation (DLWC) to provide an understanding of the response of rivers and their associated wetlands to the provision of environmental water allocations (Chessman and Jones 2001). This paper represents the vegetation data collected for the testing of the hypothesis that 'protecting or restoring a portion of freshes and high flows and otherwise maintaining natural flow variability will replenish anabranches and riverine wetlands, restoring their biodiversity'.

The study area is the Gwydir Wetlands, located on the Gingham and Gwydir (Big Leather) Watercourses in the Lower Gwydir Valley, 100 kilometres west of Moree. These wetlands are one of the most extensive and significant semi permanent, terminal wetlands in north-western NSW (Keyte 1994). The Gwydir Wetlands were the first wetlands in Australia to have private land listed under the Ramsar convention.

Prior to river regulation, the Gwydir Wetlands comprised some 220 000 hectares of floodplain woodlands and wetlands (Bennett and Green 1993). There has been a significant reduction in the frequency and duration of flooding since the late 1970's with the construction of Copeton Dam in the upper catchment. The expansion of irrigated agriculture in the lower Gwydir valley has further altered flow regimes in the wetlands. Water that once sustained them is now being diverted for irrigation.

Water regime

Water regime is often considered the most important ecological factor for wetlands (Breen 1990, Roberts 1990). Water regime is characterised by Roberts *et al.* (2000) as a pattern of flooding, drying or water level changes. These changes can be described according to when water level changes occur, how much, how fast and for how long. For plants, water regime is also the pattern of wetting and drying that particular species require, for their maintenance and regeneration. The components of water regime most commonly studied are depth, frequency of flooding, period of inundation, season of flooding, rate of rise, variability and interval between flooding. Brock (2000) found that water regimes stimulated and sustained different plant communities in experimental wetlands. The flooding requirement of individual species and plant associations in the Gwydir Wetlands is not fully understood.

The recent flooding history of the Gwydir Wetlands shows the years prior to the commencement of the study in June 2000 to be wetter than the early 1990's (Figure 1).

