Using soil seed banks to guide large-scale floodplain restoration in the Macquarie Marshes

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Keywords: wetlands; regeneration; native vegetation; seed bank

Abstract

This paper describes the regeneration potential of agricultural landscapes within a temporary wetland area of the Macquarie Marshes. In each of 49 sites, plant origin (native/exotic) and α- diversity (number of species) from the soil seed bank and in-situ vegetation were used to assess potential differences in native plant regeneration for six vegetation communities (lignum, water couch, redgum, river cooba, grassland and cropping) and two land use histories (grazing and cropping). Seedling emergence counts from soil seed banks showed that cropping resulted in a significantly lower proportion of native species compared to other vegetation communities such as river cooba and native grasslands that retained some regeneration potential under grazing and limited clearing. These differences were mostly reflected in the in-situ vegetation. However, a high proportion of bare ground occurred in all cropping sites and vegetation communities suggesting that all may be susceptible to further weed invasion. We describe the implications of these results for the restoration of this wetland.

Introduction

The Macquarie Marshes (MM) in central west NSW is one of the most important wetland systems in Australia and contains two Ramsar-listed 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. While the re-introduction of more frequent flood inundation periods has been cited as a central activity for the restoration of these areas, it is unknown if sufficient natural regeneration capacity remains within areas traditionally managed for agricultural production. Such information is vital to guide and prioritise the delivery of water to both sustain and restore these important semi-permanent wetlands. In January 2009, part of “Pillicawarrina”, a pre-existing irrigation and dry land farming property of 2,436 ha, was purchased by the NSW Department of Environment, Climate Change and Water (DECCW) as it was situated between two significant areas of the Macquarie Marshes Nature Reserve. Here, we report the preliminary results of a seed bank study designed to determine the regeneration potential of the “Pillicawarrina” flood plain. The study is part of a larger “Pillicawarrina Environmental Water Management and Floodplain Restoration Project” that aims to improve the condition of the Pillicawarrina floodplain.

Methods

A total of 49 sites, each 20 x 20m, were used to sample five vegetation communities (lignum, water couch, red gum, river cooba, grassland and cropping). Lignum, water couch, red gum, river cooba and grassland were classified as grazed and cropping sites as short (2 years), medium (6 years) or long-term cropping (>10 years). At each site, three pairs of randomly located cylindrical soil cores, each 5cm diameter x 5cm deep, were collected in May 2009. Largely following the methods of Roberts (1981), each soil core pair was transferred to a tray (30cm x 35cm) as a thin layer approximately 1cm over 3cm of commercial potting mix. Trays were kept in a glasshouse and watered sufficiently to maintain high soil moisture for a period of 6 months. Seedlings were identified to species and Family (or the best taxonomic resolution possible) and removed, initially once a week and later once every few weeks. Unidentifiable seedlings were transplanted into pots and grown until identification was possible (usually following flowering). Plant identity was verified by comparison with herbarium samples and voucher specimens of each species were lodged at the National Herbarium of NSW. Mean number of native seedlings germinating in the soil seed bank was calculated as a percentage of all germinating seeds. Mean values and standard errors for each vegetation community and land use category were calculated.

At each site, species composition of above ground vegetation was determined using five randomly placed 1 x 1m quadrats. Within each quadrat, the percentage contribution of understorey species was determined for both cool and warm season growth periods. Sampling was undertaken following significant rainfall events in June (cool season) and November (warm season) in 2009. For each site, ground cover attributed to bare ground, native and exotic species was calculated as a percentage of total ground cover at that site. The mean values and standard errors in each vegetation community and land use category were calculated.

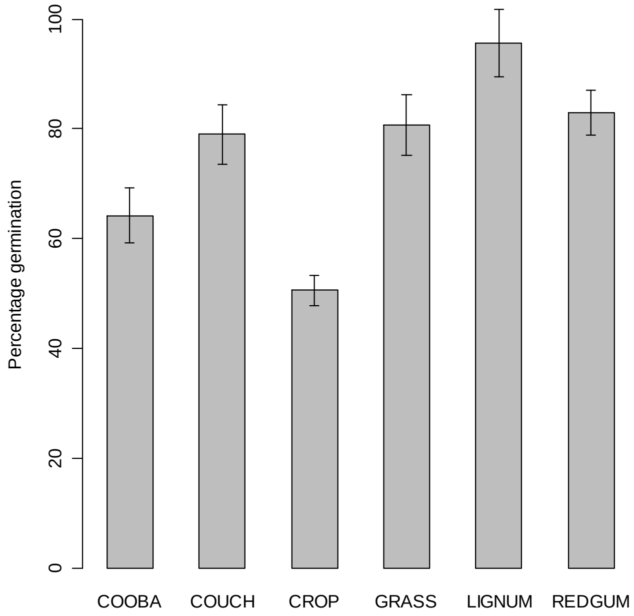
Results

A total of 52 and 53 species were recorded in the soil seed bank and aboveground vegetation respectively. Only 19 species that were recorded in the soil seed bank were also found in the aboveground vegetation.

