Accelerator trial update 2021

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EXECUTIVE SUMMARY

Analysis of growth data from the three oldest Accelerator Trial sites (Southern Kaingaroa, Rangipo and Central Kaingaroa) indicates that the treatments identified and applied to enhance productivity at these particular locations are having a positive impact on growth, albeit partially at Central Kaingaroa. Given the size and age of the trees it was then relevant to consider the thinning options to maximise the potential productivity and financial returns available from the sites. This was achieved by developing and evaluating numerous scenarios using the Forecaster tool. The optimal scenarios are presented and discussed, however further data and stakeholder engagement is needed before any decisions are made regarding the thinning regime that will be applied at the oldest Accelerator Trial sites. A brief summary of activity and plans at the other three sites (Ashley, Tairua and Tokoiti) is also provided.

INTRODUCTION

The Accelerator trials were established under the MBIE GCFF programme from 2015 – 2018 with the intention of supporting the forestry sector's goal of sustainably increasing the productivity of the New Zealand planted forest estate [1]. The treatment applied to each site of the six trial sites (Fig. 1) are largely site specific, based on a detailed assessments of site properties and the potential pathways to achieve productivity gains based on the current limitations. At all sites the treatments included the selection of various radiata pine genotypes (Table 1), while the optimisation of nursery practice to raise that stock, and significant modification to site preparation and establishment practices were also employed at some sites (Rangipo, Ashley, Tokoiti). Following establishment, nutrient management treatments have been applied to selected sites as well (South Kaingaroa, Central Kaingaroa, Tairua).

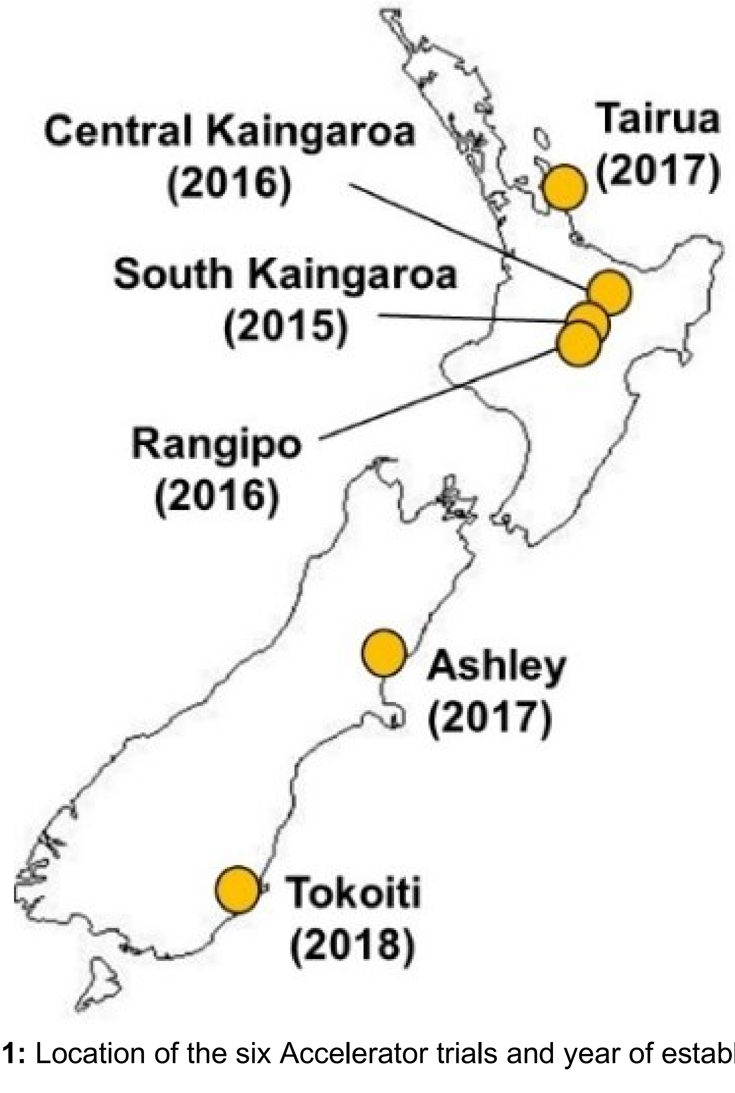

Figure 1: Location of the six Accelerator trials and year of establishment.

Table 1: The traits of the stock types used in the Accelerator trials and their distribution across the trial sites.

Stock Code	High DBH	High MOE	High density	Low density	Dothistroma resistant	Drought tolerant	Sites present
15	✓	✓	✓		✓	✓	All sites
19	✓	✓		✓			All sites
24	✓	✓	✓			✓	1,2,3,4,5
25	✓	✓	✓				1,2,3
30	✓	✓		✓			1,2,3
31					✓	✓	1,2,3
37	✓	✓		✓			1,2,3,4,5
38	✓	✓	✓		✓		1,4,5,6
43	✓	✓		✓			All sites
48	✓	✓	✓				All sites
50	✓						4,5,6
60	✓	✓	✓		✓		2,3,4,5,6
66	✓	✓		✓			6
74	✓						4,5,6
77	✓	✓					6
A x C hybrid						✓	All sites
GF19							All sites

Overall, specific focus has been given to treatments and treatment application processes that have the potential to improve the site rather than just the growth of the current crop. Considerable detail regarding the design, conditions and treatments to date at each of the site has been provided in various previous technical and file notes[2-6], and will therefore not be reiterated here. The focus of this report is to identify the need to apply appropriate silvicultural management to the trial design given the age, growth rate and treatment response of the trees at the first three trials (Southern Kaingaroa, Rangipo and Central Kaingaroa), and then to communicate the plan than has been developed to meet this need. A brief update on the other three sites is also provided.

ASSESSMENT OF RECENT GROWTH DATA

Southern Kaingaroa

This site is nitrogen (N) limited, and therefore manipulating N availability underpins the current treatment plan at this site. However, the site is also poor in a number of other elements as well. Consequently, the long-term objective at this site is to address these issues by allowing the current rotation of trees to develop a greater biomass, increasing soil organic matter nutrient pools and thereby improving site productivity in perpetuity. The treatments deployed to achieve this objective are urea and biuret[7], with the timing and rates of application guided by NuBalM[8]. Prior to the 2021 tree measurement, the urea treatment involved the broadcast application of 150 kg ha^{-1} of N over three events and the biuret treatment involved the application of 22.2 kg ha^{-1} of N directly to an area of one m^2 around the base of each tree, split over four application events.

The 2021 growth data indicate that both the urea and biuret treatments significantly increased live volume at the Southern Kaingaroa trial site at age six (Fig. 2). Biuret application increased volume numerically more than the urea treatment, but this difference was non-significant.

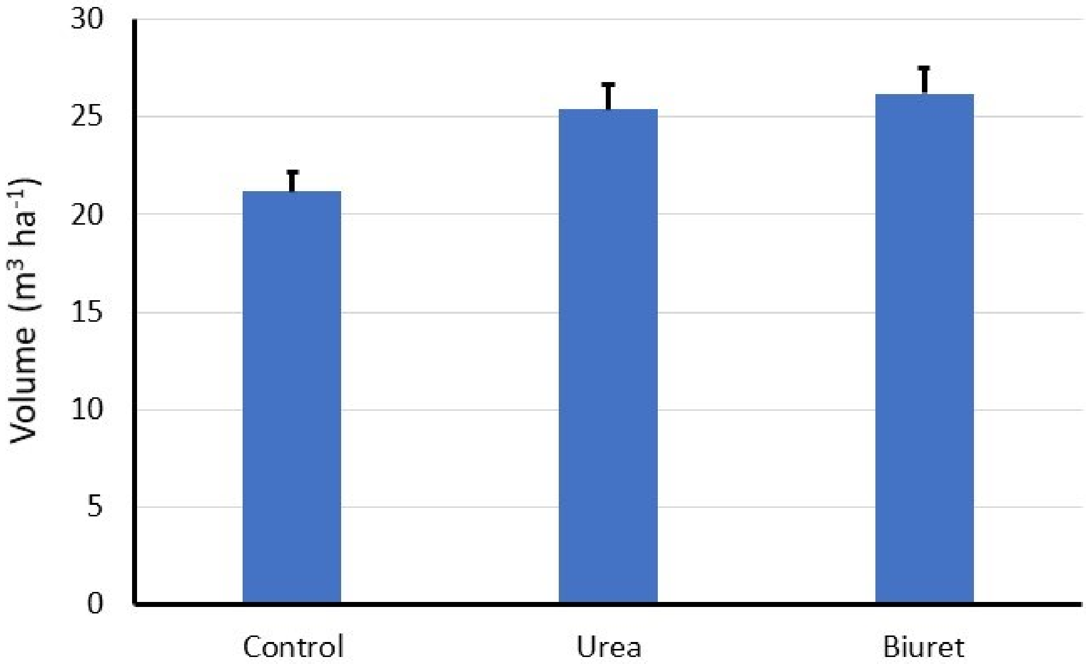

Figure 2: Volume response to nitrogen addition at the Southern Kaingaroa Accelerator trial. Error bars indicate standard error of the mean.

Further analysis revealed that the volume gains at age six were driven by increases in basal area with urea and biuret (both $P < 0.001$) (Fig. 3) as mean top height was statistically unaffected by either treatment relative to the control (Fig. 4).

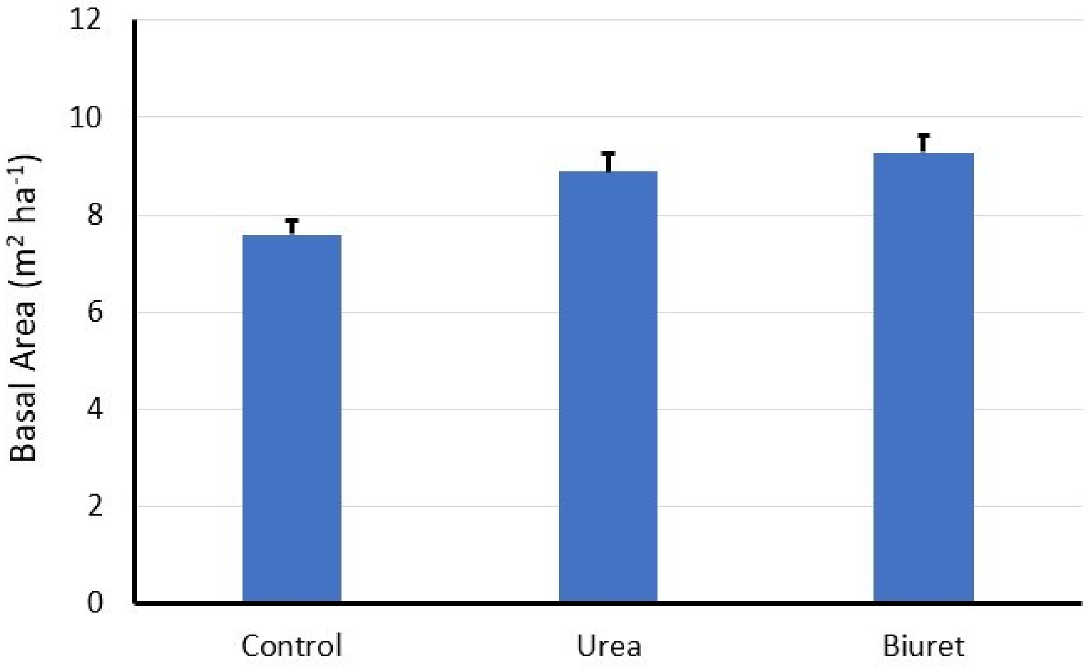

Figure 3: Basal area response to nitrogen addition at the Southern Kaingaroa Accelerator trial. Error bars indicate standard error of the mean.

