Influence of cropping and grazing on soil seed bank composition and in-situ vegetation on the "Pillicawarrina" floodplain, Macquarie Marshes

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Abstract: *The results reported here provide an insight to the in-situ revegetation potential of agricultural landscapes within an ephemeral wetland area. In this paper we document the dominant species and the proportion of native and exotic species within soil seed banks and above ground vegetation. A total of 49 sites were sampled representing four vegetation communities that had been grazed (Lignum, Water couch, Red Gum and native Grassland) and two communities that had been cropped (River Cooba and Cropping). We found that under wet conditions or flooding, grazed areas retained considerable revegetation potential suggesting these communities may have some resilience to grazing. On the other hand areas that had been cultivated, even for short periods (2 years) had reduced capacity for native plant regeneration.*

Introduction

The Macquarie Marshes (MM) in central west NSW are one of the most important wetland systems in Australia and contain two listed Ramsar sites. The Draft Macquarie Marshes Adaptive Environmental Management Plan (MM AEMP 2009) highlighted the reduction in extent and frequency of flood inundation of the Macquarie Marshes and subsequent decline in a number of ecologically important vegetation communities. Landholders within the MM are under increasing pressure to undertake cropping as a response to lost production resulting from reduced water allocations, and much of the marsh areas have been lost through clearing. In January 2009, part of "Pillicawarrina" was purchased by DECCW, as the property lies between two significant areas of the Macquarie Marshes Nature Reserve. This seed bank study is part of a larger "Pillicawarrina Environmental Waters Management and Floodplain Restoration Project" that aims to undertake restoration of the Pillicawarrina floodplain and improve its condition.

The restoration potential of these areas is unclear and, although some vegetation communities (e.g. native water couch (*Paspalum paspalodes*)) in the Gwydir Wetlands have been shown to be intolerant of intense grazing when stressed (either from lack of water or when flooded), anecdotal evidence suggest some grazing regimes result in beneficial shifts in vegetation composition (Wilson *et al.* 2008). However, there is little direct evidence of the impact of agricultural practice (grazing or cropping) on the MM vegetation or an understanding of the restoration potential within these areas. Such information is vital to guide and prioritise the delivery of water to both sustain and restore these important semi-permanent wetlands.

Methods

A total of 49 (20 x 20 m) sites were chosen to cover four vegetation communities historically managed as grazing, with no clearing apart from some ringbarking at the turn of the century (Lignum, Water Couch, Red Gum and native grasslands) and areas previously utilised for cropping for between 2 and >10 consecutive years (River Cooba and Cropping).

At each of the 49 sites, a total of 6 soil core pairs (each 5 cm x 5 cm) were sampled in 2009 to determine soil seed bank composition. Three soil core pairs were randomly assigned between two experiments, one designed to mimic high rainfall conditions – 'dry land experiment' (I&I NSW, Trangie) and the second, to promote germination of aquatic species – 'flooding experiment' (University of New South Wales, Kensington). For the dry land experiment, each soil core pair was transferred to a separate tray (30 cm x 35 cm) as a thin layer approximately 1 cm deep over 3 cm of commercial potting mix. Plants were kept in a glasshouse for a 6 month period (mid July 2009 to 31 December 2009). Glasshouse temperatures were maintained between 15–25°C for the initial four months followed by an increase to 30–35°C for the remaining 3 months. Over this time, trays were watered sufficiently to prevent them from drying out completely. For the initial period (temperatures 15–25°C), frequency of watering was approximately every 2–3 days but for the 30–35°C period this was increased to daily watering. For the flooding experiment, no additional potting mix was added to the samples, which were placed into small canvas wading pools and flooded. Water depth was maintained at between 30 and 40 cm and the ambient air temperature between 20 and 30°C. Seedlings in both experiments were identified to species and Family (or the best taxonomic resolution possible) and removed at regular intervals. Unidentifiable seedlings were transplanted into pots and grown until identification was possible. Plant identity was verified by comparison with herbarium samples and Voucher specimens of each species were pressed and lodged at the National Herbarium of NSW. All species germinating were categorised as native or exotic. For the dry land experiment, means and standard error were determined using the three soil cores as replicates, firstly by combining counts from each replicate to get a percentage for each site, then averaging over sites. Sample sizes in the standard error calculations come from the number of sites in each vegetation community.

The species composition of above ground vegetation was determined for each site using five randomly placed 1 m x 1 m quadrats. Within each quadrat, the percentage contribution (%) of understorey species was determined for both cool (late June) and warm season (late November) growth periods following significant rainfall in 2009. Means and standard errors were determined for each vegetation community.