Species diversity was highest within cropping areas (50 species) and lowest in the lignum community (25 species). There were significant differences ($P<0.001$) in seed bank composition (as measured by emerging seedlings) between vegetation communities. Cropping sites had a significantly lower ($P<0.05$) proportion of native species than all other vegetation communities except cooba (Fig. 1a). The soil seed bank for all vegetation communities was dominated by a few abundant species (e.g. Juncus aridicola (Cyperaceae), Eriochloa sp. and Echinochloa colona (Poaceae)). Land use category had a significant ($P<0.001$) effect on seed bank composition. Long term cropping had a significantly ($P<0.05$) lower proportion of native species than grazed, short-term and medium-term cropping sites (Fig.1b).

Generally, cropping and water couch sites had the lowest percentage of native species in the aboveground vegetation but these differences were only significant ($P<0.001$) in the warm season (Fig. 2). During the warmer months there was a high proportion (>40%) of bare ground in all vegetation communities. In the warm season, cooba sites had a significantly ($P<0.05$) higher percentage of native species than all other vegetation communities. There were no significant differences between land use categories in percentage of native species in the in-situ vegetation.

a



b

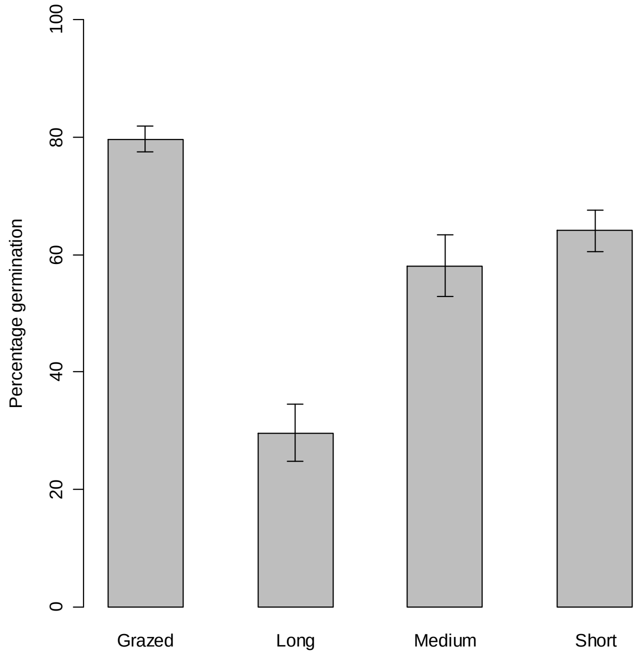


Fig. 1. Proportion of native species in seedlings emerging from the soil seed banks for each vegetation community (a) and land use category (b). Bars represent standard errors.

