FUTURE FORESTS RESEARCH

RADIATA MANAGEMENT TECHNICAL NOTE
Site Productivity

Number RSPTN-009

Tree Growth and N Leaching Response to N Fertiliser

Summary

There is an opportunity to increase forest productivity through nitrogen (N) fertiliser application. However, the environmental consequences of N application to forests are not well known. A new study is being set up to investigate both the tree growth and nitrogen leaching response to N application. Relationships between soil and climatic properties and tree growth and N leaching will be determined to allow prediction of both parameters in response to N application. The study will use plots at twenty Long Term Site Productivity trial sites where soils and climate have already been well characterised.

Authors: Murray Davis and Graham Coker

Background

There is an opportunity to improve plantation forest productivity through use of nitrogen (N) fertiliser. Historically, plantations were established in areas generally unsuitable for farming. Since the late 1960s, tree planting on more fertile farm sites has become common. Trees planted on farms grow 30-40% faster up to canopy closure and produce 15-25% more wood at harvest. This 'farm site effect' is attributed primarily to higher farm soil N levels because of fertiliser inputs and N-fixation by clovers. Fertiliser trials show similar results. For example, fertilised *Pinus radiata* averaged 24% more volume growth at age four than unfertilised trees in Long Term Site Productivity trial series plots (Watt *et al*. 2008). Fertilised *Cupressus lusitanica* averaged 55% more than unfertilised trees (Fig. 1). Mixed fertilisers were applied to these plots, but foliar analysis showed that the response was most likely due to N.

While there is an opportunity to improve productivity with N fertiliser, the environmental consequences of N application to forests are not well known. Few studies of N leaching have been undertaken in plantation forests in New Zealand – these have shown little N is leached from unfertilised plantations planted into undeveloped land (Hamilton 2005, Larned *et al*. 2004). In contrast, substantial N leaching may occur from plantations established in pasture, especially late in the rotation and for a short period immediately after harvest (Quinn 2005). Therefore, increased N fertilisation could lead to increased N leaching to drainage waters. The occurrence and amount of leaching is likely to be highly dependent on rainfall, soil type and stage of plantation development.

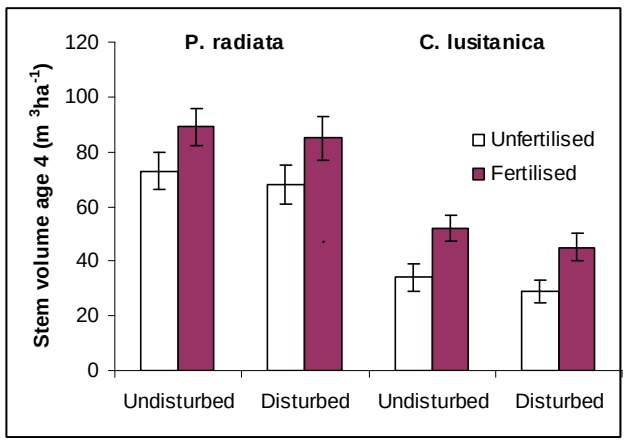

Fig 1. Fertiliser response in Long Term Site Productivity trials. Values are means of 31 sites, bars show standard errors. The disturbance at most of the sites was soil compaction caused by machinery at harvest.

A new study is being initiated to improve our understanding of both the growth response and the environmental consequences of

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz

applying N fertiliser to forests. The research areas the project will focus on are:

- Quantifying the tree growth response to N fertiliser across the forest estate, and how this varies with soil and climate.
- Determining relationships between foliar and soil indices of nitrogen availability and other variables and growth responses to enable improved prediction of nitrogen response.
- Determining N leaching losses in response to N fertilisation, and how this varies with soil, rainfall and stand characteristics.

Methods

The study will use existing Long Term Site Productivity Series 2 trial sites. This trial series is described in Watt *et al*. (2008), and featured plot installations at 35 radiata pine sites covering the full soil and climatic range experienced by plantation forests in New Zealand. The series was selected because soil and climatic parameters for the sites are already well characterised. The forest stands at the sites are now 6-9 years old. Existing permanent sampling plots at 20 of these sites will form the controls of the new study. At each of the 20 selected sites, an additional plot, to which N will be applied, is being established to match the existing plot in terms of soil, slope and aspect.