Results

A total of 52 species (representing 27 Taxonomic Families) and 10 unknown taxa were identified in the dry land experiment. Species richness in the dry land soil seed bank was highest within cropping sites with 49 species recorded (Table 1), but most seeds were contributed by a small number of species. Species that occurred in high frequency (>40 germinating seedlings/tray) were *Eriochloa* sp., *Echinochloa colona* (both Family Poaceae) and *Juncus aridicola* (Cyperaceae). The lowest seed bank species richness found on grassland and lignum sites with 28 and 25 species respectively. Areas that were grazed (Couch, Grass, Lignum and

Table 1. Species richness (average number of species) of the seed banks for the dry land and flooding experiments and above ground vegetation for each vegetation community.

	COOBA	WATER COUCH	CROP	GRASSLAND	LIGNUM	RED GUM
Seed bank						
– Species in Dry land experiment	32	35	49	28	25	36
– Species in Flooding experiment	10	11	11	11	12	10
Above ground vegetation						
– species in cool season	19	20	22	24	24	23
– species in warm season	19	11	18	18	7	23

Red Gum sites) all had a higher proportion of native species than cropping areas (Crop and Cooba) (Fig. 1). Cropping areas had the highest proportion of exotic species in the dry land seed bank.

A total of 30 species germinated in the 'flooding' experiment representing 16 Families. No exotic species were found during the flooding experiment. There was little diversity in soil seed bank species between vegetation communities under the flooding experiment. As with the dry land experiment flooded soil samples were dominated by a small number of abundant species largely from Families Cyperaceae, Characeae, Lythraceae and Poaceae. The *Cyperus difformis*/*Juncus* spp complex was the most abundant species dominating all vegetation communities within both seed bank experiments. Within the different cropping histories, long term cropping had a reduced proportion of native species in the soil seed banks compared to the grazing areas (Fig. 2).

A total of 53 species was recorded in the above ground vegetation, 19 of which also occurred in the seed banks (Waters *et al.* 2010). However, for the different vegetation communities above ground vegetation diversity was lower than diversity observed in the soil seed bank of the dry land experiment (Table 1). The proportion of native and exotic species within

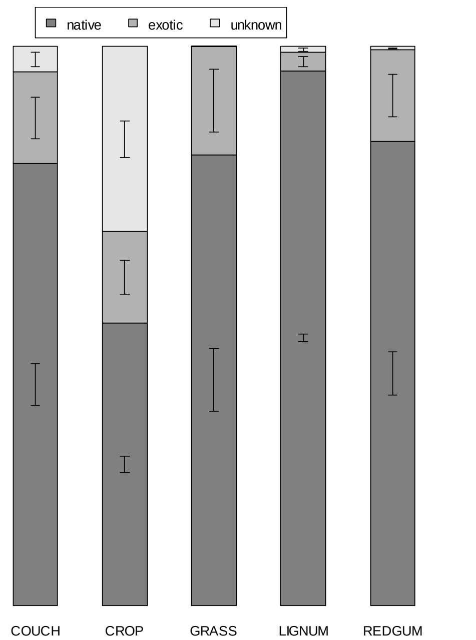

Figure 1. Percentage plant origin (se) for each vegetation community within the dry land seed bank experiment.

each vegetation community is given in Fig. 3. Grazing sites (Red Gum, Lignum, Grassland and Couch) had a higher proportion of native species than cropped sites (Crop and Cooba). Bare ground was higher in the summer months. During warmer months, a relatively high proportion of native species was present in the

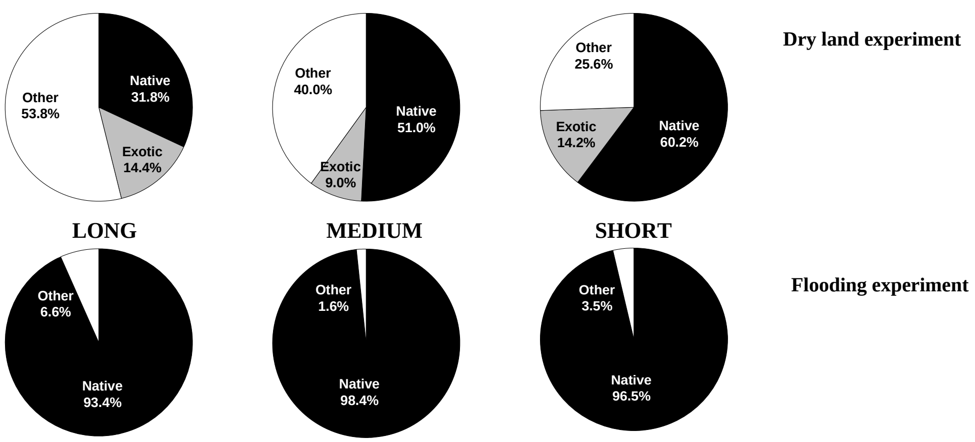

Figure 2. Plant types germinating from areas with long-term (>10 years), medium term (6 years) and short term (<2 years) cropping history. Proportions are given for seedlings germinating under dry land experiment (top) and flooding experiment (bottom).