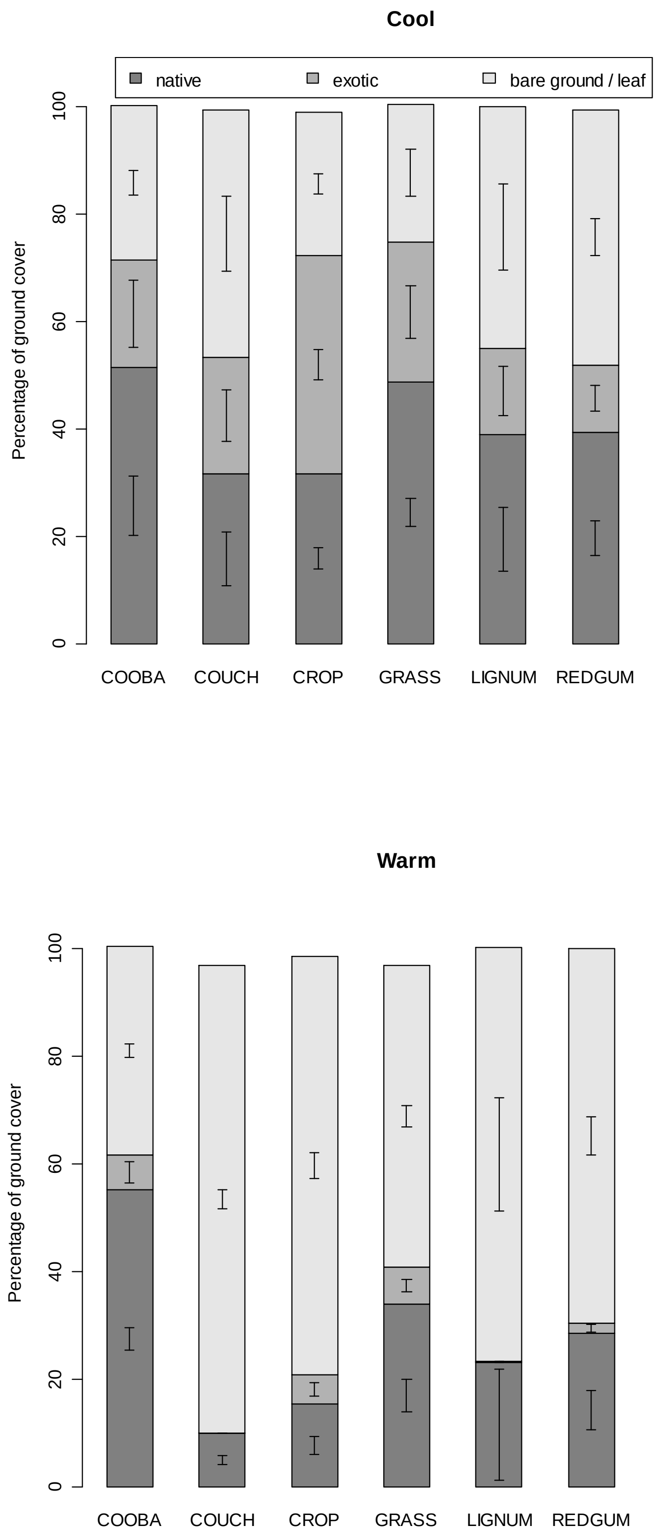


Fig. 2. Percentage[1.] of bare ground, native or exotic species in above ground vegetation (cool and warm season) for each vegetation community. Bars represent standard errors

[1.] Where a species occurred in low proportions (<1%) and could not be identified they were omitted form the analysis

Discussion

These results provide evidence that each of the red gum, lignum, grassland and couch vegetation communities have good potential for self-regeneration. However, rates of recovery will be determined by the provision of water (either by flooding and/or higher rainfall) as the experimental conditions can be considered as essentially 'wet'. We found a significantly lower proportion of native species in soil seed banks of cropping areas, which suggests these areas have a limited capacity for regeneration of native plant communities. This suggestion is also supported by the lower percentages of native species that were generally found within the in-situ vegetation of these areas. Areas previously cropped, even for short periods (2 years), may be vulnerable to weed invasion especially given the high proportion of bare ground and exotic species found there. These areas may require active restoration and/or re-seeding, particularly targeting summer active species. However, high proportions of bare ground were also recorded for all other vegetation communities in the summer months and it may therefore be expected that these areas too may be susceptible to continued weed invasion.

Overall, these findings support recommendations that recovery of the MM requires increased frequency of "inundation for a minimum of four and preferably six months between July and April" (MM AEMP 2009) but also suggest that without active re-seeding the restoration of native plant communities may not occur on cropping areas.

The soil seed bank analysis suggests that areas that had been utilised for grazing have retained a greater capacity for native plant regeneration, from both soil seed banks and in-situ vegetation, than those used for cropping. Native plant communities within these wetlands apparently have greater resilience to disturbance from grazing than from cultivation and cropping. Some European studies (e.g. Wellstein et al. 2007) have shown the composition of soil seed banks in highly disturbed agricultural landscapes to have a high accumulation of ruderal species (fast growing species capable of responding rapidly to available nutrients) similar to the results reported here. The aboveground vegetation at "Pillicawarrina" suggests that most of these are exotic, cool season species. Management of exotic species should therefore be targeted during the cooler months.

The high proportion of native species found in seed banks of most vegetation communities was not always reflected in the aboveground vegetation. However, this mismatch between seed bank analysis and above ground vegetation is not uncommon. Soil seed banks can often contain species lost or temporarily absent from the above ground vegetation and thus provide a source of new cohorts 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 “Pillicawarrina” site represents a potentially valuable study area in which monitoring of the long-term regeneration of degraded agricultural landscapes can be undertaken. It thus provides an opportunity to assess the reliability and feasibility of using seed banks to predict actual recovery. Such information could be used to inform management of future large scale acquisitions in the Macquarie Marshes, or at other locations where re-seeding is being considered as a management option.

Acknowledgements

Support for this research was provided by Industry & Investment NSW staff, Warren Smith and Jayne Jenkins, and UNSW staff, Viyanna Leo, John Porter and Sharon Ryall. Funding for this research was provided by DECCW, RERP (Rivers Environmental Restoration Program).

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Waters, C., Nairn, L. and Melville, G. (2010). Using soil seed banks to guide large-scale floodplain restoration in the Macquarie Marshes**.** In: *Proceedings of the 16th Biennial Conference of the Australian Rangeland Society*, Bourke (Eds D.J. Eldridge and C. Waters) (Australian Rangeland Society: Perth).