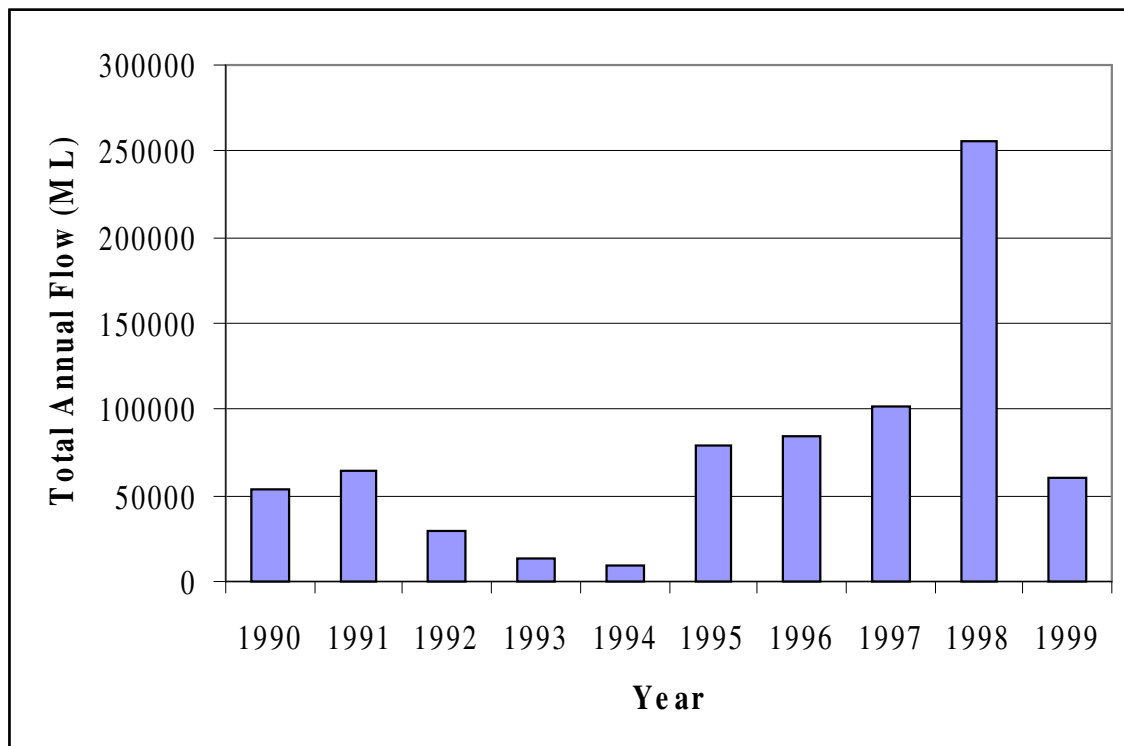


Figure 1: Total annual flows in megalitres for the Gwydir River at Brageen Crossing, located upstream of the Gwydir Wetlands

Exotic plant invasions

As well as changes to water regime, the introduction and spread of exotic species has had an impact on the native vegetation of the Gwydir Wetlands. The two species of concern are *Phyla canescens* (Lippia) and *Eichhornia crassipes* (Water hyacinth).

The spread of *P. canescens* is of major concern to landholders in the Gwydir Wetlands. This weed can germinate in a wide range of conditions. It spreads rapidly and is able to reproduce both sexually (by the production of seed) and asexually (by producing roots at stem nodes). *P. canescens* is able to compete for moisture effectively because of its deep taproot and extensive surface root system. This allows plants to remain dormant when soil moisture is low, and grow rapidly and out compete other species following rain. McCosker (1994a) felt that the spread of *P. canescens* in the Gwydir Wetlands might have been aided by the disturbance caused by the changing of water regime. With regular flooding the natural vegetation (mostly *Paspalum distichum* (Water couch) and *Eleocharis plana* (Ribbed spike-rush)) was able to withstand the grazing pressure by livestock. As the frequency and extent of flooding decreased, *P. canescens* was able to spread as the wetland plants disappeared.

E. crassipes can also reproduce vegetatively, by short runners that radiate from the base of the plant to form daughter plants, and by seed. It was first reported in the Gingham Watercourse in the 1950's but it did not become a major concern until the 1970's (SPCC 1978). By 1999, *E. crassipes* had re-emerged as a serious weed problem. A management strategy was implemented during 1999 to try and bring the weed under control. An aerial survey by the Moree Plains Shire Council in April 2001 revealed that about 4 000 hectares of wetland were affected by *E. crassipes* (McCosker 2001). Although *E. crassipes* has invaded the Gingham Channel, it has as yet not been detected in the Big Leather system.

METHODS

Three 100 metre transects were chosen for five sites in the Gwydir Wetlands. The location of the sites is shown in Figure 2. Transects were located after a general vegetation assessment of the site to maximise the number of community types sampled, and to reflect the rise and fall of water levels. In some cases, a transect may have been positioned to target a specific macrophyte community, to monitor spatial and temporal response to water regime.

A one metre by one metre quadrat was used to assess vegetative cover. This is smaller than that used by some studies because the Gwydir Wetlands have a higher diversity at a smaller spatial scale. The quadrat was centred at ten metre intervals along each 100 metre transect. The information recorded includes:

- All species present also noting reproductive status and the form/status (prostrate, erect, desiccated or dead) of individuals;
- The percentage of ground cover of each species was visually estimated using Braun-Blanquet (1932) categories of <1%, 1-5%, 5-25%, 25-50%, 50-75% and >75%;
- Water depth at each ten metre interval; and
- Any impact from stock, vehicle or fire.

The results presented in this paper represent the data from one sampling occasion in June 2000.