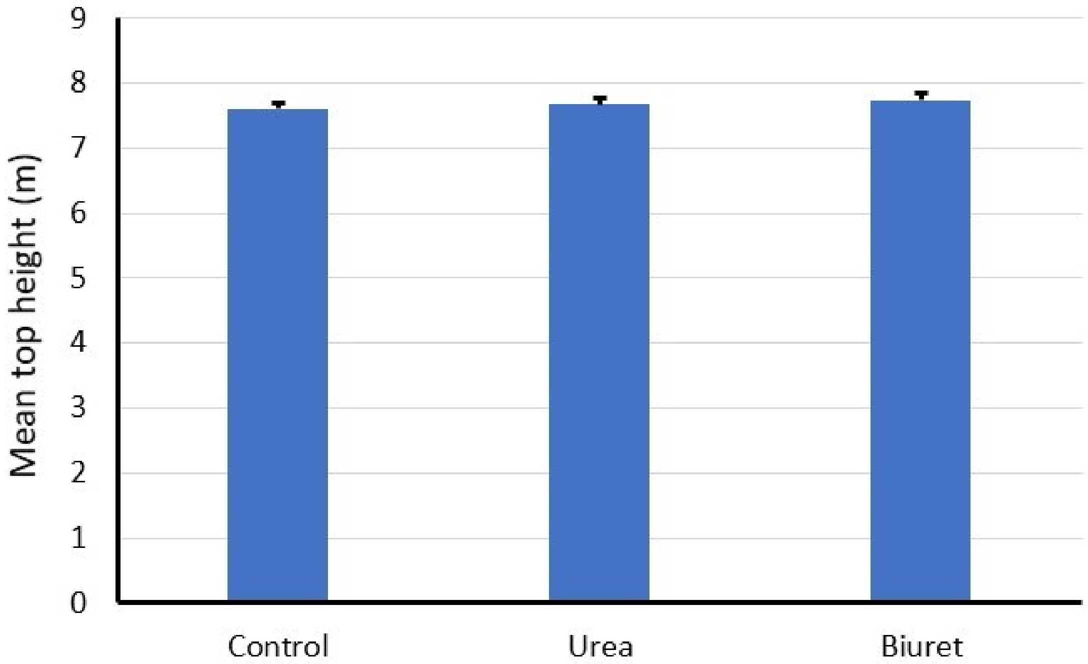

Figure 4: Mean top height response to nitrogen addition at the Southern Kaingaroa Accelerator trial. Error bars indicate standard error of the mean.

Significant variation between the different trees (10 clones, the AxC hybrid, and GF19) was also observed ($P < 0.001$). Clone 31 displayed the greatest volume, but clustering made it more meaningful to place the trees into one of three groups as shown in Fig. 5. The variation in basal area and mean top height are shown in Figs. 6 and 7; for basal area only the smallest three trees separated into a group whereas for mean top height the response was on a gradient. No significant interactions between N addition treatments and the stock were observed.

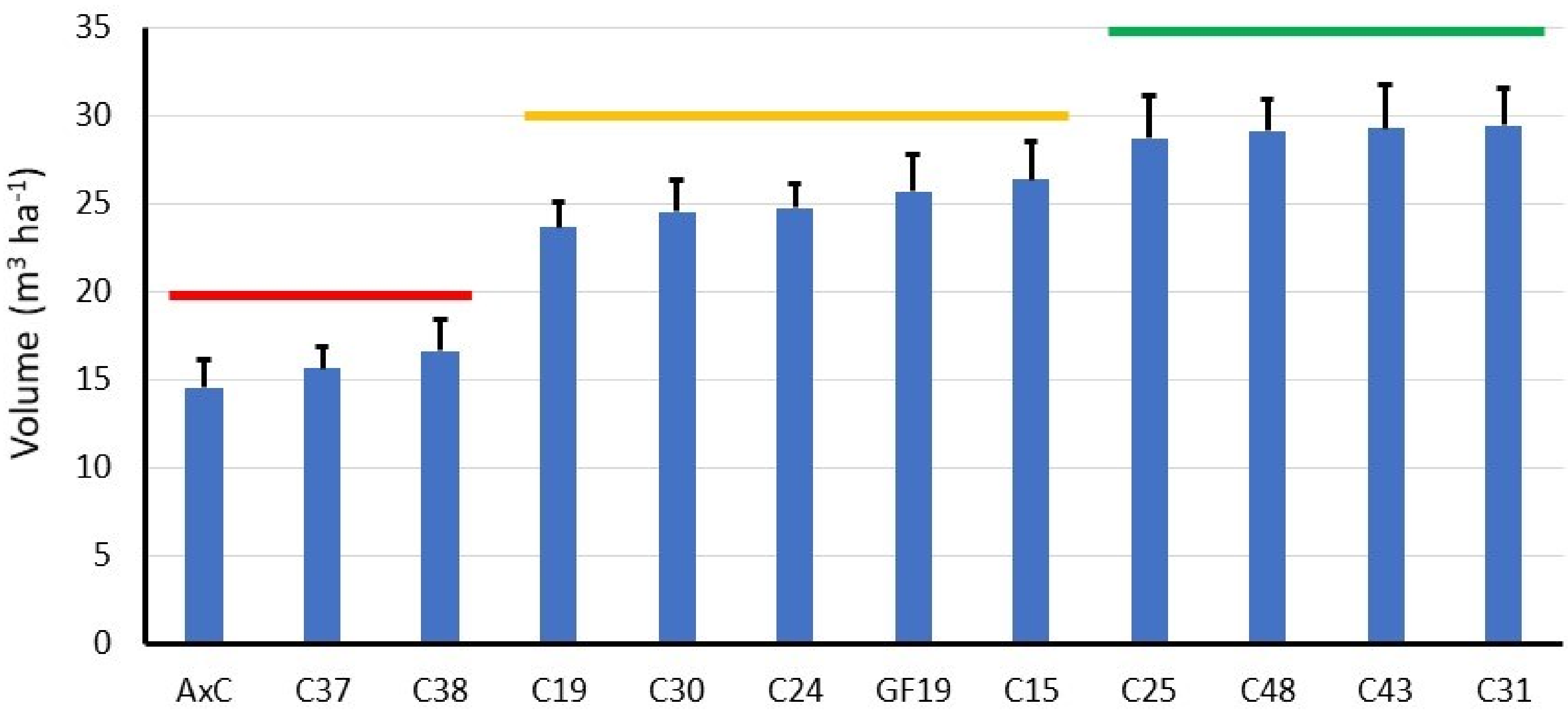

Figure 5: Variation in the volume of different stock at the Southern Kaingaroa Accelerator trial, differentiated into three broad groups. Error bars indicate standard error of the mean.

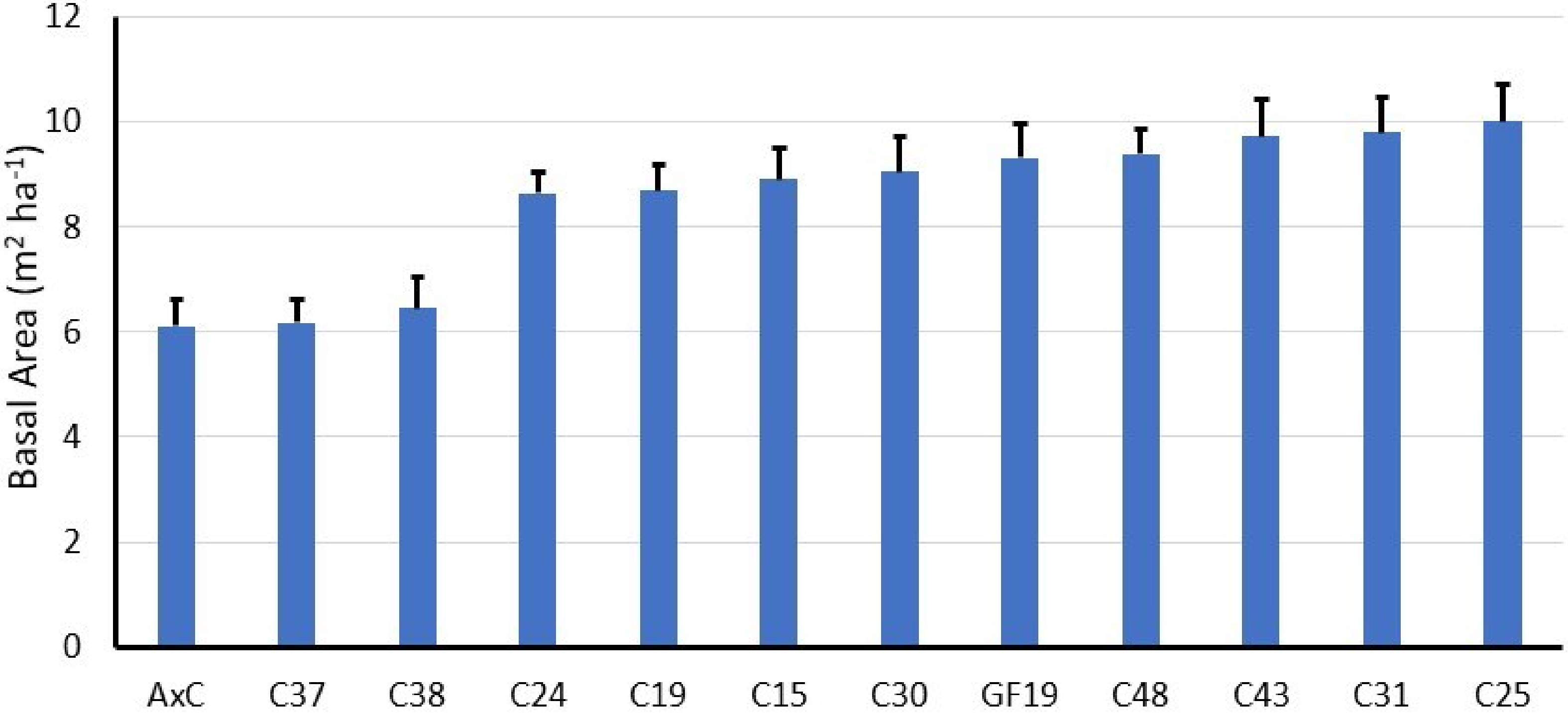

Figure 6: Variation in the basal area of different stock at the Southern Kaingaroa Accelerator trial. Error bars indicate standard error of the mean.

