RADIATA MANAGEMENT TECHNICAL NOTE

Site Productivity

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Influence of Native Understory Plant Species on Litter Decomposition in *Pinus radiata* Stands: An Update

Summary

Leaf litter is a significant store of carbon and other nutrients in forest ecosystems. The process of litter decomposition is complex, and only recently have scientists begun to focus their attention on the importance of mixed litter sources, the effect of these mixtures on decomposition rates, and their impacts on nutrient cycling.

The research we report here is part of a larger milestone that is quantifying the contribution of native biodiversity to ecosystem services in plantation forests. Other long term trials include an investigation of the effect that wood boring insects have on dead wood decomposition rates[1]. Here we report the results from of a pilot study that tests the hypothesis that mixing native understory plant litter with *Pinus radiata* needles will increase decomposition rates and promote nutrient cycling compared with pure *P. radiata* litter. From a management perspective we want to know if the presence of native understory plant species litter enhances overall litter decay in plantations.

Percent mass loss of mixed species litter was non-additive and could not be predicted from the decomposition rates of pure litter, i.e., the litter mixture was decomposing at a rate that was different from that of pure litter. In our pilot trials the addition of nitrogen-rich wineberry leaves did not alter the decomposition rate of *P. radiata* needles. However, the presence of *P. radiata* did increase the rate of mass loss of wineberry. At this stage we cannot determine the actual mechanism that underpins these changes in mass loss. However, we are currently examining the changes in microclimatic conditions and soil invertebrate fauna that are associated with pure and mixed sources of litter. A final report will summarise implications of the completed work to FFR members.

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The Importance of Leaf Litter and Litter Mixing

Leaf litter is a significant store of biomass in forest ecosystems. Conifers, such as *Pinus radiata*, have leaves with a relatively large proportion of dead highly lignified cells. These properties result in slower decomposition rates than most broadleaved plant species. The composition of the leaf litter on a forest floor influences many attributes of the surface soil layers, e.g., depth of accumulated litter and the soil fauna.

More than 100 years ago German foresters postulated that mixed conifer-broadleaved forests had a faster rate of litter decomposition than pure conifer forests [2]. Despite this long history, it is only relatively recently that scientists have begun to quantify the effects of mixing leaf litter on decomposition rates. Gartner and Cardon [3] reviewed over 30 studies that examined decomposition rates of 162 different leaf litter mixtures. In 108 cases there was a non-additive effect; this means that the change in litter decomposition rate of the mixture could not be predicted solely from the decomposition rates of the constituent parts. Positive non-additive effects were recorded in 77 cases where mean decomposition rate increased by 17%. However, negative non-additive effects of leaf mixtures were recorded in 31 cases with a mean decrease in decomposition rates of 9%.

A number of hypotheses have been proposed to explain these non-additive effects, namely; a transfer of nutrients from high to low quality litter, presence of stimulating or inhibiting compounds in litter from particular species, changes in microclimate conditions, (i.e., mixed litters can have a structurally more diverse litter layer that provides a more aerobic environment), and changes to soil biodiversity [4].

Why could understory native plants be a good thing in *P. radiata* stands?

The canopy of *Pinus radiata* plantations in New Zealand is traditionally a monoculture. In the absence of understory species (as occurs in drier regions or unpruned/thinned stands with high stocking rates) this produces a deep uniform litter layer composed entirely of slowly decomposing needles. Such a scenario can store considerable nutrients that may otherwise be recycled and made available for continued tree growth.

New Zealand's invertebrate biota is interesting in that many groups have a disproportionate number of

species that feed on detritus, such as leaves and twigs. However, this complex detritus-feeding biota evolved in the absence of many conifer species, particularly those of the family *Pinaceae* that includes *P. radiata*. Thus we have a situation where our local biota is not adapted to the dominant leaf litter present in plantations.

This raises the interesting question of what effect do the native understory plants have on litter decomposition and nutrient cycling in plantation stands? For example, the addition of native leaf litter may stimulate invertebrate populations that then 'spill over' onto pine needles and increase the overall rate of litter decomposition.

What we did

We have established two trials to examine the effect of mixing *P. radiata* needles and litter from common native understory plant litter on decomposition rates and invertebrate community composition.

This technical note contains the initial results of a pilot study that compared decomposition rates of pure *P. radiata* litter, pure *Aristotelia serrata* (wineberry) litter, and mixtures of the two. We chose wineberry as its litter has a relatively high nitrogen content (1.19%) compared to *P. radiata* needles (0.56%). Nitrogen content is an important predictor of decomposition rates, as it is critical element required by invertebrates and fungi in the decomposition process.

Figure 1. Mixed leaf litter bags of radiata pine needles and wineberry leaves.

Litterbags were removed from the field and invertebrates were extracted using a modified Berlesse funnel (Fig. 2) before the remaining litter in each sample was separated by species. Separated litter samples were then oven dried at 70°C for 48 hours and the remaining weight compared with the initial litter weight as a measure of mass loss.

Results

The rate of mass loss in mixed litter treatments was greater than would be predicted from the mass loss of individual species (Figure 3). Interestingly the strength of this non-additive effect, and thus the difference between predicted and actual effects, increased slightly with the increasing proportion of wineberry. Total mass loss in mixed species litter bags increased with an increasing proportion of wineberry (Figure 3). This reflects the slower mass loss of *P. radiata* needles (average mass loss across all treatments, 22.7%) as opposed to *Aristotelia* leaves (average mass loss across all treatments, 62.0%).