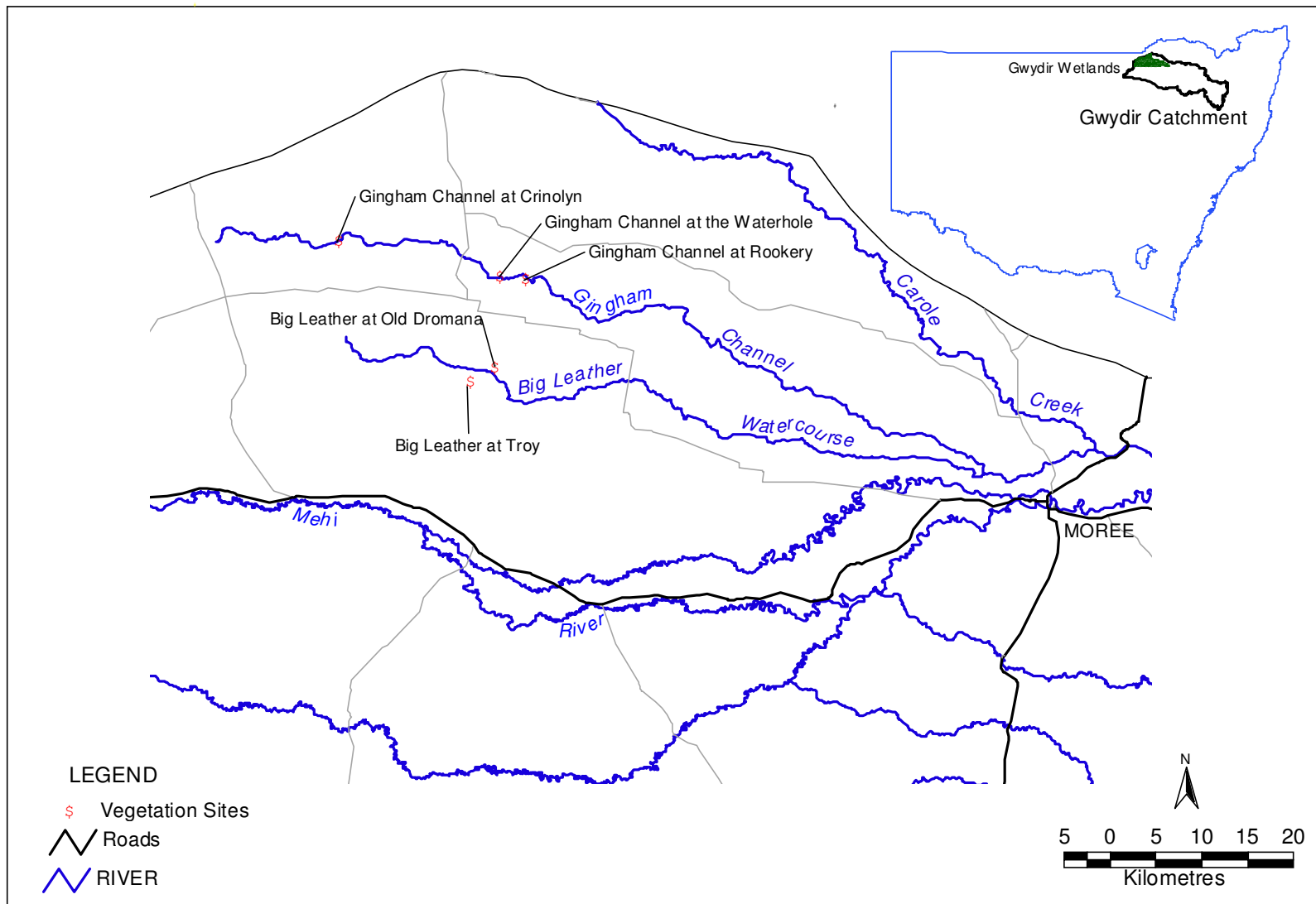


Figure 2. Location of Integrated Monitoring of Environmental flows study sites in the Gwydir Wetlands

RESULTS

Species-area and Distance-area Curves

Species-area curves were applied to preliminary sampling data to evaluate the adequacy of sample size (ie the robustness of any analyses to further sampling). The procedure was used to determine if the collection of thirty quadrats at each site was adequate to describe the vegetation communities. If this sampling intensity is sufficient to characterise the site, then inter-site comparisons can validly be made. As non-metric multi-dimensional scaling (NMS) uses distances, the distance-area curve can be used to assess whether the major ordination patterns would change if more samples were collected.

The species-area curves showed that the collection of thirty quadrats adequately describes the vegetation communities present at each site. Meaning sampling intensity has sufficiently characterised the sites to allow accurate inter-site comparison. Similarly, the distance-area curves for each site level off before the last quadrat. Ordinations conducted with the number of samples after the distance-area curve has flattened out effectively characterise any major trends and will not change much with additional replication. This shows that there would not be major changes to the ordination patterns if more samples were collected.

