Integrated management of *Mimosa pigra*

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Abstract

1. **Biological control is seen as the most promising long-term control technique for mimosa. However, other control techniques are currently required.**
2. **Fire and a range of chemical and mechanical control techniques have been used against mimosa, but are rarely effective when used in isolation. We therefore investigated the impact of combinations of these various control techniques on both mimosa and on the survival and abundance of the biological-control agents released against mimosa.**
3. **The experimental design and preliminary results are given in this paper.**

***Keywords*:** mimosa, integrated weed management, biological control.

Introduction

In Australia, biological control is considered the most promising long-term control strategy for mimosa, *Mimosa pigra* L. This is due to the costs of chemical and physical control (Forno 1992), which are exacerbated by difficult access to stands that can be protected from aerial spraying beneath *Melaeuca* swamp forests, and that often flood for months. Eleven insect herbivores and two fungal pathogens of mimosa have been released in Australia (Paynter 2004) and whilst there are promising signs that this biological-control program will eventually be successful (Paynter 2004), other control methods are currently required in Australia.

A range of other techniques has been tried to manage mimosa, including aerial application of herbicide (Miller and Siriworakul 1992), mechanical control (Siriworakul and Schultz 1992) and fire (Lonsdale and Miller 1993). There are advantages and disadvantages associated with each technique. For example, mechanical control rarely kills plants; healthy mimosa is difficult to burn, plants often re-sprout and buried seeds survive and become germinable, so follow-up control is necessary (Miller and Lonsdale 1992). For these reasons, Miller *et al.* (1992) suggested that an integrated management program, combining various techniques, may provide cost-effective management.

The mimosa integrated control experiment

A split-plot experiment was performed at Wagait Aboriginal Reserve, on the Finniss River catchment, NT (12°56'S, 130°33'E alt. *ca.* 20 m) to measure the impact of herbicide, crushing by bulldozer, and burning on both mimosa and its biological-control agents (Figure 1a). The design, originally described by Paynter *et al.* (2000), was modified slightly to include additional herbicide treatments (Figure 1b). We intend to publish this work elsewhere (Paynter and Flanagan 2004) so detailed descriptions of the site, methods and analyses are not presented here. Four replicates of

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the following herbicide treatments were performed, with or without a bulldozing treatment.

1. Control (no herbicide).
2. Single herbicide applications (fluroxypyr: Starane 300®; DowElanco Co, Frenchs Forest, Australia) diluted to 0.5% v/v at 1.5–2 L ha^{-1}) April 1998, January 1999, December 1999.
3. Double herbicide applications (April 1998 + January 1999, April 1998 + December 1999, January 1999 + December 1999).
4. A triple herbicide application (April 1998 + January 1999 + December 1999).

The April 1998, January 1999 and December 1999 herbicide treatments, corresponding to the 1997/98, 1998/99 and 1999/2000 wet seasons (the wet season in northern Australia is from October to the end of April) are henceforth referred to as the 1997, 1998 and 1999 wet season treatments, respectively.

Following construction of a firebreak around the perimeter of the study site, the burn treatment was conducted on 3 November 2000. Fire passed through all plots, burning for at least two weeks, until it was extinguished by heavy thunderstorms.

Quantitative data on the impacts of the control treatments on mimosa, competing vegetation and on the relative abundance of four biological control agents — *Neurostrota gunniella* (Busck), *Carmenta mimosa* Eichlin & Passoa, *Coelocephalapion pigrae* Kissinger, and *Chlamisus mimosae* Karren — were collected. *Acanthoscelides puniceus* Johnson could