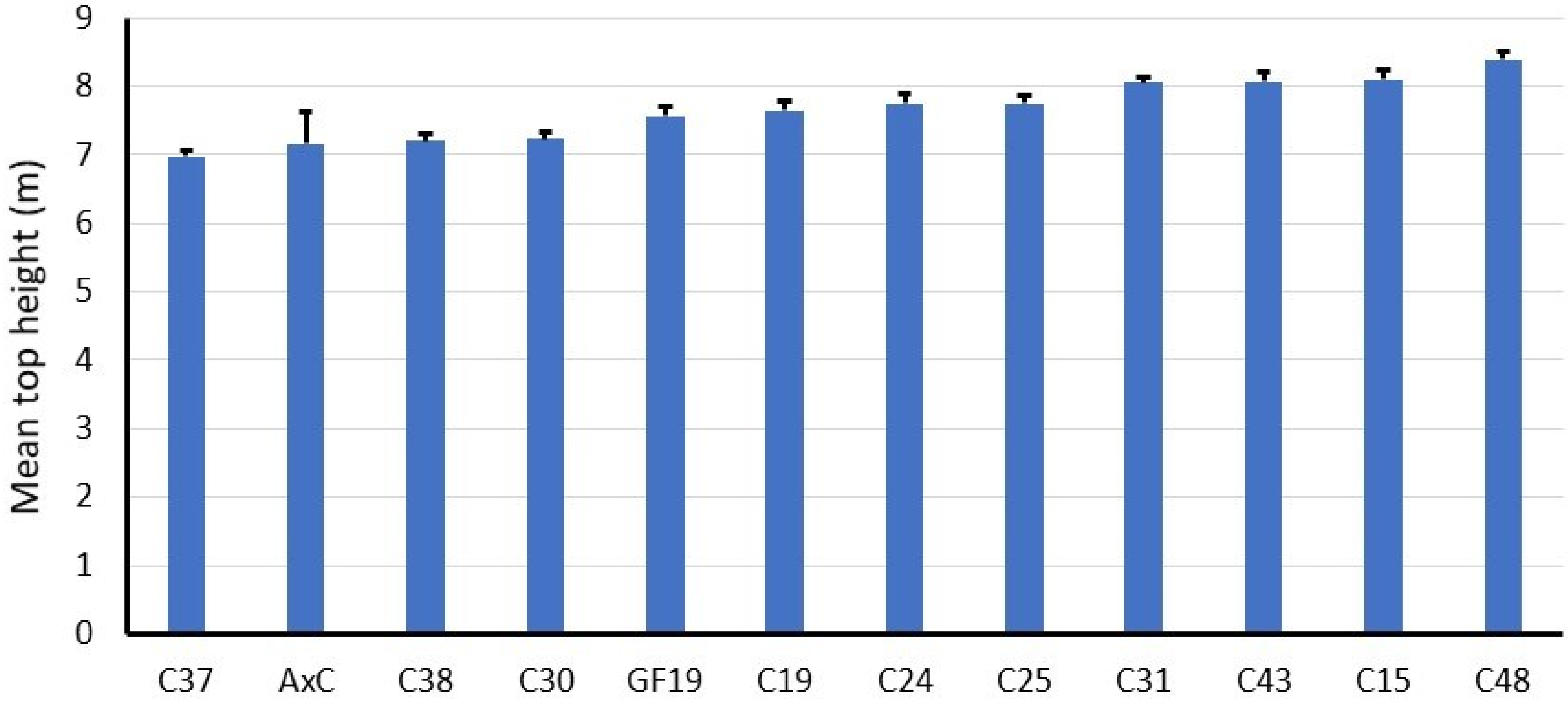

Figure 7: Variation in the mean top height of different stock at the Southern Kaingaroa Accelerator trial. Error bars indicate standard error of the mean.

Rangipo

The Rangipo trial was an afforestation planting established on a moderately fertile ex-farm site. A site preparation treatment was applied here by comparing the standard afforestation cultivation practice of ripping with planting into the undisturbed surface. In addition, the standard stocking rate of 833 sph was compared to 1282 sph as it was suggested that the improved nutritional status of the site would support this. The initial concept was to test which treatment combination would enable rapid exploitation of this relatively fertile site.

As expected from previous growth data, the greater stocking rate at Rangipo resulted in greater live volumes at age five when measured in 2021 ($P < 0.001$), but high stocked plots also benefitted from a lack of cultivation far more than low stocked plots ($P < 0.001$) (Fig. 8). The lack of cultivation did numerically enhance volume at the lower stocking rate, but this was not statistically significant.

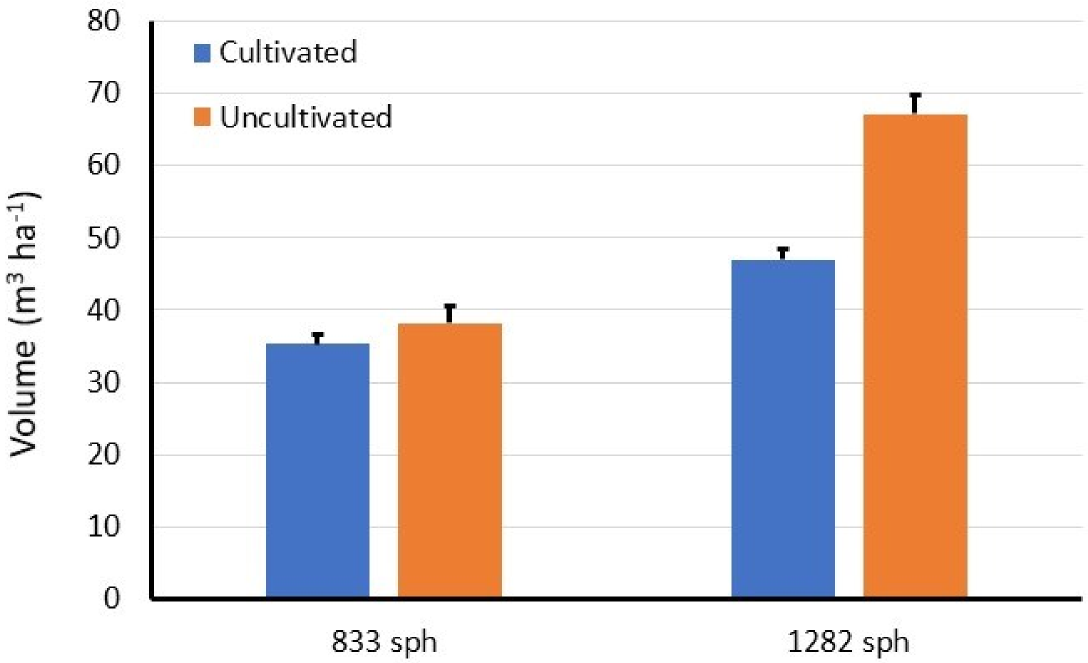

Figure 8: Variation in the volume at the Rangipo trial with cultivation and stocking rate. Error bars indicate standard error of the mean.

The observed volume gains associated with the greater stocking rate and the no cultivation treatment were also reflected in the data for basal area and mean top height (Figs. 9 and 10). These increases with greater stocking rate, and in the uncultivated high stocked plots were also statistically significant at $P < 0.001$.

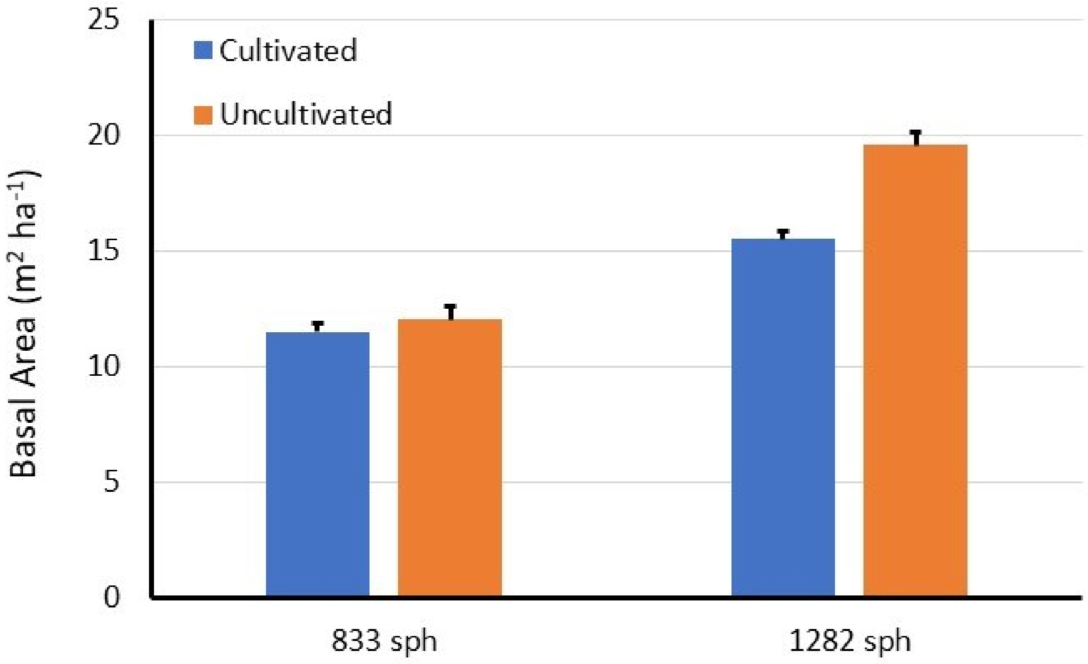

Figure 9: Variation in basal area at the Rangipo trial with cultivation and stocking rate. Error bars indicate standard error of the mean.

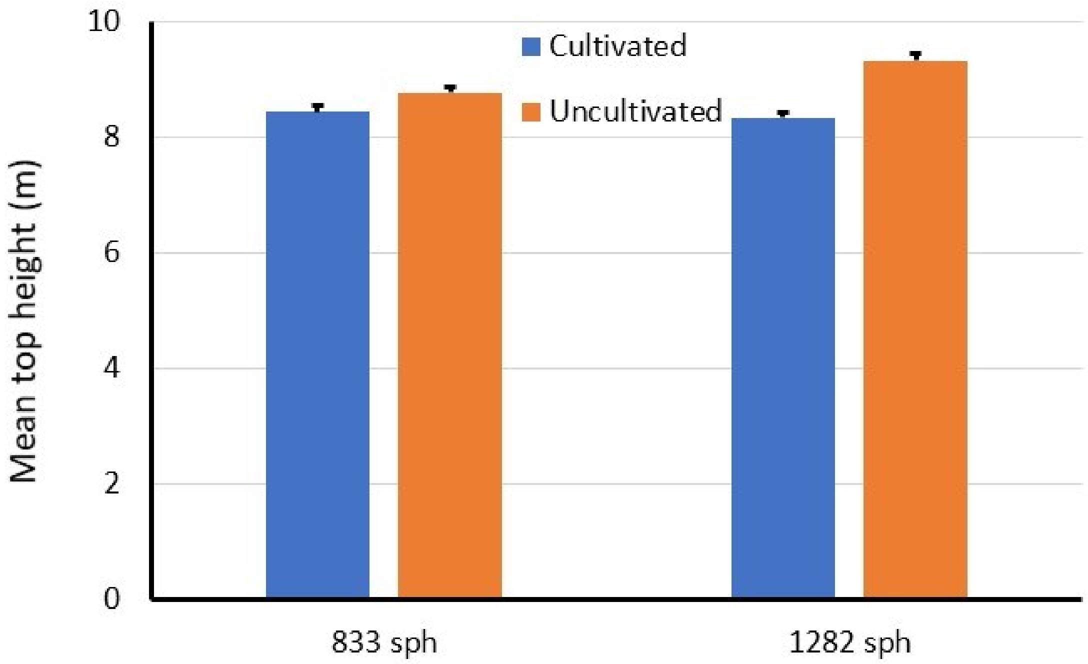

Figure 10: Variation in mean top height at the Rangipo trial with cultivation and stocking rate. Error bars indicate standard error of the mean.

