

An experimental approach to quantify the contribution of invertebrates to the decay of dead wood in New Zealand plantations

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Dead wood represents a significant store of carbon and other nutrients, and has important structural and functional roles in forest ecosystems (Harmon et al. 1986). Understanding the accumulation and decay rates of such coarse woody debris is crucial when quantifying changes in ecosystem carbon and nutrient storage (Beets et al. 1999). In addition to its carbon storage capacities, dead wood provides significant habitat and resources for native fauna and flora (Buchanan et al. 1999, Allen et al. 2000). Those species that are dependant on coarse woody debris to complete their life-cycle are termed saproxylic. Saproxylic is a broad term that includes a range of functional guilds, such as wood-eaters (xylophages), predators, fungivores, and detritivores (Grove 2002b). Internationally there has been significant research on the diversity and conservation requirements of saproxylic invertebrate species in managed forest ecosystems, particularly in Europe and North America (Grove 2002a, b, Vanderwel et al. 2006, McGeoch et al. 2007, Langor et al. 2008). This work has led to management recommendations stipulating the quantity of dead wood and high-cut stumps required to preserve saproxylic communities and ensure a sustainably managed forest landscape (Lindhe et al. 2004, Lindhe and Lindelow 2004, Lindbladh et al. 2007). In New Zealand preliminary guidelines have been developed to benchmark the required levels of dead wood in managed indigenous forests to average values derived from the national Carbon Monitoring System (Richardson et al. 2008).

Decomposition rates of coarse woody debris in New Zealand's *P. radiata* plantations have, or are in the process of being quantified (Ganjugunte et al. 2004, Garrett et al. 2007, Garrett et al. 2008). However, our knowledge of the diversity and ecology of saproxylic invertebrates and their contribution to the process of wood decomposition in New Zealand's native and plantation forests is limited. The only detailed study was undertaken by Somerfield (1974) who characterised the invertebrate fauna associated with *P. radiata* logs in various parts of New Zealand. Somerfield made no attempt to quantify the contribution of these species rates of wood decomposition. Evans et al (2003) did not look directly at dead wood, but at the influence that coarse wood debris has on the adjacent leaf litter invertebrate fauna.

An international literature search found an abundance

of studies that quantify the diversity of saproxylic invertebrates, and the impacts of forest management practices on these species. However, only a single study by Edmonds and Eglitis (1989) attempted to quantify the contribution of saproxylic insects to the rates of wood decomposition and subsequent nutrient release. It appears that the relative contribution of invertebrates to wood decomposition remains largely under studied. Edmonds and Eglitis (1989) cut down two large (41.7 cm d.b.h) and two small (26.3 cm d.b.h) diameter Douglas fir (*Pseudotsuga menziesii*) in Washington, USA. A total of 12 log billets (91 cm length) were cut from these trees and half were screened from insect activity. They subsequently monitored decomposition rates for 10 years and found no statistical differences in mass loss (some insects had penetrated their screens), however screened logs had lower rates of mass loss than unscreened logs in both size classes. The slightly lower rates of mass loss in screened samples would reduce the rate of nutrient cycling, whereas valuable nutrients, e.g., Nitrogen, from unscreened samples could potentially be dispersed long distance in the tissue of emerging beetles.

As part of the new Scion led programme “**Protecting and Enhancing the Environment Through Forestry**” we are attempting to quantify the contribution that insects make to the decomposition of dead wood in plantation forests around New Zealand. Eight sites have been selected that span two environmental gradients, temperature and moisture. It was deemed appropriate to control for these two variables as they are key determinants of dead wood decomposition and the diversity of understorey native plant species present in plantations (Brockerhoff et al. 2003, Garrett et al. 2007). At this stage we do not know the distribution of native invertebrates in plantations as a function of temperature or moisture. The location and general characteristics of these sites is shown in Figure 1 and Table 1.

Design

At each site two treatments were established, insect exclusion and insect attack. Insect exclusion cages were made using 1.5 x 1 mm square aluminium fly-mesh (Figure 2). Inside this sealed cage log billets were placed on a bed of peat moss, billets were 0.4 m in length and were enclosed in an additional fibre glass mesh bags (1.5 x 1 mm mesh). The dual layers of protection were necessary to separate longhorn beetles (e.g., *Prionoplus reticularis*, the huhu) that have long ovipositors which could reach through a single layer of fine mesh and lay eggs on the log billets. In addition the two layers of protection provide added

