ESTABLISHMENT OF NURSERY-RAISED INDIGENOUS SEEDLINGS IN SELECTIVELY LOGGED FOREST IN PUREORA FOREST PARK

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ABSTRACT

Nursery-raised seedlings of four podocarp species were established in selectively logged forest at Pureora in 1976-8. Fertiliser applied at time of planting was not shown to be advantageous. Survival after 6 to 8 years was high — exceeding 90% for all species on most sites. Mean annual height growth varied between species with matai demonstrating the slowest growth, totara slightly better although form was poor, whilst kahikatea and rimu showed strong apical dominance and grew well at rates approaching 20 cm/yr. The implications of these results for operational planting in logged areas are discussed.

INTRODUCTION

In 1961, the Forest Research Institute established a trial in the North Block of Pureora to test the feasibility of selective logging and examine the prospects for the re-establishment of podocarp seedlings (Beveridge, 1975; G. Steward, pers. comm.). In October 1975, the government approved a policy for the management of indigenous forests which had been formulated during the 1974-5 Forestry Development Conference (N.Z. Forest Service, 1977). This policy changed the system of indigenous timber production at Pureora from clearfelling to one of selective logging "that maintains the diversity of age, tiers and species within the indigenous structure to provide a wide range of social, economic and environmental values". The policy stipulated "the wood cannot be harvested unless a forest structure is retained or restored after logging". As a result, trials to test techniques and rates of selective logging in dense podocarp forest (Tihoi) and podocarp tawa forest (North Block) were established in what is now Pureora Forest Park (Gamble, 1979; Herbert,

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1980). These trials were followed by operational selective logging to fulfil contractual commitments. During 1976-8, four trial plantings of nursery-raised podocarp seedlings were undertaken within these areas. This paper describes the establishment phase of these seedlings.

STUDY SITES AND METHODS

Location of Trials

Two of the trial areas are located in selectively logged forest off Waimonoa Road, Tihoi, at an altitude of *ca* 700 m a.s.l. (NZMS 260, T17, 435942). These two trials were established in similar forest that had 30% of merchantable volume removed but were established in different years (1976-7).

The other two trial areas are located in the North Block of Pureora. The areas are adjacent to Select Loop Road at 575 m a.s.l. (NZMS 260, T17, 315018). The first area established (1977) had 30% of merchantable timber removed prior to re-establishment whilst the area re-established in the following year (1978) had been logged partly at 60% rate of removal as a trial and partly at 30% in subsequent operations.

Planting

Table 1 gives the species and numbers of trees established at each trial location with the mean height at time of establishment given in parentheses. Trees were measured by fully extending the longest leader and measuring maximum height in centimetres.

At Tihoi the seedlings were planted in groups of five whilst at Pureora groups varied from 3 to 5 trees in each group. In both cases trees were planted 1-3 m apart with *ca* 20 m between groups.

TABLE 1: SPECIES AND NUMBERS OF TREES AT TIME OF ESTABLISHMENT
(Mean Height in cm given in Parentheses)

Location	*Tihoi*	*Tihoi*	*Pureora*	*Pureora*
Year planted	Nov. 76	Nov 77	Jul. 77	Sep. 78
Kahikatea		95 (129)	700 (90)	400 (88)
Totara	500 (60)	327 (80)		50 (72)
Rimu				800 (59)
Matai		48 (104)		

TABLE 2: PROVENANCES OF TREES ESTABLISHED IN THE TRIAL AT TIHOI

Year	*No.*	*Species*	*Source*
1976	500	totara	Stoke, Nelson
1977	327	totara	Opepe
1977	95	kahikatea	Ashley Clinton
1977	48	matai	Minginui

The local policy for re-establishment of selectively logged forest aims to restrict the source of indigenous seedlings to a local seed region — in this case, West Taupo (N.Z. Forest Service, 1984). When these trials were established, however, this was not the case. Whilst the seedlings established in North Pureora were grown from local seed, the source of seed for the Tihoi plantings was widespread. The provenances of these seedlings are shown in Table 2.