Volume at Rangipo varied significantly with clone ($P < 0.001$), but it was observed that the best performing stock also tended to perform proportionally even better at the high stocking rate ($P < 0.001$) (Fig. 11). This outcome was also evident in the data for basal area at Rangipo (Fig. 12) but not to the same extent for mean top height (Fig. 13). Although mean top height did vary significantly with stock ($P < 0.001$), the extent of any effect and interaction was far less, indicating variations in basal area were driving the observed variation in tree volumes.

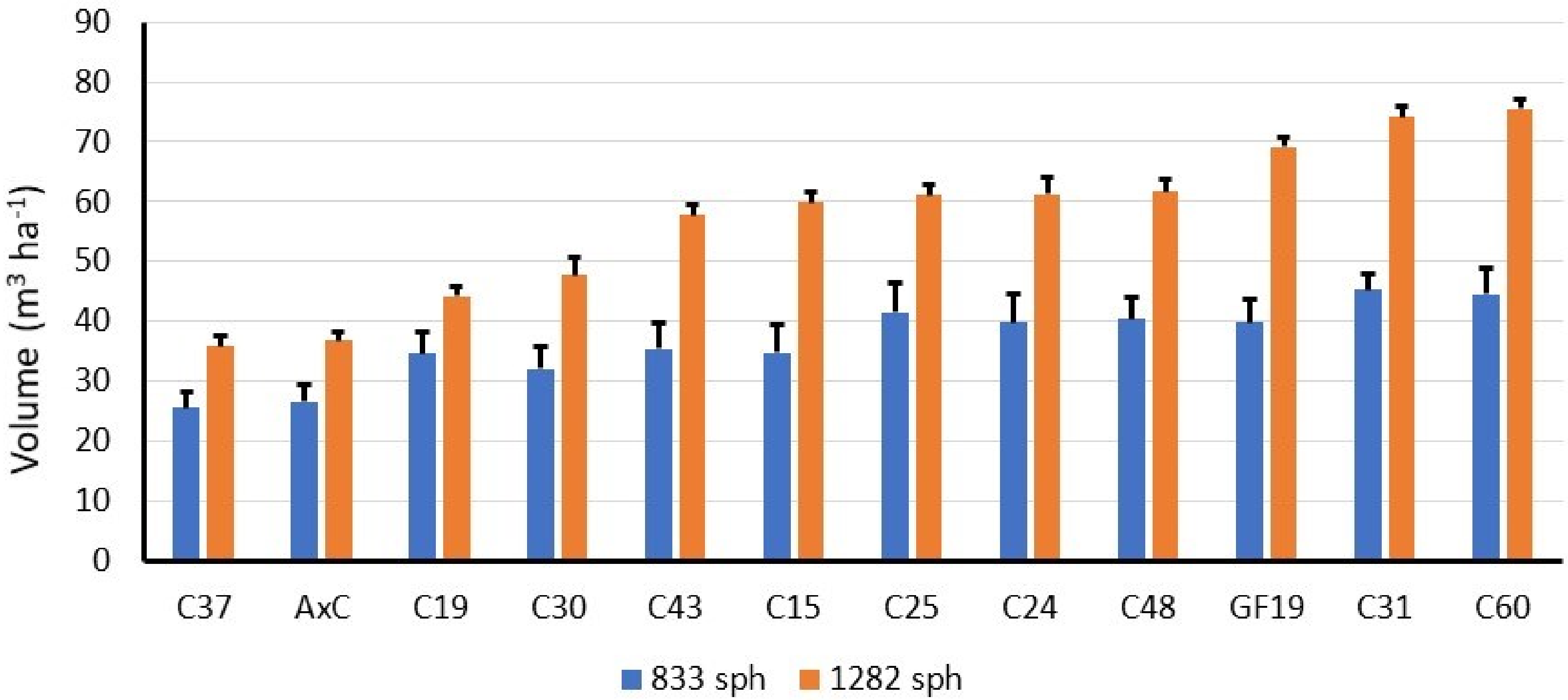

Figure 11: Variation in the volume of different stock at the Rangipo Accelerator trial, indicating the relative response to stocking rate. Error bars indicate standard error of the mean.

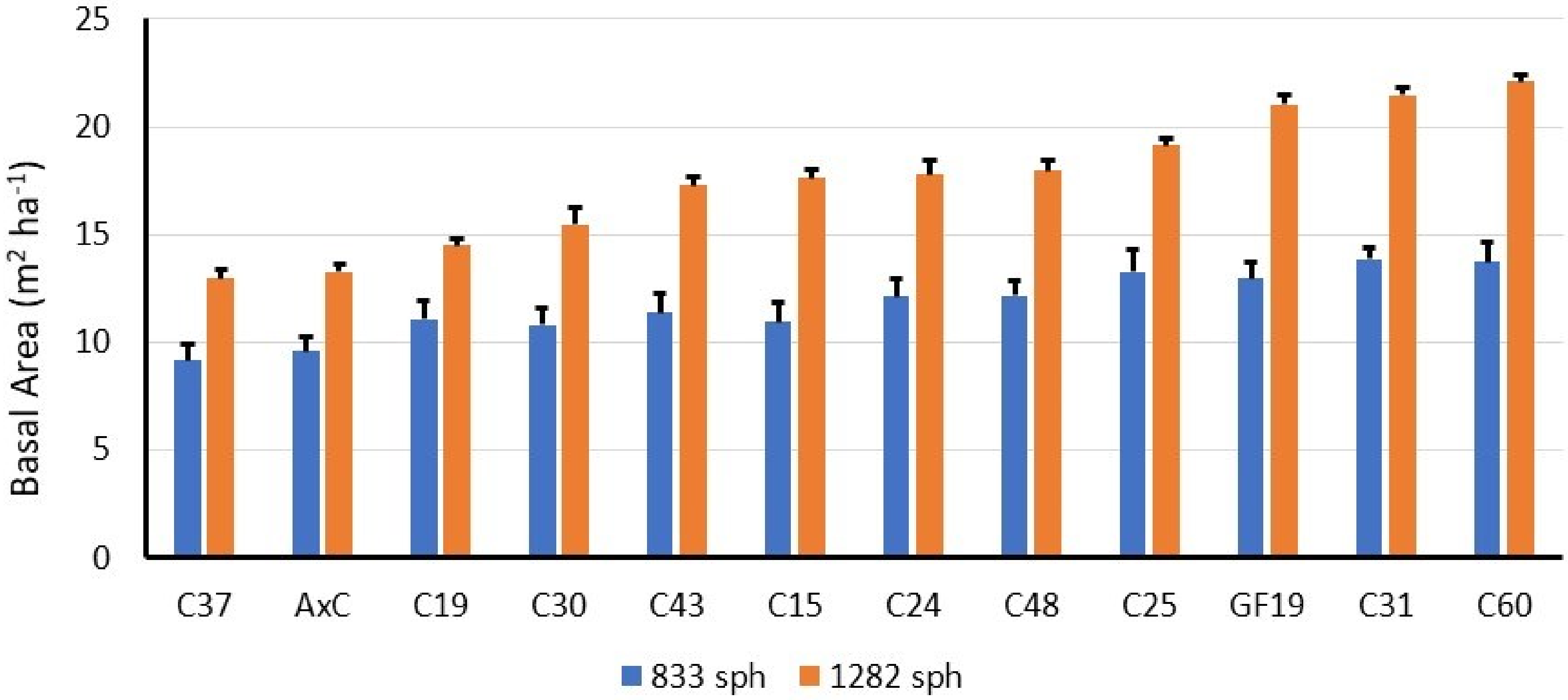

Figure 12: Variation in the basal area of different stock at the Rangipo Accelerator trial, indicating the relative response to stocking rate. Error bars indicate standard error of the mean.

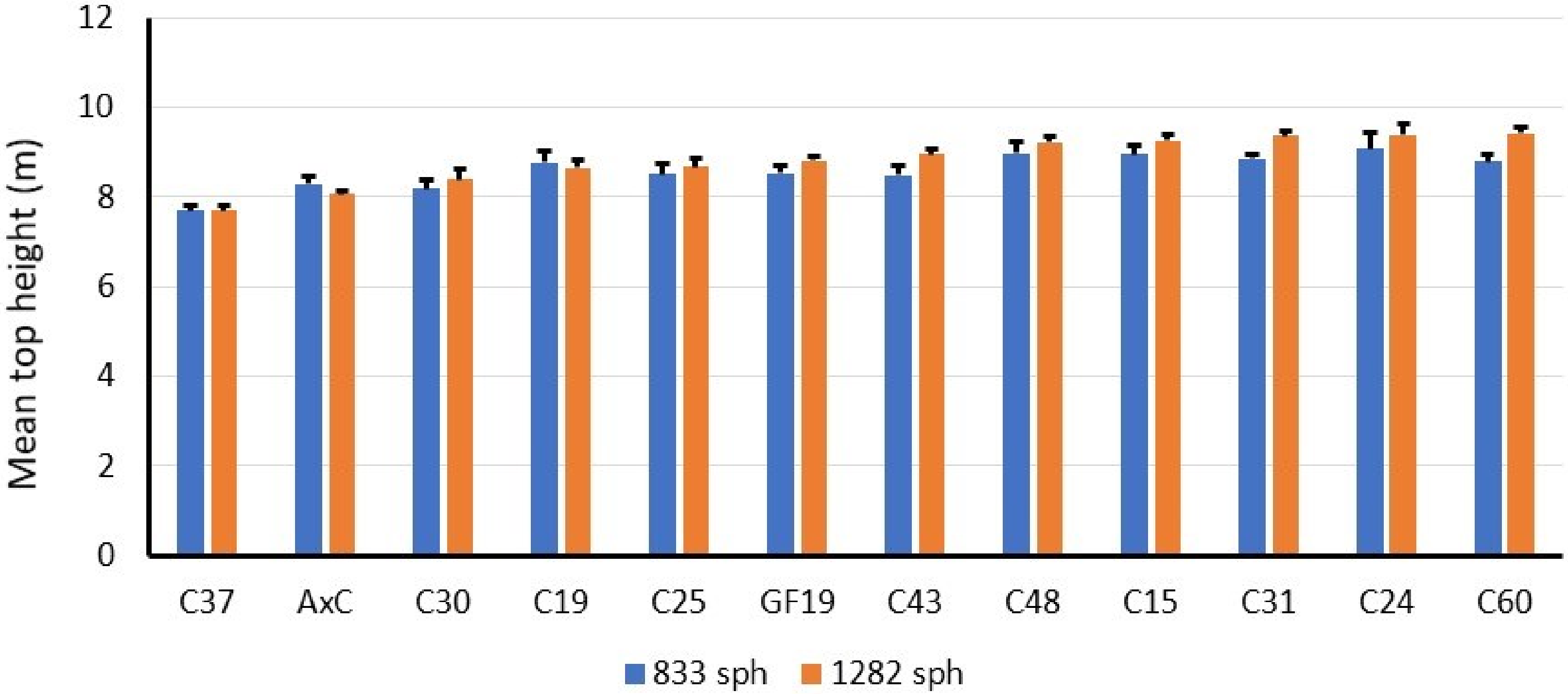

Figure 13: Variation in mean top height of different stock at the Rangipo Accelerator trial, indicating the relative response to stocking rate. Error bars indicate standard error of the mean.

Central Kaingaroa

Nitrogen is the dominant nutrient limitation at this site and given the warmer climate relative to Southern Kaingaroa it was decided to address this by increasing organic carbon stocks, thereby increasing the nutrient storage capacity in the soil. at this. Consequently, it was decided to introduce lupins to increase both organic carbon inputs and N supply over time. The lupins initially established well but were heavily browsed by rodents; this was demonstrated through the use of enclosures. This herbivory caused a massive reduction in the coverage of the lupin understory, likely reducing any input of biologically fixed nitrogen to enhance tree performance.

The 2021 growth data from Central Kaingaroa trial site at age five indicated that the influence of the lupins was insufficient to affect tree volume (P = 0.41) (Fig. 14). Further examination showed that basal area was unaffected (P = 0.96) (Fig. 15), but mean top height was increased by the presence of the lupins (P = 0.003) (Fig. 16). This result was highly surprising as it was expected that lupins would not have had an impact given the lack of coverage but given the level of statistical significance it is apparent that the lupins have had some effect.

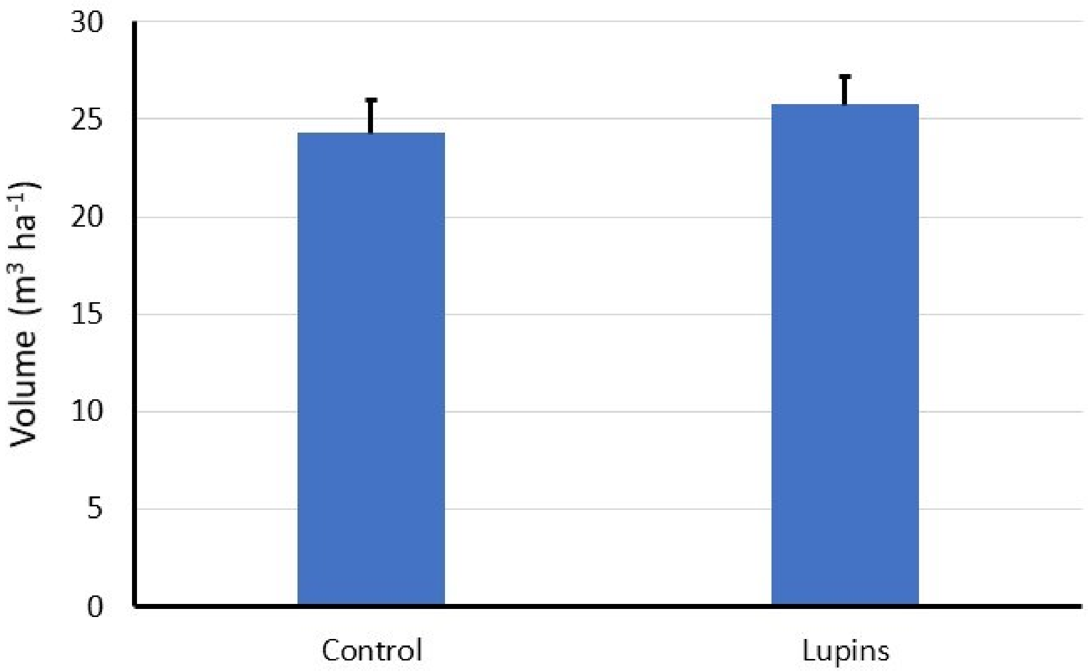

Figure 14: Volume response to lupins at the Central Kaingaroa Accelerator trial. Error bars indicate standard error of the mean.

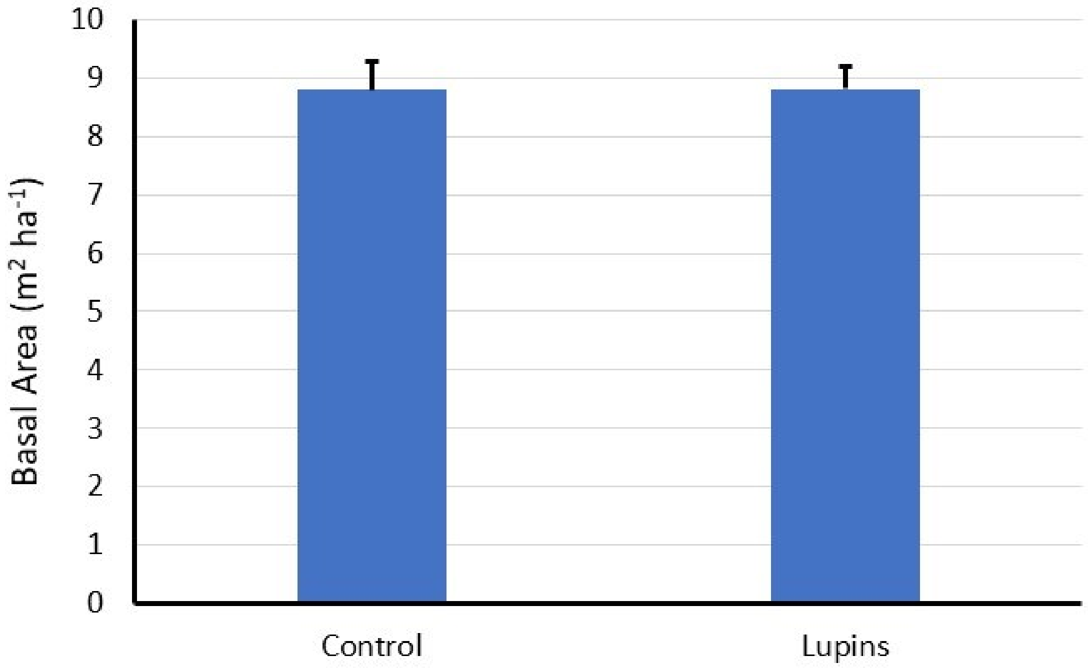

Figure 15: Basal area response to lupins at the Central Kaingaroa Accelerator trial. Error bars indicate standard error of the mean.

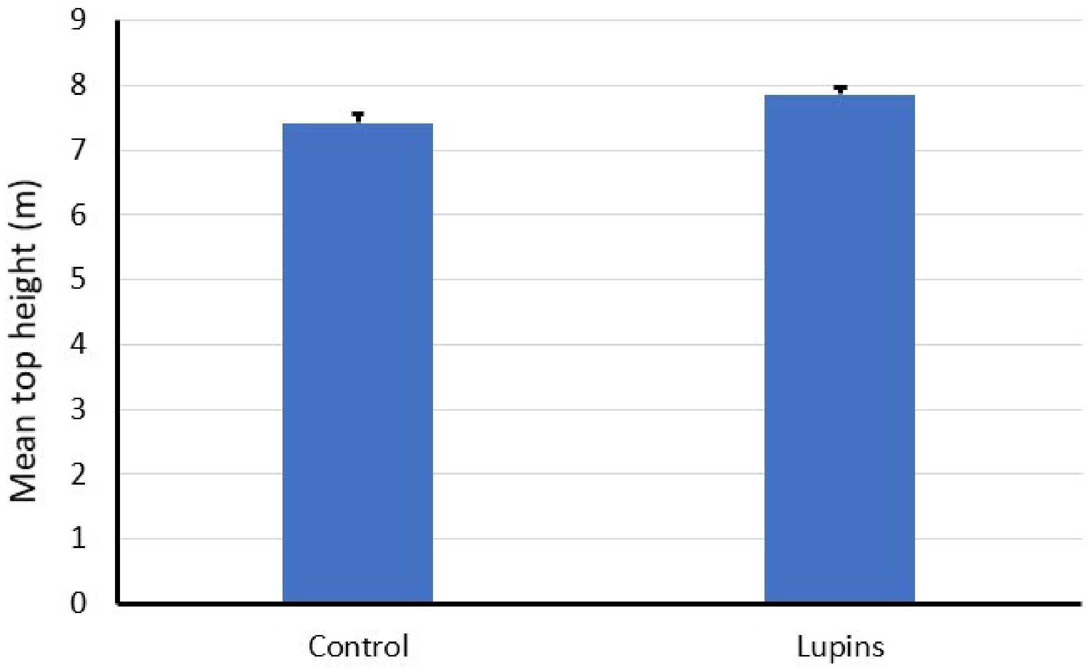

Figure 16: Mean top height response to lupins at the Central Kaingaroa Accelerator trial. Error bars indicate standard error of the mean.

As at the other sites, volume varied considerably with stock (Fig. 17), largely driven by basal area (Fig. 18) (both $P < 0.001$). Mean top height also varied with stock ($P = 0.002$), but the extent of the variation was less (Fig. 19).

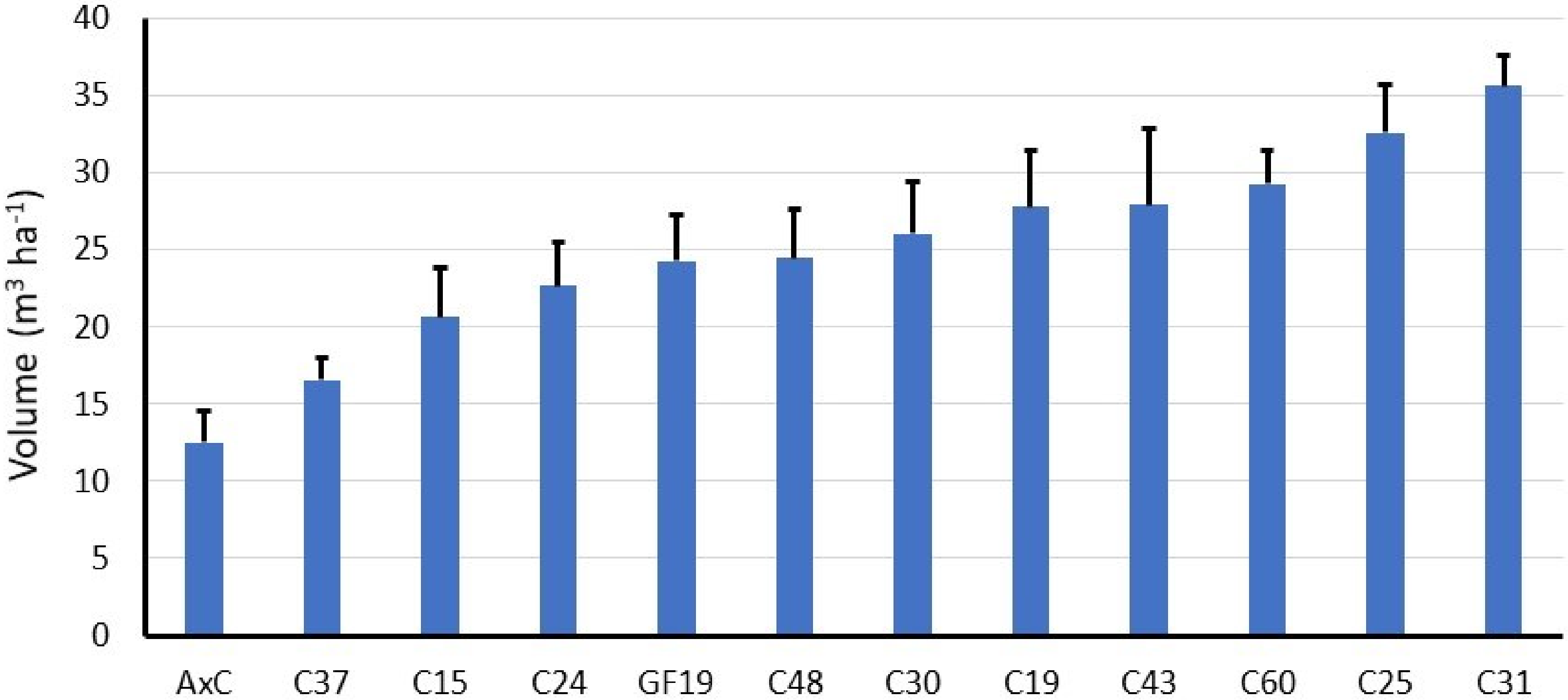

Figure 17: Variation in volume of different stock at the Central Kaingaroa Accelerator trial, indicating the relative response to stocking rate. Error bars indicate standard error of the mean.

