RADIATA MANAGEMENT TECHNICAL NOTE
Site Productivity

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Native Understory Plants Support Biodiversity in Plantation Stands

Summary

Consumers are increasingly concerned about the environmental credentials of forest products, and because of this there has been a trend towards the adoption of certification schemes, such as FSC. Applying such schemes and verifying the sustainability of forest management practices requires an understanding of how forest management practices affect environmental attributes such as biodiversity. To contribute to a growing body of knowledge we conducted a large scale field experiment to compare the composition of the invertebrate fauna associated with deadwood from three native understory tree species and *Pinus radiata* deadwood in both plantation stands and adjacent native forest remnants. We measured invertebrates that had colonised experimental deadwood sections placed in stands and native remnants in the Tarawera Forest. In total 12 846 individual invertebrates were extracted belonging to 15 taxonomic groups. The taxonomic richness of ordinal groups and species extracted from pine wood was greater in native forest remnants than in the adjacent young *Pinus* stands. The beetle species that colonised native wood changed significantly across the native to plantation forest boundary. However, the same species dominated *Pinus* wood across the two habitats. Although the *Pinus* wood supported a greater species richness, the native wood is nevertheless important as it provides habitat for a distinct group of species not represented in the *Pinus* wood.

This research shows that promoting native understory species improves overall stand biodiversity because of the unique fauna associated with the different wood species. It also highlights the importance of native remnants and the proximity of stands to those remnants. Deadwood situated adjacent to native forest boundaries is thus a very important habitat for saproxylic (deadwood feeding) species, and where possible should be retained (for example leaving a buffer of uncollected deadwood residue around native remnants if removing biofuels etc).

Although this study quantified deadwood feeding invertebrates it is likely that additional biodiversity benefits may be provided by native understory plants, e.g., foliar feeders.

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Aims

To determine if the number and diversity of deadwood feeding invertebrates colonising native understory and pine wood differs between young *P. radiata* plantation stands and adjacent native forest and radiata pine plantation forest.

Introduction

New Zealand's plantation forests often support a rich understory of native flora, including many threatened species. In some landscapes plantations may provide a significant proportion of the available forest habitat, given the historical conversion of native forest ecosystems to grassland. In addition plantation forests often include remnants of native habitat that provide relatively stable source populations of flora and fauna to re-colonise adjacent stands after harvesting. We know that such remnants of natural vegetation are important in fragmented landscapes. However, as yet we have not quantified the significance of native understory tree species (within plantation stands) to the conservation of biodiversity. A relevant question to ask is: "What invertebrate species would be missing from plantation stands if the understory native plants were not present to provide appropriate habitat and food resources?"

Saproxylic invertebrates (those that feed on deadwood) are frequently used in other countries as indicators of sustainable forest management practices, particularly in the Northern Hemisphere. This is because saproxylic species are sensitive to the availability of deadwood [1]. In plantation stands this deadwood is largely determined by forest management actions such as thinning and harvesting. From related work (Sky *et al*. 2012) we know that *P. radiata* deadwood is an important resource for saproxylic invertebrates. This study extends the related research to quantify the importance of deadwood derived from native understory plants, to the conservation of saproxylic species in a production stand. We also examine how the importance of native understory deadwood changes with proximity to native forest remnants.

Methods

Three sites were selected within the Tarawera Forest, each site having approximately 20% native forest cover in the surrounding 2 km radius (Figure 1). At each site a single sampling transect was established that spanned 125 m into native forest fragment and 125 m into adjacent young stands. At these sampling sites wood billets (30-cm sections of stems) of the native understory tree species, *Schefflera digitata* (pate), *Melicytus ramiflorus* (mahoe) and *Aristotelia serrata* (wineberry) were placed alongside billets of *P. radiata* (Figure 2).

