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Technical Note

The Accelerator Trial series – underlying concepts and progress at the first trial site

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Summary: The core focus of the Accelerator Trial series is the development of novel treatment combinations that provide forest managers with cost-effective options to increase the productivity of any given radiata pine plantation and approach the biological potential of the site. Given the wide range of potential limitations to productivity, and that the removal of one limitation will only promote the next limitation, multiple treatments will be needed. In this technical note we provide more details around the range of sites and site properties being studied in this trial series, the rationale for the inclusions of these sites, and treatments that will be tested in the trials themselves. Specific attention will be given to the development of the first Accelerator trial, as the initial tranche of site modification treatments at this site have already begun.

Introduction

The forestry sector has set the ambitious target of increasing the value of New Zealand's forest exports to $12 billion by 2022[1]. Meeting this goal will require investment and development across all components of the supply chain, but will ultimately rely on the ability of the sector to sustainability increase the productivity of the New Zealand radiata pine estate. Given the size of this challenge, and wide range of climatic and soil conditions that influence the performance of the estate, and the need to develop sustainable systems that retain licence to operate, it is clear that concepts like throwing on a bit of urea will no longer be sufficient.

The "Growing Confidence in Forestry's Future" (GCFF) research programme[2] has responded to these needs by developing the Accelerator Trial series. This trial series has been designed to identify the key current and future limitations to productivity at specific sites, and then sequentially overcome these limitations through the application of targeted interventions based on state of the art science.

This science is supported by past research into tree nutritional status, indices of soil fertility, silviculture, and genetics which have altered biomass, nutrient uptake, tree water use, and stand productivity across a range of sites and initial conditions. This research suggests that stand productivity can be approximately doubled through combining site fertility improvements with the use of superior genotypes grown at a final crop stocking level that fully utilises the carrying capacity of the site.

This trial series is the flagship project of the GCFF programme, with ongoing management interventions at the sites planned to extend throughout the life of the planted radiata pine rotation. This also provides the additional benefit of generating full rotation data sets, which are critical to demonstrating the long term sustainability of the treatments. The various treatments to be tested are beyond "business as usual", and leverage off the advances made in the previous MBIE funded "Future Forests Research" (FFR) programme to develop new, practical management options that can be used with confidence.

In this technical note the process for identifying candidate sites, developing treatment options and the implementation of those treatments will be presented. The establishment and management of the first Accelerator Trial site will be presented in detail as the first tranche of treatments at this site have recently commenced.

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Trial Site Identification

To ensure relevant sites for the Accelerator Trials were found, two strategies were pursed. Firstly, a national productivity gap analysis model[3] was developed to project the likely impact of altering various site parameters on future productivity, then compare this to the known productivity figures for that area of forest. The difference between the current and potential productivity figures was then assessed to determine the extent of the productivity gain that could be made. This analysis also included a consideration of the how representative any given site was compared to other forested areas, with a view to making sure that any research done at that specific site would have utility across a sufficiently large area of the national estate. This modelling work focused on factors that contribute to forest productivity to provide guidance on fertility treatments.