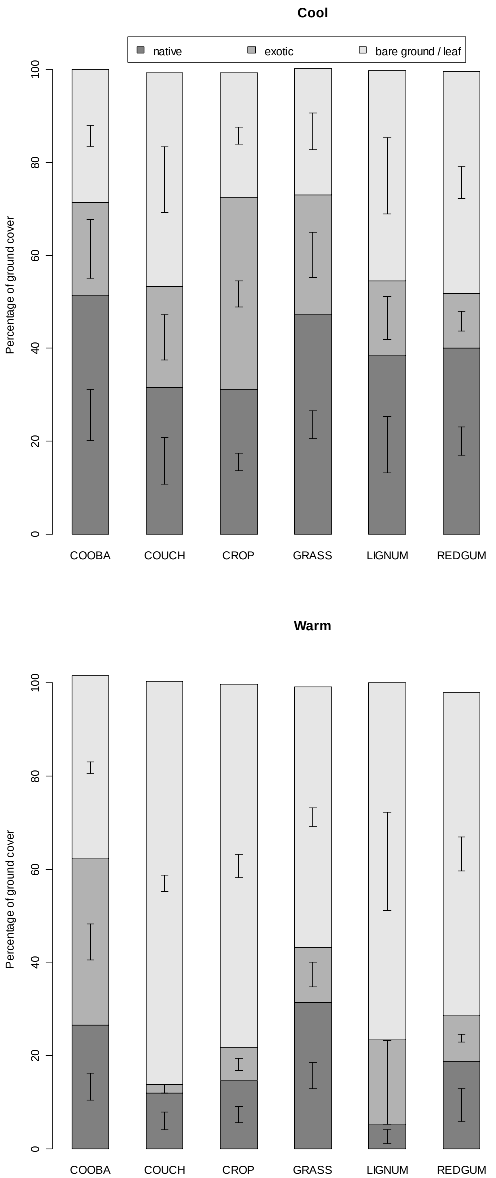

Figure 3. Percentage of ground cover within the above ground vegetation for cool season (above) and warm season (below) growth periods.

above ground vegetation in most vegetation communities. Exceptions to this were found in both Cooba and Lignum communities, where 35% and 18% of the vegetation was exotic in origin respectively. *Oxalis per-caprae* occurred in higher frequency within the Lignum sites, and Cooba sites were dominated by *Cucumis myriocarpus*. In cool months, cropping sites had a high proportion of exotic species, mainly *Sclerolaena* sp. and *Brassica* spp. The native species *Einadia nutans* occurred widely within all vegetation communities except at cropping sites. The amounts of bare ground and leaf litter varied between vegetation communities, but generally higher amounts of bare ground and litter occurred in summer than in winter months. This was particularly the case for Cropping, Lignum and Couch communities. Most of the litter in the cropping areas was associated with crop residue.

Conclusions

The high proportion of native species found in seed banks of most vegetation communities was not reflected in the above-ground vegetation. However, this mismatch between seed bank analysis and above ground vegetation is not uncommon. Soil seed banks can often contain species lost from above ground vegetation and thus represent a source for regeneration and maintenance of plant communities. The composition of species within seed banks will depend on the contribution of the present above-ground vegetation, seed rain from adjacent areas, seed longevity, and most importantly, previous above-ground vegetation (Bekker *et al.* 1997). The experimental conditions for this study provide an insight into the potential for native plant regeneration if flooding or at least wet conditions were to be re-introduced to this floodplain. The results reported here suggest that without the re-introduction of flooding, areas previously cropped, even for short periods (2 years) will be vulnerable to high levels of bare ground, and may subsequently be prone to weed invasion. Areas that had been utilised for grazing appeared to have retained capacity for native plant regeneration from both soil seed banks and from in-situ vegetation. This suggests the native plant communities within such ephemeral wetlands have greater resilience to disturbance from grazing than from cultivation and cropping.

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