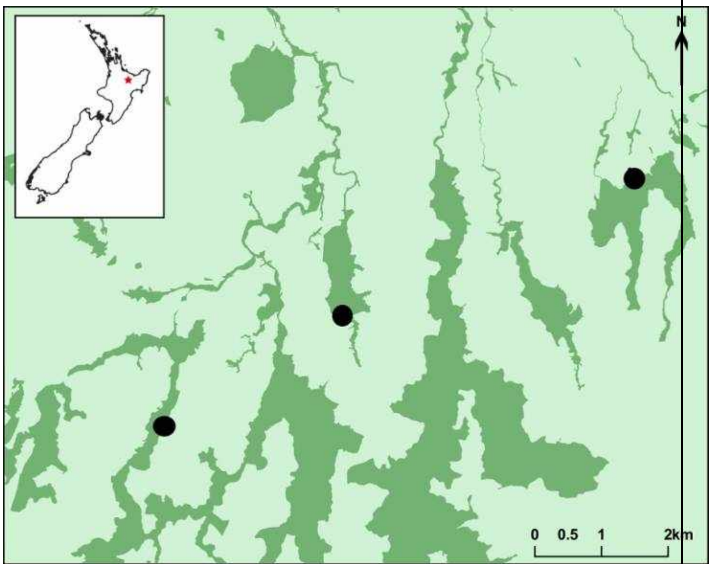

Figure 1 Study sites (circles) were located at the boundary of native remnants (dark green) and plantation stands (light green) within the Tarawera forest. Study area location within insert of New Zealand coastline is indicated with star symbol.

The three native wood species were selected because they commonly occur as understory species in plantation stands and have a wide distribution through New Zealand's native forests. As such, they represent a deadwood resource commonly available to saproxylic invertebrates in both plantation and native forests.

Wood billets were placed in the forest to allow invertebrate colonisation for three months during the 2009/2010 summer. Invertebrates were allowed to develop in the logs over a six-month period in a customised rearing facility at Scion's Rotorua campus where emerging adults were collected. The abundance, richness and community composition (CAP) of invertebrates were statistically compared

Figure 2 Three experimental wood billets of each native tree species; *M. ramiflorus*, *S. digitata* and *A. serrata*, alongside six *P. radiata* wood billets (foreground).

using the edge fitting functions [2]. The use of CAP axis scores provides a visual interpretation of differences in the community composition of invertebrates, as it combines information on the relative abundance of all species in each particular treatment.

Results

A total of 12,864 individuals belonging to 15 taxonomic groups were extracted from the deadwood samples. Beetles, flies and springtails were most abundant and represented 96% of the overall catch. Invertebrates were most abundant in the *P. radiata* wood (6514 individuals) compared to 3504, 1244 and 1602 individuals for *S. digitata*, *M. ramiflorus* and *A. serrata* respectively.

There was no significant difference in the species richness (expressed as number of species) between different types of wood, but species richness was dependent on the proximity to native habitat. Invertebrate richness (expressed as orders, e.g., flies, beetles etc.) decreased with increasing distance from native forest in *S. digitata* and *M. ramiflorus* wood (Figure 3 A).

Beetle species richness also declined with increasing distance from native forest in all species of deadwood (except for *S. digitata* – Figure 3 B). The declines in beetle species richness with increasing distance from native forest was linear for *P. radiata*, but for *M. ramiflorus* and *A. serrata* the declines were rapid at the native forest/plantation stand boundary, with a distinct difference in the species richness of beetles colonising the deadwood in the different habitats (Figure 3 B).

