The capacity of lantana (*Lantana camara* L.) to displace native vegetation

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Summary Lantana (*Lantana camara* L.) is a highly aggressive exotic weed well established throughout eastern Australia and is able to displace native vegetation under a range of circumstances. Whether lantana is able to displace native vegetation in the absence of anthropogenic disturbance is subject of some disagreement in the literature. Some authors claim lantana can displace rainforest and resist its re-establishment. On the other hand, other authors claim that lantana cannot displace rainforest. Lantana in the rainforests of south-east Queensland is able to maintain large and dense patches apparently for long periods. This leaves open the question whether lantana in these forests is able to displace the forest or whether the rainforest displaces lantana. In this study lantana has been observed in a number of different locations in the border ranges between New South Wales and Queensland and there is little evidence of its capacity to displace forests in the absence of external disturbances. The study being pursued here explores the reasons for the apparent inability of lantana to displace forest and focuses particularly on the shading of lantana by the forest and the capacity of forest species to grow through patches of lantana.
Keywords Lantana, *Lantana camara*, competitive displacement, canopy gaps, subtropical rainforest.

INTRODUCTION

Lantana (*Lantana camara* L.) is an aggressive weed that has naturalised in eastern Australia under a wide range of climatic conditions. It is recognised as a weed of pastures, plantations and native forests throughout coastal and sub-coastal areas from southern New South Wales to northern Queensland.

Lantana/forest dynamics Lantana has become well established throughout the rainforest in Springbrook National Park and is considered the park's biggest weed problem (Hall pers. comm. 2001). It is spread by seedling growth especially along the edges of lantana patches. If left unchecked, lantana can alter the structure of wet sclerophyll and warm temperate rainforests to the detriment of these forests (Gentle and Duggin 1998). It appears that lantana's success is due to its reported ability to out-compete native species in frequently disturbed sites (Gentle and Duggin 1998) and its shade tolerance. The level of this tolerance is not well known however.

Lantana's success may also be due to allelochemicals that inhibit both the germination and growth of other plants (Sharma *et al.* 1988). Many studies have highlighted these chemicals as an important component of lantana's competitive strategy. Even though some studies have found that lantana-derived chemicals act negatively on many crops and plantation species, no thorough research on the effects of these chemicals on native flora has been conducted (Swarbrick *et al.* 1995). There is also some doubt about lantana's allelopathic ability in the field (Sharma *et al.* 1988).

Rainforests in south-east Queensland The rainforest community studied in this work is at the upper end of the elevation range for subtropical rainforest at these latitudes. Although the canopy is comprised of typical subtropical rainforest species, elements of warm temperate rainforest occur as well, particularly in the understorey, and the community might be described as transitional subtropical/warm temperate rainforest.

Various sources of information drawn upon in this report refer to the competitive capacity of lantana in 'moderate rainfall' subtropical rainforests, and compare it with 'higher rainfall' rainforests. The annual rainfall at the study sites is in the range of 2000 to 2600 mm y^{-1}, which makes them clearly higher rainfall rainforests in this context.

Lantana in subtropical rainforest Lantana plays a role as a persistent weed, and some workers claim that it has little ability to invade some rainforest ecosystems. Humphries and Stanton (1992) state that lantana is 'unable to invade tropical rainforest in northern Queensland but persists along edges and where the canopy is open'. They also claim that lantana is not considered to be a conservation threat to the rainforest of the wet tropics as it only persists along forest edges and there is little evidence of its expansion under intact canopies. However it does persist for extended periods along forest edges and thus has become a feature of the northern Queensland rainforest edge (Humphries and Stanton 1992). When it does occur in the rainforest it is usually found in canopy gaps created by logging and windthrow, and in clearings that once supported rainforest, although in the relatively small canopy gaps it is found infrequently and in poor health (Humphries and Stanton 1992).

The 1995 review of lantana in Australia (Swarbrick *et al.* 1995) states that many rainforest species are able to germinate and grow through lantana, eventually shading it out, but it does not state which ones are able to do this. Williams *et al.* (1969) suggests that in cleared/disturbed moist subtropical rainforest, lantana may not prevent native regeneration if a sufficient canopy is established over the lantana or pioneer species, providing sufficient shade: this planting is required in the early successional stages. Scherrer (1998) postulates that lantana 'cannot live under closed forest canopy' of subtropical rainforest in south-east Queensland and thus cannot displace rainforest in the study area.

On the other hand Webb *et al.* (1972) and Lamb (1991) both have shown that lantana thickets 'can withstand replacement by rainforest species and prevent the re-establishment of the rainforest'. Lantana still prevents the re-establishment of rainforest after forty years in an artificially created canopy gap created by Webb in 1957 in dense subtropical rainforest, at Mt. Glorious north of Brisbane, even though it is surrounded by tall, undisturbed rainforest (Webb *et al.* 1972). Floyd (1999) suggests, in his discussion concerning the natural succession in rainforest, that the persistence of lantana in his pioneering stage (Stage 2) of rainforest regeneration may prolong the stage for up to 15 more years.

Nevertheless there is anecdotal evidence that lantana thickets may over time be replaced by rainforest species in lower rainfall rainforest areas, if local sources of re-establishment are sufficiently maintained (Anon. 2000). In areas of higher rainfall rainforest species have reportedly a lesser capacity to do this due to the competitive advantage of lantana (Anon. 2000). Furthermore, Stocker and Mott (1981) reported that, in northern Queensland, lantana has the potential to impede or even deter grass invasion into disturbed rainforest sites and thereby reduces the advent of low intensity fires early in the dry season.

Lantana, disturbance and shading In rainforest areas with lower rainfall it seems that lantana operates differently than in higher rainfall areas. Even so, disturbance appears be a key facilitator of the introduction and establishment of lantana in dry rainforest/open forest ecotones (Gentle and Duggin 1997) and in wet sclerophyll and warm temperate rainforests (Gentle and Duggin 1998). Lantana invasion is strongly correlated with disturbance and thus with significant breaks in the canopy (Fensham *et al*. 1994, Gentle and Duggin 1997). Scherrer (1998) found that, in subtropical rainforest, disturbance and canopy gap size were the best predictors of lantana density amongst numerous environmental variables tested. Similar results have been show in dry rainforests and eucalypt woodlands by Lamb (1987), Gentle and Duggin (1997) and Duggin and Gentle (1998). It would appear that all stages of lantana's life cycle, including germination, survival and early seedling growth are strongly positively correlated with disturbance intensity which in turn is also strongly positively correlated with resource availability (Duggin and Gentle 1998). That is the higher the level and effects of the disturbance the higher the germination, seedling survival and growth rates will be. However, in the presence of low intensity disturbances, lantana may establish but not extend its range (Duggin and Gentle 1998).

Species richness declines as the density of lantana infestation increases in dry rainforest (Fensham *et al.* 1994) and lantana has a tendency to become a monospecific thicket. Lantana infestation intensity is negatively correlated with tree cover, that is, as tree canopy density increases, lantana infestation intensity decreases (Fensham *et al*. 1994, Gentle and Duggin 1997). Duggin and Gentle (1998) have postulated that in dry rainforest-open forest ecotones, lantana may be susceptible to shading interference from neighbouring species. Thus, in dry rainforest, lantana is limited by shading more than any other factor (Gentle and Duggin 1997).

Hence, it appears that lantana infestations only become serious when disturbances can cause severe damage to previously closed forest canopies (Fensham *et al.* 1994).

Areas of agreement It appears lantana does have the ability to invade and displace eucalypt woodland vegetation and decrease the species richness in this community type (Lamb 1987, Fensham *et al.* 1994, Gentle and Duggin 1998).

Areas of disagreement There is some dispute whether lantana has the ability to displace subtropical rainforest. Some authors claim that lantana thickets may displace it, preventing its re-establishment, and thus disrupt succession of disturbed sites (Webb *et al.* 1972, Floyd 1999, Lamb 1991). On the other hand some authors claim that lantana cannot displace rainforest (Williams *et al.* 1969, Humphries and Stanton 1992, Swarbrick 1995, Scherrer 1998).

Objectives Despite extensive qualitative observation on lantana since the early 20th century, many aspects of its ecology, biology and, specifically, its invasion ecology as a weed are unclear (Fensham *et al.* 1994). There have been incidental reports of some facets of lantana ecology in relation to studies conducted on rainforest regeneration in Queensland (Williams *et al.* 1969, Webb *et al.* 1972). Successful rainforest management will require a better understanding of the impacts of lantana on community dynamics so that the integrity of local ecosystems can be preserved (Gentle and Duggin 1998).

As previously stated there is much speculation amongst weed biologists and researchers as to what processes influence lantana infestation and success, especially in subtropical rainforest (Anon. 2000). The question remains however, as to what is the future for subtropical rainforests in the face of invasion by lantana? Will the lantana displace the rainforest progressively, as natural disturbances create ever more opportunities for the weed and turn the rainforest into a monolithic stand of lantana? Will the rainforest reclaim space that has been lost to lantana and eventually return to its natural rainforest state? Or is there a permanent stand off between lantana and the rainforest?

This study is mainly directed at looking at the dynamics at the lantana/rainforest interface, especially in the wetter subtropical rainforests of the MacPherson Ranges of south east Queensland, where the studies will be centred on Springbrook and Lamington National Park. The aims of this research are to determine 1. whether lantana can displace rainforest, 2. whether rainforest can reclaim space lost to lantana, and 3. what are the mechanisms and processes involved?

METHODOLOGY

Germination experiment This experiment is to assess how shading or canopy tree species influence the germination of lantana and/or selected experimental rainforest species. The experiment will permit separation of shading and allelopathic effects.

In this experiment seeds will be bagged and placed under rainforest canopy trees or lantana, above or below the leaf litter and the number of seeds germinated will be assessed at regular intervals over a six-month period. The suntrack Canopy Gap Fraction (CGF) will be measured to provide a surrogate for shading. The rate of germination will be compared (i) with the amount of shading at the point where the seeds were located and (ii) the species of canopy to determine the relative contributions of shading and species (e.g. allelopathy).

Seedling experiment This experiment investigates the relative contribution of shading and canopy tree species in seedling survival and growth. It will explore the interactions between older plants to determine what mechanisms are involved in the competition of lantana expansion with intact rainforest.

Young seedling plants will be planted under rainforest trees and lantana and their rate of growth and their survival over a period of 12 to 18 months compared. The suntrack CGF will be measured to provide a measure of shading. The rate of growth will be compared with the amount of shading and the species under which they are planted to determine the relative contributions of shading and species (e.g. allelopathy) to survival and growth.

Lantana health study This study is to determine: (i) the difference in the relative health of lantana growing under rainforest canopy compared to that growing in a canopy gap and (ii) the rainforest canopy density by which lantana growth is significantly reduced.

The health of the lantana will be estimated by various parameters (see below) and the canopy density by measurement of the CGF. At each site, measurements will be made in lantana patches, which had vigorous lantana in the gap, and around its edge, lantana growing under the canopy of surrounding rainforest. At each patch stems in the gap and stems under intact rainforest will be selected. For each branch, the final 100 mm will be scored for health (live or dead). Measuring back from the tip, the region of the stem from 100 to 1600 mm will be assessed as follows: the total number of branchings, nodes, leaves, the number and location of nodes with missing leaves, the branch characteristic at each node, the approximate size of each leaf (blade length by maximum width, divided by 2), the length and thickness (at the middle of each internode) of the internodes, the petiole length for each leaf, estimate of relative leaf health using a transmitted light leaf colour chart, the CGF (predictor variable) above the stem and the dominant and sub-dominant canopy species above the stem

Rainforest regrowth study Since rainforest tree species are sometimes observed to grow through lantana patches, it would appear that rainforest does have the ability to regrow through or over lantana patches and reclaim the area invaded by lantana (i.e. by infilling). The National Strategy for Lantana Management (Anon. 2000) reports anecdotal evidence that lantana thickets may be replaced by rainforest species and that planting rainforest species can produce enough canopy to reduce lantana and restore disturbed rainforest. This study provides an opportunity to investigate this process in detail and determine the capacity of rainforest to replace lantana in subtropical areas.

Native trees growing through patches of lantana will be identified, measured (diameter at breast height, canopy width and height) and photographed. Where possible, such plants will be located in historical air-photographs and development of canopy estimated over time, providing a list of competitive species and data on growth rates and potential trunk densities.

Canopy closure study Where a gap occurs in rain-forest canopy, the gap could be closed by either or both of (a) infilling or (b) canopy expansion into the gap by trees at its edge. In small gaps, closure may occur solely by canopy expansion. Infilling has been considered in the previous experiment.

This study will determine how far canopy can expand simply by the growth of the branches of existing trees providing an idea how large a gap can be closed without infilling, or alternatively, how much of the shading which may occur at the edge of a lantana patch could be attributable to canopy expansion rather than the growth of new trees.

Ten old lantana patches in subtropical rainforest will be chosen from four locations around south-east Queensland. At each site, the gap will be mapped noting all major canopy trees on the edge of the gap. The canopy trees will be identified and then the following will be assessed: (i) the direction in which the lateral growth would occur (into the gap perpendicular to the overhang from the centre of the trunk at ground level edge) as an azimuth reading and (ii) the length of the canopy growing in the direction of the gap and also directly opposite back into the intact rainforest. The data will comprise a list of trees, their species and paired measurements of canopy overhang. The asymmetry of canopy will indicate the potential of each species to close lantana-dominated gaps.

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