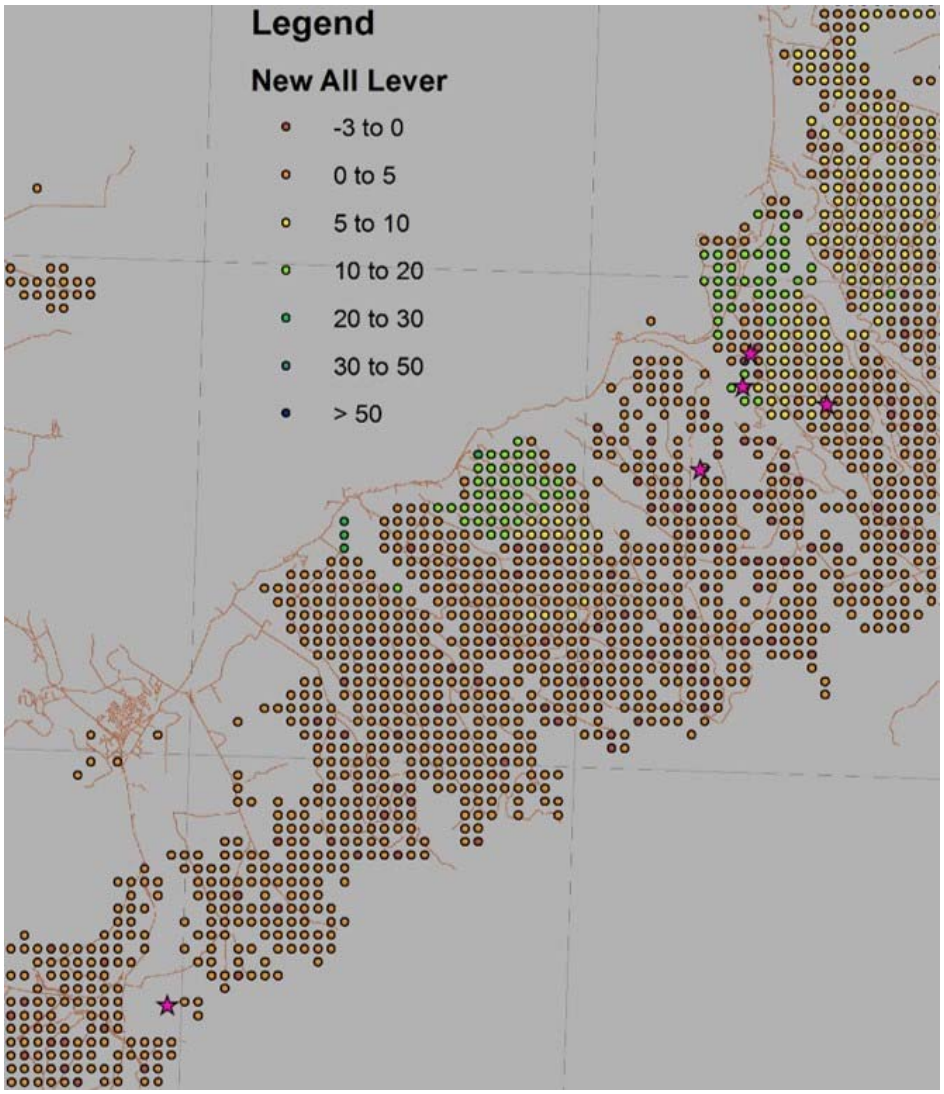

Figure 1 An example of the output of the productivity gap analysis model, identifying areas where the greatest gains in productivity could be made.

The second strategy for site location was based on identifying areas with known resource limitations, such as moisture and phosphorus. This was determined through examination of historical records, past trial results in the area and consultation with forest managers to obtain local knowledge. In all cases, field visits, soil sampling and other site characterisation efforts were carried out to confirm the nature of the site limitations. Site simulations with NuBalM[4] are also being used to provide a greater understanding of nitrogen (N) and phosphorus (P) dynamics at the sites, and also to provide estimates of the change in N and P availability required to meet productivity targets. These strategies have resulted in the selection of six sites, shown below.

Table 1 Accelerator trial site locations.

ID	Establishment	Location
556_1	2015	Southern Kaingaroa
556_2	2016	Rangipo
556_3	2016	Central Kaingaroa
556_4	2017	Ashley
556_5	2017	Tairua
556_6	2018	Otago region

Trial treatments

The Accelerator trials are established following a split plot design, using a single plot for treatment that contains 12 subplots each populated with the different stock types. This approach reduces the risk of cross-contamination between treatments.

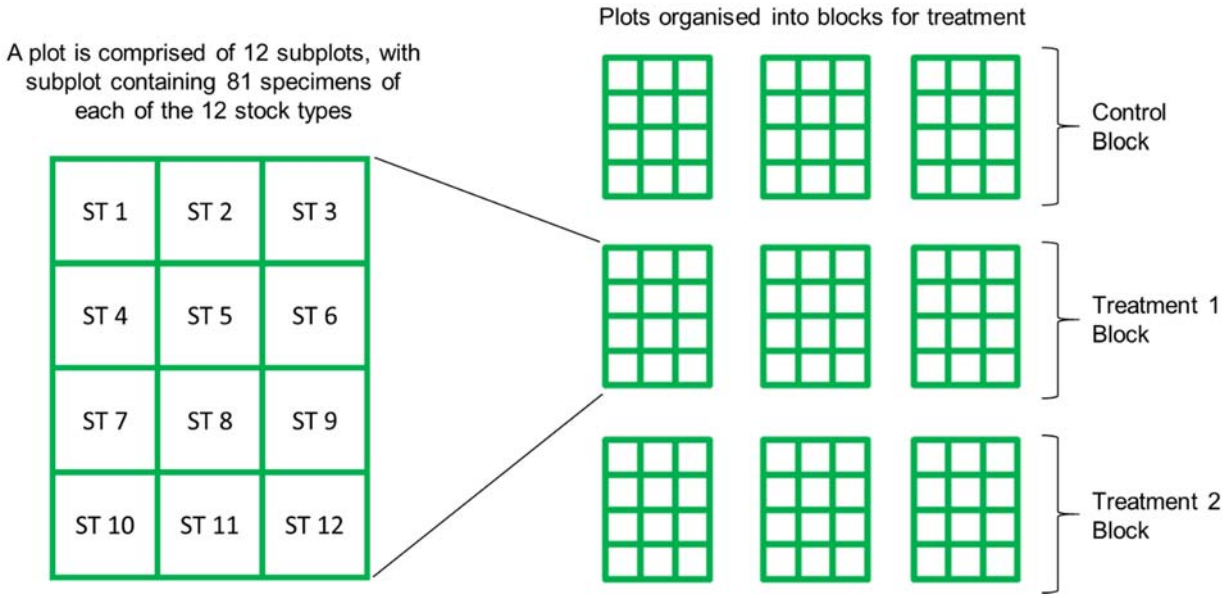

Figure 2 Layout of the subplot, plots and blocks in the Accelerator trials.

