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Ecological Studies to Optimise the Integrated Management of the Wetland Weed, *Mimosa pigra*

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Abstract

The tropical American shrub, *Mimosa pigra* L. (Mimosaceae) is now widespread throughout the world's tropical wetlands. In Australia, it forms impenetrable thickets over more than 800 km^2 of the Northern Territory (NT), greatly reducing biodiversity. It competes with pastures, hinders mustering and access to water.

Biological control is a promising control strategy due to the cost of chemical and physical control exacerbated by difficult access to stands that can be protected from aerial spraying beneath *Melaleuca* swamp forests, and often flood for months. Nine insect and two fungal biological control agents have been released in Australia over the last sixteen years. However, it is too soon to tell if biological control will provide sufficient control, and alternative methods are currently needed.

Physical and chemical measures can eradicate small infestations, although these often require sustained control for several years. Managing large stands is more difficult, and we believe an integrated approach combining biological control, aerial herbicide applications, mechanical control, fire and revegetation is required.

To study the interactions between control strategies a large-scale integrated control experiment was established at Wagait, in the Finniss river catchment, NT, Australia (12º56'S, 130º33'E alt. *c.*20 m). This paper describes how treatments were applied, the aims of the experiment, and the measurement of mimosa population dynamics parameters to provide a scientific basis for the development of an integrated control strategy for mimosa.

Keywords: Integrated Management, Woody weeds, Mimosa.

Introduction

Mimosa pigra L. (Mimosaceae), henceforth mimosa, native to tropical America, is now widespread throughout the world's tropical wetlands (Lonsdale, *et al.* 1989). In Australia, it forms impenetrable, nearly monospecific thickets over more than 800 km^2 (Lonsdale 1992) of the Northern Territory within the wet-dry tropics where the climate is typified by well defined wet (December-April) and dry (May-November) seasons.

Mimosa greatly reduces biodiversity (Braithwaite *et al.* 1989), competes with pastures, hinders mustering and prevents access to water (Miller *et al.* 1981).

Mimosa control

Biological Control. Paucity of specialist insect herbivores in mimosa's introduced range (Wilson *et al.* 1990, Harley *et al.* 1995) may explain dramatic growth and fecundity there, populations within the plant's native range (Lonsdale & Segura 1987). Mimosa infestations may flood for months, making access difficult, and mimosa can invade paperbark (*Melaleuca* sp.) swamp-forest understorey where aerial herbicide spraying and burning cannot be performed. This and the cost of chemical and physical control makes biological control the most promising long-term strategy (Forno 1992).

Although described as a difficult target for biological control (Harley *et al.* 1995), programs have been established in Malaysia, Thailand, Vietnam and Australia. In Australia, nine insect herbivores and two fungal pathogens of mimosa have been released (Heard *et al.* 1997). It is too soon to tell if biological control will succeed, however, one agent, *Neurostrota gunniella*, is beginning to impact on plant performance (Lonsdale & Farrell 1998). Biological control can be slow, for example the pyralid, *Euclasta whalleyi*, reached outbreak densities four years after it was considered that biological control of *Cryptostegia grandiflora* had failed (Vitelli *et al.* 1996). Other control methods are currently needed for mimosa in Australia.

Physical and Chemical Control. Eradicating small satellite infestations or nascent foci, a priority for managing invasive weeds (Moody & Mack 1988) is a viable approach for mimosa (Cook, *et al.* 1996). Several control options were tried for such small infestations in Kakadu National Park (in the Northern Territory, Australia), including hand-pulling, cutting, burning and herbicides, and many infestations (*c.* 30%) were eradicated within one year. However, 20% required sustained control for 7 years or more to prevent regeneration from the seed bank (Cook, *et al.* 1996).

