Eucalypt regeneration and ecological restoration of remnant woodlands in Tasmania, Australia

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Much of the material in Chapter 3 is published as:

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The following people contributed to the publication of the paper comprising Chapter 3 undertaken as part of this thesis:

Tanya G. Bailey (70%), Neil J. Davidson (20%), Dugald C. Close (10%).

The ideas for this study were those of the candidate with Neil J. Davidson providing some advice on experimental design. All experimental work was carried out by the candidate. The manuscript was written entirely by the candidate with editorial advice from Neil J. Davidson and Dugald C. Close.

We the undersigned agree with the above stated "proportion of work undertaken" for the above published peer-reviewed manuscript contributing to this thesis:

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Abstract

Lack of eucalypt regeneration is a key factor in the decline of forest and woodland remnants in low rainfall agricultural regions in Australia. This thesis provides a new insight into dry forest and woodland regeneration by demonstrating how important and tightly circumscribed the eucalypt seedling regeneration niche is in these forests in Tasmania. The potential of soil water repellency to be a barrier to eucalypt recruitment and the difficulty of mimicking the regeneration niche to improve natural regeneration processes in degraded forests are highlighted. A section on management implications is included.

Key to effective management of dry forests and woodlands is an understanding of the requirements and conditions that promote seed germination and seedling establishment (recruitment niche) and the persistence of lignotuberous sprouts (juvenile persistence niche). The processes of eucalypt recruitment and persistence were investigated in dry forest and woodland remnants in the Midlands of Tasmania at the scales of the stand and microsite. The work was conducted with a view to applying the results to the discipline of restoration ecology.

Measurements of structural complexity at thirty remnant forest stands that were in a range of stages of decline revealed that healthy remnants contained four times the amount of eucalypt regeneration (seedlings, lignotuberous sprouts and saplings) than stands in a degraded condition and that regeneration was absent in stands of paddock trees (except for one stand in which there had been a fire). An additional lack of trees in smaller diameter size classes in both intermediate and paddock tree sites relative to the amounts shown in healthy sites implies a long-term recruitment scarcity and an unavoidable future bottleneck in the development of mature trees. The quantity of eucalypt regeneration was positively associated with other structural attributes: perennial species and life form richness; cover of vegetation 0.5-6m high; litter; dead trees; large trees; and total length of fallen logs >10cm diameter; and negatively associated with quadratic mean tree diameter at breast height. Across the thirty stands, the majority of eucalypt regeneration was in the form of lignotuberous sprouts and saplings. Only in stands burnt 2-6 years prior to the survey did newly recruited seedlings form part of the regeneration.

Within these burnt sites the seedling recruitment niche differed significantly to the juvenile persistence niche (occupied by lignotuberous sprouts), while the juvenile persistence niche had characteristics similar to the general forest floor. Seedling microsites were characterised by the following: canopy gaps and ashbeds; a predominantly northerly aspect; over 220° shelter in profile; an average distance to a sheltering object of < 30cm; shelter provided by coarse woody debris (80% of seedlings sheltered by logs and branches); soil that was significantly softer and less water repellent than the forest floor; and low cover of grass. All these characteristics of seedling microsites affect moisture availability.

The role of ashbeds, coarse woody debris and soil water repellency in eucalypt recruitment was further investigated. Soil water repellency (hydrophobicity) can be severe in dry eucalypt forests as hydrophobic organic compounds coat the surfaces of soil particles and this has implications for the movement and storage of water in the system. Other studies have shown that soil hydrophobicity is differentially affected by fire depending on the temperatures reached, with repellency increasing as temperature increases until a threshold is reached at which repellency is removed (approximately 260°C). Logs lying on the forest floor provide heavy fuel for intense fire which creates ashbeds. The current study showed that in ashbeds hydrophobicity was removed in surface layers but the hydrophobic layer moved lower (1-3cm) down the soil profile. The wettable surface soil zones enabled the germination of eucalypt seed and subsequent establishment of seedlings. Remaining adjacent and partially burnt coarse woody debris provided a soil moisture store (with threefold the amount of moisture in soil under logs compared to 5m away) and probably protection from microclimatic fluctuations and browsing animals. Surface soil outside of the ashbed areas was severely water repellent suggesting that soil water repellency may be a barrier to eucalypt recruitment in lightly burnt and unburnt soils.

These findings were applied to restoration ecology. Patch scale restoration trials were conducted in six dry forest remnants in the Midlands of Tasmania in an attempt to mimic the eucalypt recruitment and persistence niches through the use of intense spot burns or cultivation with and without the addition of large logs. Survival of seedlings established from introduced seed and natural seed rain was variable within and among sites resulting in no treatment effects. Thus the 'Burn with the addition of logs' treatment did not successfully mimic the recruitment niche, probably because the experiment did not mimic the natural heterogeneity of hydrophobicity following wildfire. However, the survival of planted seedling was greatest in 'Cultivated with no log' treatments, which most closely resembled the juvenile persistence niche. Burning treatments did provide a relatively weed-free seed bed for over a year and surviving seedlings grew significantly better than those in cultivated treatments which quickly became infested with grassy weeds despite granular herbicide application.

Survival of planted seedlings and the amount of observed germination of sown seed were each significantly correlated with the structural complexity score of the planting site with seedling survival significantly higher in sites of healthy condition. This suggests that the more degraded sites had crossed an abiotic threshold (using state and transition model terminology) that was not completely removed by the experimental restoration treatments. The early establishment of planted eucalypt seedlings was also shown to be significantly affected by species; the underlying soil water repellency of the planting plot; the proximity to an adult tree and the type of soil amelioration used in the restoration treatment but not by the presence or absence of logs.

Suggestions for further work include trialling treatments that more closely mimic the recruitment niche by partially burning and retaining logs *in situ* rather than post burn addition; investigating the timing and intensity of weed control in cultivated treatments; testing the effects of soil water repellency amelioration through the use of wetting agents; and investigating spatial aspects of treatment patch placement.

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