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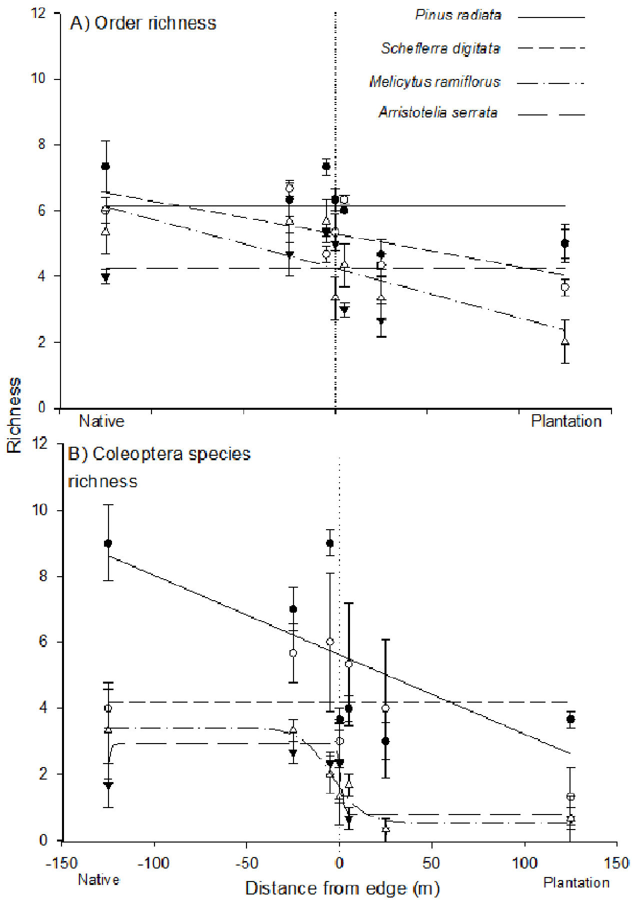

Figure 3 Rarefied species richness (the species count standardised for differences in sample size between treatments) (A) taxonomic order and (B) Coleoptera species richness (±1 SE) along transects from native forest to regenerating plantation stands. All fitted lines indicate significant changes in taxon richness across the edge, except horizontal lines that indicate no change with distance from edge.

The invertebrate community expressed at an ordinal taxonomic level was similar between *P. radiata*, *S. digitata* and *M. ramiflorus*, but *A. serrata* supported a distinctly different community of saproxylic invertebrates (Figure 4a). The invertebrate community colonising the *P. radiata* deadwood was different in plantation stands compared to native forest, but there were no differences in overall community composition between the habitats for native wood species (Figure 4A).

Beetle community composition in native forest did not differ between the different deadwood types. However, the beetle community colonising native wood species in the plantation stands was very different from that colonising *P. radiata* (Figure 4B). The beetle fauna colonising *P. radiata* did not change with habitat type (Figure 4B). Both linear and rapid 'step changes' in the community of beetles colonising native deadwood occurred with the transition from native forests to plantation stands (Figure 4 B).