Such control methods are highly labour intensive. For larger stands, that may cover thousands of hectares (eg. Cook, *et al.* 1996), less intensive strategies are available:

1. Herbicide: Aerial application of herbicide is most practicable for many large infestations (Miller & Siriworakul 1992). However, spraying may not achieve 100% kill and plants can regrow from the base or stems.
2. Mechanical control: Methods of mechanical control are outlined by Siriworakul & Schultz (1992), and include ploughing, chaining and bulldozing. They noted that, generally, regrowth occurs unless treatments are combined with herbicides and contaminated machines can disperse mimosa seed. Blade ploughing is effective against mature plants (T. Schatz, personal communication), although it is not be appropriate for some soils (Siriworakul & Schultz 1992).
3. Fire. Mimosa is difficult to burn and plants often resprout (Miller & Lonsdale 1992). Lonsdale & Miller (1993) described a technique that cleared thickets, killed by herbicide, using gelled gasoline applied from a helicopter. Fires were hotter, killing seeds at the soil surface, when stands were initially flattened with a bulldozer. However, buried seeds survived and became germinable, indicating that follow-up control is necessary.
4. Revegetation. Revegetation with grasses may inhibit regeneration and infestation by other weeds because native vegetation is often impoverished beneath stands.

Although this approach has not yet been proven as a control method, it is known that competition reduces mimosa seedling emergence and survival (Lonsdale & Farrell 1998).

The Mimosa Integrated Control Experiment

Miller *et al.* (1992) suggested an integrated management program, combining the various control techniques, may provide the most effective management strategy. Integrated Weed Management (IWM) is a sustainable approach to managing weeds which combines biological, cultural, physical and chemical methods in a way that maximises their effectiveness while minimising economic, health and environmental risks. It is a form of ecosystem management, and requires sufficient knowledge of the ecology of the weed and the invaded system to allow prediction of the outcome of control efforts. Studying weed population ecology (eg. Briese 1993; Scott 1996; Paynter *et al.* 1998) is, therefore, an important component of weed biological control programs. In addition, modelling plant population dynamics (eg. Lonsdale *et al.* 1995; Rees & Paynter 1997; Freckleton & Watson 1998) has proved useful when explaining or designing a range of weed control programs.

We designed a split-plot experiment, to measure the effects of herbicide, crushing by bulldozer, burning, and revegetation on mimosa and its biocontrol agents. The experiment was designed to address the following questions:

1. Do individual or combined measures kill mature mimosa plants?
2. Do individual or combined measures affect regeneration of mimosa seed?
3. Do these measures interfere with, or enhance, the activity of introduced biological control agents?
4. What is the best technique or combination of techniques to manage mimosa?

Materials and Methods

Experimental Plots

The experiment was set up within mature mimosa stands at Wagait Aboriginal Reserve, in the Finniss River catchment, Northern Territory, Australia (12º56'S, 130º33'E alt. *c.* 20 m). The experiment covers *c.* 128 ha, recreating the scale that will be required for practical control of mimosa.

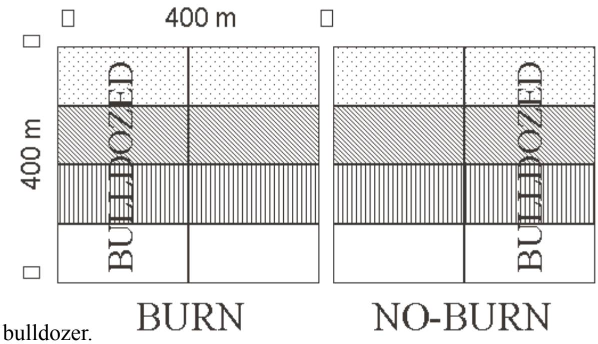
Allocation of Treatments

The design consists of four blocks of the following (See Fig. 1): two *c.* 400 x 400 m sub-blocks, one to be burnt, one not burnt (randomly assigned). The following treatments were then applied within each block:

a) Herbicide: Two 100 m by 800 m strips were sprayed with Starane 300®, in April 1998, leaving two 800 x 100 m unsprayed strips (Fig. 1). In early January 1999, Starane was re-applied to one of the sprayed strips and to one of the unsprayed strips. This gave paired sub-plots with the following treatments:

1. A control.
2. Early dry season herbicide application (April)
3. Wet season herbicide application (January)
4. Early dry + wet season herbicide application (April + January)

Fig. 1. Summary of treatments for one replicate of the Integrated Experiment.