Tree dimensions will be measured in unfertilised and fertilised plots at each site to determine the growth response to fertiliser. Relationships between response and soil, climate and crop variables, including leaf area index, will be examined to determine the drivers of N response.

Suction cup lysimeters (Fig. 2) have been installed to a depth of 0.6-1.0 m (depending on site) at 10 of the selected sites to provide samples for measurement of the N leaching response to fertiliser addition. Nitrate-N (NO_3^-) concentration will be determined in leachate samples collected at six-weekly intervals. A water balance model will be used to estimate the amount of water drainage from the sites. Leachate NO_3^- concentrations will be multiplied by the estimated amount of drainage to determine the amount of NO_3^- leached. Initially, ammonium and total N will also be determined in the samples to provide information on background levels of these forms of N present.

Fig. 2. A suction cup lysimeter in a plot at Kaingaroa forest.

It is planned to monitor the growth response periodically through to the end of the rotation, but the leaching response will be monitored for only two years, unless results indicate substantial losses are likely to occur over a longer period.

Initial Results

Concentrations of the different forms of N in samples collected from the suction cups to

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz

provide background measurements, prior to fertiliser application, are shown in Table 1. At most sites, organic rather than mineral N (NH_4^+ and NO_3^-) is the dominant form present, as occurs in unpolluted natural forests (McGroddy *et al.* 2008). Three sites – Bulls, Eyrewell and Ashley – had somewhat greater NO_3^- concentrations than other sites. At Bulls, the forest was planted into pasture, so the greater levels there reflect agricultural inputs. Gorse is present at Eyrewell and Ashley Forests, so the higher NO_3^- levels at these sites reflect inputs from this N-fixer as has been found in other studies where gorse is present (Dyck *et al.* 1983, Magesan and Wang 2008). While it is possible that NO_3^- leaching may be increased by fertiliser, leaching of the organic and NH_4^+-N forms is not expected to increase..

Table 1. Concentration of different forms of N in initial samples from unfertilised control plots at 10 sites, extracted in September 2009.

Site	NO_3^-	NH_4^+	Total N	Organic N[2]
Tikitere	0.02	0.08	1.92	1.82
Mamaku	0.35	0.19	2.57	2.03
Kaingaroa	0.03	0.15	2.07	1.90
Karioi	0.02	0.09	1.65	1.53
Waimarino	0.04	0.09	1.31	1.18
Bulls	0.57	0.40	1.55	0.20
Eyrewell	1.72	0.26	3.03	1.05
Ashley	0.84	0.61		
Otago1	0.11	0.12	1.51	1.28
Catlins	0.15	0.31	1.65	1.19

1Otago Coast
2Organic N = Total N–(NH_4^++NO_3^-)

References

Dyck W, Gosz J and Hodgkiss P 1983. Nitrate losses from disturbed ecosystems in New Zealand - a comparative analysis. New Zealand Journal of Forestry Science 13, 14-24.

Hamilton D. 2005. Land use impacts on nutrient export in the central volcanic plateau, North Island. New Zealand Journal of Forestry 49, 27-31.

Larned S, Scarsbrook M, Snelder T, Norton N, and Biggs J 2004. Water quality in low elevation streams and rivers of New Zealand: recent state and trends contrasting land-cover classes. New Zealand Journal of Marine and Freshwater Research 38, 347-366.

Magesan G and Wang H 2008. Nitrogen leaching from leguminous weeds. WISPAS 100, 9.

McGroddy M, Baisden T and Hedin L 2008. Stoichiometry of hydrological C, N, and P losses across climate and geology: An environmental matrix approach across New Zealand primary forests. Global Biogeochem. Cycles 22 (1), GB1026.

Quinn J. 2005. Pine plantations and water quality in central North Island lakes. Tree Grower, November 2005, 31-32.

Watt M, Davis M, Clinton P, Coker G, Ross C, Dando J, Parfitt R and Simcock R 2008. Identification of key soil indicators influencing plantation productivity and sustainability across a national trial series in New Zealand. Forest Ecology and Management, 256, 180-190.

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz