The Dynamics of *Lantana camara* (L.) Invasion of Subtropical Rainforest in southeast Queensland

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The Degree of Doctor of Philosophy

by

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Statement of Originality

The material presented in this thesis has not previously been submitted for a degree or diploma in any university and to the best of my knowledge contains no material previously published or written by another person except where due acknowledgement is made in the thesis itself.

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Daniel H. Stock

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Abstract

Lantana *Lantana camara* L. is a highly aggressive exotic environmental weed that is well established throughout eastern Australia and is reportedly able to displace native vegetation under a range of conditions. Whether lantana is able to displace native vegetation in the absence of anthropogenic disturbance is subject of some disagreement in the literature. The question remains, however, as to what is the future for the Gold Coast hinterland rainforests in the face of invasion by lantana? This study is mainly directed at addressing the dynamics at the lantana/rainforest interface, especially lantana's capacity to invade and ability to compete with the wetter subtropical rainforests of the MacPherson Ranges of southeast Queensland, where the studies are centered on the Springbrook Plateau and the Springbrook and Lamington National Parks. The aims of this research are to determine: whether lantana can displace rainforest; whether rainforest can reclaim the space lost to lantana; and what are the mechanisms and processes involved.

To investigate these questions a conceptual framework was determined where key processes at the rainforest/lantana interface were determined and set in a logical context. A wide variety of possible processes whereby lantana could resist or displace rainforest or forest could resist or replace lantana were identified. The framework questions were addressed by observations made at lantana patches in Springbrook and Lamington National Parks in southeast Queensland.

These answers/conclusions indicate that lantana is not invading further into intact rainforest and is seemingly isolated to canopy gaps, suggesting that rainforest is *suppressing* further expansion of lantana. Even though lantana may not commonly occur thriving in subtropical rainforest, it was determined that the issues/interactions that need to be pursued via experimentation were as follows: (i) how common is lantana in the national parks of southeast Queensland; (ii) what limits lantana expansion (is it physical shading, processes attributable to biological effects, such as allelopathy or a combination of both) and; (iii) what physical/biological conditions suppress lantana health and aggressiveness.

Although some previous work has looked at the correlation between lantana density and tree cover in dry rainforest and savanna woodland, there have been no reported studies looking specifically at the quantity and abundance of lantana throughout a forest community. An extensive transect study in subtropical rainforest in southeast Queensland assessed habitat variables and the density of the lantana at numerous points along four transects running through rainforest and other mesic communities. The study was conducted in national parks to ensure that the typical disturbances present were, as much as possible natural rather than anthropogenic. From this study the extent of lantana infestation in particular forest types was determined and forest variables such as canopy density and canopy type were compared with

lantana density providing indications of the current extent of infestation and the types of forest especially prone to infestation by this environmental weed. The density of lantana in intact rainforest was low and only slightly more lantana was observed in secondary forest than in primary forest. These differences are however driven by the density of the forest rather then the nature of the forest. Finally, lantana appears to be disturbance–dependent in that there is significantly more lantana in disturbed areas than undisturbed areas of the forest: these differences were attributable to the more open canopies above disturbed sites, rather than the disturbance itself.

According to previous work the germination of lantana seeds is significantly reduced in low light conditions, such as occur under intact rainforest. A germination experiment investigated the contributions of shading and canopy type to the germination of lantana seeds. The experiment permitted the separation of shading and species–specific effects and the study of rainforest seeds under lantana. Seeds were bagged and placed under rainforest canopy trees and lantana, above and below the leaf litter for a six-month period or until maximum likely germination was achieved. The amount of germination was compared with the amount of shading, the position relative to leaf litter and the species of canopy they were placed under, to determine the relative contributions of shading, litter cover and canopy species. The results of this study show that native rainforest seeds germinate differently under rainforest canopies than under lantana with most showing a higher level of germination under rainforest canopies. This difference was found to be attributable to both the nature of the canopy (canopy species) and the changing level of shading (canopy openness). For most rainforest species, the difference attributable to the level of shading and nature of the canopy was indicative of greater germination capacity under the rainforest canopy than under lantana. Thus, lantana reduces the germination of natives and therefore, in this manner, reduces the forest's capacity to replace lantana. Lantana seed did not germinate in this study and thus their capacity to out–compete native species is, based on this work, unknown.

It appears that the competitive ability of lantana seedlings may gives them the edge over rainforest seedlings when colonising canopy gaps. It is therefore important to examine the survival and growth of lantana seedlings compared to rainforest seedlings and the effect of canopy species and shade levels on lantana seedling survival, growth and thus competitive ability. Lantana and rainforest seedlings were planted under rainforest trees and lantana, and their survival and rate of growth over a period of 24 months compared. The survival and rate of growth was compared with the amount of shading and the species under which the seedlings were planted, to determine the contributions of shading and canopy species to survival and growth. The results of this study suggest that, as a seedling, lantana survival was greater under secondary forest canopies and lantana, than under the primary forest species. The growth of lantana seedlings was significantly different under different forest canopies, but differences in growth were not attributable to the different canopy openness ranges with each canopy species and better explained by the actual canopy species themselves. This suggests that there are canopy specific differences in seedling growth beyond that explicable by canopy openness. As a canopy, lantana does not appear to suppress the survival and growth of rainforest seedlings and thus as a canopy, lantana may not prevent the establishment of native forest seedlings that were studied here.

In the rainforests of southeast Queensland, lantana is able to maintain large and dense patches apparently for long periods, leaving open the question of whether lantana in these forests is able to displace the forest or whether the rainforest displaces lantana. In this study, lantana was 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 additional disturbances. The study here explored the reasons for the apparent inability of lantana to displace forest and focused particularly on the shading of lantana by the forest and the capacity of forest species to grow through patches of lantana. Lantana's inability to successfully expand its patch size, under intact rainforest, appears to be due to two main reasons: (i) the increased level of shade provided by the intact canopy of the rainforest compared to the open canopy of the disturbance; and (ii) the particular nature of (species in) the intact rainforest. The results suggest that lantana has little capacity to adapt to shading, only developing slightly larger leaves, longer petioles and longer thinner internodes in moderate shade. Conversely, there is a marked degradation of most health characteristics when lantana is growing in low light conditions. Where the canopy is denser than 75%, lantana will be unthrifty, probably unable to grow and certainly unable to flower. Therefore, maintaining at least 75% shading should prevent the successful encroachment of lantana and early achievement of this level of canopy density should be aimed at in revegetating disturbed sites.

This thesis suggests that lantana does not appear to have the ability to competitively displace rainforest. Conversely reclaiming the land taken over by lantana is very slow. More research is required to fully understand the rainforest's ability to recolonise lantana infestations. Although lantana thrives in the canopy gaps created by disturbances, it appears to be restricted (to these gaps) and seems unable to expand the patch beyond the canopy gap. If rainforest reclamation can be confirmed to take place at such a pace that gaps can be closed in an ecologically reasonable time, little active control of lantana maybe required. If active intervention is desired then control efforts should focus on the physical removal of the lantana from initially, small gaps, accompanied by the planting of fast growing rainforest species that can increase the shade at a disturbed site to prevent the reestablishment of the weed.

List of Publications Submitted and Accepted

Stock, D.H. and Wild, C.H. 2002. The capacity of lantana (*Lantana camara* L.) to displace native vegetation. Pages 104-107 in Spafford Jacob, H., Dodd, J. and Moore, J.H. (Eds.) 2002. *13th Australian Weeds Conference: Papers and Proceedings*. Plant Protection Society of Western Australia, Perth, Western Australia.

Stock, D.H. 2002. The dynamics of Lantana camara invasion of subtropical rainforest in Southeast Queensland. Pages 66-67 in Grice, A.C. and Setter, M.J. (Eds.) 2002. *Weeds of Rainforests and Associated Ecosystems.* Cooperative Research Centre for Tropical Rainforest Ecology and Management, Cairns.

Stock, D.H. and Wild, C.H. 2003. The capacity of lantana (*Lantana camara* L.) to displace subtropical rainforest along the lantana/rainforest interface. Page 206 in Oliver, I., Kristiansen, P. and Silberbauer, L. (Eds.) 2003. *Ecological Society of Australia Ecology 2003 Conference: Abstracts*. University of New England, Armidale, New South Wales.

