Mimosa pigra seed bank remains significant 10 years after stand removal: further investigation on a floodplain in northern Australia

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Summary A monitoring site on a floodplain was established to assess seed bank decline following the complete removal of a *c.* 250 hectare stand of the invasive introduced shrub *Mimosa pigra*. The site was revisited ten years after control. During this time, germinating plants were actively controlled, preventing local addition to the seed bank. Seed input from off-site is not quantifiable but is believed to be minimal. Despite time since control, there were still 109 (±25.8) viable seeds m^{-2}. The aim was to evaluate *M. pigra* seed bank persistence and inform weed management decisions. The results indicate that *M. pigra* seeds can remain viable under grass cover for over a decade unless work is performed to break seed dormancy in some way. This should be taken into consideration when devising management strategies including type of control, stocking rates and duration of follow-up control of seedlings.

Keywords Seed bank, *Mimosa pigra*, seed dormancy, integrated control.

INTRODUCTION

Mimosa pigra L. seeds are hard coated and can remain dormant in the soil for long periods of time. After removal of adult plants, regenerating plants must continue to be controlled for many years (Lonsdale *et al.* 1988). Seed banks of *M. pigra* in its native range have been measured at 117 seeds m^{-2} to a depth of 10 cm, but thickets typically have a density of one plant m^{-2} (Lonsdale and Segura 1987), so even low levels of seed density can potentially regenerate dense stands.

The study site utilised was previously a large scale integrated mimosa control site, comparing the different management options available for mimosa (Barratt *et al.* 2004, Paynter and Flanagan 2004).

When faced with the task of controlling large dense *M. pigra* stands, the ideal management practice is to spray herbicide in year one, just before the Wet season, so that germinating seedlings drown. In year two the dead plants would be mechanically crushed with a chain and then burned. In year three follow-up with herbicide, whilst limiting small-scale disturbance would be performed (Buckley *et al.* 2004, Paynter and Flanagan 2004). If this control method was utilised at this site, it would effectively stop the seed input to the local system by removing all reproducing plants.

The next issue faced, is the management of recolonisation, by *M. pigra*, from the seed bank. The hard-coated seed of *M. pigra* is expected to persist in the system for many years after removal of adult mimosa plants (Lonsdale *et al.* 1988); the exact duration managers have to be vigilant is still not satisfactorily established. Lonsdale *et al.* (1995) suggested that seed lifespan may be up to 23 years, depending on the soil depth and soil type.

Ideally, occurrences of the plant should be brought below levels that are economically or environmentally damaging. Biological control may be able to assist in this respect (Briese 2000). Paynter (2005) found that damage caused by the stem-mining moth *Neurostrota gunniella* (Busck) on regenerating plants was an order of magnitude higher than in adult *M. pigra* stands.

The study site used continues to be monitored for *M. pigra* seedlings, and the maintenance of healthy vegetation cover suppresses the germination of *M. pigra* seedlings (Paynter and Flanagan 2004, Paynter 2005, Boustead 2009). If it will be many years until all seeds are depleted, is there an acceptable density of seeds in the soil where ongoing management is viable (Lonsdale *et al.* 1988)?

MATERIALS AND METHODS

Collection Seed bank samples were collected from the Finniss River catchment within Wagait Aboriginal Reserve in October 2010. Samples were taken from an experimental integrated control site (12°56'S, 130°33'E, Figure 1.) that had been previously used for two soil seed bank studies (Barratt *et al.* 2004, Paynter and Flanagan 2004). We sampled from an area of 10 m radius centred on the above coordinates.

Fifty replicate seed bank samples were taken to a depth of 5 cm using a 7 cm diameter auger. The sample area was divided into quadrants and either 12 or 13 samples were taken from each quadrant. Samples were placed in plastic bags for transport to the laboratory.

Testing Mimosa seeds were extracted from replicate samples by washing them through a 1 mm mesh sieve.

