Long-term Recovery and Availability of ^{15}N-fertilizer Applied to Immature Douglas-fir

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Introduction and Background

In forest ecosystems, high amounts of nitrogen (N) are stored but only about 1% of it is available in inorganic form. Growth is therefore often nitrogen limited. Fertilization is used to increase the amount of available N for stand growth. Urea is commonly used mainly because of its high N content and low cost. However, the efficiency of fertilization is quite poor; uptake by crop trees in one growing season can be as low as 5-15% of added N and most of it seems to occur during the first growing season (Hulm and Killham 1990; Preston *et al.* 1990). If conditions are favourable for volatilization, leaching, or denitrification, there can be a loss of added N from the ecosystem. A high proportion of the added N often remains in soil in immobilized or fixed forms, but it has been shown to be more easily remineralized than native soil N (Popovic 1977). More detailed studies are needed on the long-term fate of applied N and on the nature of processes involved , so that we can determine what forest management practices could be used for optimizing tree uptake and minimizing losses of N from the ecosystem. The use of N-15 labelled fertilizers makes it possible to study nitrogen redistribution quantitatively in the ecosystem.

Previous Results

A long-term field study on 15-N uptake and growth response of added N by 11 year old lodgepole pine in interior British Columbia (Spillimacheen) was recently completed at the Pacific Forestry Centre. Small (2 m radius) single tree plots were destructively sampled, 1 and 8 years after fertilization, and recovery of N-15 in trees, understory, and soil was determined. After eight growing seasons, trees increased 34% in stem volume in fertilized plots compared to controls. However, only a small proportion of the applied N (5.8%) was taken up by plot trees, while larger proportion of it remained in the soil. Most uptake occurred during the first growing season after application and only a small additional uptake in the next 7 years (Preston 1992). It was also found that up to 50% of the soil N-15 was lost during this 7-year period, which suggests continuing mineralization of the immobilized N-15. Although insignificant amounts of residual fertilizer N-15 were taken up by trees in the field, these amounts were taken up by lodgepole pine seedlings at twice the rate of native soil N in a greenhouse study. Further research is needed to determine what factors are limiting the uptake of available N by trees.

Nitrogen Dynamics in Immature Coastal Douglas-fir Stand

A further opportunity has arisen to study the long-term fate of N fertilizer applied at an operational level to a stand type that would be a candidate for commercial fertilization. This coastal Douglas-fir stand of intermediate productivity and 40 years old at the time of application is situated on east-central Vancouver Island at Northwest Bay, near Nanaimo, and is similar to the immature stands of Douglas-fir in the chronosequence experiment. Nitrogen-15 urea (200 kg N/ha; worth $250,000) was applied in spring and fall

1982 on six (11 x 11 m^2) plots. There is good background information available on the fate of N in the first 3 years after fertilization (Nason 1989). The results agreed with previous observations that increased plant uptake of N occurs soon after application and that urea N is rapidly immobilized, with high amounts retained in soil in organic forms.

Objectives of the present study are to get better insight of mechanisms of N transformation, transport, and loss over 10 years, and to combine results with the results obtained from previous studies at Shawnigan Lake to enhance understanding of the effects and efficiency of fertilization in second-growth Douglas-fir. This is done by determining the amounts, form, and distribution of N-15 urea fertilizer in trees, understory, litter, and soil. The distribution of N-15 in various functional groups of soil fauna and the proportion in microbial biomass in different layers of forest floor are also under study. The availability of residual soil N-15, as well as native N, to trees is to be estimated by a pot trial. A second pot trial has also been established using N-15 labelled soil to examine the role of soil fauna and the importance of functional diversity of fauna on the N dynamics of these Douglas-fir forest ecosystems.

Besides urea, another common fertilizer, ammonium nitrate, was also used in the study in Spillimacheen. Once immobilized in soil in an organic form, the residual soil N behaved similarly regardless of its original form (Preston 1992). In contrast, results from a long-term forest fertilization trial in Finland, which used a slow-release form of N (urea formaldehyde), as well as urea and ammonium nitrate in a Scots pine stand, showed that the greatest amounts of N were available in urea formaldehyde-treated plots (Martikainen *et al.* 1989). Laboratory incubations using soil from the Northwest Bay site are in progress to study the initial transformations of added N-15 (urea and urea formaldehyde) and the behaviour of different kinds of organic N compounds. The results will be compared to those obtained from the field and pot trial studies.

References

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