Bulldozed = Plots crushed by bulldozer.
Burn = sub-blocks to be burnt during the dry season of 1999.
Stippled = Herbicide application early dry season 1998 + Wet season 1999.
Diagonal shading = Herbicide application wet season 1999 alone.
Vertical shading = Herbicide application early dry season 1998 alone.
No shading = Unsprayed.

b) Crushing. In October/November 1998, half of each sub-block (randomly assigned) was bulldozed at right angles to the sprayed strips, giving eight 100 x 200 m plots/sub-block.

c) Burning. Sub-blocks allocated to the burn treatment will be burnt late during the 1999 dry season.

d) Revegetation. The effect of competition on mimosa seedling establishment will be tested, by sowing native grasses in each plot in late 1999, following the burn treatment. See *Sampling* section below.

Sampling

1. **Sampling original stands within 1 x 5 m quadrats.** Parameters to be measured:
2. **Stand survival** - the effect of treatment on the survival and biomass of the original stand.
   I. Proportion of plants killed by treatment.
   II. Change in mimosa biomass and percentage cover before and after treatment.

I. Estimating survival and above-ground biomass. Before allocating treatments (November 1997), four 1 x 5 m quadrats were located in each 100 x 200 m plot and the number and diameters (at ground level) of mimosa stems recorded. Aboveground biomass was estimated using a correlation between stem diameter and dry weight (T. Schatz, unpublished data). An analysis of variance was performed, using these estimates and the Genstat statistical package (NAG Ltd.), to test for differences between plots. There were no significant differences and the mean aboveground biomass of mimosa was 33.6 t/ha (dry-weight). Subsequent censuses will measure the effect of treatment on survival and biomass.

II. Estimating percentage cover. Within the 1 x 5 m quadrats further samples were performed in Oct/Nov 1997 using a random quadrat (1 x 1 m) to estimate percentage cover of each plant species, litter, and bare ground before the treatments were applied.

2. Sampling seedlings. Parameters to be measured:

1. *Stand regeneration - the effect of treatment on seedling establishment and survival.*
   - I. Regeneration of mimosa from the seed bank following treatment.
   - II. Native flora regeneration.
   - III. Regeneration following revegetation treatment.

Seedling establishment and survival. Two 5 x 5 m quadrats have been established in each 100 x 200 m plot to investigate the effect of treatment on seedling establishment and survival. One will have the treatment allocated to the plot alone the other will have the treatment plus revegetation. Native grass seeds were collected in May 1999 for sowing following the burn treatment in late 1999. Detailed sampling within these quadrats will be performed as follows:

a) Two permanent quadrats (0.25 x 0.25 m) will be marked out, mimosa seedlings within will be counted so survival rates can be estimated.
b) Four random quadrats will be used to record the number of mimosa seedlings and the approximate percentage cover of all plant species. Quadrats will be randomised at each sampling date for statistically independent samples across dates.
c) Soil cores will be taken after treatments have been applied so the effect of treatment on the mimosa seed bank can be estimated.

3. Sampling natural enemies. Parameters to be measured:

Impact of biocontrol agents. Effect of control treatments on introduced or native biocontrol agents. Biological control agent populations will be sampled within each treatment to indicate presence and relative abundance, according to standard protocols developed by CSIRO and DPIF researchers.

Potential outcomes

The aim of this research is to develop an effective control strategy that incorporates an optimal use of available control measures with a knowledge of the basic ecology of mimosa. Collating mimosa population parameters within a simulation model (eg Rees and Paynter 1997) could develop this strategy further. The development of an expert systems approach (eg Warwick *et al.* 1993) would allow informed decisions regarding the modification of management practices, according to the local conditions. Such an expert system may be suitable for adaptation to a range of woody leguminous weeds.

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