Stock selection

Different radiata genotypes vary in their tolerances and responses to their environment, which is known to impact on site productivity and the uniformity of the trees[5]. Consequently, the selection of the stock that populates the Accelerator Trials represents the first treatment. This is also the only treatment which is common across the sites. While the length of time taken to establish the sites means that the exact same genotypes were not available to be included all trial sites, the same combinations of traits have been maintained. These are:

- High DBH
- High MOE
- High density
- Low density
- Dothistroma resistance
- Drought tolerance

A stable combination of these traits has been provided through ten selection of 10 clones, an Attenuata x Radiata (Cedross) pine hybrid, and a GF19 seedling. Note that given the dominance of radiata pine in the New Zealand planted estate, only this species was chosen for use in the trials.

Nursery management

Research conducted in the FFR programme has established the potential to improve seedling quality when leaving the nursery gate[6], and the results of further investigations into nursery management conducted under the GCFF programme have confirmed the significance of this in the nursery and for the post-nursery success of the stock.

Consequently, alternations to standard nursery management, based on recent results from operational scale nursery trials, will be implemented during the initial development of the stock to be planted in the 2018 Accelerator Trial.

Site Management

It is anticipated that the site management factor will have the greatest impact on the outcomes of the Accelerator Trials, as this represents the greatest external influence on the trees during their time in the planation. Examples of the drivers that will be modified and studied include:

- N availability
- Phosphorus availability
- Trace element availability
- Moisture availability
- Disease incidence
- Soil structure
- Site preparation
- Weed control

The design of the trials will also enable any interaction between site treatments and tree stock to be identified, and the impact on productivity to be determined. As noted, each site will received multiple treatments to address the most pressing limitation to productivity as the site develops through time. For several sites, it is anticipated that these limitations will change as the trees mature.

Silvicultural Management

Planting and maintaining a sufficient number of trees is a critical step towards reducing the gap between

the total biomass produced and the useable biomass extracted. Analysis suggests that New Zealand planted forest have historically been understocked[3], which has negatively affected productivity. In the Accelerator Trials, stocking rates will be informed by the latest research conducted to assess carrying capacity, modified by an influence of the applied treatments to enhance the carrying capacity of the site. A treatment of this kind has already been put in place in the Rangipo Accelerator Trial (556_2). This site was established on a relative fertile ex-pasture, where, with the expected improvement in tree uniformity achieved by using subplots each with a single stock type, it should be possible to support a higher final crop stocking rate. This was included in the trial design by establishing half the trial at the standard stocking rate for the area (833 sph), and the other half at an enhanced rate (1282 sph).

Other studied parameters
The effect of the treatments on wood quality will be assessed, including the effects of tree stock type and the effects of the site management treatments such as nutrient additions. This is a necessary component of the trial work given the known potential for fertiliser amendment to diminish wood quality[7].

A key area of additional research will be examining how the stock type and site management treatments affect the activity of soil microbial communities. These communities have the potential to strongly influence tree growth, and their functions are sensitive to variations in forest management[8,9] .

The environmental outcome of the treatments, and the long term sustainability of the treatments for the nutrient capital in the site will also be studied at all sites. This concern directly relates to issues around the maintenance of licence to operate, and the ability of the site to continue to support planted forests over multiple rotations[10].

Progress at the Southern Kaingaroa Trial

This site was selected due to the inability of the previous rotation to generate sufficient biomass to produce a pool of available N in the organic cycle. While the site had a sufficient reserve of available N in the soil (determined using three pre-harvest sampling plots located adjacent to the trial area to be 2440 kg per ha to 30 cm depth), the trees were apparently unable to readily access that N. This was considered to be the critical limit to productivity at the site, as each new rotation would struggle to acquire the initial nutrients needed from soil and remaining harvest residues. The lack of a sufficient organic layer during the growth of the previous rotation meant few nutrients were available from this source for the following rotation.

Figure 3 .Following harvest, very little organic matter was left on site to provide nutrition for the growth of the next rotation

A 44% increase in productivity compared to the previous rotation was set as the initial target for this trial site. NuBalM was implemented to determine the additional N required to enter into the organic cycle to achieve this productivity gain, and this figure was estimated to be 500 kg per ha. In addition, P and magnesium would also need to be added. Further modelling determined that once the additional N was in the organic cycle it would be largely retained, supporting increased productivity for subsequent rotations as well.