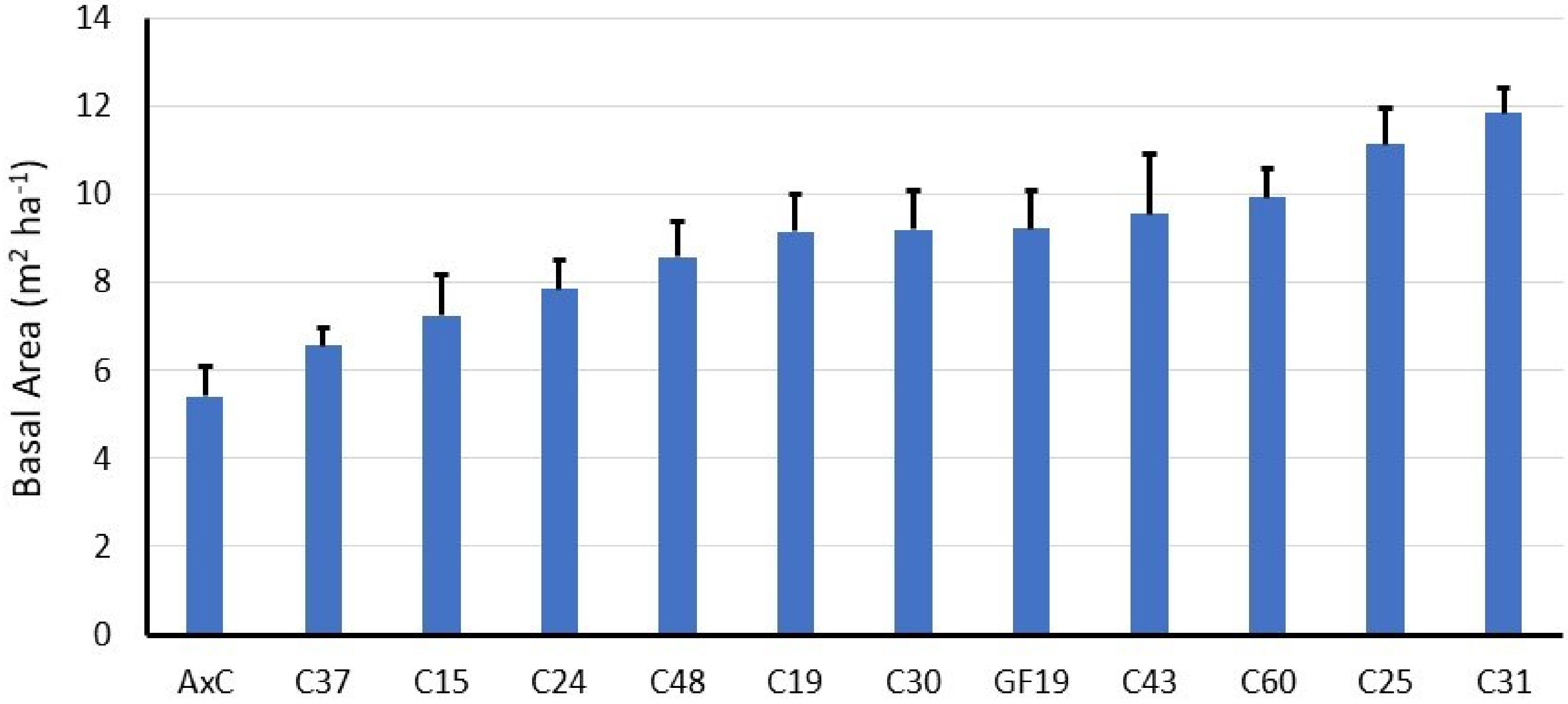

Figure 18: Variation in basal area of different stock at the Central Kaingaroa Accelerator trial, indicating the relative response to stocking rate. Error bars indicate standard error of the mean.

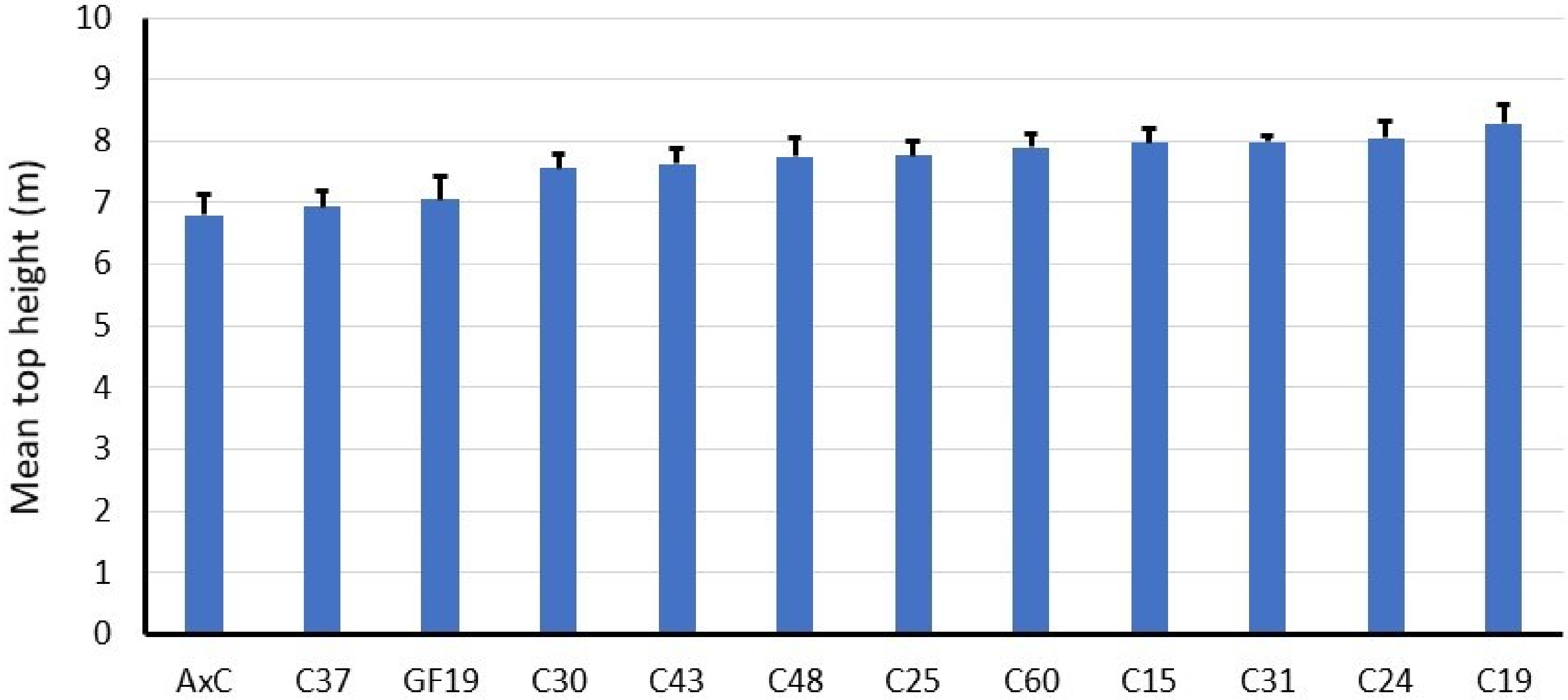

Figure 19: Variation in mean top height of different stock at the Central Kaingaroa Accelerator trial, indicating the relative response to stocking rate. Error bars indicate standard error of the mean.

Summary

An overarching outcome from the growth results to date is proof of the sensitivity of the trees to management, and the possibilities this raises to enhance productivity by identifying and addressing the limitations and potential of a given site. The gains at Southern Kaingaroa and Rangipo, which present inherently very different issues, provide clear evidence of this. Although the lupin treatment at Central Kaingaroa was initially thought to have failed due to low coverage, this too produced a consistent, positive impact on tree height growth without compromising basal area.

The considerable variation between the clones, the AxC hybrid and the GF19 stock provided yet more evidence of the gains that can be made by matching stock to the site they will be planted in. Earlier measurements at the sites had indicated that some stock was clearly performing better based on diameter increment and health, but the comparison of standing volumes even at this relatively early stage provides solid evidence of the value of utilising site properties as a tool to select the genotype of the trees to be deployed at that site. Comparison of the performance of the stock at Rangipo and Central Kaingaroa adds to this argument. Given both sites were planted with the same mix of stock in the same year, the relative gain of planting the stock on the more fertile Rangipo site can be observed (Figure 20). Averaging across the two stocking rate treatments at Rangipo, the mean stock volumes increased by 93%, but it was apparent that some stock benefitted far more than others. This provides insight into the drivers of the growth for each tree, as Rangipo can provide the trees with more nutrients, but largely has the same disease risks as Central Kaingaroa based on assessments of needle health.

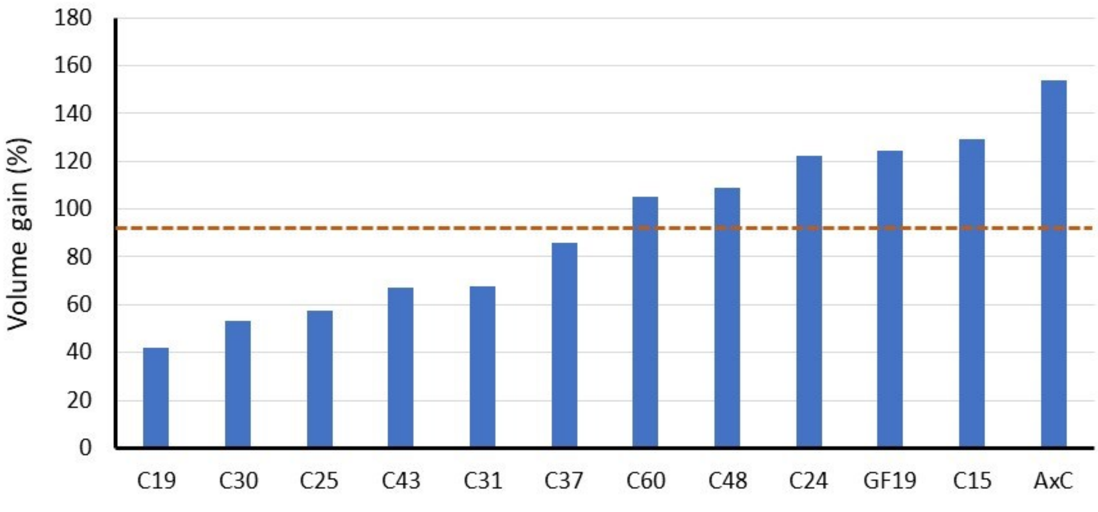

Figure 20: Variation in volume gain for stock at Rangipo compared to Central Kaingaroa. The dotted line indicates the average gain.

Data collection will continue in perpetuity at the sites, and as the three other sites develop the volume data from these will be incorporated into the analysis as well.

THINNING STRATEGY

Given the age and growth rate of the trees at the Southern Kaingaroa (KANG 861), Rangipo (RAPO 209) and Central Kaingaroa (KANG 127) sites it has become necessary to develop a suitable thinning strategy that follows the underlying concept of the Accelerator trial series – that is, to sustainably maximise the productivity of the sites. To that end a number of analysis were conducted to produce recommendations for thinning at these three sites.