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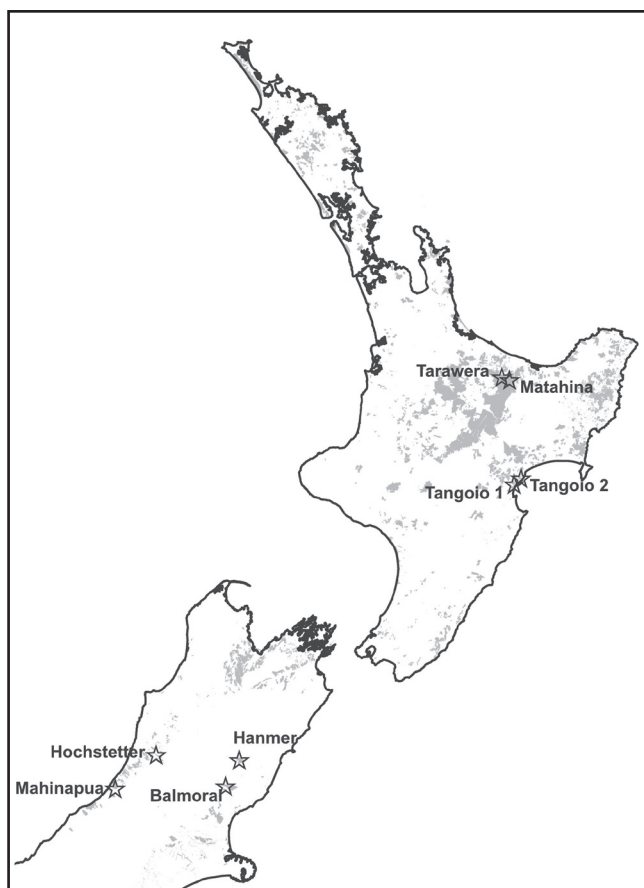


Figure 1. Location of eight study sites.

insurance against unwanted insect attacks if the larger cage was damaged by falling tree branches. The unscreened insect attack treatments consisted of identical 0.4 m log billets placed on a peat moss surface that was covered by an open sided aluminium mesh screen identical to the top surface of the cages. In addition a sheet of fibre glass mesh was pegged over the group of logs billets and then large cuts made in the fabric. Having these two screens above the insect attack samples is designed to reduce within site microclimate variation, e.g., temperature and moisture. An initial check of one site 4 weeks after establishment found that these two screens did not prevented insect attack on the log billets as shown by frass deposits from bark and ambrosia beetles.

Wood used and analyses to undertake

All timber used in the experiment was felled from a single stand in Bottle Lake Forest, Christchurch. A series of five billets were taken from a single tree and thin wood discs were cut either side of these billets. The discs provide a means to measure initial wood parameters (i.e., time 0) and sufficient billets to monitor decomposition at 6, 12, 24 and 36 months post-harvest. At this stage it is anticipated that we will monitor mass loss overtime and changes in carbon, nitrogen and potentially phosphorous from the timber billets.

Table 1. Characteristics of each study site

| Name | Mean min Temp | Mean max temp | Rainfall (cm) | Elevation m.a.s.l. |
|-------------|---------------|---------------|---------------|--------------------|
| Tarawera | 7.03 | 19.00 | 170.25 | 76 |
| Matahina | 6.89 | 17.58 | 166.25 | 280 |
| Tangoio 1 | 9.20 | 17.94 | 106.08 | 160 |
| Tangoio 2 | 9.31 | 18.18 | 105.5 | 10 |
| Balmoral | 4.37 | 16.70 | 60.25 | 267 |
| Hanmer | 3.78 | 15.84 | 96.41 | 407 |
| Hochstetter | 5.61 | 15.28 | 236.75 | 272 |
| Mahinapua | 6.75 | 15.63 | 278.07 | 67 |

Where to for the future?

In addition to monitoring changes in wood mass and nutrients the surplus billet sections will be transferred to insect emergence containers to allow saproxylic beetles to complete development, and emerge as adults. We will then analyse the community structure of the saproxylic insect communities as a function of temperature, moisture, location and time since harvest. In the near future we wish to expand on our studies of saproxylic beetle communities in different geographic regions, using a wider variety of host species and examining commercial stands and adjacent native remnants. As part of this we welcome industry partners who are interested in this subject and would like to contribute by providing study sites to collect dead wood.

Why undertake the research?

There are many reasons to undertake this important research. The emerging carbon trading market requires accurate forecasts and inventories of carbon stocks. Invertebrate decomposition is a key variable dictating the breakdown of wood and subsequent release of carbon. Understanding these processes will allow us to predict regular changes in carbon stocks, and quantify the impact of mass outbreaks of insects that could significantly alter deadwood resources in forests. In addition to the carbon markets there has been the suggestion of future biodiversity credit markets (Bishop et al. 2008). To work these markets will require reliable indicators of biodiversity across different habitat types, and an estimate of the impacts of alternative management scenarios on this biodiversity. By assessing the community composition of saproxylic beetles, this trial sets the foundations for future work towards a potential biodiversity credit markets where biodiversity value can be compared between different land use options.

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