Terrain maps and on the ground observations were used to identify suitable locations for the plots at the site. Plots were established in blocks of three, with each plot established as described in Fig 2. From within each block, one plot was assigned as the untreated control, another was assigned to be treated with 500 kg N per ha in the form of urea, and the last was assigned to be treated with biuret at 125 kg N per ha. Fertiliser use efficiency will be enhanced by applying urea and biuret when NuBalM indicates that

native supplies are inadequate to meet the growing demand for nutrients associated with tree canopy development. The fertiliser prescription currently being developed will ensure that potential losses from volatilisation and leaching are minimised.

Biuret was selected as an alternative N source for two reasons. Firstly, it is a known stimulant of microbial activity, and therefore has the potential to enhance access to the reasonable pool of apparently recalcitrant N that is present in the soil at the site. Secondly, biuret has been shown to act as a very efficient N supplement for radiata pine seedlings in a number of nursery trials, repeatedly providing greater N to the growing seedlings than greater masses of urea.

In December 2016 the first application of biuret was made to the site, with the equivalent of 1/3 of the total N dose delivered to each seedling. The remainder of the biuret dose will be delivered in Spring 2017. The urea treatments will also begin at this time.

The site has also been flown by UAV in order to collect survival data from the developing seedlings. This will be repeated through time to provide growth data, and will be combined with on the ground growth measures to help improve remote phenotyping efforts.

Beyond the site characterisation data, no results are yet available from this trial. By September 2017 two years of growth data will be available assessing the variations between the genotypes. The following year the initial growth results of the N treatments will be available.

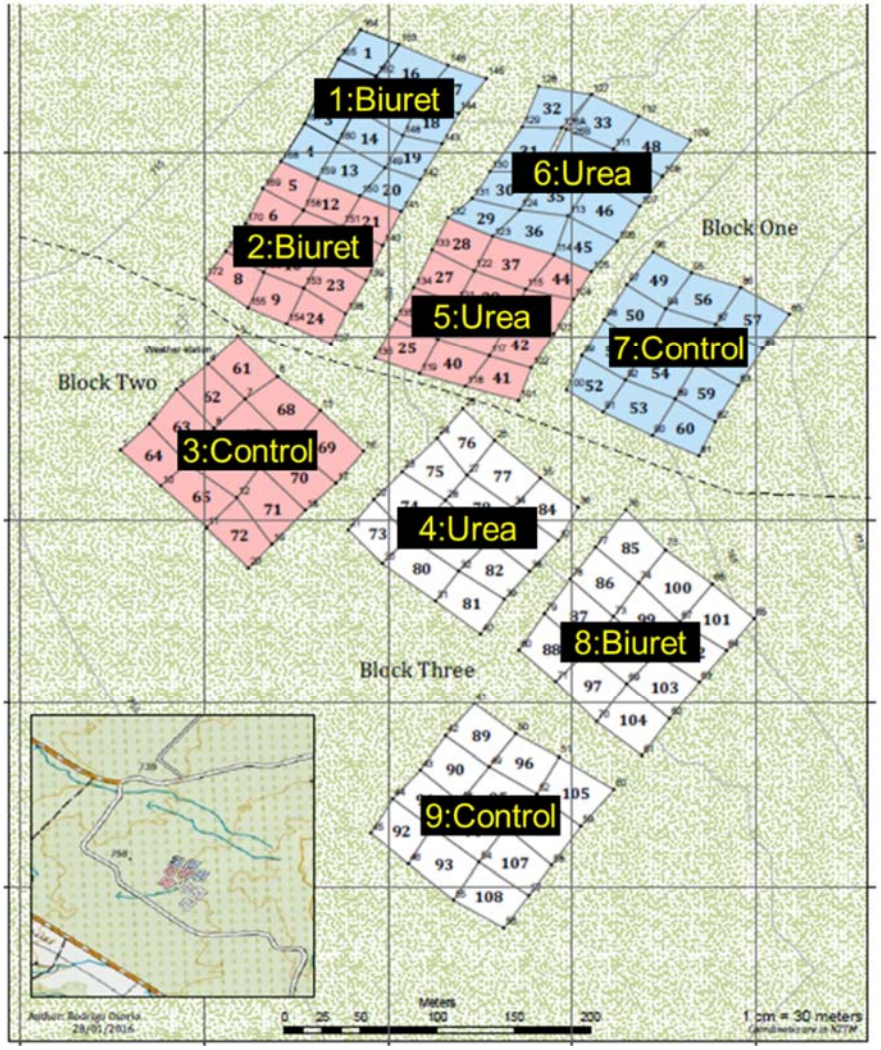

Figure 4 Layout of the plots and initial treatment designations at the Southern Kaingaroa Accelerator trial.

Acknowledgements

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