Figure 2. Berlesse funnels use a low powered light to dry samples from the top down. Invertebrates that seek moisture move to the base of the sample and eventually fall into the funnel and are collected in the jar beneath.

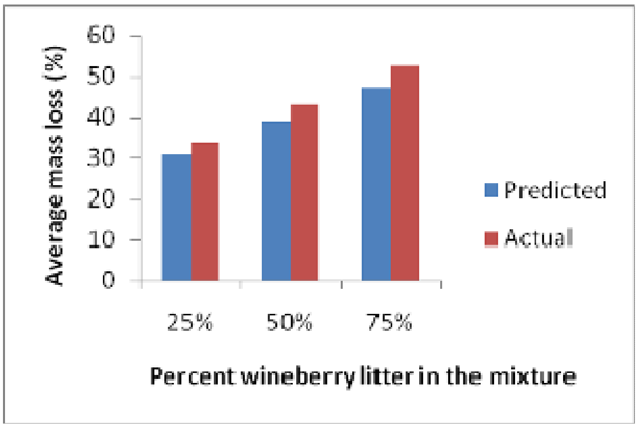

Figure 3. Actual mass loss in mixed litter treatments compared with the predicted loss rates calculated from decomposition of pure P. radiata and wineberry litter.

The faster decomposition of wineberry was anticipated, as the higher nitrogen content and lower proportion of lignified cells in wineberry leaves makes them more palatable to decomposers than *P. radiata* needles.

Variation in litter decay rates within each treatment was relatively small, as illustrated by the narrow standard error bars on Figure 3. This is encouraging as it shows that the agents responsible for decomposition were acting in a uniform manner at our study site. This is important as some biological processes can be highly variable over very short distances.

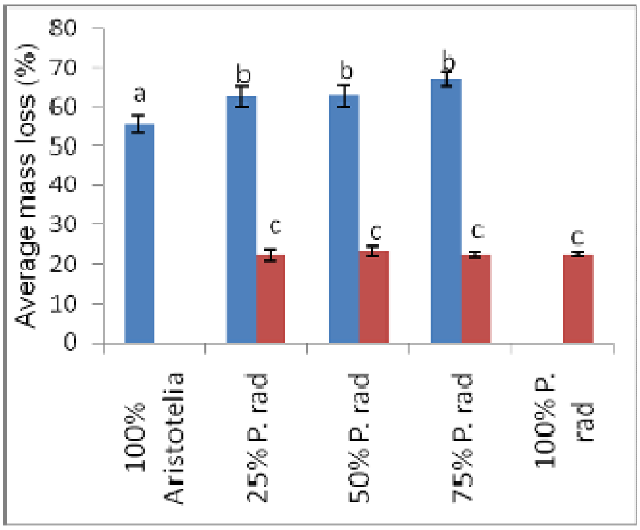

Figure 4. Average percent dry mass loss of Aristotelia serrata (blue bars) and P. radiata (red bars).. Treatments with different letters have significantly different rates of mass loss.

The addition of *A. serrata* leaves to litter bags did not change the decomposition rate of *P. radiata* needles. However, the presence of 25% *P. radiata* needles in litterbags resulted in a significant 7% increase in the short-term mass loss of *A. serrata* as compared to pure *A. serrata* leaf litter (Fig. 4). The strength of the non-additive effect increased slightly with the addition of greater proportions of *P. radiata* needles. However, there was no significant difference between treatments (25, 50, 75% *P. radiata* needles). Average mass loss of *A. serrata* peaked at 67.0% when litterbags comprised 75% *P. radiata* needles (Fig. 4).

Where to next?

The pilot study clearly illustrates the presence of non-additive effects when mixing *P. radiata* litter with a common understorey of native plant species such as wineberry. As yet we do not know the cause of the faster rate of mass loss of wineberry; however it may be related to changes in litter layer structure, e.g., pine needles prevent the thin leaves of wineberry forming a slimy matt, providing more aeration for

bacterial and fungal decomposers. Alternatively it may be due to a concentration effect where the native litter attracts decomposers from the surrounding litter. We are in the process of quantifying the impact of mixing leaf litter on invertebrate biodiversity. This will provide insights into which decomposers are associated with pine litter and whether additional biodiversity benefits are derived by the presence of a mixed understory of native plants. Invertebrate samples will be sorted in the next three months and results presented at the next FFR members' meeting. In addition we are evaluating miniature humidity and temperature sensors as a method of quantifying the microclimatic differences between pure and mixed litter types.

Additional field trials have been established to evaluate the influence of a range of different understory plant species on *P. radiata* decomposition rates. For this larger experiment, litterbags were distributed at four sites on the West Coast and included:

- *Aristotelia serrata* (wineberry),
- *Dicksonia squarossa* (treefern), and
- *Coprosma grandifolia* (Large-leaved coprosma)

The aim of this study is to see if native plant species with differing decomposition profiles have an influence on *P. radiata* litter decomposition and invertebrate diversity. The experiment is also run over a longer time period, with early decomposition rates measured at two months and a later sample at six months.

References

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