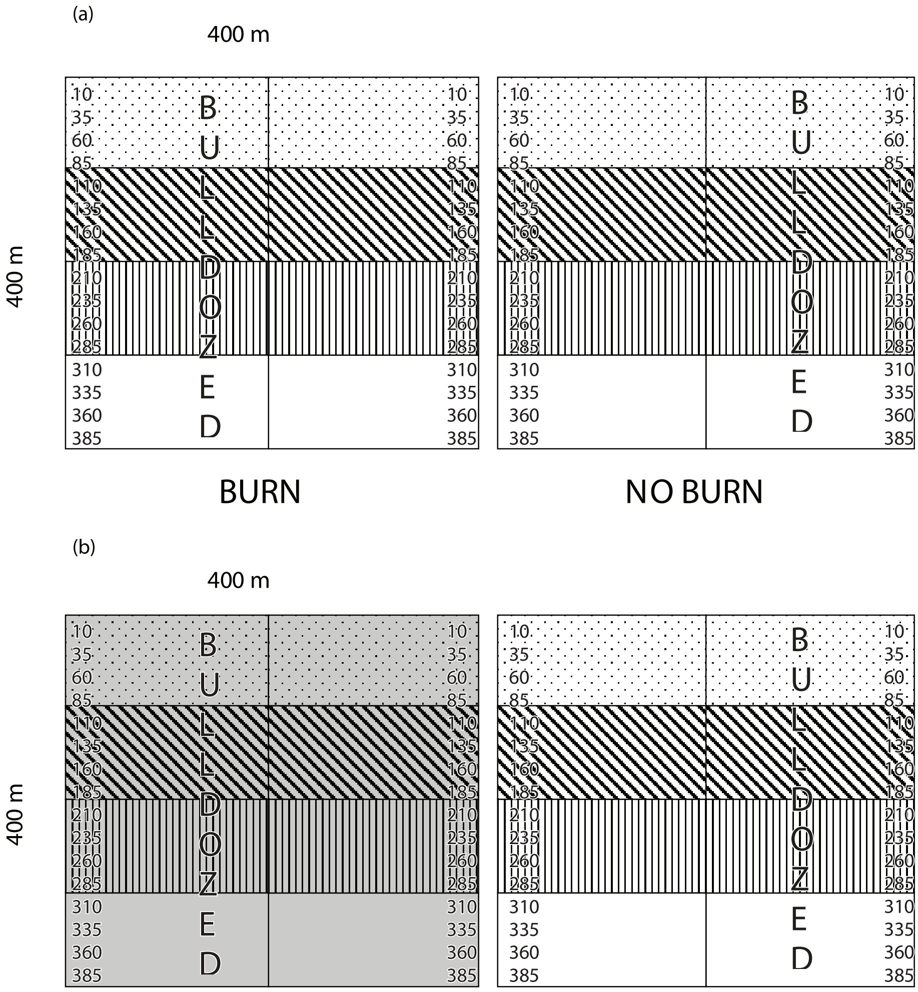

Figure 1. Summary of treatments for one replicate of:
(a) The original experimental design. Bulldozed = Plots crushed by bulldozer. Burn = sub-block to be burnt in the 1999 dry season. Herbicide applications: No shading = unsprayed; Vertical shading = 1997 wet season; Diagonal shading = 1998 wet season; Stippled = 1997 + 1998 wet seasons.
(b) The final design. herbicide and bulldozing treatments as above, but grey shading = plots also sprayed in 1999 wet season. Both sub-blocks were burnt. Numbers within each plot refer to positions of permanent quadrats (m).

not be quantified (by rearing beetles from seed (Wilson and Flanagan 1991)) because mimosa seeds most prolifically shortly after the wet season (Lonsdale 1988), when the field site could not be accessed due to seasonal flooding. *Malacorhinus irregularis* Jacoby was not present at the field site, during the course of this study.

Results and discussion

Impact of control treatments on mimosa

Mimosa was initially present as a virtual monoculture (mean percentage cover, above-ground biomass per hectare and number of stems per hectare were estimated at 96.3%, 39,279 kg (dry-weight) and 15,137, respectively). Nevertheless, impenetrable thickets were turned into productive, biologically diverse, grassland within just a few years. Single treatments, however, did not provide substantial control. For example, by November 2000, mimosa cover in plots left untreated following single herbicide applications in the 1998 wet season was just *ca.* 25% less than levels in the control plots (Table 1). Similarly, mimosa cover in bulldozed-only plots was *ca.* 50% of control levels and fire reduced mimosa cover by only *ca.* 30% in unsprayed, non-bulldozed plots (Table 1).

Repeat herbicide applications were generally more effective than single applications, as were combined herbicide and bulldozing treatments, compared to either treatment in isolation (Table 1). Fire was generally most effective in bulldozed plots where compaction of dead mimosa branches should have enabled a hotter, more destructive, fire to occur (Lonsdale and Miller 1993).

Impact of control treatments on biological control agents

Biological control agent populations were remarkably resilient, indicating they either survived the control treatments or that their dispersal abilities were sufficient to rapidly recolonise plots. *Neurostrota guniella* and *C. pigrae* are known to disperse extremely rapidly over many kilometres. For example, *N. guniella* spread at least 160 km within two years of release (Wilson and Forno 1995). Abundance of all agents was unaffected by, or even increased, following herbicide and bulldozing treatments, while fire was only detrimental to *C. mimosa*. The decline of *C. mimosa* following the fire was probably because few regenerating plants were large enough to support larvae, rather than a poor ability to recolonise plots. However, *C. mimosa* is less mobile than other agents – invading at a rate of *ca.* 2 km yr^{-1} (Ostermeyer 2000), so this agent may be prone to local extinction when very large or isolated mimosa stands are treated.