Initial selection process

Following a site visit a decision was made to initially base the thinning strategy for each site on the performance of the single best combination of treatments and stock, as this would allow the best trees to make best use of the site. At Rangipo it was decided to vary this approach slightly by identifying the best combination for each of the two stocking levels. This thinning regime would then be applied across the entire site, or in the case of Rangipo, for that stocking level. This data in shown in Table 2.

Table 2: The combination of treatments and tree to produce the greatest volume at each site.

Trial	Treatment	Stocking rate (sph)	Best tree	Volume (m^3 ha^{-1})
KANG 861	Biuret	NA	C31	32.7
RAPO 209	Not cultivated	833	C60	47.8
RAPO 209	Not cultivated	1282	C60	87.0
KANG 127	Control	NA	C48	36.5

Calibration of Forecaster

The data describing the best performing trees where then used to calibrate the Forecaster model for each site. The data for the respective crops and sites were inserted into Forecaster and growth simulations conducted. For the initial comparison between measured and modelled growth the site indices (SI) were selected from the NZ map ("Forecaster Standard") in the Forecaster tool, which use underlying site parameters to define SI and 300 Index of the respective site. An example is provided showing the improved mean top height (MTH) growth of the clone C60 at RAPO 209 (measured data) compared to the "standard growth simulation" with GF13 and site parameters selected through the NZ map implemented in Forecaster (Fig. 21).

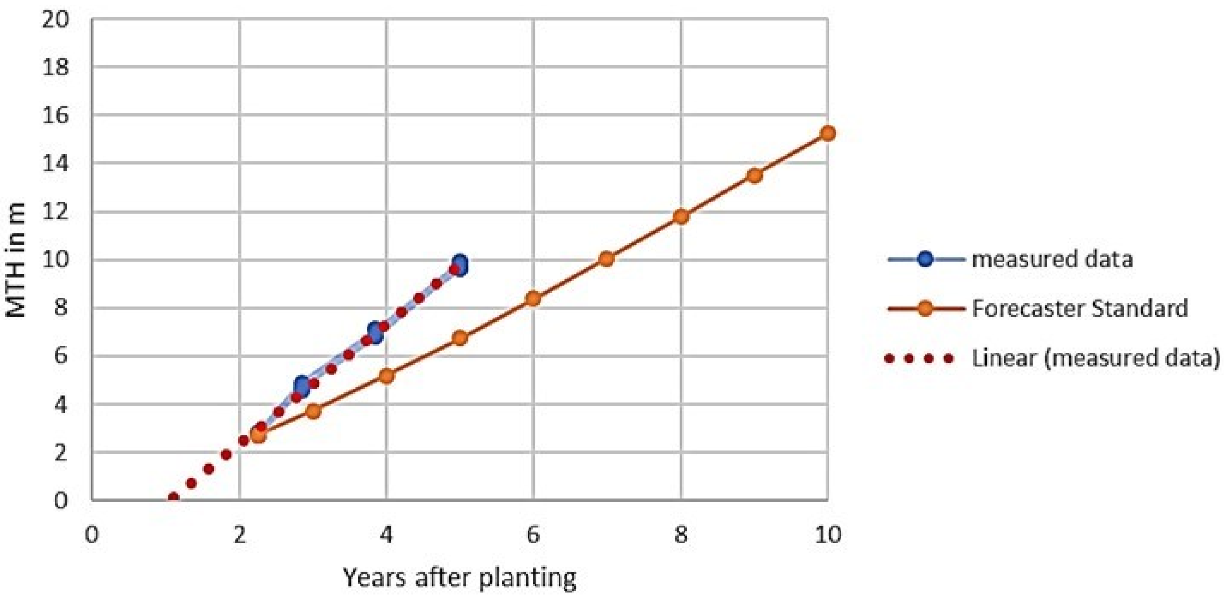

Figure 21: Comparison of measured MTH values for C60 at Rangipo (1282 sph) with projected MTH values from Forecaster

To reflect the better growth of the trees compared to the standard settings of Forecaster evident in the example in Fig. 21 we adjusted the growing parameters (i.e. SI and 300 Index) when necessary. The aim of the calibration was to adjust SI and 300 Index settings in Forecaster so that the growth of the measured data matches the growth curves of the simulation.

Site Index is derived from the height of the stand at a certain age and is thus related to MTH. We adjusted the SI in Forecaster to match MTH of measured and modelled growth until the measured data of MTH are congruent to simulated Forecaster data. An example of is shown for RAPO 207 at 1282 sph; here the measured MTH matched the settings of the site index of 48 (Fig. 22).

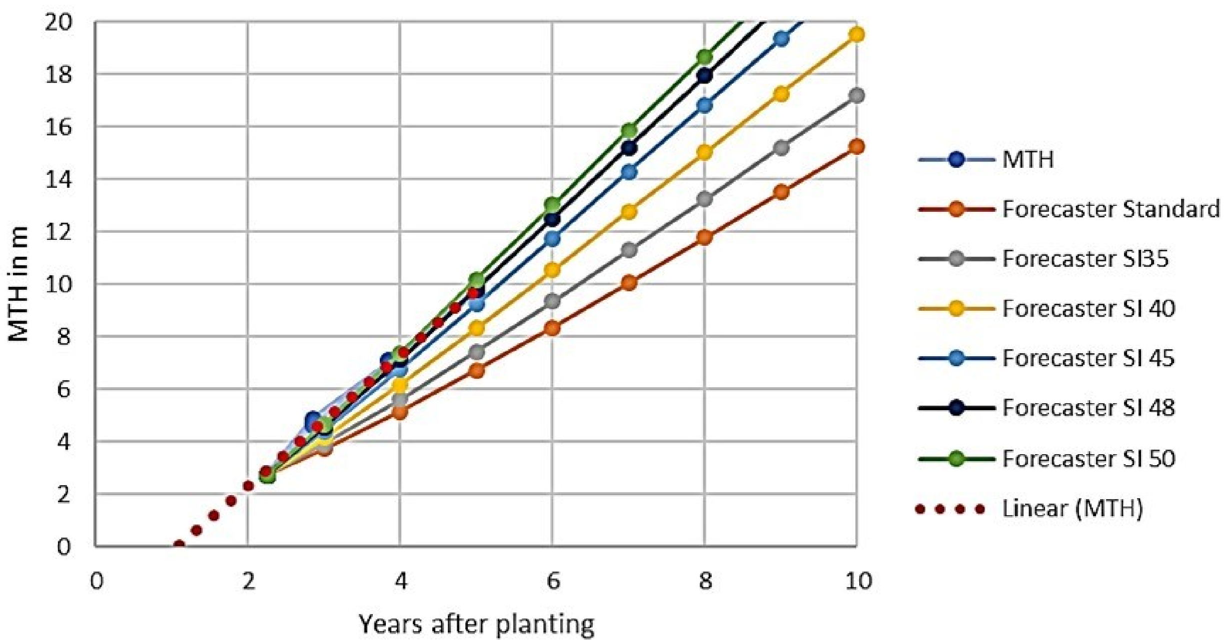

Figure 22: Identification of a suitable SI value to match measured MTH values

The 300 Index is based on stand basal area. Therefore, a process analogous to that used for MTH was conducted with BA and 300 Index values until the curve of the BA graph matched the simulated courses in the model. Again, using RAPO 207 at 1282 as an example, Fig. 23 shows the comparison with different settings of the Forecaster model vs the measured data (yellow). The best match for the 300 Index with the measured data in this case is at a 300 Index setting of 34.

Figure 23: Identification of a suitable 300 Index value to match measured BA values

Following this process for all sites produced the following table of adjusted SI and 300 Index values to inform the Forecaster thinning simulations.

Table 3: The SI and 300 Index values generated for use in Forecaster simulations.

Trial	Stocking rate (sph)	Adjusted SI	Adjusted 300 Index
KANG 861	NA	42	25
RAPO 209	833	45	32
RAPO 209	1282	48	34
KANG 127	NA	40	28

To calibrate the economic outcomes of Forecaster, specification, log product definitions and current 12-quarter median prices (weighted average prices) for domestic grades were identified from the MPI website; these are shown in Table 4.

Table 4: Log grading definitions and valuations used in Forecaster simulations.

Grade	Definition	Weighted average (NZ$ per ton delivered)
P1	Pruned log, min SED 40cm.	188
P2	Pruned log, min SED 30cm.	167
S1	Structural sawlog, min SED 40cm, branch size max 7cm.	142
S2	Structural sawlog, min SED 30cm, branch size max 7cm.	137
S3 and L3	Small sawlogs, min SED 20cm, branch size 12cm (for S3 and L3).	124
L1 and L2	Utility sawlog, min SED 30cm, branch size max 12cm.	126
Pulp	Pulp grade log, min SED 10cm. No branch max.	58

Thinning scenarios

Various thinning scenarios were tested using the settings described above for each site. Two different rotation periods were tested (rotation of 22 years and 30 years). The aim of the thinning was to optimise value and recovered volume over the rotation. The thinning options ranged from no thinning up to three thinning events (two of which were production thinning, one thin to waste). Trees were removed “worst first” to ensure that the remaining logs are the highest grades. Thinning intensity was also constrained based on the 35-55% stand density index (SDI) rule (management zone of SDI) and keep the stand in the management zone as much as practicable (Fig. 24).

Pruning scenarios where not analysed so the resulting log grades after harvest were Pulp, S3 and L3, L1 & L2 and S2. Shares of these grades varied with thinning frequency and intensity. Other key criteria were:

- no harvesting costs/ thinning costs are included
- economic impacts of risk (health, stability of stand) are not included
- although future timber value is expected to vary, the relative proportional value of log grades was assumed to remain stable

An example of the thinning scenario assessment is shown in Fig. 25, utilising RAPO 209 at 1282 sph over 22 years.