Fertilising

A range of fertiliser treatments was applied to all or some of the trees in each area at time of planting. Table 3 lists these treatments and the numbers of each species involved. Apart

TABLE 3: FERTILISER TREATMENTS APPLIED AND NUMBER OF TREES INVOLVED

	Tihoi 76	*Tihoi 77*			*Pureora 77*		*Pureora 78*	
	Totara	*Totara*	*Kahik.*	*Matai*	*Kahik.*	*Rimu*	*Kahik.*	*Totara*
No fertiliser		54	47	24	32	27	15	18
25 g magamp to surface		53	48	24				
100 g magamp to surface	500							
25 g magamp to hole		110						
50 g magamp to hole					14	26	9	
100 g magamp to hole		110			14			
30 g blood & bone to hole						27	23	
50 g blood & bone to hole					14			
50 g magamp & 50 g blood & bone to hole					13			

from the totara established at Tihoi in 1976 which was fertilised when one-year-old, all fertilising was conducted at time of establishment. The very low sample size in some treatments should be noted.

Releasing

The trial areas differed in their history of releasing treatments. The Tihoi trials, established in 1976 and 1977, were not released until January 1981 but then were subsequently released and measured in the winters of 1982 and 1984. The North Pureora trials, however, were intensively released biennially from 1978 to 1984. All releasing was done manually using slashers.

Assessment

Apart from the releasing treatment of the Tihoi trials in January 1981, the trees were assessed for survival and growth at time of releasing. Trees were measured by fully extending the longest leader and measuring maximum height in centimetres — although depending on the growth of the differing species this method may constitute an index of growth rather than an absolute assessment of height. Despite this problem, the method has the advantage of being consistent with time.

RESULTS

Survival

The 1984 survival assessments of the seedlings 6 to 8 years after planting are given in Table 4.

Survival for all species has been excellent, particularly those planted at the lower sites in the north block of Pureora. The

TABLE 4: PERCENT SURVIVAL OF PLANTED SEEDLINGS
(No. of Seedlings Monitored given in Parentheses)

Years since Planting	*Rimu*	*Kahikatea*			*Totara*		*Matai*
	Pureora	*Pureora*	*Pureora*	*Tihoi*	*Pureora*	*Tihoi*	*Tihoi*
6	98 (108)		96 (51)		100 (18)		
7		94 (87)		96 (95)		85 (327)	92 (48)
8						94 (500)	

trend in assessments conducted since 1980 has been for the minimal mortality to be due not to establishment factors but to external influences — *e.g.*, being crushed by windfall of adjacent trees.

Growth

Table 5 summarises the average growth per annum for each species in the different trials as determined by the 1984 assessments. Rimu and kahikatea both show strong apical dominance and grow well although kahikatea with two main leaders are not uncommon. Totara growth is reasonable but form is generally poor and the growth rates do not reflect the tendency of the seedlings to grow in a bushy or prostrate form. Matai growth form is similar to that of totara — the growth rates recorded here are similar.

TABLE 5: MEAN ANNUAL HEIGHT GROWTH OF THE PLANTED SEEDLINGS (cm)

Years since Planting	*Rimu*	*Kahikatea*			*Totara*		*Matai*
	Pureora	*Pureora*	*Pureora*	*Tihoi*	*Pureora*	*Tihoi*	*Tihoi*
6	18.3		16.5		11.7		
7		18.6		14		7	7
8						12	

Growth rates appear to increase during the first few years after establishment and then even off. Table 6 illustrates the growth trends for the Pureora 1978 plantings as determined at the biennial assessments. These show that the growth of the podocarps in the early years is not comparable with later growth. Similar trends have been noted by the Forest Research Institute at Pureora and Mamaku (D. O. Bergin, pers. comm.).

In addition to the closely monitored trees in this trial, a large number of other trees planted and marked at the same time were also measured in 1984. The mean height for all trees was calculated and compared with the sample previously described to give an overall indication of mean annual height increment. In addition, the mean height of the largest tree in each group was calculated for comparison (see Table 7). Comparison by *t*-test for unpaired plots between trees in the monitored sample and trees throughout the area show no significant difference in mean height for rimu ($t = 1.616$, $df = 371$) or totara ($t = 0.749$,

TABLE 6: GROWTH TRENDS FOR SPECIES PLANTED AT PUREORA IN 1978

Species	*Year*	*No. Measured*	*Mean Height (cm)*	*Std Devn*	*Current Annual Increment (cm)*	*Mean Annual Increment (cm)*
Rimu	1978	108	59	8.1		
	1980	94	83	15.7	12.0	12.0
	1982	103	123	26.4	20.1	16.1
	1984	99	169	33.8	23.0	18.3
Totara	1978	18	72	8.4		
	1980	18	85	22.4	6.5	6.5
	1982	18	115	26.9	14.8	10.6
	1984	18	142	44.7	13.8	11.7
Kahikatea	1978	51	88	11.9		
	1980	47	113	19.7	12.4	12.4
	1982	46	152	39.7	19.4	15.9
	1984	42	187	54.9	17.5	16.5

$df = 41$); however, the kahikatea in the monitored sample were significantly smaller than average for all trees planted throughout the area ($t=2.279$, $df=438$, $p=0.02$). For all species, the largest tree in each group was *ca* 30 cm larger than the mean height for the group.