Vegetation communities

The ecological software package PC-ORD (McCune and Mefford 1999) was used to evaluate all ordinations. The ordination method used NMS with biological distance being represented by the Bray-Curtis dissimilarity measure. The Bray-Curtis distance is used in this analysis as it best represents ecological distance (Faith, Minchin and Belbin 1987). NMS is a visual representation of the site by species matrix (Ter Braak 1994), and has been shown to produce a more accurate representation than other indirect gradient analysis methods (Minchin 1987).

The vegetation samples in the NMS ordination (Figure 3) show some clustering of sites. Multi-Response Permutation Procedures (MRPP) showed this grouping by site was statistically significant ($P < 0.001$). There is one cluster in the upper right-hand side (Gingham Channel at Gingham Waterhole), another in the top left-hand corner (Big Leather at Troy) and another in the bottom left-hand corner (Gingham Channel at Rookery). The other two sites (Gingham Channel at Crinolyn and Big Leather at Old Dromana) are distributed through the centre of the plot. These clusters appear to be aligned parallel to axis 1 forming a gradient from right to left. This may be due to a composition difference between the clusters and/or some environmental reason. Figure 4 is an ordination of data points sized in proportion to water depth in individual quadrats. This figure indicates depth of inundation is a likely environmental reason, with depth of water increasing from right to left, parallel to axis 1. Figure 3 shows some variability within sites. This variability may be due to the over-riding effect of variation in water depth between quadrats at a site.

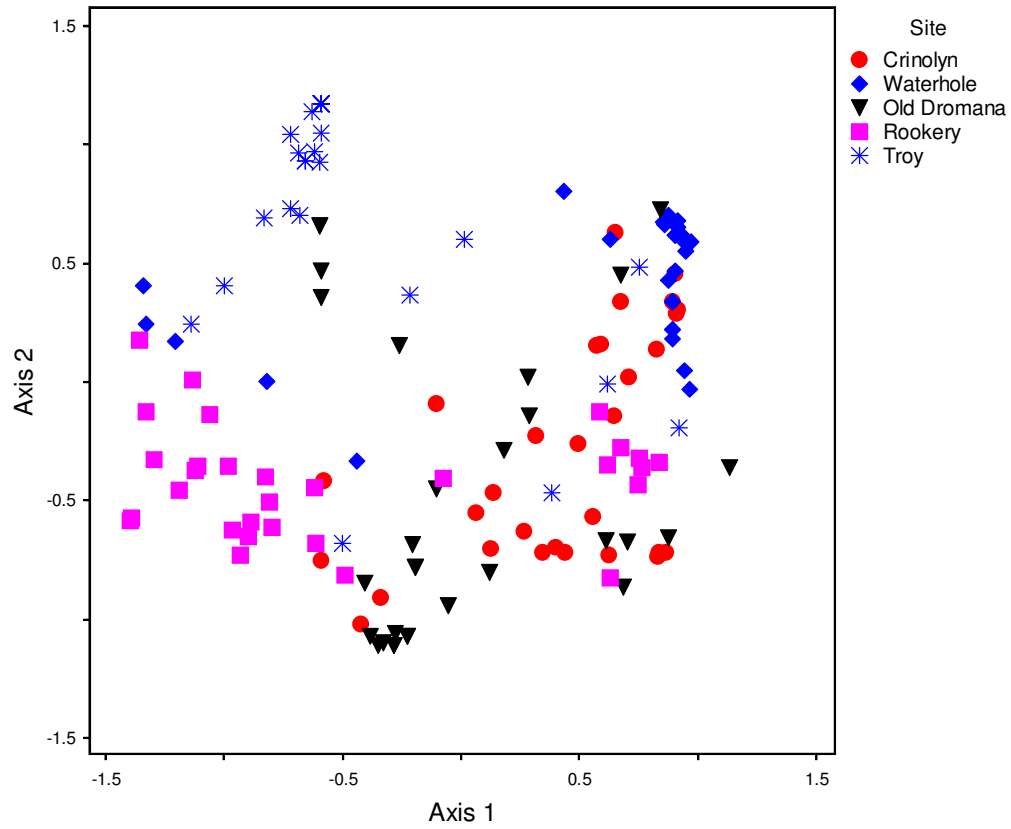


Figure 3: NMS ordination of vegetation cover data in individual quadrats in June 2000. Data points are grouped by site. Stress = 25