The best combination of treatments to clear thickets

Fire is essential to clear thickets (including deadwood) and enable vehicular access if mimosa-infested floodplains are to be cleared for cattle grazing. This allows cattle to be herded and other property maintenance to be conducted and it facilitates ground control of regenerating seedlings to prevent reinvasion, especially in heavily grazed or trampled areas. Although this study indicates that bulldozing or a single herbicide application should enable a successful fire treatment (Table 1), in practice, these treatments left sharp stumps that could stake car tyres. A single herbicide application, followed by a bulldozing treatment and fire, cleared stands more effectively.

If vehicular access is unnecessary, so that fire is not required to clear deadwood (e.g. when controlling patches of mimosa in a national park), control costs are considerably lower and the potentially adverse effect fire has on competing vegetation that can suppress mimosa seedling establishment (Lonsdale and Farrell 1998) can be avoided.

Table 1. The effect of herbicide and bulldozing treatments on percentage cover of mimosa recorded in November 2000 (before the fire treatment) and in December 2000 (after the fire treatment).

Treatment	Approximate reduction in percentage cover of mimosa			
	November 2000 (pre-fire)		December 2000 (after fire)	
	–Bulldozed	+Bulldozed	–Bulldozed	+Bulldozed
Control	0	50	30	95
Herbicide (1997)	60	95	65	100
Herbicide (1998)	25	90	70	100
Herbicide (1999)	99	99	100	100
Herbicide (97+98)	95	100	99	100
Herbicide (97+98+99)	95	99	99	100