Few podocarp seedlings survive without having leader growth, tree form or general vigour affected by at least one of a number of damaging or inhibiting agencies (G. Pardy, pers. comm.). The most serious noted in these trials affects kahikatea. The damage is usually initiated by cicadas scarring the stem for egg laying,

TABLE 7: GROWTH OF ALL MARKED TREE PLANTED AT PUREORA IN 1978

Species	*No. Measured*	*Mean Height (cm)*	*Std Devn.*	*Estimated M.A.I. (cm)*
rimu-all trees	267	154	42.2	15.9
rimu-biggest/group	90	182	32.5	
totara-all trees	25	132	43.5	10.0
totara-biggest/group	8	165	44.5	
kahikatea-all trees	396	210	62.9	20.2
kahikatea-biggest/group	128	246	51.1	

and frequently followed with invasion by stem borers (*e.g., Oemona hirta* and *Navomorpha lineata*). Their spiral tunnelling weakens the stem which dies or frequently snaps — resulting in the loss of up to one metre of growth.

Effects of Fertiliser

Despite the range of fertiliser treatments applied to the different species, none has demonstrated any benefit in survival or growth than can be detected. There is a trend in treatments where heavy applications of magamp were added to the planting hole for growth to be depressed. The trend, however, is not statistically significant in these trials but has been also noted elsewhere (D. O. Bergin, pers. comm.).

Releasing

Most of the planted trees have benefited from regular hand releasing since establishment. The major competing vegetation in these areas is wineberry which grows prolifically on sites disturbed by logging where compaction of the soil has not been severe. The benefits of releasing were demonstrated when the trials at Tihoi were remeasured in 1982.

Of the 94 groups planted in 1977, 6 groups were not found and released in January 1981. Of the 30 trees in these groups, 7 (5 totara, 2 matai) were dead in 1982 (*i.e.,* 23%). This mortality was over twice as high as the overall mortality at that time for the 1977 plantings (11%). The average height of the surviving 17 totara trees in these 6 groups was 65 cm compared with 82 cm overall.

Of the 100 groups of totara planted in 1976, 6 were not released in 1981. Once again 7 of the 30 trees were dead (*i.e.,* 3 times the overall mortality rate. The average height of the 23 surviving trees in these plots was 111 cm compared with the overall average of 134 cm.

Although these data are limited, the conclusions support findings elsewhere in the Central North Island that releasing in early years is essential for optimum survival and growth (D. O. Bergin, pers. comm.). All the trials described are now considered to be established and unlikely to require further releasing. These trees have, however, received on average 3 hand releasing treatments. Such releasing is time consuming and therefore expensive. In response to the problem, a further trial has recently been estab-

lished which will investigate the optimum method of releasing rimu in such conditions. Early results indicate that chemical methods of weed control may be cheaper and equally as effective as manual methods.

CONCLUSIONS

These trials have demonstrated that re-establishment of nursery-raised indigenous seedlings in selectively logged forest can be extremely successful. The survival rates six to eight years after planting are excellent — exceding 90% in most situations. Growth rates, assessed from the closely monitored groups of trees and other marked groups planted at the same time and which have been released regularly, are generally encouraging. There is significant variation in growth between species, with form of the trees also contributing significantly to the performance of each species. Growth apparently increases in rate after the first few years of establishment, but there are no indications that this acceleration continues beyond five years after planting.

Successful establishment is dependent upon reasonable site selection (disturbed but uncompacted soils with side shade but overhead light) and control of competing vegetation in the early years. Fertilisers have shown no benefit at time of establishment.

With the development of more cost-effective releasing systems, the results of these trials and similar ones elsewhere should indicate the potential for the re-establishment of other areas. The experience gained from these trials is now being tested on more severe sites at Pureora including old heavily cutover and clear-felled and burnt areas. There are already indicatioens that survival and growth will be much impaired as exposure increases and that the degree of success reported here may not be expected on such sites.

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