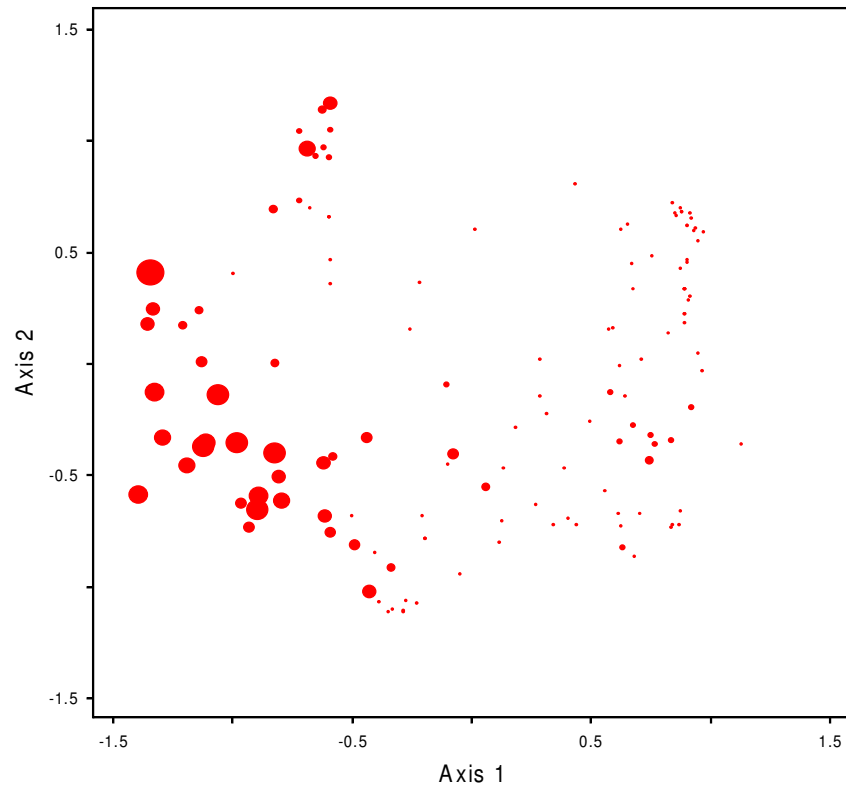


Figure 4. NMS ordination with data points sized in proportion to water depth in individual quadrats

Sites were allocated to one of three water regimes based on local knowledge of long-term trends; The three water regimes are wet, intermediate and dry. The wet sites are Gingham Channel at Rookery and Big Leather at Troy, the intermediate sites are Gingham Channel at Crinolyn and Big Leather at Old Dromana and the dry site is Gingham Channel at Gingham Waterhole (Table 1).

Long-term water regime	Site
Wettest	Gingham Channel at Rookery, Big Leather at Troy
Intermediate	Gingham Channel at Crinolyn, Big Leather at Old Dromana
Driest	Gingham Channel at Gingham Waterhole

Using long-term water regime as a factor, a second ordination (Figure 5) shows the sites are aligned along an inundation gradient from right to left along axis 1. The wetter sites have aligned along the left-hand axis. The quadrats from the dry site are aligned along the right-hand axis and the intermediate sites in the middle. This indicates that wetting and drying cycles influence the vegetation communities at a site. There is some variability within each flood regime. Again, this is due to the effect of variation in water depth between quadrats at a site.