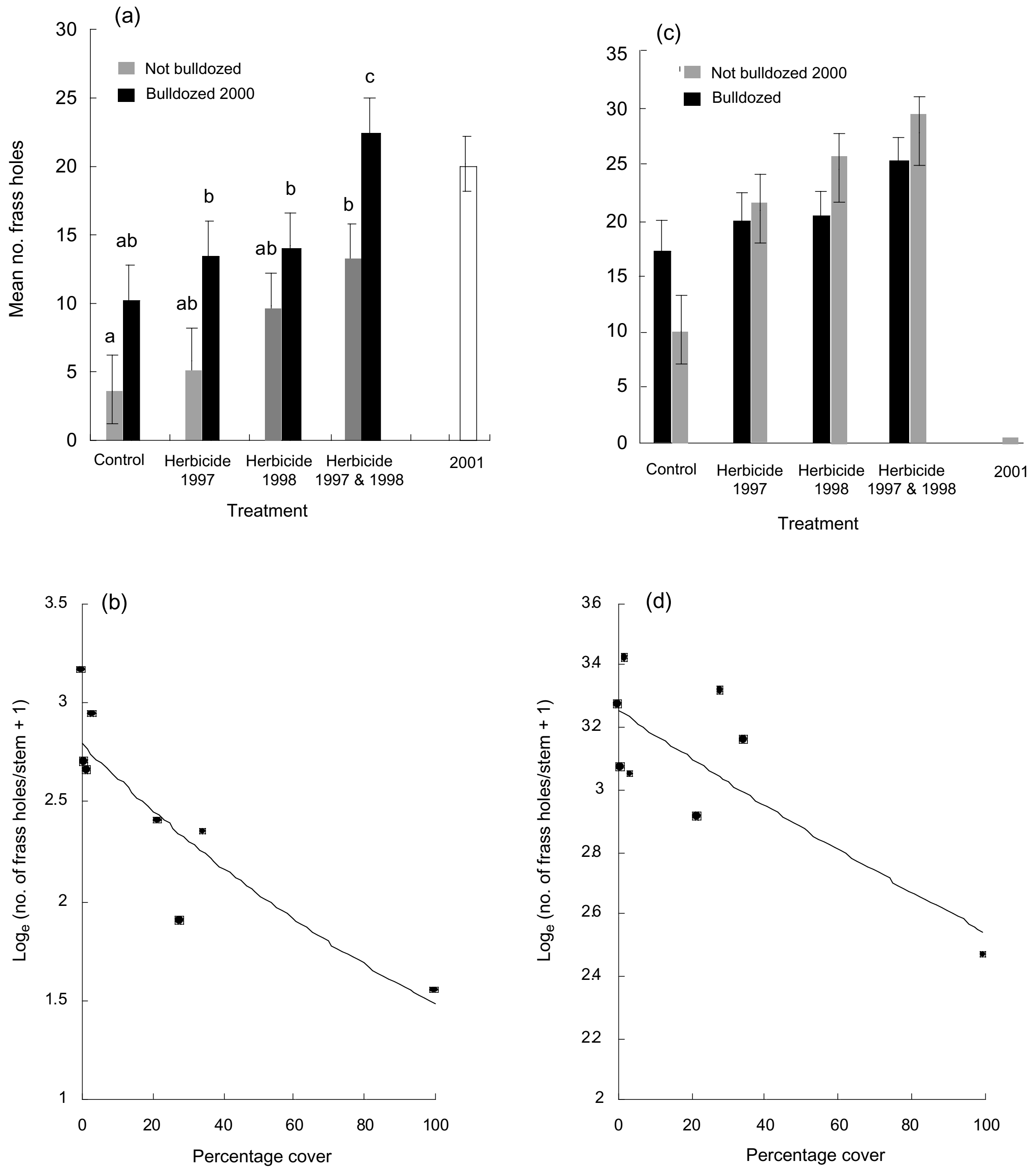

Figure 2. (a) Effect of herbicide and bulldozing treatments on *Neurostrota gunniella* abundance [mean no. frass holes per 50 cm stem (±SE)] in 1999 and overall abundance in 2001, following the fire. Columns with the same letter are not significantly different (LSD). (b) *Neurostrota gunniella* abundance versus percentage cover of mimosa recorded in 1999. Loge (no. of frass holes +1) = $2.793e - 0.0063x$, $R = 0.91$, $P < 0.001$. (c) Effect of herbicide and bulldozing treatments on *Carmenta mimosa* abundance [mean no. frass holes per 5 min. count (±SE)] in 1999 and overall abundance in 2001, following the fire. (d) *Carmenta mimosa* abundance versus percentage cover of mimosa recorded in 1999. Loge (no. of frass holes +1) = $y = 3.2571e - 0.0025x$, $R = 0.82$, $P < 0.001$.

Table 2. Approximate costs of the control treatments (M. Ashley and C. Deveraux, pers. comm. 2002). The cost for the fire treatment is the estimated cost of creating and supervising a firebreak around the perimeter of a 100 ha mimosa stand.

Treatment	Approximate cost ha^{-1} (A$)			
	No bulldozing		+Bulldozing	
	No fire	+Fire	No fire	+Fire
Control	0	30	60	90
Single herbicide application	20	50	80	110
Two herbicide applications	40	70	100	130
Three herbicide applications	60	90	120	150

This study indicates that two aerial herbicide applications in consecutive years (costing *ca.* A$40 ha^{-1}; Table 2) would greatly reduce the mimosa infestation (Table 1) and enhance *N. gunniella* abundance whilst having no detrimental impacts on *C. mimosa* (Figure 2).

Conclusions

An unexpected feature of this study was the low degree of mimosa reinfestation, following control. For example, mimosa cover remained at very low levels in bulldozed plots treated with repeat herbicide applications in 1997 and 1998 (at a cost of *ca.* A$130 ha^{-1}), almost two years after any control measures had been applied to those plots (Table 1). This is remarkable, considering the highly invasive nature of this weed during the 1970s and 1980s, when populations doubled in size every 1.2 years and thickets advanced at a rate of 76 m yr^{-1} (Lonsdale 1993). We believe there are two explanations for this.

1. Eradication of feral water buffalo, *Bubalis bubalis* Lydekker, during the late 1980s and early to mid-1990s will have reduced overgrazing of competing vegetation, allowing competitive perennial species to recover (Braithwaite and Roberts 1995) and therefore reducing the ability of mimosa to reinvade (Lonsdale 1993).
2. Spatial models of invasive legume shrubs (e.g. Rees and Paynter 1997) indicate that by reducing fecundity (Lonsdale and Farrell 1998, Paynter 2004) biological control will have enhanced the impact of control treatments by reducing seedling regeneration, due to smaller seed banks and reduced reinvasion from dispersing seed. High levels of *N. gunniella* herbivory in treated plots (Figure 2a) should have enhanced this effect by stunting seedlings, reducing the probability of their survival during wet season floods (Paynter and Hennecke 2001), when entire cohorts of seedlings can drown (Lonsdale and Abrecht 1989). It is also likely that *N. gunniella* herbivory delays sexual maturity of regenerating mimosa, so that plants can be treated by ground control operations before they set seed (C. Deveraux, pers. comm. 2002).

A potential explanation why *N. gunniella* abundance increased, relative to mimosa in treated plots, is that *N. gunniella* attack is aggregated at stand edges (Smith and Wilson 1995). By reducing mimosa populations from dense thickets to smaller patches or individual plants, control treatments will have increased the ratio of "edge" plants to "thicket" plants and, therefore, the proportion of plants susceptible to *N. gunniella* attack. Indeed, *N. gunniella* abundance increased exponentially as the percentage cover of mimosa declined (Figure 2b).

Acknowledgements

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