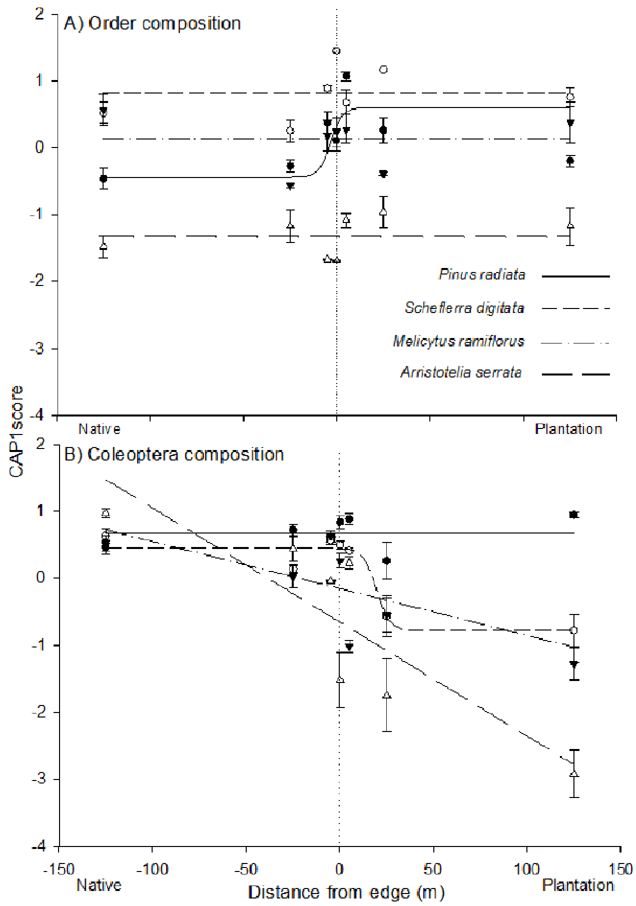

Figure 4 (A) Order and (B) Coleoptera (beetle) community composition. The position of the symbol along the y-axis reflects the combination of species found in that sample, thus symbols with similar y-axis values have similar community composition and those widely spaced have distinctly different communities. All fitted lines indicate significant changes in taxon richness across the edge, except horizontal lines that indicate no change with distance from edge.

Discussion

The decline in ordinal and beetle species richness with the transition from native forest remnant to plantation stand for some wood species suggests that there are habitat differences that prevent the colonisation of plantation stands by some species. These differences are unknown but could reflect

difference in habitat structure. We deliberately paired the native remnants with young *Pinus* stands that would have large amounts of deadwood from harvesting residue. Thus the mature native forests would have had a different microclimate from the recently harvested stands. To ascertain the reason for the change in species richness with proximity to native remnants, additional paired studies are needed to compare the invertebrate fauna across the boundary between native forest and plantation stands of a variety of ages. This research should also incorporate plant species differences along the habitat gradient, as native deadwood abundance may be highest in close proximity to native forest remnants. The fact that these changes in species richness can be abrupt, linear or non-existent between habitat types depending on deadwood type (Figure 3B) highlights the complexity of this relationship.

Community composition is potentially a more important factor to consider than just species richness as it reflects the type of species that colonise the wood, which is more ecologically meaningful. For example, in native forest there was no difference in the composition (the type of species and their relative abundance at the site) of beetles that colonised the different types of wood. However, in plantation stands, *P. radiata* and native wood billets had a different composition of beetles. This shows that deadwood derived from native understory plant species provides an important complementary resource that allows some species to exist in plantations that could not survive if the understory tree species were not present. Although understory tree species can increase the invertebrate biodiversity within the plantation, the functional significance of this is largely unknown apart from the contribution the invertebrates make to the decomposition of native wood.

Implications

Native remnants are important habitat for some groups of deadwood-feeding insects. The decline in richness of these groups with distance from native habitat remnants supports previous research that recognised the importance of native remnants within plantations [3]. As such, in plantations an interconnected network of smaller reserves is likely to improve biodiversity conservation at the landscape scale. Retaining deadwood resources close to native remnants in young stands will improve habitat for saproxylic beetles

The different fauna associated with native understory deadwood (as opposed to *P. radiata*) in stands reinforces the importance of understorey plant diversity for biodiversity conservation in plantations. Stand management that encourages greater understorey development will have beneficial flow-on effects by providing resources for deadwood feeding invertebrates. Understorey development can be improved by thinning practices or including an over sowing component with seeds of native understorey plants when aerial spraying for other reasons, such as correcting trace element deficiencies.

Greater understanding of the habitat associations between native understory species and saproxylic invertebrates (or other groups, e.g., foliage feeders) would facilitate indirect monitoring of biodiversity in plantations via the measurement of plant diversity. To be successful, this approach would require detailed research of habitat associations by habitat type and geographic region, as some species are restricted by climate, e.g., average temperatures. Some of these relationships are available from existing insect collection data. An initial database could be created rapidly to capitalise on this past research, with future activities targeted to fill the gaps.

Importantly, this study makes the point that invertebrates, particularly wood decay insects, are very sensitive to changes in forest condition. This is illustrated by the distance effects and sensitivity to wood species. This raises the question of how such invertebrates could be used to monitor other management impacts such as fungicides, herbicides, fire, and woody residue management.

References

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