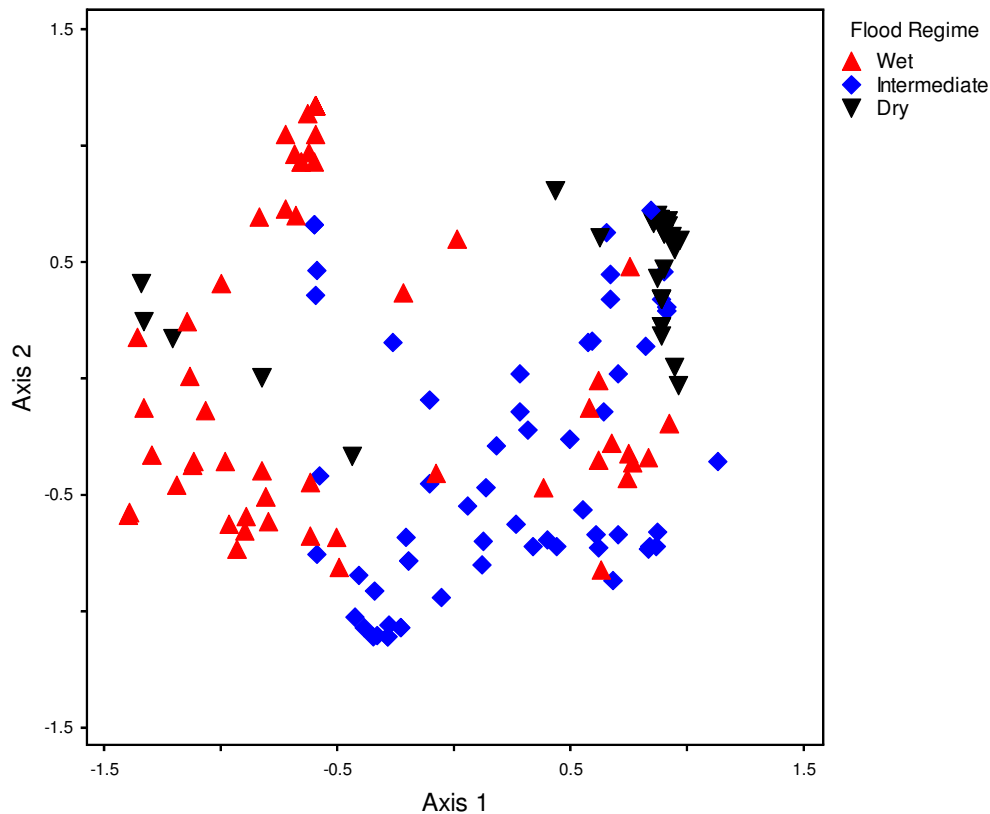


Figure 5: NMS ordination of vegetation cover data in individual quadrats in June 2000. Data points are grouped by long-term flooding regime

Indicator species analysis is used to detect and describe the value of different species in indicating environmental conditions. In this case, using long term water regime as a grouping variable, we can determine which species characterise each of the flood regimes and how the assemblages differ. We can then investigate ecological reasons to explain why species are in each flood regime. Dufrene and Legendre's (1997) method for calculating species indicator values combines information on the concentration of species abundance in a particular group and the faithfulness of occurrence of a species in a particular group. It produces indicator values for each species in each group. The indicator values range from zero (no indication) to 100 (perfect indication). Perfect indication means that presence of a species points to a particular group without error. The species listed are those that characterised quadrats from each different long-term water regime (Table 2).

Table 2: Plant species showing a strong association with different long-term water regimes in indicator species analysis for the Gwydir Wetlands, June 2000

Species	Indicator Values	Long-term water regime
<i>Eleocharis sphacelata</i>	31	Wet
<i>Persicaria decipiens</i>	35	Wet
<i>Ludwigia peploides</i>	36	Wet
<i>Myriophyllum variifolium</i>	13	Wet
<i>Eichhornia crassipes</i>	32	Wet
<i>Eleocharis plana</i>	37	Intermediate
<i>Paspalum distichum</i>	62	Intermediate
<i>Muehlenbeckia florulenta</i>	23	Dry
<i>Phyla canescens</i>	64	Dry

The wet sites are characterised by the presence of five species, *E. sphacelata*, *Persicaria decipiens*, *Ludwigia peploides*, *Myriophyllum variifolium* and *E. crassipes*. The dominant plant species at the Rookery site is *E. crassipes*. The drying down of the Gingham Watercourse in 1999-2000, helped control hyacinth in the more elevated or drier areas, however it was able to persist in the areas that remained wet. Two of the transects at the Gingham Channel at Rookery extend into these inundated areas. *E. crassipes* has been restricted to the Gingham Watercourse, so it was not detected in the Big Leather at Troy. *P. decipiens*, *L. peploides* and *M. variifolium* are mainly found on the margins and in shallow water of the wetlands. They can persist in low areas subject to periodic flooding. *P. decipiens* can also colonise areas as the water level recedes. *E. sphacelata* prefers long periods of inundation. The Big Leather at Troy is historically regarded as one of the last waterholes in the Gwydir Wetlands to dry out. For this reason, *E. sphacelata* dominates the margins of this waterhole.