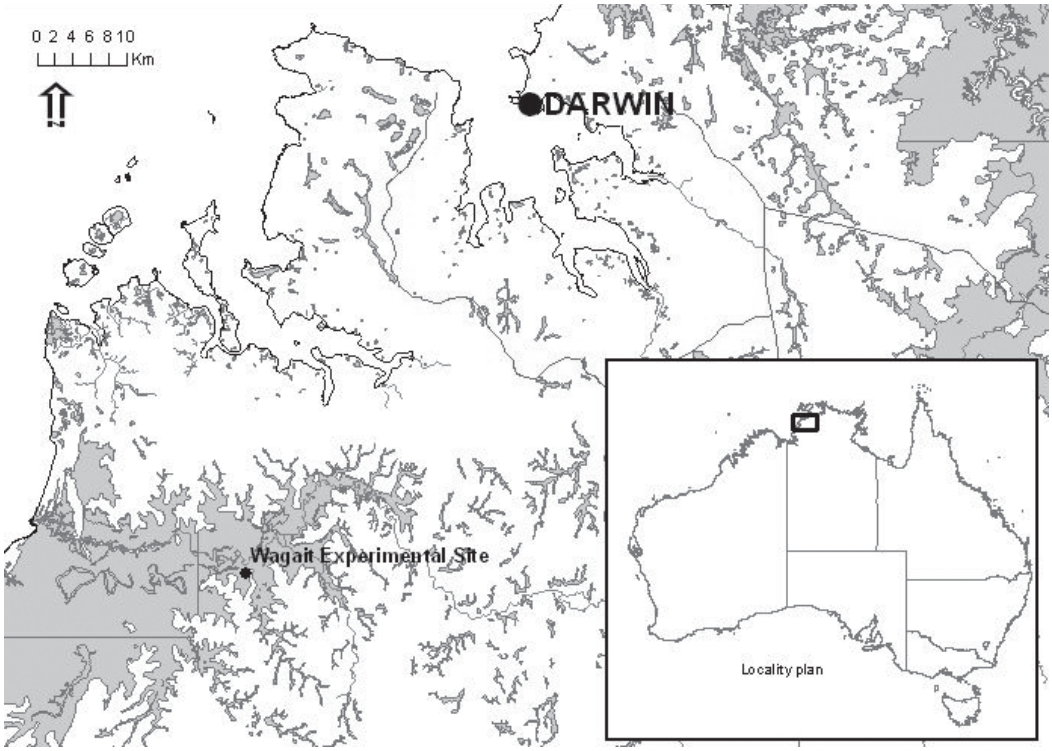

Figure 1. Position of the experimental integrated control of mimosa site, on the Finniss River floodplain (area of inundation shaded in grey), in the Northern Territory of Australia.

Seeds were then tested for viability and germinability, following the general method of Lonsdale *et al.* (1988) and described as follows. Seeds were placed on moist filter paper and incubated for seven days at 30°C. Any seeds germinating during this time were considered the germinable fraction. Non-germinating seeds were scarified by abrasion with fine sandpaper at the embryo end to ensure imbibation, and incubated for a further seven days. Seeds germinating after scarification were classed as viable but not germinable. The total in these two categories comprised the viable fraction.

RESULTS

There were 22 seeds extracted from 50 soil core samples. None of these seeds were germinable. After scarification, 21 seeds were determined to be viable, but not germinable. One seed was not viable.

This indicated that ten years after the removal of all adult plants, a *M. pigra* seed bank of 109 viable seeds m^{-2} (SE = 25.8) remained at this site, see Figure 2.

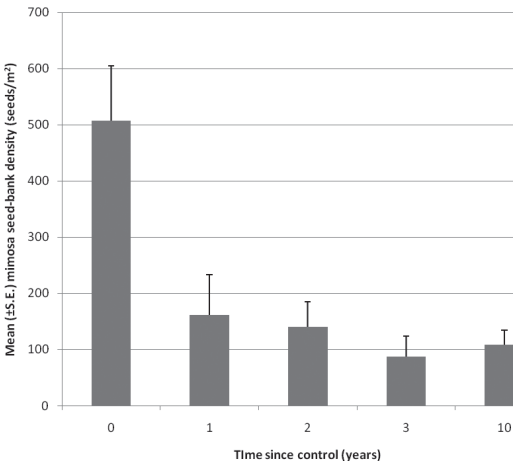

Figure 2. Comparison of historic *M. pigra* soil seed bank (before control [time = 0] and 1–3 years after control: data sourced from Barratt *et al*. 2004) and 10 years later at a site in the same study area.

DISCUSSION

Lonsdale *et al.* (1988) indicated that loss of viable seeds from the seed bank approximates an exponential pattern under field conditions in Australia (half life 9–99 weeks). The seed density that we measured after 10 years was much higher than we would have expected given such rates of decay. Protection from the diurnal heating and cooling on the soil surface limits decay rates of seeds within the seed bank (Lonsdale *et al.* 1988). It appears that the method of suppressing seedling emergence by maintaining healthy vegetation cover (in this instance grasses), also prolongs the survival of seeds in the soil seed bank.

There is still room for innovation in management practices for the control of *M. pigra* thickets. Paynter and Flanagan (2004) found that combinations of control methods gave better results than any one method in isolation. Once the adult stands are removed there may also be alternative strategies in areas with existing *M. pigra* seed banks depending on land use. Removal of insulating vegetation and then cultivation of the soil, to expose seed, could be an option to expedite the depletion of the seed bank. This would only be of use in areas where the risk of reintroduction of seed from outside the local area was low, such as isolated stands. In the majority of situations, annual management of regenerating seedlings and maintenance of healthy vegetation cover is likely to be the most economical plan, due to the possibility of seed input from neighboring infestations.

The presence of neighboring infestations of *M. pigra* may also have a positive aspect in that they are a source of biological control agents that can exert herbivorous pressure on regrowth (Paynter and Flanagan 2004, Paynter 2005).

Land managers in Boustead (2009) reported that the clearing of adult stands of *M. pigra* enabled them to run cattle and gain returns that could sustain the continued management of regenerating seedlings. However land managers may become frustrated with the number of years they are expected to continue to control emerging seedlings and might consider alternative management tactics that could draw-down the seed bank further, such as removing vegetation cover (using grazing or fire) and then cultivation of the soil to expose buried seeds. The follow-up effort to control emerging seedlings would obviously need to be larger, and damage to the flood plain by the more aggressive control methods would have adverse effects on regenerating vegetation (Paynter and Flanagan 2004).

Maintenance of suitable grass cover and a hard seed coat have ensured that 109 (±25.8) *M. pigra* seeds m^{-2} have remained in the seed bank at the study site despite a duration of ten years since the removal of seed producing adult plants. Land managers must take into account the local seed bank density when making management decisions.

ACKNOWLEDGMENTS

Thank you to White Eagle Aboriginal Corporation especially Margy Daiyi, Linda Ford and Colin Deveraux for providing the experimental site. Adrian (Red) Hendry assisted with field work, Natasha Burrows produced the map and Tomoko Okazaki assisted with germination.

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