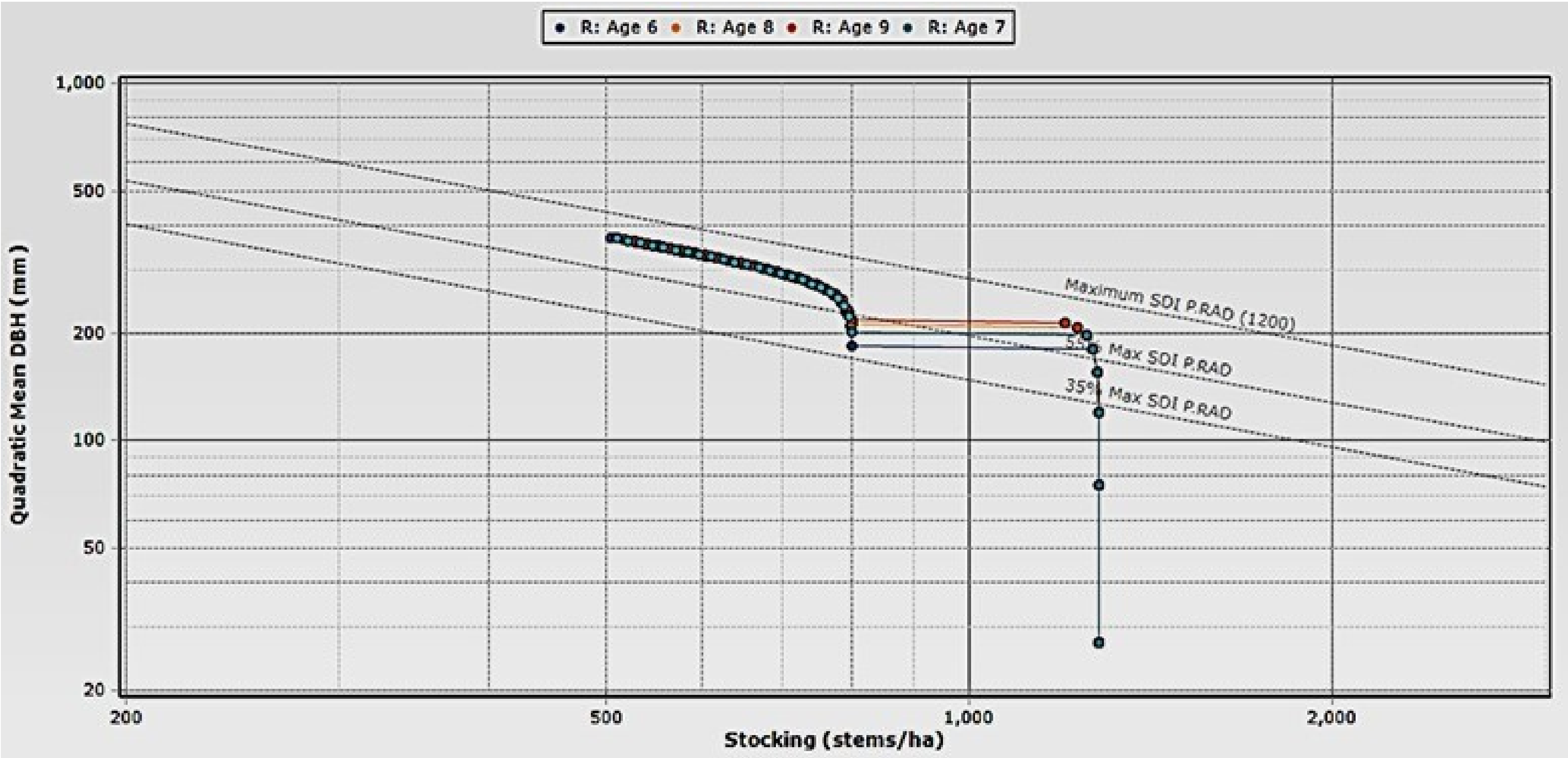

Figure 24: Example of impact of thinning on stand density index values, and the retention of stocking levels within the 35% - 55% stand density index zone.

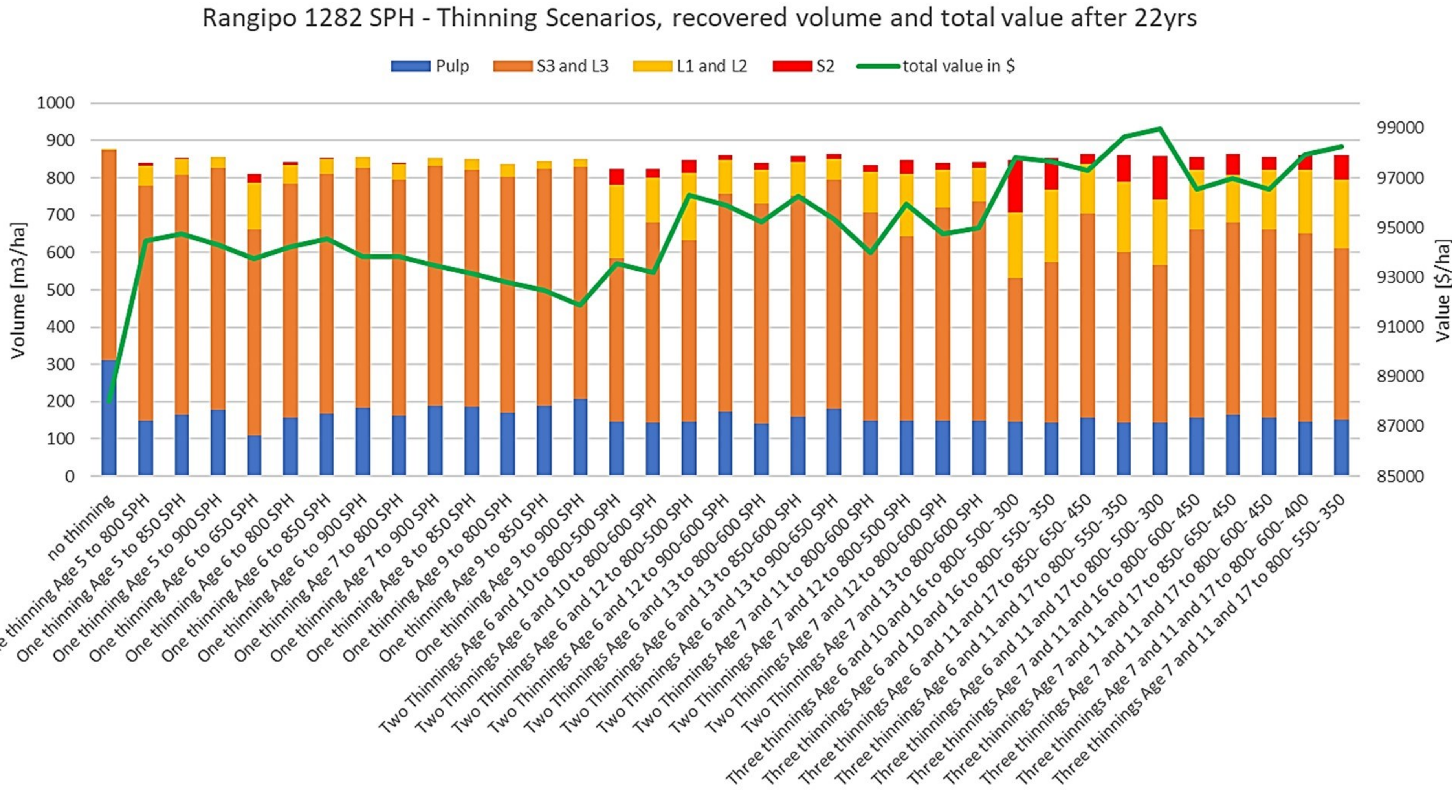

Figure 25: Projection of the impact of different thinning scenarios on stand volume and value at RAPO 209 in the 1282 sph treatment.

All sites were analysed at the two rotation lengths and a summary of the best options for thinning is presented in Table 5. Note that Rangipo (RAPO 209) is split into the 833 and 1282 sph treatments.

Table 5: List of the optimum thinning scenarios for each site over 22 and 30 year rotations.

Rotation length	Trial	Thinning Scenario	Volume recovered (m^3 ha^{-1})	Timber value (NZ$ ha^{-1})
22 Years	KANG 861	One thin Age 6 to 900 SPH	667	66888
22 Years	KANG 861	One thin Age 7 to 900 SPH	667	66787
22 Years	KANG 861	Two thins Age 8 and 17 to 800-500 SPH	635.3	65116
22 Years	RAPO 209: 833	No thin	819.8	85978
22 Years	RAPO 209: 833	Two thins Age 7 and 16 to 733-450 SPH	814.4	87165
22 Years	RAPO 209: 833	Two thins Age 7 and 17 to 733-400 SPH	824.7	88049
22 Years	RAPO 209: 1282	One thin Age 6 to 850 SPH	951.1	94568
22 Years	RAPO 209: 1282	Two thins Age 6 and 12 to 800-500 SPH	1010.7	96311
22 Years	RAPO 209: 1282	Three thins Age 6, 11 and 17 to 800-500-300 SPH	859.3	98985
22 Years	KANG 127	One thin Age 7 to 900 SPH	763.2	81948
22 Years	KANG 127	Two thins Age 6 and 17 to 900-500 SPH	756.1	81674
22 Years	KANG 127	Two thins Age 7 and 17 to 900-550 SPH	757.4	81836
30 Years	KANG 861	No thin	956.4	106115
30 Years	KANG 861	One thin Age 8 to 800 SPH	922.8	104679
30 Years	KANG 861	Two thins Age 8 and 17 to 800-500 SPH	901.7	100337
30 Years	RAPO 209: 833	No thin	1078.9	120942
30 Years	RAPO 209: 833	One thin Age 7 to 750 SPH	1056.8	119683
30 Years	RAPO 209: 833	Three thins Age 7, 13 and 20 to 650-500-350 SPH	1068.9	122443
30 Years	RAPO 209: 1282	One thin Age 6 to 900 SPH	1113.6	130440
30 Years	RAPO 209: 1282	Two thins Age 7 and 13 to 700-400 SPH	1085.6	131250
30 Years	RAPO 209: 1282	Three thins Age 7, 13 and 20 to 800-550-350 SPH	1155.9	138399
30 Years	KANG 127	No thin	1065.8	119523
30 Years	KANG 127	One thin Age 7 to 900 SPH	1032.6	118987
30 Years	KANG 127	Three thins Age 9, 15 and 20 to 850-600-400 SPH	1009.1	116923

While a 22 year rotation offers considerably less financial gain, the opportunity to produce a return on investment more quickly and restock the site with the latest genetics could make this option warranted. This approach is likely most feasible at the Rangipo site, as this site has the greatest nutrient stocks and would therefore be more resistant to an increased frequency of harvest disruption.

Although “No thin” option features several times as advantageous in terms of productivity and financial gain, it is reinforced that this does not incorporate the additional risk in terms of stability and the health impacts of maintaining a dense stand. It is also noted that if a 22 year rotation is pursued at KANG 861, the window for the “One thin Age 6 to 900 SPH” option has nearly expired.

A final consideration relates to the assumptions around the stand density that can be supported at the sites. It is feasible that the SDI scenarios outlined in Fig. 24, which informed the thinning intensities, may also no longer be appropriate given the productivity observed at the Rangipo site in particular, and the implications this may have for enhanced carrying capacity. Consequently, it has been determined that all decisions on thinning will be made next year immediately after the 2022 trial measurement have been completed and the data processed, including foliar nutrition data. This extra time will allow assumptions around the validity of the SDI scenarios to be tested, which could have considerable impact on thinning intensity. This will also provide additional time to discuss these results with the forest owners and consider the wider implications of any decisions.

UPDATE ON OTHER SITES

Ashley

This site has been measured in 2021. Plans for the collection of baseline plant stress data are now underway with the availability of instrumentation to measure chlorophyll fluoresce on trees in the field. This data will be tested against the growth data form the different stock established at the site. Following this, treatments with aminoethoxyvinyl glycine hydrochloride[9] and pyrazinecarboxamide[10] to manipulate plant stress response will commence.

Tairua

This site has been measured in 2021. Phosphorus (P) additions have begun at this site, with the second treatment completed recently; application rates were determined based on the outcomes of NuBalM simulations. The concept behind the application process is to increase the store of P in the forest organic layer (forest floor) and soil organic P pool which the plants can access as P demand increases. Focussing on maintaining the P in the organic pools will restrict competition with the mineral soil, which can tightly bind any added P given the nature of the allophanic soil at this site.

Tokoiti

This site has been measured in 2021. Effort to replant areas of this site where the initial crop failed due to water logging were severely disrupted by Covid19. With support from Timberlands Te Ngae nursery, all needed clonal stock was sourced, but the day before planting was due to occur all planting activity had to cease for several weeks due to another Covid19 Lockdown. Although the stock was planted at the earliest possible opportunity, it is likely that establishment success will not be as high as hoped. An evaluation of the replanted stock will take place prior to the 2022 planting season.

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