P. canescens is able to compete for moisture effectively because of its deep taproot and extensive surface root system. This allows plants to remain dormant when soil moisture is low, and grow rapidly and out compete other species following rain. Transects at the Gingham Channel at Gingham Waterhole are located in an area that dries out rapidly after flooding. These areas have become dominated by *P. canescens*. *Muehlenbeckia florulenta* (Lignum) also characterise this dry site. It is able to regenerate rapidly following flooding or wet years, and persist during dry times.

The *P. distichum/E. plana* association is an extensive vegetation community in the Gwydir Wetlands. The Gingham Channel at Crinolyn and Big Leather at Old Dromana are both flat sites that are inundated at low depth but remain moist for long periods. *P. distichum* and *E. plana* dominate these two sites. The results from these sites (intermediate long-term water regime) indicate that this association can maintain dominance over *P. canescens* if flooding occurs on a

semi regular basis. In areas that are not flooded regularly (dry site), these two species are slower to respond than *P. canescens*. Research undertaken by McCosker (1994b) found that *P. canescens* is able to survive long periods of inundation at water depths of less than 0.2 metres. He also found that following continuous inundation of depths of 0.2 to 0.3 metres, large areas of the Gwydir Wetlands that had been previously dominated by *P. canescens* had reverted to a *P. distichum*/*E. plana* association.

CONCLUSION

The recent flooding history of the Gwydir Wetlands shows that the years preceding the June 2000 sampling were far wetter than those of the early 1990's were. As this sampling (June 2000) occurred after these wetter years, the data provides a baseline against which we can assess the capacity of the environmental flow rules to retain the diversity of the wetlands.

Analysis has shown that sampling intensity in the Gwydir Wetlands has sufficiently characterised the sites to allow inter-site comparison. The distance-area curves for each site level off before the last quadrat. Ordinations conducted with the number of samples after the distance-area curve has flattened out effectively characterise any major trends and will not change much with additional replication. This shows that there would not be major changes to the ordination patterns if more samples were collected.

Long-term flood regime was used to determine if the sampling sites are aligned along an inundation gradient. Sites were allocated to one of three water regimes based on long-term trends; wet, intermediate and dry. These water regimes are based on the relative flow regimes within the Gwydir Wetlands.

It was found the wetter sites clustered to the left-hand axis of an NMS ordination, the dry site on the right-hand axis and the intermediate sites in the middle. This shows that wetting and drying cycles have an influence on the vegetation communities in the Gwydir wetlands. If there had been one site in each flood regime, this pattern could be dismissed as a function of spatial heterogeneity, with the intermediate site existing in the middle by pure chance. However, there are two sites each in the wet and intermediate regimes, and these sites have clustered together within long-term flooding regime with some overlap. Consequently, it may be concluded that long-term flooding regime has an impact on assemblage structure, although there is some spatial variability within each inundation pattern.

Environmental flows can assist in suppressing alien wetland plants (Roberts 2002). Results from the vegetation sampling in June 2000 confirm a preference of *P. canescens* for drier sites, suggesting that a wetter regime reduces its competitiveness with native wetland plants, such as *P. distichum* and *E. plana*. Conversely, *E. crassipes* is a rampant noxious weed of open water in the Gwydir wetlands, and can quickly spread in areas that are inundated for long periods. A management strategy for this weed requires periodic drying of the wetlands to cause desiccation and death of the plants.

Based on these preliminary results, it is anticipated that, with time, this study will develop information on the flooding requirement of individual species and plant associations in the Gwydir Wetlands. It will also provide information on changes in vegetative assemblages in response to environmental allocations. The desired outcome of the study will be the implementation of a more natural flooding regime, which will shift the dominance from introduced to native plant species, restoring biodiversity.

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