Stock, D.H. 2005. (In Press). The Future Direction of Lantana Management in Eastern-Australian Subtropical-Rainforests. In Worboys, G.L., Lockwood, M. and DeLacy, T. 2005. *Protected Area Management: Principles and Practices (2nd edition)*. Oxford University Press, Melbourne.

List of Conference Presentations

Thirteenth Australian Weeds Conference (2002): Weeds – Threats now and forever? Perth, Western Australia.

Weeds of Rainforests and Associated Ecosystems Workshop: A joint workshop of the Cooperative Research Centre for Tropical Rainforest Ecology and Management and the Cooperative Research Centre for Australian Weed Management (2002). Cairns, Queensland.

Ecological Society of Australia Ecology Conference (2003). Armidale, New South Wales.

Cooperative Research Centre for Tropical Rainforest Ecology and Management Conference (2003). Cairns, Queensland

Table of Contents **Page No.**

List of Tables **Page No.**

List of Figures — Page No.

List of Appendices

Page No.

List of Abbreviations

ANECCFM	Australian and New Zealand Environment and Conservation Council and Forestry Ministers
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
ARMCAN	Agriculture and Resource Management Council of Australia and New Zealand
CGF	Canopy Gap Fraction
CRCAWM	The Cooperative Research Centre for Australian Weed Management
FC	Flowering Capacity
GP	Growth Potential
NCS	Nature Conservation Strategy
PC	Photosynthetic Capacity
QDNRM	Queensland Department of Natural Resources and Mines
QDNRM&E	Queensland Department of Natural Resources, Mines and Energy
QPWS	Queensland Parks and Wildlife Services
RSS	Residual Sum of Squares

Glossary of Terms

In the context of this thesis, the following terms have distinct definitions:

Aggressive — fast growing, tending to spread quickly and invade

Disturbance — a disturbance has been best defined by Sousa (1984) as "a discrete, punctuated killing, displacement, or damaging of one or more individuals (or colonies) that directly or indirectly creates an opportunity for new individuals (or colonies) to become established"

Economic weed — a weed whose impacts are, or are thought to be, detrimental to economic systems

Environmental weed — a weed whose impacts are, or are thought to be, detrimental to the environment and occur in relatively undisturbed and mostly native vegetation and are undesirable ecologically, but not always economically

Exotic plant/weed— a plant/weed existing in an area outside its native range

Forest canopy — as used here, is foliage that is wider than twice its height above the lantana

Healthy —showing signs of active growth, and lacking evidence of extensive disease or environmental stress (e.g. dead leaves)

Invasion — the arrival of an organism in regions beyond its natural range (Williamson 1996)

Invasive species — species that spread where they are not native

Lantana patch — as used here, is defined as the total area of lantana and may, or may not, extend under the rainforest canopy

Thrifty —healthy and in vigorous growth (i.e. thriving)

Unhealthy —showing extensive signs of disease or environmental stress

Unthrifty —showing evidence of succumbing to environmental stresses

Weed — a weed is a plant that grows where it is not wanted/a term that is used by the public, farmers and ecologists for the infestation of an unwanted plant into a garden, a paddock or a National Park

Preamble

"In nineteenth–century Europe a vegetable Frankenstein was created in hothouses by hybridising various Latin American shrubs. The monster so spawned, lantana (*Lantana camara*), went on to become one of the world's worst weeds" (Low 2002).

It has long been recognised that exotic plant invasions represent a major threat to the integrity of natural ecosystems. Many studies have looked at the patterns and processes of invasive species. On the other hand, very few studies have looked at the mechanism of invasion in respect to the invaded community itself (Hobbs and Humphries 1995, Burke and Grime 1996, Prieur-Richard and Lavorel 2000).

The future of lantana *Lantana camara* L. (Lamiales: Verbenaceae) in the rainforests of central eastern Australia appears to be reliant on the interaction at the lantana/rainforest boundary (Fensham pers. comm. 2000). This work directly addresses these processes.